NATIONAL COOPERATIVE
HIGHWAY RESEARCH PROGRAM REPORT 295

AUTOMATED FIELD SURVEY DATA COLLECTION SYSTEM

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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AUTOMATED FIELD SURVEY DATA COLLECTION SYSTEM

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AREAS OF INTEREST:

Facilities Design
Pavement Design and Performance
(Highway Transportation)

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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FOREWORD

By Staff
Transportation Research Board

The primary objective of the research covered herein was to develop a standard file format for field surveying data that would facilitate its subsequent transfer to engineering design systems. The standard file can also be used to provide uniformity in the output requirements of surveying equipment and be included in procurement specifications. Development of the standard file required an examination of the entire process of collecting, processing, storing of field surveying data, and the subsequent transfer of data to design or graphic systems. Consequently, surveyors, specification writers, and designers will find the report of interest and useful.

In the past, few transportation agencies performed comprehensive analyses of survey operations within their organizations. However, with a diversity of high-tech "total stations" and "data collectors," and various software systems now available, many agencies are faced with problems of integrating these components into their surveying operations. In addition, field survey data must be suitable for fast, efficient transfer to and from other engineering systems, such as computer-aided design and drafting programs. These issues, coupled with an increase in transportation construction projects nationwide, and an increased need for more accessible survey data, create pressure on agencies to provide "quick fix" purchases and approaches. This, in turn, can result in possible wasted time and duplicated effort, as similar, but incompatible, systems are developed and tested.

Because of the demand for field survey information in varying formats and accuracies for projects and records, there was a need to integrate the different phases in handling survey information and to automate as many tasks as possible. As an initial step in dealing with this problem, NCHRP Project 20-21, "Development of an Automated Field Survey Data Collection System," was undertaken by the joint effort of ARE Inc. and Cooper Technology. Surveying data collection and processing systems were examined and recommendations made that included as a primary feature a standard file format. This initial effort was directed at facilitating the transfer of information to engineering design and graphic systems. However, the recommendations for automating the entire data collection system and the file format are flexible, making them easily adaptable to many surveying procedures. A basis has also been provided that will allow future expansions such as for construction staking.

Appendixes G and H contain information on computer programs that were developed under Project 20-21 for demonstration purposes. All source code and example data files are available on four 5¼-in. IBM-PC compatible floppy disks formatted double sided/double density. The four floppy disks may be obtained by sending blank disks to the Transportation Research Board, National Cooperative Highway Research Program, 2101 Constitution Avenue, NW, Washington, DC 20418.

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Hubert Henry, Professional Engineer, and Frank Cooper, Professional Engineer, were the principal investigators, and Leonard O. Moser was the Project Manager. Other authors of this report are: LaNelle Kahlbau, Senior Technical Assistant at ARE Inc., and Carrie L. Cooper of Cooper Technology.

The Technical Advisory Committee (TAC) was most helpful and supportive. The TAC members were: Keith Slater, District Surveyor, Minnesota Department of Transportation; Donald E. Wilbur, Chief of Photogrammetry, Pennsylvania Department of Transportation; Fred B. Bales, Assistant State Location & Design Engineer, Virginia Department of Highways and Transportation; Roger L. Merrell, Director of Automated Surveys & Electronic Services, Texas Department of Highways and Public Transportation; C. J. Tircuit, Location & Survey Engineer, Louisiana Department of Transportation and Development; Fred Murphy, Assistant Survey Engineer, California Department of Transportation.

The State of Louisiana and Mr. Tircuit provided a test site for the project, which included their support staff. Their cooperation is greatly appreciated. Mr. Thomas E. Carlsen, Mr. Gene Haferman, and the State of Wisconsin provided additional equipment for the testing of the system. Mr. Keith Slater, who has an automated survey system operating in Minnesota, was most helpful in providing an experienced view of the problems and advantages of a more sophisticated system.

Much of the work was done at ARE Inc. in Austin, Texas, under the management of Mr. Leonard Moser and his computer division staff.

AUTOMATED FIELD SURVEY DATA COLLECTION SYSTEM

SUMMARY

NCHRP Project 20-21 recognized the need for an automated surveying system to facilitate field data collection using total stations and data collectors. All the states were sent a questionnaire concerning their field surveying operations, present surveying equipment, and computer facilities available to their surveyors. Sixty-two percent of the states responded, which indicated strong interest in this research. The Integrated Survey Information Management System (ISIMS), as developed and demonstrated, meets the requirements of the surveying tasks defined in Project 20-21; however, other aspects of surveying need to be put into the system, such as construction staking and computer graphics interfacing.

The product of this research project, ISIMS, is a flexible data structure system that can easily be adapted to any surveying procedure. ISIMS was designed within the operating parameters of a total station (computerized theodolite) and a data collector (small computerized field notebook). Processing of satellite data or stereoplotter data was not considered, although their results can be incorporated within ISIMS. It is the opinion of the combined research team and Technical Advisory Committee that the design and demonstration of a good automated field survey system has been developed which is now ready to be applied by state DOTs and other agencies. Use of this system will also further develop ISIMS and expand its capabilities.

CHAPTER ONE

INTRODUCTION AND RESEARCH APPROACH

PROBLEM THAT LEAD TO THE STUDY

NCHRP Project 20-21 resulted from a need to efficiently transfer survey data from the field to roadway design and CADD (Computer-Aided Design and Drafting) systems. Transportation agencies strive to maximize the advantages of the advanced equipment and technology available to them in the surveying field. The project is an attempt to achieve these advantages.

Project 20-21 was the initial step in developing an Integrated Survey Information Management System (ISIMS), which is a coordinated process linking automated field survey data collection systems to a wide variety of engineering design systems, including ICES and RDS (Roadway Design System).

OBJECTIVES AND SCOPE

The objective of this research project was to define and develop an automated system for collecting, editing, and storing field survey data in a standard file format suitable for subsequent and selected electronic transfer to transportation engineering design systems. The scope of this research was to identify common surveying procedures, to create standard computer file formats, to demonstrate a system that accomplishes the objectives, and to provide documentation so that the system can easily be implemented by transportation agencies.

In essence, a language had to be created to standardize the terminology for field data that passed from any total station through any data collector and subsequently into a central repository—a universal data file for use by design systems.

TECHNICAL APPROACH

Work was accomplished in keeping with the chronological list of project activities shown in Figure 1.

Through numerous personal telephone contacts, a six-man Technical Advisory Committee (TAC) was formed. Each region of the United States was represented on the TAC so that local problems would be considered when defining a surveying system.

Surveying personnel from state departments of transportation, as well as Manitoba, Canada, and the FHWA were mailed a questionnaire to determine the procedures and equipment they used. The rapid response by most states indicated there was great interest in the research.

Manufacturers of surveying equipment and their designated representatives were contacted by telephone and letters in order to gather data on equipment currently in use. This search was intended to identify compatibilities between the equipment of various manufacturers.

Because it had an advanced surveying system tailored for its specific requirements, the Minnesota DOT was visited first. The Minnesota surveying system records were thoroughly studied in order to document problems generally found in the field as well as details handled in the office.

After assimilating data on surveying equipment, collection procedures, and processing procedures, the research team designed a Universal File Format (UFF). Concurrently, a Standard Survey Data File Format (SSDFF) was developed. As the UFF was refined, it became obvious that the UFF and SSDFF were almost identical. Therefore, for this project, the two were consolidated into a single UFF—a central repository for data. This consolidation gave greater meaning to the UFF which became a repository for multiple types of survey position data:

UFF-HVD: data collected by angle-angle-distance convention.
UFF-XYZ: data stored in Cartesian coordinates.
UFF-SOR: data collected by station-offset and rod reading conventions.
UFF-SOE: data stored in station offset and elevation convention.

At the same time, the Louisiana DOT was developing an automated surveying system. The system, specialized for Louisiana's needs, was instrumental in helping to define the first set of general survey data features for a more generic automated system. The project team spent a week in Louisiana to familiarize itself with the automated surveying system and to further detail surveying problems.

The project team also visited the surveying departments of Wisconsin, New York, and Nevada, and the concepts of ISIMS were discussed. The visits were made in conjunction with other trips and projects that ARE Inc had in the areas. These states showed a strong interest in the development of ISIMS or a similar automated surveying system that would make better use of the new surveying equipment available.

A. Establish the Technical Advisory Committee (TAC)
B. Conduct a survey across all states of survey equipment and design systems
C. Obtain vendor and design systems' documentation
D. Communicate with TAC members
E. Visit first State DOT (Minnesota)
F. Finalize the first set of survey data features
G. Prepare the preliminary design of the universal file format
G1. Visit second state DOT (to be selected)
H. Write the system/subsystem specifications
I. Prepare for TAC meeting
J. Start the computer program design and documentation
K. TAC meeting
L. Submit a software documentation outline to the sponsor
M. Finalize the data collection procedure for the second set of survey data features
N. Send package to TAC members for review and comments
O. Test the data collection procedure in Louisiana
P. Finalize specifications for a generic data collection device
Q. Beta test the survey data collection procedure subsystem
R. Prepare for second TAC meeting
S. Second TAC meeting
T. Complete one path of the ISIMS software for alpha testing in Louisiana
U. Implement ISIMS in Louisiana
V. Perform ISIMS quality assurance testing
W. Redocument and recode ISIMS
X. Complete all manuals
Y. Beta test ISIMS in a selected state
Z. Prepare the final report
AA. Finalize the report vis a vis sponsor comments

Figure 1. Chronological list of project activities.

The system/subsystem specifications (Appen. B) were sent to the TAC members prior to the first TAC meeting that was held at ARE Inc in Austin, Texas. The TAC meeting defined and quantified surveying needs of state DOTs. A new survey data collection device, the SDC71, was brought to the meeting by a representative of the Minnesota Department of Transportation. The SDC71 expanded the boundaries of data collection. It was the first data collector to tie successfully to several total stations and provide support. Furthermore, it was programmed to facilitate entry of survey data by prompting the operator. Because this machine constituted a great improvement in data collection, the UFF had to be critically reexamined.

Computer programs were designed and the software documentation outlined as the project progressed. The set of survey features was expanded and the data collection procedures were finalized prior to the second TAC meeting. The data collection procedures were extensively tested in Louisiana, the alpha test site, prior to finalizing specifications for a generic data collection device.

A demonstration application of ISIMS was installed and implemented in Louisiana for the second TAC meeting. Using Louisiana's equipment, 30 topographical features were collected, listed, edited, and plotted in order to complete one path of the

ISIMS software. A second path was charted with cross-section data taken using Wisconsin's SDC71 (without a total station) and converted into the Road Design System (RDS) format from the UFF. For a third path, a subset of features was tested using the SDC71 data collector with a Wild TC2000 total station. Although no previous testing was done on this configuration, UFF files were created, edited, listed, and plotted in less than one hour.

The demonstration, although a success, was not perfect. The cabling between the SDC71 and the Wild TC2000 was loose and the equipment produced a random response. After the defect was discovered, ISIMS application progressed smoothly.

The UFF was modified several times in the course of the project, necessitating the modification of all documentation and programs with each change.

Wisconsin was selected as the beta test site because of its progress in implementing an automated surveying system. Wisconsin had selected a specific vendor and had established immediate needs and goals. However, Wisconsin had not realized the full potential of its equipment. The use of ISIMS opened more paths through Wisconsin's equipment. The Project 20-21 demonstrator showed that ISIMS and sophisticated data collecting equipment were compatible, and it tied the collection and processing of cross-section data into an RDS format. Project 20-21 took advantage of the work Wisconsin already had accomplished. In a like manner, Wisconsin was aided in meeting its goals and benefited from work related to developing the Project 20-21 ISIMS.

CHAPTER TWO

FINDINGS

Twenty-nine states, Manitoba, and the FHWA surveying personnel responded to the Project 20-21 questionnaire. The questionnaires revealed the following:

1. State DOTs used total stations and data collectors manufactured by many different companies. No single manufacturer prevailed.
2. By far, RDS was predominant for design. Therefore, RDS was used in the Project 20-21 demonstrations.
3. Intergraph clearly led the graphic systems in use.
4. There was no favorite manufacturer in the area of software.
5. All of those who responded were interested in receiving progress reports on the development of ISIMS.
6. Eighty percent of those who responded planned to purchase additional automated surveying equipment in the near future.

A sample of the questionnaire and tabulations of the responses are provided in Appendix A.

An in-depth study of specifications received from manufacturers of total stations and data collectors indicated the following:

1. Except for one company, manufacturers produced both pieces of equipment with interface as part of the package.
2. Present equipment had enough capability to be made compatible with ISIMS.
3. Several data collectors had a programming capability, and all interfaced with microcomputers.
4. Data collector display screens varied in size from one to eight rows with from 14 to 40 characters per line.

A vendor literature review is discussed at the end of Appendix A.

The research team's visits to Minnesota, Louisiana, Wisconsin, New York, and Nevada helped significantly in obtaining an overview of the problem and in recognizing potential pitfalls. Minnesota had an automated survey system that was operational. Survey files were being extensively used by its engineers. Most aspects of field surveying had been addressed and implemented. Minnesota's system was the most advanced and had been in use longer than any other in the United States. Louisiana was in the process of developing an automated survey system. Its feature set and comprehensive survey collection procedures were carefully studied.

ISIMS was designed around three hardware components: total station, data collector, and data processor. (Appendix B discusses in detail the ISIMS system/subsystem specifications.) Primarily, ISIMS was designed to work when using any total station with a data collector for collecting field survey information. However, ISIMS can function without a total station. Positioning information can be fed directly to the data collector. ISIMS also accommodates direct entry of position data from other sources, such as satellite readouts or manual field computations.

ISIMS can work across a wide range of data collectors. However, the choice of data collectors influences the efficiency in both establishing and operating ISIMS. The most desirable data collector is one that conforms to UFF concepts. A data collector of this type is preferred because (1) the data collection procedure does not have to be adjusted from data collector inconsistencies, vis-a-vis the UFF; (2) there is no need for data collector output to be converted to UFF (i.e., it would already be in the desired format for further processing).

A programmable data collector is desirable to perform the initial field data checking and later to avoid conversion routines. Many data collectors in use today are not programmable and surveying procedures and conversion routines must be written to accommodate them. When agencies purchase new equipment, ISIMS compatibility of the data collector to the UFF framework should be a major consideration.

Ideally, the processing of field survey data should be done in the field by the surveying crew so that mistakes can be corrected before leaving a location. The UFF provides guidance for data collector programming based on data input, data checking, and data output. Once data are in the UFF format, several software modules created by Project 20-21 are applicable.

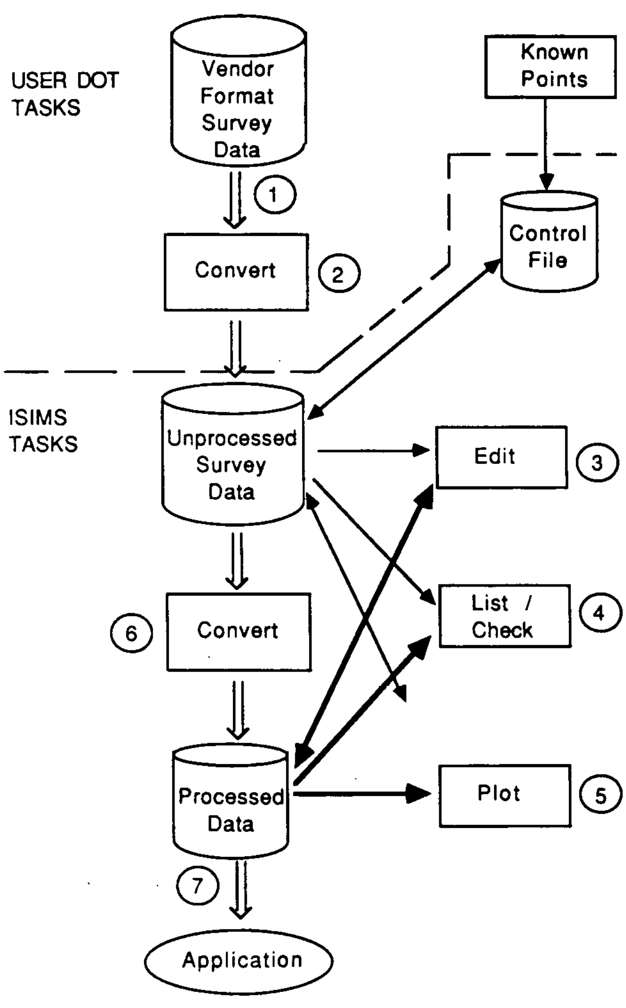


Figure 2. ISIMS data processor subsystem.

Figure 2 outlines the data flow relative to processing survey data using ISIMS. Some programs are available now as a result of this project. Because the programs were made for the project demonstration, there may be restraints on their use in statewide applications. However, the programs can easily be modified to specific user needs.

Appendix C gives a detailed three-part operating description of the UFF. The first part is a general description. The second part describes detailed command sets, and the third part explains conversion algorithms.

In order to establish an agency-tailored ISIMS two steps are necessary: (1) Define all features according to UFF specifications, and align the surveying procedures to both the data collector and the UFF. (2) Incorporate the software modules to process the data through to one's applications.

Step 1 is described in Appendixes D, E, and F. Appendix D contains guidelines for filling out the user-defined UFF data. It provides a guideline of four easy steps for implementing ISIMS, including the definition of surveying procedures for a particular data collector. Worksheets and forms are provided. Appendix E provides the example of ISIMS implementation in Louisiana. Appendix F defines a comprehensive set of features that are common among surveyors. Features that are state, county, or city-specific can be added easily.

Appendix G provides a focus for Step 2. This appendix discusses the three demonstrators—Louisiana, Wisconsin, and Generic—that were produced for this project. A menu in the Generic computer demonstrator explains the purpose of each software module available to the user and the sequence in which it is to be executed. The following is the menu that will appear on your screen.

1 DOWNLOAD THE FIELD DATA
2 CONVERT DATA COLLECTOR FORMATTED TOPO DATA TO THE UFF-HVD
3 CONVERT DATA COLLECTOR FORMATTED X-SEC DATA TO THE UFF-SOE
4 PLOT UFF-HVD OR UFF-XYZ
5 PRINT UFF-HVD OR UFF-XYZ
6 PRINT UFF-SOE CROSS SECTIONS
7 CONVERT UFF-SOE CROSS SECTIONS TO RDS FORMAT
8 EDIT DATA
9 CONVERT DATA FROM UFF-HVD TO UFF-XYZ
A PRINT A FILE
B INSTALL NEW SET OF FEATURES
C CONTROL FILE DATA
0 EXIT THE SYSTEM

User actions related to each menu item are explained in detail in the Appendix G, Demonstrator 20-21G.

A menu is provided that allows the user to step through ISIMS for each demonstrator. It is strongly recommended that readers "walk-through" the generic demonstrator. Appendix G provides guidance for running each demonstrator.

Documentation of the programs written for demonstration purposes is presented in Appendix H. Program flow and algorithm descriptions are included. All source code and example data files are available on 5¼-in. IBM-PC floppy disks formatted 2S-2D.

CHAPTER THREE

INTERPRETATION, APPRAISAL, APPLICATION

State transportation surveying agencies are enthusiastic about new equipment that facilitates the development of an automated survey system. The advent of total stations, data collectors, and microcomputers made the creation of ISIMS feasible, possible, and practical. Processing of survey data through to applications can now be made for existing systems, such as RDS, IGRDS, and INTERGRAPH. Presently, vendors are selling total stations, data collectors, and software packages that are equipment specific. That means there can be little or no interchange of software between different collection systems within a state or between states. Therefore, a need exists to put uniformity into the collection, configuring, and processing of survey data in order to further streamline the automated survey environment. Project 20-21 created ISIMS, a system with a design capable of functioning either independent of total stations or across a wide variety of total stations. UFF, which is the heart of ISIMS, provides users with survey collection guidelines that tie together existing equipment. As a result, software written to UFF specifications now can be applied across a wide range of agencies.

ISIMS should have wide acceptance because it provides manufacturers with guidelines for the types of survey data being collected by transportation agencies. The guidelines will aid manufacturers in designing a specific data collector that is UFF oriented. Furthermore, the guidelines will permit manufacturers to write processing software that can used universally by surveyors.

The "road map" ISIMS provides to states for the development and implementation of an automated survey system is a major result of this project. ISIMS presents a basic set of survey features along with guidelines that allow expansion of this set through incorporation of each state's specific data collector. States can modify the demonstration software that was written in Project 20-21, or states can produce their own software to better suit their individual needs. Appendix H contains the documentation of the programs developed for demonstration purposes. This demonstrator software provides a solid base for a particular agency's ISIMS application.

The Interactive Graphics Road Design System (IGRDS) AASHTO Development Team has coordinated its input procedure with ISIMS and accepts the UFF survey data. Our demonstrator has a module that converts UFF-SOE data into AASHTO Road Design System (RDS) format. The availability of the UFF facilitates the making of conversion routines to accommodate any application program's survey data input.

Many applications of ISIMS remain to be explored. Nevertheless, users now are able to set up an automated survey system more efficiently because the Project 20-21 guidelines exist. The study team believes that better data collectors that are UFF based will be designed and built. Improved software can be written for processing survey data because of the specifications available in ISIMS. All states can make use of new programs as they are developed. ISIMS permits the on-site data reduction of field survey information which is especially useful when surveyors are far from the home office. Survey data can easily be listed, plotted, and edited using an inexpensive personal computer, plotter, and printer before leaving a specific location. ISIMS is a product that can be expanded to suit any state's individual survey data processing needs.

CHAPTER FOUR

CONCLUSIONS AND SUGGESTED RESEARCH

ISIMS provides state DOTs and surveying equipment manufacturers with three valuable tools—a UFF, data collection guidelines, and demonstration software. By the use of these tools, as detailed in this report, many benefits can be accrued.

State DOTs can design ISIMSs that fit highly individualistic needs. They can have a universal exchange of data between agencies and equipment. And on the basis of ISIMS-UFF specifications they can more effectively choose hardware and software packages.

Surveying equipment manufacturers can design and build better coordinated total station-data collector systems with improved interface and outputs for microcomputer tie-ins. Software experts can design more highly specialized programs for surveying and transfer of data. Overall, ISIMS coordinates the efforts of state DOT surveyors and road designers, survey equipment manufacturers, and software consultants.

ISIMS has numerous special features that are related to user-supported enhancement. ISIMS will need continuing support to be effective over a long term. It is desirable for an organization to assume responsibility for coordinating and embellishing ISIMS for the state users through a surveying committee and additional contracts for software development. As more advanced equipment becomes available and more knowledge is gained from actual field surveying, expansion of ISIMS should be done.

The immediate need is to develop sets of software that incorporate the UFF for surveying activities, such as project control, topography, cross sections, and construction staking.

A specifically programmed and UFF-based data collector is a viable extension of ISIMS. This modification would further define and coordinate surveying data collection procedures. As more surveying activities are incorporated into ISIMS data processing software, data-collector-based software will be created.

There are other application modules that would be worth incorporating into ISIMS software. For example, many states have expressed a desire to have the UFF go directly into the INTERGRAPH in order to produce a plot of the topographic field data immediately after it is collected. Presently, UFF feeds only to RDS.

Additional research is needed to support implementation of Project 20-21 into the real world. Areas for study include the following:

1. Refinement of the existing ISIMS/UFF through expansion of the surveying feature list and implementation of the codes.
2. Standardization for DOT applications that would establish common names for descriptor values.
3. Development of documentation and training material for education through Technology Transfer Centers for national dissemination of the project.
4. Expansion of ISIMS to all types of surveying used in DOTs.
5. Development of common specific applications or conversions that would optimize or simplify design and plan preparation, and the transfer of design data to surveyors for construction staking.
6. Development of a data collector that outputs UFF format.
7. Identification and evaluation of new surveying procedures and accuracy standards that would use radial type surveying techniques.
8. Preparation of requirements for a surveying vehicle that would address the real time verification needs of computerized field surveying. This probably would be a technology transfer effort because the seismic and military already field process data.
9. Expansion of ISIMS/UFF to include satellite survey technology (GPS). This would include investigation of GPS technology for adaptation to topographic surveying.

APPENDIX A

QUESTIONNAIRE RESULTS

INTRODUCTION

Survey Management Questionnaires, Figure A-1, were sent to 53 states, provinces, and FHWA's to gather information on specific components used in current survey operations. The results of the questionnaire illustrated much enthusiasm on the part of the member states. Thirty-one responses were used during the analysis. Some additional data were received from states but they were too late to include statistically. The state responses used are:

Alaska	Minnesota	Rhode Island
Arizona	Missouri	South Dakota
Arkansas	Montana	Tennessee
California	Nevada	Texas
Florida	New Jersey	Virginia
Georgia	New Mexico	Washington
Idaho	New York	Wisconsin
Illinois	North Carolina	Wyoming
Louisiana	Oregon	Manitoba
Maine	Pennsylvania	FHWA Colorado
Maryland		

QUESTIONNAIRE CONTENTS

To assess the current status of surveying operations, the questionnaire was divided into five parts. First, it was desirable to know which vendors were chosen for total stations and data collectors. The recipients of the questionnaire were also asked to name highway design systems in use as well as the graphics systems of their choice. In addition, it was of interest to know what information management system existed in the DOTs. Finally, questions were asked for general information, such as: Would they like to receive a progress report? Would they like to be a test site? Is data reduced at a central location? Are they planning to buy survey equipment soon?

The results of the questionnaire have been processed and are shown in Figures A-2 through A-6.

SUMMARY OF QUESTIONNAIRE RESULTS

Survey Collection Equipment—Figure A-2

The information recorded about the survey collection equipment can be summarized as follows:

I. Total Work Stations & Data Collectors Used

	Model No.
TopCon	________
Wild	________
Lietz	________
Zeiss	________
Geodometer	________
Other	________
Survey Calculations (traverse adj. net working) type of computer used	________

II. Design Systems

Type (ICES, RDS, etc.)	Type of Computer Used	Computer Language Used
________	________	________
________	________	________
________	________	________
________	________	________

III. Graphics System

Type (Integraph, Synercom, ComputerVision, Autotrol, etc.)	Type of Computer Used
________	________
________	________
________	________
________	________

IV. Information Management Systems

Type of Computer Used	Database Management Software
________	________
________	________

V. General Information

	YES	NO
1. Would you like to receive the progress reports on this project?	____	____

Name: ________________

Address: ________________

____

Phone: ________________

	YES	NO
2. Would you consider being a test site for this project?	____	____
3. Is survey data reduced in a central location?	____	____
4. Do you plan to purchase automated survey equipment in the near future?	____	____

Please comment on this project's objectives and how it may be useful to your automated surveying operations or procedures:

____

____

____

____

____

____

Name: ________________

Figure A-1. Survey management questionnaire.

SURVEY COLLECTION EQUIPMENT USAGE
BY DEPARTMENTS OF TRANSPORTATION

STATE	TOPCON	WILD	LIETZ	ZEISS	GEODOMETER	OTHER
ALASKA		X				
ARIZONA			X			X
ARKANSAS			X	X		
CALIFORNIA		X			X	
FLORIDA					X	
GEORGIA	X					
IDAHO	X	X	X			
ILLINOIS					X	
LOUSIANA		X				
MAINE			X			X
MARYLAND	X		X			
MINNESOTA					X	X
MISSOURI			X	X		X
MONTANA			X			
NEVADA		X			X	
NEW JERSEY					X	X
NEW MEXICO						
NEW YORK	X					X
NORTH CAROLINA		X				
OREGON		X				
PENNSYLVANIA					X	X
RHODE ISLAND						X
SOUTH DAKOTA						
TENNESSEE	X	X				
TEXAS	X		X	X	X	X
VIRGINIA	X					
WASHINGTON	X	X	X	X		
WISCONSIN		X			X	X
WYOMING					X	X
MANITOBA						
FHWA					X	X

Figure A-2. Tabulation of DOT questionnaire results.

Vendor	Number of States
TopCon	8
Wild	10
Lietz	9
Zeiss	4
Geodometer	11
Nikon	1
Kern	1
Radio Shack data collector	1
Various HP equipment	8
Others	5

Also, note that 18 states have already purchased equipment from two or more vendors. From question number four of general information, it was learned that 25 of the 31 states say they are planning to buy more data collection equipment in the near future.

Thus, there is a definite interest on the part of many states in this topic and there will be a significant number of states purchasing survey equipment in the near future. Most states are buying equipment in tandem; that is, states are purchasing a total station and a data collector from the same vendor rather than purchasing an independent data collector.

The research has shown that the data collector hardware of many vendors may not be suitable relative to DOT needs with respect to this project. Because many states are buying total stations from multi-vendors, a data collector that can be used in conjunction with many different total stations is desirable.

Highway Design Systems—Figure A-3

The responses of highway design systems can be enumerated as follows:

Design System	Number of States
RDS	20
ICES	5
COGO	2
"in house"	2
Others	12

As can be seen from the responses, RDS is the predominant system and was used in the project demonstration so that most states were covered.

Graphics Systems—Figure A-4

Relative to the responses of the states, Intergraph clearly predominates the graphics systems. In fact, 23 states are using it. Since Intergraph is used exclusively with VAX machines, at least 23 states have access to a VAX. This suggests that it would be relatively easy for these states to standardize an RS-232 peripheral because they have common hardware. This would result in interface uniformity.

General Information

Figure A-5 shows that there is a wide range of vendor software being used to support engineering management. This is expected because of state size, differing host vendor models, computer facility administration, and individual preference.

Finally, from general information responses tabulated in Figure A-6, question numbers one and four indicate an active interest in our project. One-hundred percent of the states who responded are interested in receiving progress reports. In addition, 16 of the 31 states are willing to commit their labor resources to this project to work as a test site. Responses also indicate that many states are interested in the results of the survey equipment review. More than 80 percent of the states responding to the questionnaire are planning to purchase more equipment in the near future.

VENDOR LITERATURE REVIEW

The purpose of the vendor literature review was to look across various data collectors and total stations to determine what actually exists in today's market and how this existing equipment will help to determine guidelines, restrictions, and/or limitations applicable to the project survey features procedure. Literature from the following vendors was examined:

	ZEISS	LIETZ	TOPCON	WILD	NIKON	KERN
data collector	REC 200 REC 500	SDR 2	FC-1	CRE3	DR-1	ALPHACORD
total station	ELTA 3 ELTA 46R	SET 3	ET-1	T2000 TC2000	DTM-1	E2 + DM 503

Upon review of the vendor and design system documentation, the project team found many data collectors quite flexible with respect to the needs in the design of project survey features procedure and universal file format (UFF). Several data collectors have programming capability. This allows flexibility in data prompting, defaulting, and checking.

STATE	RDS	ICES	COGO	"IN HOUSE"	OTHER
ALASKA					X
ARIZONA	X				
ARKANSAS	X				
CALIFORNIA	X			X	X
FLORIDA		X			
GEORGIA	X				X
IDAHO	X				X
ILLINOIS		X			
LOUSIANA	X				X
MAINE					
MARYLAND	X		X		
MINNESOTA		X			
MISSOURI				X	
MONTANA	X				X
NEVADA	X				
NEW JERSEY					
NEW MEXICO	X				X
NEW YORK	X		X		X
NORTH CAROLINA	X				
OREGON	X				X
PENNSYLVANIA	X				
RHODE ISLAND					X
SOUTH DAKOTA	X				
TENNESSEE		X			
TEXAS	X				
VIRGINIA					X
WASHINGTON					X
WISCONSION	X	X			
WYOMING	X				
MANITOBA	X				
FHWA	X				

Figure A-3. Highway design systems usage by Departments of Transportation.

STATE	INTERGRAPH	SYNERCOM	OTHER
ALASKA			X
ARIZONA	X		
ARKANSAS			
CALIFORNIA	X	X	
FLORIDA	X		
GEORGIA	X		
IDAHO	X		
ILLINOIS	X		
LOUSIANA	X		
MAINE			
MARYLAND			X
MINNESOTA	X		
MISSOURI			
MONTANA	X		
NEVADA			
NEW JERSEY	X		X
NEW MEXICO			X
NEW YORK	X		X
NORTH CAROLINA	X		
OREGON	X		
PENNSYLVANIA	X		
RHODE ISLAND			
SOUTH DAKOTA	X		X
TENNESSEE	X		
TEXAS	X		
VIRGINIA	X		
WASHINGTON	X		
WISCONSION	X		
WYOMING	X		
MANITOBA	X		
FHWA	X		

Figure A-4. Graphics system usage by Departments of Transportation.

STATE	ADABAS	IMS	DMRS	OTHER
ALASKA	X			
ARIZONA				
ARKANSAS				
CALIFORNIA				X
FLORIDA		X		
GEORGIA				X
IDAHO				X
ILLINOIS		X	X	
LOUSIANA		X		X
MAINE				X
MARYLAND				X
MINNESOTA			X	X
MISSOURI				
MONTANA				X
NEVADA				X
NEW JERSEY				X
NEW MEXICO	X			X
NEW YORK				
NORTH CAROLINA				
OREGON				
PENNSYLVANIA				X
RHODE ISLAND				X
SOUTH DAKOTA				
TENNESSEE		X		
TEXAS	X			
VIRGINIA				
WASHINGTON	X			
WISCONSION		X	X	X
WYOMING				
MANITOBA	X	X		
FHWA			X	X

Figure A-5. Information management system usage by Departments of Transportation.

STATE	QUESTION 1	QUESTION 2	QUESTION 3	QUESTION 4	COMMENTS?
ALASKA	Y	Y		Y	
ARIZONA	Y	Y	Y	Y	Y
ARKANSAS	Y		Y	Y	Y
CALIFORNIA	Y			Y	
FLORIDA	Y	M		M	
GEORGIA	Y		Y	Y	
IDAHO	Y	Y		Y	Y
ILLINOIS	Y			Y	Y
LOUSIANA	Y	Y	Y	Y	Y
MAINE	Y	Y	Y		Y
MARYLAND	Y		Y	Y	
MINNESOTA	Y			Y	
MISSOURI	Y			Y	Y
MONTANA	Y	Y		Y	Y
NEVADA	Y		Y		Y
NEW JERSEY	Y	Y		Y	Y
NEW MEXICO	Y	Y	Y	Y	Y
NEW YORK	Y	Y			Y
NORTH CAROLINA	Y				Y
OREGON	Y			Y	Y
PENNSYLVANIA	Y				Y
RHODE ISLAND	Y				
SOUTH DAKOTA	Y	Y		Y	
TENNESSEE	Y	Y		Y	
TEXAS	Y	Y		Y	Y
VIRGINIA	Y	Y	Y	Y	Y
WASHINGTON	Y			Y	Y
WISCONSION	Y	Y		Y	Y
WYOMING	Y	Y	Y	Y	
MANITOBA	Y		Y	Y	
FHWA	Y	Y		Y	Y

QUESTION 1: Would you like to receive progress reports?
QUESTION 2: Would you consider being a test site?
QUESTION 3: Is survey data reduced in a central location?
QUESTION 4: Do you plan to purchase automated survey equipment in the near future?

Y = YES
M = MAYBE

Figure A-6. General information.

Hand in hand with programming capability are alphanumeric characters that make programming the data collector possible. Alphanumeric characters (vs. numeric characters only) are also an aid to the surveyor. Alphanumerics will make the prompt easier to understand and allow the surveyor to enter comments as he deems necessary.

The size of the display screen is another feature worth discussing. Some data collectors have one line displays of 14 or 16 characters. These displays are restrictive relative to prompting. However, the display on 3 of the 7 data collectors researched is notably larger, thus allowing flexibility in terms of data prompting and checking. The REC 500, by Zeiss, was found to be the most flexible. The REC 500 has a display of 8 rows by 40 characters.

The data collectors were, in most cases, paired by the vendor with a total station. For example, Leitz makes the data collector SDR2 along with the total station SET 3. In addition to supplying the total station, the vendor also supplies an interface between the data collector and total station as part of his package.

During the review, one vendor (ABACUS) was found of an independent data collector. At this time, ABACUS is still in design stages and documentation is not yet readily available. More independent generic data collectors will probably soon be on the market, and these data collectors will have greater flexibility. The states should know how to take advantage of these, but it is important to know what kind of interface is supplied by the vendor to connect it with existing total stations. At this time, the review has not revealed any specifications for the interface between the total station and the data collector in tandem. It may be possible to use an RS-232C port, but we do not have the specifications necessary to conclude this. The vendor should take the responsibility of connecting his independent data collector with total stations. In fact, ABACUS has already accomplished this task. ABACUS has interfaced their data collector with four different total stations.

The data collector must also be interfaced with microcomputers in order to finish processing the data. Careful study of vendor documentation shows that all data collectors mentioned so far are equipped with an RS-232C interface. Thus, all vendors are in compliance with the standard RS-232C interfacing specification.

In conclusion, the project data collector data entry design will be geared toward data collectors with multiline displays and programming capability. This design will not preclude the use of one-line display, nonprogrammable data collectors, but will take advantage of the capability offered by the programmable, multiline display data collectors.

APPENDIX B

ISIMS SYSTEM/SUBSYSTEM SPECIFICATIONS

ISIMS SYSTEM OVERVIEW

The Integrated Survey Information Management System (ISIMS) is an automated system for collecting, editing, and storing field survey data in a universal file format (UFF).

ISIMS allows utilization of many different combinations of equipment, personnel, procedures, computer programs and systems to streamline the collection and processing of survey data for the production of engineering plans and specifications.

ISIMS consists of the three subsystems shown in Figure B-1: (a) the total station, (b) the data collector, and (c) the data processor. Also shown in the figure are the universal file format (UFF) and the applications which subsequently use the UFF. The main objective of the data processor subsystem is to convert the survey data into the UFF. The UFF is important because it allows applications to access the survey data in a common file format regardless of the specific equipment and procedures originally used to collect the data. Refer to Appendix C for a detailed description of the universal file format (UFF). An example of application usage, the conversion of UFF to RDS (Road Design System) format, is documented as a FORTRAN program in Appendix H.

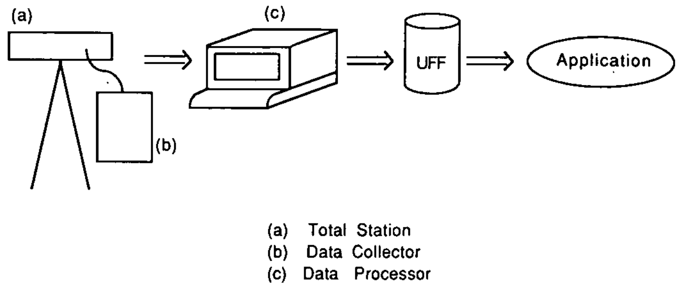


Figure B-1. ISIMS system overview.

ISIMS SUBSYSTEMS

This section describes each subsystem in more detail.

Total Station

The total station is the surveying instrument which measures angles and distances. This discussion will refer to an automated surveying instrument such as the WILD TC2000, although traditional surveying instruments such as transits, chains, and levels may also be used.

Data Collector

The data collector is a piece of hardware, similar to computer equipment, on which survey data, traditionally recorded in the field book, may be recorded. These data may be measurement data, such as angles and distances, as well as descriptive survey data which include survey feature identification, material, owner, and condition.

The specifications for a generic data collector are as follows:

1. Portability

The data collector may be a separate piece of equipment, or it may be an integral part of the total station. It is often desirable to have a data collector that is a separate piece of equipment so that it may be used to collect data when it is not connected to the total station. The device should be small and light to facilitate carrying and attaching to the total station. A suitable size would be 8 in. x 4 in. x 2 in., with a maximum weight of 2 pounds.

Also, if the data collector is a separate piece of equipment, physical attachment to the total station is needed. The attachment mechanism, which may be provided by the vendor or the user, should allow the data collector to rotate with the total station. When attached in this manner, it will always be in a convenient position for the user, and the cable which connects the two pieces of equipment will not become twisted around the tripod.

2. Communication Protocols

a. *Between the Total Station and the Data Collector.* If the data collector is a separate piece of equipment, a cable is needed for connection to the total station. If the total station and the data collector are furnished by the same vendor, the cable should come packaged with one or the other. If the total station and the data collector are furnished by different vendors, requirements should be placed on one of them to provide a cable that is compatible with both pieces of equipment.

The total station and the data collector must be able to communicate with each other via the physical cable mentioned above coupled with a compatible software communications protocol. This requires that compatible communications software be installed on each system. The data collector should be able to receive information from the total station, and each user must determine if there is also a need to send information from the data collector to the total station. The total station and/or the data collector should provide the necessary transmission capabilities or should be programmable to provide such capabilities.

This is not a point at which the user will interface to the system. It is unreasonable and not in the best interest of the DOTs to place limitations such as a "RS-232C type" compatability on this protocol and its hardware interface. Because this particular interface ties two "separate" pieces of hardware together to form a "product", the efficiency and durability of that connection should be a function of the vendor's design.

b. *Between the Data Collector and the Data Processor.* The data collector should also be able to communicate with the data processor. Again, this communication will be via a physical cable connection and a compatible software communications protocol. This requires that compatible communications software be installed on each system. The connectors and pin configurations on the cable should be compatible with the data collector on one side and with the data processor on the other. A gender switcher and/or pin switcher may be required in order to get the proper cable-to-system connections. The data collector should be able to send data to the data processor via the asynchronous RS-232C communications protocol, and each user should also be able to receive information from the data processor. The data collector and/or data processor should provide the necessary transmission capabilities or should be programmable to provide such capabilities.

3. Programmability

In addition to the potential transmission needs for programmability mentioned above, a program can also be written for the data collector to prompt the user for the appropriate information during survey data collection and to output data in the UFF. This is an optional data collector feature. There are both advantages and disadvantages to implementing prompting. The prompting scenario is slower; however, it is desirable during the learning phase and for infrequently collected and/or unfamiliar items. The user may also want to program in the option to forego the prompting after the learning phase and on form familiar and/or frequently collected items. The no prompting scenario is faster, but it puts the responsibility on the user to remember the exact format and sequence in which the data should be entered.

If the ability to use prompting is desired, the data collector should be programmable. Depending on the vendor, there may be one or more ways to program such prompting on the data collector. One way is just to program a fixed sequence of prompts per feature. Another way is to provide prompting via function keys on the data collector. These function keys may be user programmable and/or preprogrammed by the vendor. Function keys provide the user with the flexibility to have prompting for each data item but without fixed sequences for each feature.

Having the data collector set up to output in the UFF is very advantageous for the processing of survey data. The data collection procedure will conform very closely to the UFF because the data collector is configured for the UFF. Thus, state DOTs will not have to design a survey procedure that both fits the UFF and fits the data collector. Also, there will be no need to write data-collector-specific software to translate data collector output to the UFF.

4. Displays

The larger the display on the data collector, the more meaningful prompts and information can be displayed. When prompting is desired, the user should be able to both enter and display alphanumeric characters, but the display need not be so large that it increases the size of the data collector beyond practical use. A single line display of no less than 16 characters should be sufficient in a limited or no prompting environment. A larger display of up to 4 x 16 characters is more appropriate when prompting is used extensively.

5. Recording Modes

In addition to the direct transmission capability between the total station and the data collector, the user should also be able to manually enter data into the data collector. For example, the direct transmission mode would most likely be used to transfer measurement data such as angles and distances from the total station to the data collector, and the manual entry mode lends itself more to nonmeasurement attribute data such as material, owner, and condition, or to nontotal station survey jobs.

6. Storage Capabilities

In addition to providing the ability to manually enter data and to receive transmitted data from the total station, the data collector must also be able to store these data. This enables the surveyor to collect data for one or more projects while in the field, and then transfer the data to the data processor at a later time.

The actual procedures used to collect the data are an important part of the data collection subsystem. Refer to Appendixes C and D for specifications that define the information needed when collecting specific survey features and activities. Appendix E is an example of how a specific state has met these specifications utilizing their procured vendor products.

The storage capacity needs will be a function of the total survey system, the procedures of a particular state, and the vendor's data collection format and record size. Each state must determine the equipment that will be made available to the field surveyor to download the data, verify that the data have been transferred and assure that the data collected is reasonable prior to reuse of the data collector storage.

A conservative rule of thumb would be to allow 500 points collected per day. States capable of transferring data daily should allow for 1000 to 1500 points. States transferring weekly should allow for 2000 to 3000 points. To maintain productivity, a state should plan to rotate a minimum of two data collectors per field party to provide for backup and verification procedures.

7. Survey Functions

Most present data collection procedures are based on a point-by-point concept requiring downstream system intervention for the finite definition of a feature. However, there are states developing feature-oriented data collection procedures and the trend appears in that direction. This is primarily because of the eventual uses of the survey data in design systems and the building of Geographical Information Systems (G.I.S.).

The project has noted that certain functions, needed to easily collect data, are not readily available through the survey instruments without interrupting the collection of measurement data. These functional capabilities are noted as follows:

a. Skip the connection between two points
b. Collect the data backwards
c. Close the data string
d. Special point characteristic indicators
   1. PC (point of curvature)
   2. START/END curve
   3. Position offset
   4. Store elevation
   5. Secondary features
   6. Direction indicator

While most of these point characteristics can be obtained through "CODES" or multiple measurement procedures, they add time and complexity to the process.

Programmable collectors should be able to easily comply with these needs. Those total station systems where input is at the theodolite itself could provide the capability through a "function key" concept. This would allow measurement records to be terminated by different characters. The user could interpret and process the data according to the termination character. There are several other methods that appear suitable and reasonable for the vendor in future equipment design.

Data Processor

The primary purpose of the data processor is to convert the vendor-formatted survey data into a universal file format (UFF).

The data processor consists of hardware and software.

The hardware is a piece of computer equipment sufficient to house the data processor software in addition to any other required system software.

The data processor software consists of the computer programs necessary to: (1) communicate with the data collector, (2) convert vendor formatted survey data to a universal file format (UFF), (3) edit UFF data, (4) list/check UFF data, (5) plot UFF data, (6) convert/merge field UFF data to processed UFF data, and (7) communicate with the system on which the application program resides if it resides on a different system.

Figure B-2 shows the general interrelationships between the files and computer programs of the data processor subsystem.

The following sections describe each component of the data processor subsystem in more detail.

1. Communication with the Data Collector

The data processor should be able to communicate with the data collector. This communication requires a physical cable connection and a compatible communications protocol between the systems. Thus, each system must have compatible communications software installed. The connectors and pin configurations on the cable should be compatible with the data collector on one side and with the data processor on the other. A gender switch and/or pin switcher may be required in order to get the proper cable-to-system connections. The data processor should be able to receive data from the data collector via the asynchronous RS-232C communications protocol. Each user must determine if there is also a need to send information from the data processor to the data collector. The data collector and/or data processor should provide the necessary transmission capabilities or should be programmable to provide such capabilities.

2. Convert Vendor-Formatted Survey Data to UFF

To write a conversion program, the programmer must be familiar with both the vendor file format and the UFF. Refer to Appendix H for a detailed description of the UFF. Refer to the vendor's documentation for a detailed description of a specific vendor format.

The purpose of converting all survey data to the UFF is to provide a uniform file format to other data processing subsystems. Conversion to the UFF enables the user to disregard the vendor format and equipment originally used to collect the data.

The conversion routine will vary across data collector ven-

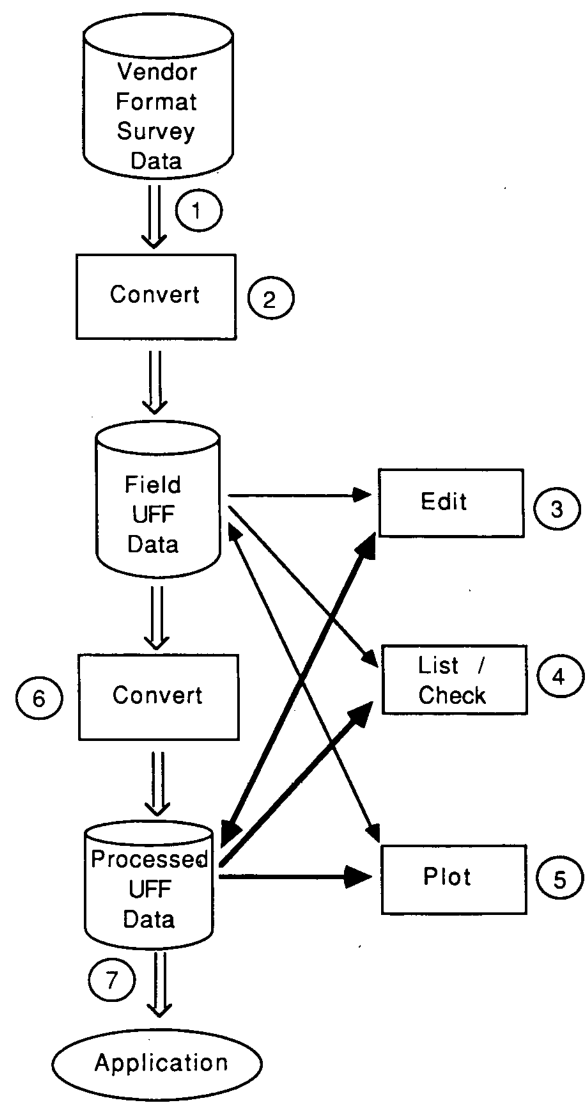


Figure B-2. ISIMS data processor subsystem.

dors, and may be unnecessary or trivial if the data collector can be programmed to store survey data in a sequence/format equivalent to the UFF. During the conversion from vendor format to UFF, a unique point identification number (ID), will be assigned to each point. However, any user assigned IDs will also be carried with the data.

3. Edit UFF Data

The edit component allows the user to manually enter and correct data in the field or processed UFF. For example, the user may want to manually enter project initiation data such as the project ID and monuments, or he/she may wish to correct some previously entered or transmitted data, once it has been listed, plotted, and checked.

It is recommended that an existing editor be used. Editors or word processing packages are readily available for most systems and provide all of the editing capabilities needed. However, the user may write a new edit program if desired.

4. List/Check UFF Data

The list component will allow the user to display and/or print a copy of the data.

The check component will perform simple data checks, such as format checking and range checking, to assist the user in finding errors in the data.

5. Plot UFF Data

The purpose of the plot component is to provide a "picture" of the data. This will aid the user in checking and correcting the data in addition to the list/check and edit routines previously described.

The plot component will provide the ability to perform a primitive plot of points and point connections along with their unique ISIMS assigned point IDs.

6. Convert Field UFF Data to Processed UFF Data

Measurement data in the UFF takes on four forms: (1) horizontal angle, vertical angle, and slope distance (HVD); (2) station, offset, and rod sealing (SOR); (3) X, Y, and Z (ZYZ); (4) station, offset, and elevation (SOE).

HVD and SOR-type data are collected in the field and as such are called field UFF data. XYZ and SOE-type data are called processed UFF data and results from conversion of HVD and SOR data respectively. The purpose of this routine is to convert data from HVD to XYZ form, or SOR to SOE form.

7. Communication with the Application System

When the application using the UFF resides on a different system from the UFF, it is necessary for the data processor system to be able to communicate with that other system. This communication requires a physical cable connection and a compatible communications protocol between the two systems. Thus, each system must have compatible communications software installed. The connectors and pin configurations on the cable should be compatible with the data processor system on one side and with the application system on the other side. The data processor should be able to send data to the application. Each user must determine if there is also a need to receive information from the application. The data processor system and/or the application system should provide the necessary transmission capabilities or should be programmable to provide such capabilities.

APPENDIX C

UNIVERSAL FILE FORMAT (UFF)

SECTION I. GENERAL DESCRIPTION

OVERVIEW

UFF consists of three file categories:

1. Unprocessed survey data file(s).
2. Processed data file(s).
3. Control file.

The unprocessed survey data and processed data are in universal file format (UFF) and have identical file formats. They use a data tag/data value concept with variable length records. The unprocessed survey data and processed data files are structured to accommodate several types of data location conventions. Other conventions could be easily added, such as longitude and latitude but for this project are considered a user conversion task.

The control file contains a set of known points (x, y, z) that are used to transform unprocessed survey data into processed data. The control file contains benchmarks, azimuth markers, monuments, and other control points. The file acts as an adjunct to universally formatted files. This file has a standard fixed-type format. The UFF location conventions available are as follows:

Unprocessed Data
1. Horizontal angle, vertical angle, slope distance (HVD)
2. Station, offset, rod reading (SOR).

Processed Data
1. X, Y, and Z coordinates (XYZ).
2. Station, offset, elevation (SOE).

Figure C-1 identifies the ISIMS subsystem processing for the UFF. The universal file format (UFF) incorporates the aforementioned four location conventions for survey data. Unprocessed UFF data can be HVD or SOR, whereas processed UFF data uses XYZ or SOE. The UFF specifications also include the algorithms used to convert unprocessed data to processed data. Section III of this appendix documents these conversion algorithms.

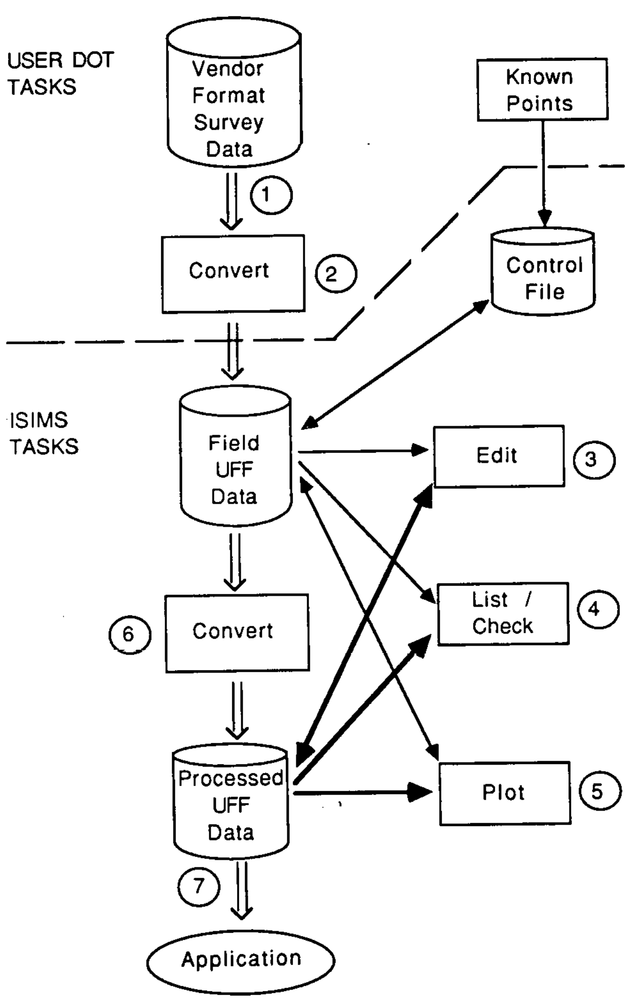


Figure C-1. ISIMS data processor subsystem.

ROLE OF UFF

The universal file format (UFF) is a structure that contains surveying data and has the following functions:

1. Creates an informational database of survey data.
2. Provides an interface between completed surveys, design systems, and other automated systems requiring survey information.
3. Acts as a common integrator for processing survey data that are collected on varying survey equipment and using different collection procedures.
4. Aids survey data editing and processing prior to its inclusion into an informational database.

The UFF is a combination of predefined command sets together with user-defined, but UFF-structured, commands. The UFF is structured so that positioning and conversion between location conventions is well defined. On the other hand, the user has much flexibility in selecting, naming, and describing his agency's set of features and surveying conventions.

UFF FILE TYPES

The universal file format is structured to accommodate several types of data locating conventions including:

1. Horizontal angle, vertical angle, slope distance (HVD).
2. X, Y, and Z coordinates (XYZ).
3. Station, offset, rod reading (SOR).
4. Station, offset, elevation (SOE).

UFF-HVD Format

The HVD format contains the horizontal angle, vertical angle, and slope distance. This format supports radial type surveying and is one of two conventions UFF provides to the surveyor for collecting data in the field.

UFF-XYZ Format

The XYZ format contains the actual X, Y, and Z coordinates of each point in the data file. Data in this format can be used as input to design/CADD systems. Conversion of UFF-HVD data results in UFF-XYZ formatted data.

UFF-SOR Format

The SOR format contains the station number, offset, and rod reading of each point, accompanied with some Z-positioning information. This format supports the traditional station and offset surveying method for collecting cross sections and is one of two conventions UFF provides to the surveyors for collecting data in the field.

UFF-SOE Format

The SOE format contains the station number, offset, and elevation of each point in the data file. This can be used as input to road design/CADD systems. Conversion of UFF-SOR data results in UFF-SOE formatted data.

Control File

The UFF-HVD format makes reference to points that are located in another file known as the control file. The control file contains points whose coordinates are already known. These points are used in establishing initial position.

File Examples

Example UFF files as well as data collector files are provided in Appendix G or can be listed using the demonstrator software. These are the example files.

	Louisiana TOPO	Wisconsin TOPO	Wisconsin Cross Sections
Data Collector Files	LOUIGRE3.GRE	WISCSDCX.SDC	WISCSDCX.XSC
Unprocessed UFF Files	LOUIGRE3.HVD	WISCSDCX.HVD	
Processed UFF Files	LOUIGRE3.XYZ	WISCSDCX.XYZ	WISCSDCX.SOE
Application Program Files			WISCSDCX.RDS
Control Files	LOUI.CNT	WISC.CNT	

Instructions for using the demonstrator are in Appendix G.

UFF RECORD LAYOUT

There are two UFF record layouts. One is for the control file and the other, the overall record format, is for all remaining file types.

Overall Record Format

Each record in the UFF file contains two parts: a data tag, followed by data values. Data tags are defined by the UFF system and serve to identify the type of record. Data values are either UFF-defined or user-defined. A colon (:) is the delimiter between data tag and data values. When there are several data values in one record, data values are separated by blanks. The following is a representative record layout.

DATA-TAG: VALUE1 VALUE2 VALUE3

The UFF was developed without regard to the units of linear measurement used. The number of significant figures and precision should be based on conditions and conventional surveying practice. As a result, there are no specifications for minimum number of significant figures on any data values or minimum number of significant figures to the right of the decimal point. In accordance with this premise, the FORTRAN code in the demonstrator programs use FORTRAN free format "reads" for all UFF records.

UFF Data Categories

In UFF all data fall into one of five categories:

Category Description	Category
File type	FT
Initial positioning	P
Accuracy	A
Feature information	F
General information	I

Thus, there are four types of UFF files (i.e., UFF-HVD, UFF-SOR, UFF-XYZ, and UFF-SOE) and, within each file, data are put into five categories. Figure C-2 shows an overview of the UFF data structure by an illustration of its data tags. A more detailed description of these categories follows.

File Type

The first record of every UFF file must be the file type record. There is only one file type record per file. Its tag is FILE:, and its possible data values are X_Y_Z, H_V_D, S_O_E, or S_O_R. These are the names of the four ways in which measurement data are represented in a UFF file. They are respectively (X,Y,Z) coordinates; horizontal angle, vertical angle, and slope distance; station, offset, and elevation; and station, offset, and rod reading.

Normally, H_V_D or S_O_R data are collected in the field and then transformed into X_Y_Z or S_O_E data respectively, for entry into road design or CADD applications.

Initial Positioning Data

The format and use of initial positioning data are fixed in UFF. The types of initial positioning data allowed by UFF are fixed as well as the ancillary information needed to well define each type of positioning. Different file types require different initial positioning information. The UFF-HVD and the UFF-SOR each requires several different initial positioning commands, whereas the UFF-XYZ and the UFF-SOE require none and one, respectively. Each initial positioning command is made up of several data records. The data tag of the first record in a command is always POS: followed by its descriptive name. Ancillary information is then entered on successive data records.

Feature Information

Feature information is divided into three major categories and several minor categories as follows:

1. Feature name
2. Feature descriptive data
    - 2a. Geometry information
        - 2a1. Geometry type
        - 2a2. Multipoint paramaters
            - 2a2a. Related feature identification
            - 2a2b. Connectivity
            - 2a2c. Curvature
            - 2a2d. Closure
            - 2a2e. Backward data collection
    - 2b. Descriptors
    - 2c. Comments
3. Measurement (point) related data

3a. Measurement data
3b. Measurement descriptors
3c. Position adjustment information
3d. Include Z?
3e. Diameter
3f. Comments

The range and diversity of this feature information are intended to make the UFF as broad and flexible as possible. Often, only the feature name, geometry type, and corresponding measurement information are mandatory for a given feature. The user may further define the feature with additional data tags according to specific DOT needs.

Feature Name. The user can develop and determine an entire set of features by filling out the feature form (see Appen. D). UFF-feature-related information is structured by the categorization shown previously, and the specifications that follow. The intent in UFF is to allow the user the flexibility to define all survey features within the UFF. This flexibility extends over different types of total stations, data collectors, and surveying procedures.

Feature Descriptive Data. There can be nine user-defined descriptors for each feature as well as several UFF-defined descriptive data. Following the instructions in Appendix C allows user-defined descriptive data to be included. In addition, there are the UFF-defined descriptive data; among these are geometry typing and multi-point feature parameters.

Measurement (Point) Related Data. This category of data is also divided into user-defined information and UFF-defined information. There are nine user-defined measurement descriptors. To define these descriptors use the forms shown in Appendix D. The UFF-defined measurement-related data includes measurement data, position adjustment information, elevation use indicator, and circle diameter.

General Information

General information is structured as feature information except there is no measurement-related data. In other words, general information is composed entirely of literal descriptors. There

Data Tag: Value	Data Tag Description	+ Data Category	Predefined ISIMS Values(vvvv)?	Use relative to file type H_V_D	X_Y_Z	S_O_R	S_O_E	Applicable only to Multi-Point Features
FILE: vvvv	File Type	FT	Y	Required	Required	Required	Required	
POS: vvvv	Initial positioning name	P	Y	Required	N/A	Required	Optional	
PP: vvvv*	Initial positioning descriptor(s)	P						
ACC: vvvv	Accuracy indication	A	Y	Optional	N/A	N/A	N/A	
CC: vvvv*	Accuracy descriptor(s)	A						
FEAT: vvvv	Feature name	F	N	Required	Required	Required	Required	
GM: vvvv	Geometry Type	F	Y	Required	Required	Required	Required	
ID: vvvv	Related feature identification	F	N	Optional	N/A	Optional	N/A	Y
CR: vvvv	Curve indicator	F	Y	Optional	Optional	Optional	Optional	Y
BK: vvvv	Backwards data collection	F	Y	Optional	N/A	Optional	N/A	Y
CL: vvvv	Closure	F	Y	Optional	Optional	Optional	Optional	Y
FF: vvvv*	Feature descriptor(s)	F	N	Optional	Optional	Optional	Optional	
SK: vvvv	Connectivity of points	F	Y	Optional	Optional	Optional	Optional	Y
CIRD: vvvv	Circle diameter	F	N	Optional	Optional	Optional	Optional	
Z?: vvvv	Valid Z?	F	Y	Optional	N/A	Optional	N/A	
CM: vvvv	Comment	F	N	Optional	Optional	Optional	Optional	
MM: vvvv*	Measurement descriptor(s)	F	N	Optional	Optional	Optional	Optional	
PADJ: vvvv	Position adjustment name	F	Y	Optional	Optional	Optional	Optional	
AA: vvvv*	Position adjustment descriptor(s)	F						
X_X_X_: vvvv**	Measurement data	F	N	Required	Required	Required	Required	
INFO: vvvv	General information name	I	N	Optional	Optional	Optional	Optional	
II: vvvv*	General information descriptors	I	N					
CM: vvvv	Comments	I	N	Optional	Optional	Optional	Optional	

* PP:
AA:
CC: Represents any of several descriptor tags. These tags are pre-defined by ISIMS, along with the name corresponding to the POS:, PADJ: and ACC: tags respectively. Per command set there can be several descriptor records, each with different tags.

FF:
MM:
II: Represents any of several descriptor tags. These tags are defined by the user when he installs ISIMS (see Appendix D). The FF: tags are feature name dependent. The II: tags are information name dependent. Per FEAT: or INFO: record there can be several descriptor records each with different tags.

** X_X_X As indicated by the FILE: data tag, one of four measurement data tags can be used here. They are H_V_D:, X_Y_Z:, S_O_R: and S_O_E:.

*** vvvv The value corresponding to the data tag.

\+ See previous page for category definition.

Figure C-2. ISIMS data tags and their description.

are two types of general information data tags. One is for unstructured comments (CM:), and the other is for user-defined and structured comments (INFO:). Each of these commands is applicable to any file type.

Record Description by Data Tag

File Type Commands

There is only one file type command and that is a one record command whose data tag is FILE:. The first record of every UFF file has a FILE: data tag. This record describes the location convention used for all measurement or positional data in the file. This record appears only once per UFF file. Its possible values are as follows:

FILE:Record	Description
FILE:X_Y_Z	Positional data will be described as X,Y,Z, coordinates, where Z is optional.
FILE:H_V_D	Measurement data will be described as horizontal angle, vertical angle, and slope distance.
FILE:S_O_E	Positional data will be described as station, offset, and elevation.
FILE:S_O_R	Measurement data will be described as station, offset, and rod reading.

Positioning Command Sets

To initiate the collection of survey data, the surveyor must determine the type of data he is going to collect, the applicable parameters for collecting that data, and the horizontal and vertical position of the point from which he is going to collect the data. This information is communicated to UFF through the POS data tag. The data values for the POS tag, and their associated descriptor tags and descriptor values, are listed below. The following specifications are for each of the data tag values. The specifications describe the descriptor tags and values, identify rules and defaults, and provide sample code formats.

DATA TAG: POS:

What follows is a table stating all POS: command sets. A more detailed description of these command sets can be found in Section II of this appendix.

POS: Value	Descriptor Tag	Description	Required Y/N	Default
SETUP		Set up on a known point		
	OP	Known point to set up on	Y	—
	BS	Known point to backsight on	Y	—
	H_V_D	Backsight measurement-distance not used	Y	—
USETUP		Set up on an unknown point		
	OP	Unknown point to set up on	Y	—
	BS	Known point to backsight on	Y	—
	FS	Known point to foresight on	Y	—
	H_V_D_	Backsight measurement	Y	—
	H_V_D	Foresight measurement	Y	—
HFORE		Establish a benchmark		
	FS	Unknown point to foresight to	Y	—
	H_V_D	Foresight measurement	Y	—
BSVERT		Backsight to a vertical benchmark		
	BM	Benchmark elevation backsighted	Y	—
	PR	Prism height	Y	—
OPVERT		Set up on a vertical benchmark		
	BM	Elevation of the occupied benchmark	Y	—
	HI	Height of the instrument	Y	—
ALIGN		Indicate the alignment		
	ALIGN#	Alignment number	Y	—
BSLVL		Backsight to a vertical benchmark using a level		
	RR	Rod reading	Y	—
	BM	Benchmark elevation	Y	—
OPLVL		Set up on a vertical benchmark using a level		
	BM	Benchmark elevation	Y	—
	HI	Height of instrument	Y	—
VFORE		Establish a benchmark using a level		
	RR	Rod reading at foresight	Y	—
	BM	New benchmark control point	Y	—

Positon Adjustment Commands Sets

UFF provides the user with the capability to describe point measurement characteristics. Similarly it is also necessary that UFF be capable of adjusting individual point locations. During the course of a project, it becomes necessary or convenient to locate a feature, or point within a feature, at some offset of the actual location. It may also be necessary to modify an elevation of a point. This specifically applies to the location of underground features. Using PADJ: command sets, these types of position adjustments are possible. All position adjustments apply only to the next point being measured.

DATA TAG: PADJ:

What follows is a table stating all PADJ: command sets. A more detailed description of these command sets can be found in Section II of this appendix.

PADJ: Value	Descriptor Tag	Description	Required Y/N	Default
OFFSET		Horizontal offset		
	OFFDIST	Offset distance	Y	—
	ANG	Angle with vertex at the prism between the feature and the instrument	N	90°
DEPTH		Vertical offset		
	DEPTH	Depth	Y	—

Accuracy Command Sets

UFF provides the user the ability to improve the accuracy of a position by closing the horizon. Accuracy command sets apply only to data collected in the HVD location convention. Accuracy command sets apply equally as well to H_V_D: records within a POS: command set as to a H_V_D: records within a feature.

DATA TAG: ACC:

What follows is a table stating all ACC: command sets. A more detailed description of these command sets can be found in Section II of this appendix.

ACC: Value	Descriptor Tag	Description	Required Y/N	Default
HORIZON		Set horizon closing calculation parameters		
	DIST	Indicates distance calculation method	N	FIRST
	ANG	Indicates angle calculation method	N	AVG
	HTOLR	Angle tolerance for each closure	N	10 sec.
	ATOLR	Tolerance for the average of angles	N	10 sec.
HREPS		Close the horizon		
		First closing:		
	I_H_V	Invert on foresight measurement	Y	—
	H_V	Foresight on backsight measurement	Y	—
		Each subsequent closing:		
	I_H_V	Invert on backsight measurement	N*	—
	H_V_D	Foresight on foresight measurement	N*	—
	I_H_V	Invert on foresight measurement	N*	—
	H_V	Foresight on backsight measurement	N*	—

* The four records in this command set are subsequent closings of the horizon. If they are used, they must appear as a set and be written in the order shown in this table.

Feature-Related Commands

FEAT. FEAT: is the feature name data tag. Its purpose is to provide a name for the feature(s): Each FEAT: record must have one data value which is a user-defined name. This name is alphanumeric. Examples of features are trees, sidewalks, traffic control boxes, curbs, and water meters, respectively. Refer to Appendixes D and E to see how a user can define a set of features for his needs.

GM. GM: is the geometry type data tag. Every feature has a default geometry type that is defined at installation. All GM: values are UFF defined and are shown below.

Data Record	Description
GM:SINGLE	The feature is composed of object(s) that are drawn as unconnected points.
GM:MULTI	The feature is composed of object(s) that are drawn as points connected by line segments or curves.
GM:CIRCLE	The feature is composed of circles whose centers are the measurement points and whose diameters are defined by the CIRD: data tag. All points on the circle lie at the center's elevation.
GM:3PTCIR	The feature is composed of circles which are defined by sets of three consecutive measurement points.

ID: ID: is the related feature ID data tag. This record is used when one feature is collected across multiple setups or there is any other intervening information collected. Any information with the same feature name and related feature ID belongs to one and the same feature. It is the user's responsibility to assign related feature ID's in an appropriate manner.

SK: SK: is the point connectivity data tag. On multipoint features, consecutive points are assumed to be connected, even across FEAT: records with the same related future ID. Insertion of a SK:SKIP record between two management points in a multipoint feature means that these two points are not connected. SKIP is the only acceptable SK: data tag value.

BK: BK: data tags indicate that a set of consecutive points in a multipoint feature has been collected in reverse order. BK: data records occur in pairs, with all enclosed measurement points being collected in reverse order. These records are only applicable in UFF-HVD and UFF-SOR files and are removed upon conversion to the UFF-XYZ and UFF-SOE, respectively. There are two acceptable BK: data tag values.

Data Record	Description
BK:START	Start collecting data backwards at the next point.
BK:END	Stop collecting data backwards after the next point.

There can be no FEAT:, POS:, or INFO: records between a BK:START and a BK:END record pair. Connectivity, curvature, and closure apply after backwards data have been transformed into forward data.

CL: The CL: data tag indicates that a multipoint object is closed. That is, the first and the last points of the object are connected. There is only one type of CL: data record and that is CL:CLOSED. Nonuse of this record assumes that the object is not closed. One feature can be described across several FEAT: records having the same name and related feature ID. In this case, closure applies once to the entire feature rather than once per FEAT: record.

Z?: The Z?: data tag indicates whether elevation for points in the UFF-HVD and UFF-SOR files is to be calculated. There are two acceptable Z?: data tag values.

Data Record	Description
Z?:YES	Subsequent measurement points have valid elevations.
Z?:NO	Subsequent measurement points do not include elevation.

When a Z?: record is not explicitly mentioned, then Z?:NO is assumed. The implications of this record applies across features.

CR: The CR: data tag indicates that a curve is just starting or ending on a multipoint feature. CR: data records occur in pairs and indicate that the connections between all enclosed measurement points are curves rather than the default of line segments. There are four acceptable CR: data tag values.

Data Record	Description
CR:START CURVE	At the next point start to connect points with curves.
CR:END CURVE	Stop connecting points with curves after the next point.
CR:START ARC	At the next point start to connect points with arcs of circles.
CR:END ARC	Stop connecting points with arcs of circles after the next point.

The algorithms used to draw the curves or arcs are not part of the UFF description and so are application specific.

CIRD: The CIRD: data tag is used in conjunction with GM:CIRCLE. A circle is defined by a diameter and a center point. Consequently, in the file there are pairs of CIRD: and measurement records, which define the diameter and center of the circle respectively. The perimeter of these circles is at the same elevation as the center.

H_V_D: The H_V_D: record holds a point number and measurement data and is only used in UFF-HVD files. The form of the record is:

H_V_D:ppppp DDDD MM SS.S dddd mm ss.s xxxxx.xxxxx

where:

ppppp = point number
DDDD MM SS.S = horizontal angle in degrees, minutes and seconds
dddd mm ss.s = vertical angle in degrees, minutes and seconds
xxxxx.xxxxx = slope distance

X_Y_Z: The X_Y_Z: record holds a point number and measurement data and is only used in UFF-XYZ files. The form of the record is:

X_Y_Z:ppppp xxxxxxxxx.xx yyyyyyyyyy.yy zzzzzzzzzz.zz

where:
ppppp = point number
xxxxxxxxx.xx = X coordinate
yyyyyyyyyy.yy = Y coordinate
zzzzzzzzzz.zz = Z coordinate. A zero Z coordinate implies no valid Z coordinate.

S_O_R: The S_O_R: record holds a point number and measurement data and is only used on UFF-SOR files. The form of the record is:

S_O_R:ppppp ssssss.sssss oooo.oo rrrr.rrr

where:

ppppp = point number
ssssss.sssss = station number
oooo.oo = offset (negative implies left)
rrrr.rrr = rod reading

S_O_E: The S_O_E: record holds a point number and measurement data and is only used in UFF-SOE files. The form of the record is:

S_O_E:ppppp ssssss.sssss oooo.oo eeeeee.eee

where:

ppppp = point number
ssssss.sssss = station number
oooo.oo = offset (negative implies left)
eeeeee.eee = elevation (a zero elevation implies there is no elevation)

PADJ: The purpose of the PADJ: command sets is to make horizontal or vertical adjustments to the subsequent measurement point. These command sets are used only in the UFF-HVD and UFF-SOR files. There are two PADJ: data tag values, OFFSET and DEPTH. The description of the PADJ: command sets has been described previously in this appendix, as well as in Section II of this appendix.

Measurement Descriptors

There are, at most, nine measurement descriptors that are used across all features. Both the data tags and values for these descriptors are user defined at installation (see Appen. D and Appen. E). Measurement descriptor data apply only to the following measurement point.

Feature Descriptors

There are, at most, nine feature descriptors for every user-defined feature in UFF. Both the data tags and values for these descriptors are user defined at UFF (see Appen. D and Appen. E) installation. Feature descriptor data apply to all subsequent measurement points until the next FEAT: record. In a UFF-HVD file, feature descriptors apply to subsequent measurement points in the order in which those points were collected (and are situated in the file). This is relevant when BK: records are in the file.

General Information Commands

The following table describes the two types of general information commands. See Appendixes D and E for additional examples and also instructions on how the user can define his own general information commands.

Data Record	Description
CM:cccccccc	Allows the user to enter any unstructured comments or notes. The cccccccc is the comment.
INFO:nnnn aaaa:jjjj bbbb:kkkk : : hhhh:mmmm	nnnn = The name of the type of information to be given. The user defines a set of such names at installation. aaaa = descriptor data tags. The user bbbb defines these tags at installation : for each and every name.

Data Record	Description
	hhhh jjjj = descriptor data values kkkk : mmmm
	For example, INFO:ENVIR DATE:xxxx TIME:xxxx TEMP:xxxx HUMID:xxxx

CONTROL FILE DESCRIPTION

Control File Record Format

The control file is in a fixed record length format. It serves to maintain a set of known points and their coordinates for a specific project. These points are generally used to establish horizontal and vertical control surveys and act as control points for other supporting surveys when they are reoccupied throughout the life of the project.

Using the points in the control file, the surveyor collects the raw survey data in a UFF-HVD or UFF-SOR file type. The appropriate horizontal and vertical positions are computed and stored in one of the processed data file types.

Points in the control file are referenced in the UFF-HVD format by the POS:SETUP and POS:USETUP command sets. In the descriptions of each type of positioning, points in the control file are referred to as known points. The OP:, BS: and FS: records give the actual reference point numbers of these known points as contained in the control file.

Each record in the control file contains the following field.

Reference Point Number

The reference point number is a unique number used as reference for each point in the control file. Reference point number is located in columns 1-4 of the record.

Azimuth Marker Point Number

When this point number is used in conjunction with a reference point number, then the azimuth angle in this record is that angle formed with the occupied point at the fulcrum—one ray fixed to the south and the other directed toward the backsight point. If the backsight point number is blank, then the azimuth angle should be blank.

Type of Control Point

This field indicates whether the point is a monument (M), a traverse adjusted point (A), or a calculated point (C).

Type of Control Point	Type Description
M	Monument point
C	Calculated point
A	Adjusted point

X Coordinate

The X coordinate of the reference point is located in columns 10-21 of the record. This field is required.

Y Coordinate

The Y coordinate of the reference point is located in columns 23-34 of the record. This field is required.

Z Coordinate

Columns 36-47 contain the Z coordinate of the point. This field is not required and is only for documentation. In UFF-HVD and UFF-SOR, Z coordinates rather than control numbers are entered directly into POS: command sets.

Azimuth Angle

If an azimuth angle exists for this point, it will be located in columns 49-60 of the record in the DDDD MM SS.S format.

Comments and/or Description

Columns 61-140 can be used for comments or descriptive information for each point. This is not a required field.

CONTROL FILE RECORD LAYOUT

Columns	Description	Req'd
1-4	Reference point number	Y
5-8	Azimuth marker point number	N
9	Occupied point type	N
10-21	X coordinate of reference point	Y
23-34	Y coordinate of reference point	Y
36-47	Z coordinate of reference point	N
49-60	Azimuth angle	N
61-140	Comments and/or description	N

POS:/Control File Relationship

For a POS:SETUP command set if the OP: control point and the BS: control point match a control file record's reference point number and azimuth marker point number respectively, then the (X,Y) and azimuth angle of that record are used for setup. If there is no match such as this, but there are two records in the control file whose reference point numbers match the OP: control point and the BS: control point, respectively, the two control record (X,Y) values are used for the occupied point and the backsight point. If there is still no match, there is a problem of either inadequate control data or improper control point input.

For a POS:USETUP command there must be two records in the control file whose reference point numbers match the FS: control point and the BS: control point, respectively. Then the two control record (X,Y) values are used to calculate the position of the occupied point.

Control File Creation

The control file is generally created in one of three ways: (1) an extraction from a state-wide control point database selecting known horizontal control points, benchmarks, and azimuth markers; (2) manually input into the control file through the data entry procedure; and (3) collected during the data collection process as survey data. Resulting coordinates are transferred to the control file manually or automatically.

SECTION II. DETAILED COMMAND SET DESCRIPTIONS FOR POS:, PADJ:, AND ACC:

In Section I of this appendix, positioning (POS:), position adjustment (PADJ:), and accuracy (ACC:) command sets are stated and briefly described. This section provides a detailed description of each of these types of command sets.

DATA TAG: POS

The first record of every positioning command set begins with the POS: tag, and is followed by the name of the positioning command. Following any POS: record are several associated descriptor records whose form and purpose vary across different positioning commands.

Descriptor Record Formats

Several of the descriptor records have multiple formats. Possible formats are shown below and pertain to all UFF records in this appendix.

In this appendix, when a POS: descriptor record is shown, any of the foregoing formats for the given descriptor record are allowed. All other POS: descriptor records have one value, and the value is numeric unless otherwise specified.

Format	Description
OP:C cccc FS:C cccc BS:C cccc BM:C cccc	where: cccc is a control point number
OP:P xxxxxx.xxxx yyyyyy.yyyy zzzzzz.zzz FS:P xxxxxx.xxxx yyyyyy.yyyy zzzzzz.zzz BS:P xxxxxx.xxxx yyyyyy.yyyy zzzzzz.zzz BS:A dddd mm ss.s	where: xxxxxx.xxxx is the X coordinate; yyyyyy.yyyy is the Y coordinate; dddd mm ss.s is the azimuth angle in degrees, minutes and seconds
BM:Z zzzzzz.zzz	where: zzzzzz.zzz is elevation
H_V_D:ppppp DDDD MM SS.S ddd mm ss.s xxxx.xxxxx	where: ppppp = point number; DDDD MM SS.S = horizontal angle in degrees, minutes and seconds; ddd mm ss.s = vertical angle in degrees, minutes and seconds; and xxxx.xxxxx = slope distance

DATA TAG: POS
DATA TAG VALUE: SETUP

The SETUP tag defines to UFF the procedure used by the surveyor to collect radial survey data, where he sets up the instrument on a known point and backsights on a known point or azimuth.

The SETUP data tag has two horizontal positioning descriptor tags, OP and BS. OP identifies the known point on which the instrument is setup or occupies. BS identifies the known point as the point which is being backsighted. SETUP is applicable to UFF-HVD files.

The SETUP data tag has vertical positioning descriptor tags, VERT, PR and HI. The VERT record indicates that vertical positioning is to be activated, and whether the known vertical benchmark is at the backsight or occupied point. If the benchmark is at the backsight then PR descriptor information is needed. If the benchmark is at the occupied point, then PR and HI descriptor information is needed. PR is the prism height. HI is the height of the instrument.

ISIMS uses the last SETUP, or USETUP tag as the active coordinates of where the instrument is located. All coordinate, distance and angle calculations are associated with this active instrument location.

UFF records related to POS:	Description
POS:SETUP OP:pppp BS:pppp VERT:nnnn PR:rrrr HI:hhhh H_V_D:ppp hhh vvv ddd	Set up on a known point and back-sight to a known point or azimuth angle. A POS:SETUP record must be followed by OP:, BS: and H_V_D records, and optionally by VERT:, PR: and HI:. The data value of OP: indicates the position of the occupied point. The data value for the BS: data tag indicates the position of the backsight point. If vertical positioning is wanted, then descriptor records VERT:, PR: and (possibly) HI: are needed. The PR: data value is the height of the prism. The HI: data value is the height of the instrument. VERT: data records are: VERT:OP - vertical benchmark is the occupied point VERT:BS - vertical benchmark is the backsight point The Z-coordinate of the vertical bench-mark must be located by using the OP: or BS: descriptor record, respectively. A single H_V_D measurement record is required to record the horizontal circle reading.

EXAMPLE:

1. Set up instrument on a known point (PT #10), backsight on known point (PT #8).

RECORD #1	POS:SETUP
RECORD #2	OP: C 10
RECORD #3	BS: C 8
RECORD #4	H_V_D: MEASUREMENT-ANGLE REQUIRED

2. Set up instrument on a known point (PT #10), backsight on known azimuth (PT #7).

RECORD #1	POS:SETUP
RECORD #2	OP: C 10
RECORD #3	BS: C 7
RECORD #4	H_V_D: MEASUREMENT - ANGLE REQUIRED

3. Set up instrument on a known point, backsight on known azimuth (PT #7). The vertical benchmark is the occupied point whose elevation is 785.3.

RECORD #1	POS:SETUP
RECORD #2	OP: P 14.73 101.24 785.3
RECORD #3	BS: C 7
RECORD #4	VERT: OP
RECORD #5	HI: 4.5
RECORD #6	PR: 5.0
RECORD #7	H_V_D: MEASUREMENT

4. Set up instrument on a known point, (PT #10), backsight on a known point (PT #7) whose Z-coordinate is also known. The vertical benchmark is the backsight elevation which is in the control file.

RECORD #1	POS: SETUP
RECORD #2	OP: C 10
RECORD #3	BS: C 7
RECORD #4	VERT: BS
RECORD #5	PR: 5.0
RECORD #6	H_V_D: MEASUREMENT

DATA TAG: POS
DATA TAG VALUE: USETUP

The USETUP tag defines to UFF the procedure used by the surveyor to collect radial survey data, where he sets up the instrument on an unknown point and triangulates between two known points. The horizontal positional coordinates for the unknown point are calculated and may be stored in the control file as a known point.

The USETUP data tag has three horizontal positioning descriptor tags, OP, BS and FS. OP identifies the location of the unknown point on which the instrument is setup or occupies. BS identifies the location of the known point which is being backsighted. FS identifies the location of a known point which is being foresighted. The OP value is the surveyor defined point number of the point with unknown (x,y) coordinates. When OP has no value, the coordinates need not be stored in the control file but will be used to perform calculations for shots during this setup. USETUP is applicable to UFF-HVD files.

The USETUP data tag has vertical positioning descriptor tags, VERT, PR and HI. The VERT record indicates that vertical positioning is to be activated, and whether the known vertical benchmark is at the backsight, foresight, or occupied point. If the benchmark is at the backsight or foresight then PR descriptor information is needed. If the benchmark is at the occupied point, then PR and HI descriptor information is needed. PR is the prism height. HI is the height of the instrument.

ISIMS uses the last SETUP, or USETUP tag as the active coordinates of where the instrument is located. All coordinates, distance and angle calculations are associated with this active instrument location.

UFF records related to POS:	Description
POS:USETUP OP:pppp BS:bbbb FS:cccc VERT:nnnn PR:rrrr HI:hhhh H_V_D:ppp hhh vvv ddd H_V_D:ppp hhh vvv ddd	Set up on an unknown point and sight two known points. This record must be followed by OP:, BS:, FS: and two H_V_D: records, and optionally by VERT:, PR: and HI:. The OP: data value indicates the position of the occupied point. The BS: data value indicates the position of the back-sight. The FS: data value indicates the position of the foresight. If vertical positioning is wanted, then descriptor records VERT:, PR: and (possibly) HI: are needed. The PR: data value is the height of the prism. The HI: data value is the height of the instrument. VERT: data records are: VERT:OP - vertical benchmark is the occupied point VERT:BS - vertical benchmark is the backsight point VERT:FS - vertical benchmark is the foresight point The Z-coordinate of the vertical benchmark must be located by using the OP:, BS:, or FS: descriptor record, respectively. Two H_V_D: measurement records are required to measure the angle at the unknown point and the two distances to the known points. The first H_V_D is always the backsight; and the second is the foresight. One turns clockwise from backsight to foresight.

EXAMPLE:

Set up instrument on an unknown point, identify it as PT #10, backsight on known point (PT #8) and foresight on known point (PT #15).

RECORD #1	POS:USETUP
RECORD #2	OP: C 10
RECORD #3	BS: C 8
RECORD #4	FS: C 15
RECORD #5	H_V_D: MEASUREMENT - ANGLE AND DISTANCE
RECORD #6	H_V_D: MEASUREMENT - ANGLE AND DISTANCE

DATA TAG: POS
DATA TAG VALUE: HFORE

The HFORE data tag value allows the surveyor to measure to a new control type point, calculate its coordinates, and store the new point in the control file. The HFORE data tag value identifies the surveyor defined point number in the control file. HFORE requires a previous SETUP, or USETUP data tag value to be acceptable.

The HFORE data tag value itself identifies the point in the control file that is to be added to the file or the point amended to include an elevation. If an (x,y) coordinate pair already exists for that point, an additional record should be created as a calculated type control point. HFORE is applicable to UFF-HVD files.

UFF records related to POS:	Description
POS: HFORE FS:pppp H_V_D:ppp hhh vvv ddd	Foresight to and establish a control point. This record will be followed by an FS: record whose data value is the new control point number of the foresight. A single HVD measurement record is required. Angle and distance is required.

EXAMPLE:

1. Set up instrument on a known point (PT #10), backsight on a known point (PT #8), and foresight on a new point to be identified as point #20.

RECORD #1	POS:SETUP
RECORD #2	OP: C 10
RECORD #3	BS: C 8
RECORD #4	H_V_D: MEASUREMENT
RECORD #5	POS:HFORE
RECORD #6	FS: C 20
RECORD #7	H_V_D: MEASUREMENT

2. Set up instrument on an unknown point (PT #11), backsight on a known point (PT #8), foresight on a known point (PT #10), and foresight on a new point to be identified as point #20.

RECORD #1	POS:USETUP
RECORD #2	OP: C 11
RECORD #3	BS: C 8
RECORD #4	FS: C 10
RECORD #5	H_V_D: MEASUREMENT
RECORD #6	H_V_D: MEASUREMENT
RECORD #7	POS:HFORE
RECORD #8	FS: C 20
RECORD #9	H_V_D: MEASUREMENT

DATA TAG: POS
DATA TAG VALUE: BSVERT

The BSVERT tag defines to UFF the information necessary to compute elevations as the surveyor collects survey data. BSVERT is used when collecting elevations only with a theodolite. BSVERT allows the surveyor to carry elevations forward from a backsight vertical benchmark.

The BSVERT data tag has two descriptor tags: BM, and PR. BM identifies the location of the backsight benchmark (BM). PR defines the prism height on the field rod. BSVERT is applicable to UFF-HVD files.

UFF uses the last BSVERT or OPVERT as the active elevation parameters for determining elevations. ISIMS computes elevations for UFF-HVD data when the BSVERT or OPVERT data records are present.

UFF records related to POS:	Description
POS:BSVERT BM:zzzz PR:rrrr H_V_D:ppp hhh vvv ddd	Establish vertical control for the setup. The POS: BSVERT record will be followed by a BM: record whose data value indicates the elevation at the benchmark. The PR: data value is the prism height. A single H_V_D measurement record is required as a backsight to initiate vertical positioning.

EXAMPLES:

1. Set up instrument on a known point (PT #10), backsight on a known BM (PT #7), the prism is set at 3 ft.

RECORD #1	POS:SETUP
RECORD #2	OP: C 10
RECORD #3	BS: C 8
RECORD #4	H_V_D: MEASUREMENT
RECORD #5	POS:BSVERT
RECORD #6	BM: C 7
RECORD #7	PR:3.0
RECORD #8	H_V_D: MEASUREMENT

DATA TAG: POS
DATA TAG VALUE: OPVERT

The OPVERT tag defines to UFF the information necessary to compute elevations as the surveyor collects survey data. OPVERT allows the surveyor to adjust the point he is setup on by the height of the instrument.

The OPVERT data tag has two descriptor tags: BM and HI. BM identifies the location of the occupied point. HI defines the height of the instrument: OPVERT is applicable to UFF-HVD files.

UFF uses the last OPVERT or BSVERT as the active elevation parameters for determining elevations. ISIMS computes elevations for UFF-HVD data when the BSVERT or OPVERT records are present.

UFF records related to POS:	Description
POS:OPVERT BM:zzzz HI:hhhh PR:rrrr	Establish vertical control for the setup. The POS: OPVERT record will be followed by a BM: record whose data value indicates the elevation of the occupied station. HI is the height of the instrument. PR is the prism height.

EXAMPLE:

1. Set up instrument on a known point (PT #10) with a known elevation and a height of instrument of 3.56 ft.

RECORD #1	POS:SETUP
RECORD #2	OS: C 10
RECORD #3	BS: C 8
RECORD #4	H_V_D: MEASUREMENT
RECORD #5	POS:OPVERT
RECORD #6	BM: C 10
RECORD #7	HI: 5.0
RECORD #8	PR: 3.0

DATA TAG: POS:
DATA TAG VALUE: ALIGN

The ALIGN: tag is used to identify an alignment. This designation defines the particular alignment in which any following station-offset data is notated. This will be an important interface to outside engineering computer systems. ALIGN is used in UFF-SOR and UFF-SOE files.

UFF records related to POS:	Description
POS:ALIGN ALIGN#:aaaa	Describes the alignment upon which subsequent station and offset pairs are based. aaaa - alphanumeric alignment number. Data following this descriptive tag has to relationship to the previous data.

DATA TAG: POS:
DATA TAG VALUE: BSLVL

The BSLVL tag defines to UFF the information necessary to establish or maintain the elevation of the instrument when collecting data by the SOR convention. BSLVL allows the surveyor to carry elevations forward from a backsight benchmark or known elevation of a backsight.

The BSLVL tag has two descriptor tags BM and RR. BM identified the location of the benchmark. BM is an optional data tag, applicable only if the backsight is a benchmark. When BM is used, it's associated elevation overrides any carried elevation. RR is the rod reading at the backsight. BSLVL is applicable in UFF-SOR files.

BSLVL or OPLVL precedes all S_O_R records and is needed after every move of the instrument.

UFF records related to POS:	Description
POS:BSLVL	Establishes the height of the level.
BM:zzzz	zzzz = known elevation of benchmark.
RR:rrrr	rrrr = rod reading at that elevation point.

EXAMPLES:

1. Backsight to a benchmark called point number 10.

```
RECORD #1:    POS:BSLVL
RECORD #2:    BM: C 10
RECORD #3:    RR: 5.0
```

2. Backsight to a benchmark called point number 10. Shoot a few cross section points, then move the instrument to an arbitrary place, turn on the last cross section shot, and shoot a few more cross sections.

```
RECORD # 1:   POS:BSLVL
RECORD # 2:   BM: C 10
RECORD # 3:   RR: 5.0
RECORD # 4:   FEAT:XSEC
RECORD # 5:   S_O_R: MEASUREMENT
RECORD # 6:   S_O_R: MEASUREMENT (turning point)
RECORD # 7:   POS:BSLVL
RECORD # 8:   RR: 7.3
RECORD # 9:   FEAT:XSEC
RECORD #10:   S_O_R: MEASUREMENT
RECORD #11:   S_O_R: MEASUREMENT
```

DATA TAG: POS:
DATA TAG VALUE: OPLVL

The OPLVL tag is used to establish or maintain the elevation of the instrument when collecting data by the SOR convention. OPLVL allows the surveyor to adjust the benchmark elevation he is set up on by the height of the instrument.

The OPLVL tag has two descriptor tags BM and HI. BM identifies the location of the benchmark. HI is the height of the instrument. OPLVL is applicable in UFF-SOR files.

OPLVL or BSLVL precedes all S_O_R records and is needed after every move of the instrument.

UFF records related to POS:	Description
POS:OPLVL	Establishes the height of the level.
BM:zzzz	zzzz = known elevation of benchmark.
HI:rrrr	rrrr = the height of the instrument.

EXAMPLES:

1. Set up on a benchmark of elevation 97.32

```
POS:OPLVL
BM: Z 97.32
HI: 4.5
```

2. Setup on a benchmark called point number 10.

```
POS:OPLVL
BM: C 10
HI: 4.5
```

DATA TAG: POS
DATA TAG VALUE: VFORE

The VFORE tag is used to establish a benchmark when collecting data by the SOR convention.

The VFORE tag has two descriptor tags RR and BM. RR is the rod reading at the newly created benchmark. BM is the control point number to be assigned to the benchmark. VFORE is applicable to the UFF-SOR files.

UFF records related to POS:	Description
POS:VFORE RR:rrrr BM: C cccc	Establishes a benchmark and optionally allows assignment of a control point number to the benchmark. rrrr = rod reading at new benchmark (foresight) cccc = control point number of benchmark (foresight) to be used for future referencing.

EXAMPLE:

1. Set up on a benchmark of elevation 47.2 and then foresight to a point which will now be referred to as control point 72.

```
POS:OPLVL
 BM:Z 47.2
 HI:  4.5
POS:VFORE
 RR: 10.23
 BM: C 72
```

DATA TAG: PADJ

UFF provides the user with the capability to describe point measurement characteristics. Similarly, it is also necessary that ISIMS be capable of adjusting individual point locations. During the course of a project, it becomes necessary or convenient to locate a feature or a point descriptor for multi-shot feature at some offset of the actual location. It is also necessary to modify an elevation of a point. This specifically applies to the location of underground features. All adjustments apply only to the next point being measured.

The PADJ: command sets make horizontal or vertical adjustments to the subsequent measurement point. These command sets are used only in the UFF-HVD and UFF-SOR files. There are two PADJ: data tag values, OFFSET and DEPTH.

UFF provides the PADJ:vvv command set data tag, OFFSET, for adjusting the horizontal position and the data tag value, DEPTH, to adjust vertical position. Another tag IGNORE, tells the station to ignore the next measurement record.

DATA TAG: PADJ
DATA TAG VALUE: OFFSET

The OFFSET data tag value is used to adjust the horizontal position of a particular measurement. There are two descriptor tags, OFFDIST and ANG that describe the distance and angle of the adjusted location. The adjustment is always measured from the point measured in the field to the feature.

OFFDIST descriptor tag defines the offset distance. ANG is the angle, whose vertex is at the measured point, that turns from the instrument to the feature in a clockwise direction. OFFSET can accompany measurement records in the H_V_D and S_O_R file formats. The X_Y_Z and S_O_E files will reflect the adjusted coordinates for actual feature location. The POS: OFFSET command set will apply only to the following measurement record. Figure C-3 illustrates the use of OFFSET.

UFF records related to PADJ:	Description
PADJ:OFFSET OFFDIST: oooo ANG: dddd mm ss.s	OFFSET defines a horizontal offset adjustment. oooo is the offset distance. dddd mm ss.s is the angle between the line of sights from the offset point to the feature and the total station (this angle is expressed in degrees, minutes and seconds.)

DATA TAG: PADJ
DATA TAG VALUE: DEPTH

The DEPTH data tag value is used to adjust the vertical position of a particular measurement. The DEPTH tag defines the distance vertically that a point is to be adjusted. DEPTH is applied to an elevation by subtracting the depth from the elevation.

The DEPTH command set will accompany the measurement records in the H_V_D or S_O_R file formats. The X_Y_Z and S_O_E file formats will reflect the adjusted value of the feature's actual elevation.

The POS:DEPTH command will apply only to the following measurement record.

UFF records related to PADJ:	Description
PADJ:DEPTH DEPTH:dddd	dddd is the depth and is subtracted from the measurements elevation.

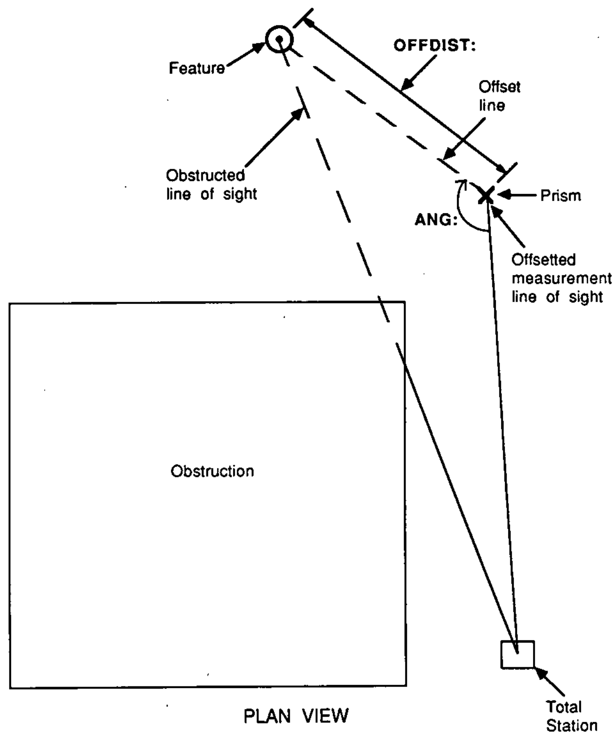


Figure C-3. PADJ:OFFSET illustration.

DATA TAG: ACC

The ability to obtain better location measurement accuracy is accommodated in the UFF by the use of the ACC: command sets. There are two ACC: command sets ACC:HORIZON and ACC:HREPS: The first provides the parameters for different calculation options and tolerances while closing a horizon. The second does the actual closing of the horizon.

DATA TAG: ACC
DATA TAG VALUE: HORIZON

The HORIZON command set determines the accuracy criteria for distance and angular measurement data. HORIZON allows the user to determine the type of calculations used while closing a horizon and, also, to specify the acceptable angular tolerances for horizon closure.

HORIZON has four descriptor tags: DIST, ANG, HTOLR and ATOLR. With DIST, the user indicates whether the calculated distance to a given position is an average or is the first distance shot while closing the horizon. Similarly, with ANG the choices for calculating angles is by averaging or using the first applicable angle. HTOLR defines the angular tolerance acceptable to the user for horizon closure (two successive angles = 360°). ATOLR defines the angular tolerance of the average of an angle being repeatedly measured. HORIZON applies to UFF-HVD data files, and its information is applicable to all subsequent HREPS command sets until another HORIZON command is used. Defaults for DIST, ANG, HTOLR and ATOLR are FIRST, AVG, 10 seconds and 10 seconds, respectively.

UFF records related to ACC:	Description
ACC:HORIZON DIST:nnnn ANG:nnnn HTOLR: ss.s ATOLR: ss.s	Defines the procedure for distance and angle calculation when turning angles. nnnn = FIRST; use first value only. nnnn = AVG; use average value. DIST: applies to distance measurements. ANG: applies to angle measurements ss.s is angular tolerance (in seconds). HTOLR: is the acceptable angle tolerance for each horizontal closure. ATOLR: is the acceptable tolerance for average of angles measured at a point.

DATA TAG: ACC
DATA TAG VALUE: HREPS

The HREPS command set is used to close the horizon. With HREPS angles may be turned as many times as the user wishes. The HREP command set always applies to the foresight measurement and its associated backsight.

HREP uses descriptor records in sets which quantify each closure. To close the horizon the first time the I_H_V: (invert on the foresight) and H_V: (foresight on backsight) descriptor records are used in this sequence. For each subsequent closure of this same foresight point, four descriptor records are used in this order: I_H_V (invert on backsight), H_V_D: (foresight), I_H_V (invert on foresight), and H_V (foresight on backsight).

HREP is applicable to UFF-HVD data files and is usually applied to HFORE: foresights (establish benchmarks) or on a USETUP: (setup on an unknown point and short two known points). HREP is not confined to these foresights, however, and can be applied to any feature related H_V_D: record. HREP uses parameters established in the HORIZON command set.

UFF records related to ACC:	Description
	HREPS closes the horizon.
	The first closure employs the first two descriptor
ACC:HREPS	records.
I_H_V: xxx	Invert on the foresight.
H_V: xxx	Foresight on the backsight.
	Subsequent closures each employ the next four descriptor records in the order shown here.
I_H_V: xxx	Invert on the backsight.
H_V_D: mmm	Foresight on the foresight.
I_H_V: xxx	Invert on the foresight.
H_V: xxx	Foresight on the backsight.
	mmm is the usual set of four H_V_D data values: point number, horizontal angle, vertical angle and slope distance (angles in degrees, minutes and seconds).
	xxx is the same as mmm except the slope distance value is ignored in calculation.

EXAMPLES:

1. Close the horizon once while establishing a benchmark. Occupy control point 12, backsight to control point 10 and foresight to new control point 99.

RECORD #1	POS:SETUP
RECORD #2	OP: C 12
RECORD #3	BS: C 10
RECORD #4	H_V_D: MEASUREMENT - ANGLE REQUIRED
RECORD #5	POS:HFORE
RECORD #6	FS: C 99
RECORD #7	H_V_D: MEASUREMENT
RECORD #8	ACC: HREPS
RECORD #9	I_H_V: MEASUREMENT - ANGLE REQUIRED
RECORD #10	H_V: MEASUREMENT - ANGLE REQUIRED

2. Close the horizon three times on a USETUP. Foresight on control point 12, backsight on control point 10 and establish a new control point 99.

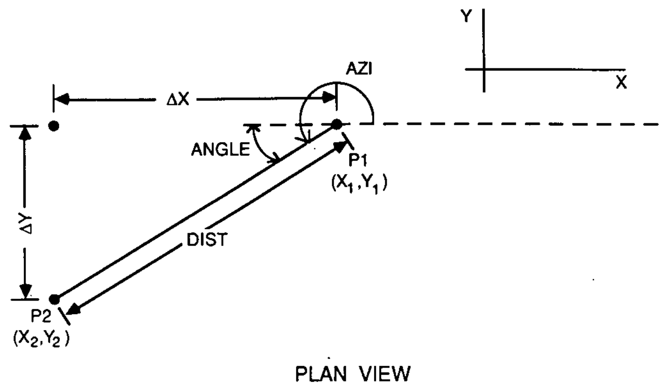
RECORD #1	POS:USETUP
RECORD #2	OP: C 99
RECORD #3	FS: C 12
RECORD #4	BS: C 10
RECORD #5	H_V_D: MEASUREMENT (FORESIGHT)
RECORD #6	H_V_D: MEASUREMENT (BACKSIGHT)
RECORD #7	ACC:HREPS
RECORD #8	I_H_V: MEASUREMENT - ANGLE REQUIRED
RECORD #9	H_V: MEASUREMENT - ANGLE REQUIRED
RECORD #10	I_H_V: MEASUREMENT - ANGLE REQUIRED
RECORD #11	H_V_D: MEASUREMENT
RECORD #12	I_H_V: MEASUREMENT - ANGLE REQUIRED
RECORD #13	H_V: MEASUREMENT - ANGLE REQUIRED
RECORD #14	I_H_V: MEASUREMENT - ANGLE REQUIRED
RECORD #15	H_V_D: MEASUREMENT - ANGLE REQUIRED
RECORD #16	I_H_V: MEASUREMENT - ANGLE REQUIRED
RECORD #17	H_V: MEASUREMENT - ANGLE REQUIRED

SECTION III. CONVERSION ALGORITHMS

HORIZONTAL POSITION

Horizontal position computations are based on total station theodolite measurements. The system expects the following information in an H_V_D: measurement record.

- Horizontal circle
- Vertical angle
- Slope distance to the foresight
- Azimuth angles measured off of a line parallel to the x-axis, and in the positive X (easterly) direction (see Fig. C-4).



$$\Delta X = X_2 - X_2$$

$$\Delta Y = Y_1 - Y_1$$

$$DIST = \sqrt{(\Delta X)^2 + (\Delta Y)^2}$$

$$SANGLE = \arcsin\left(\frac{\Delta Y}{DIST}\right);\ -\frac{\Pi}{2} < SANGLE \leq \frac{\Pi}{2}$$

$$CANGLE = \arccos\left(\frac{\Delta X}{DIST}\right);\ 0 \leq CANGLE < \Pi$$

$$ANGLE = |SANGLE| = |CANGLE|$$

Conditional statements used in AZI calculation.

```
IF CANGLE > Π/2  THEN AZI = Π - SANGLE
  ELSEIF SANGLE < 0  THEN AZI = 2Π - SANGLE
    ELSE  AZI = SANGLE
```

Figure C-4. General azimuth calculation.

POS:SETUP Command Set

The following steps are used to compute the horizontal position resulting from a foresight measurement:

Step 1. Retrieve (X,Y) coordinates of the occupied point (OP) and the backsight (BS), (OP_x,OP_y) and (BS_x,BS_y), respectively
Step 2. Compute backsight azimuth (BSAZI)
Step 3. Compute clockwise angle between BS and the foresight (FS)
Step 4. Compute foresight azimuth (FSAZI)
Step 5. Compute horizontal distance from OP to FS
Step 6. Compute foresight coordinates (FS_x,FS_y)

Step 1—Retrieve (X, Y) Coordinates of OP and BS. The known (X,Y) points for the OP and BS are retrieved from the control file or input through the POS:SETUP command set.

Step 2—Compute Backsight Azimuth. Refer to Figure C-5 for illustration. Refer to Figure C-4 for calculation of the backsight azimuth (BSAZI) in Figure C-5, where: P1 = B, P2 = A, AZI = BSAZI, (X_1,Y_1) = (OP_x,OP_y), and (X_2,Y_2) = (BS_x,BS_y).

Step 3—Compute Clockwise Angle Between BS and FS. Refer to Figure C-5.

$$\text{angle(ABC)} = M_2HA - M_1HA$$

This computation is the difference in the measurement block recorded as the backsight (M_1HA) in POS:SETUP and a recorded foresight measurement block (M_2HA).

Step 4—Compute Foresight Azimuth. Refer to Figure C-5.

$$FSAZI = BSAZI - \text{angle(ABC)}$$

where: angle(ABC) = the clockwise angle between BS and FS; if FSAZI < 0, FSAZI = FSAZI + 360°.

Step 5—Compute the Horizontal Distance from OP to BS. Refer to Figure C-5. The slope distance, M_2DIST, measured as measurement #2 is broken into horizontal and vertical components. The horizontal component (HDIST) is computed as follows:

$$HDIST = \sin(M_2VA) \times M_2DIST$$

Step 6—Compute Foresight Coordinates. Refer to Figure C-6 for the computation algorithms. The foresight point (FS_x,FS_y) is not part of the POS:SETUP command set. It is calculated by using subsequent H_V_D: records in FEAT: and HFORE: command sets.

POS:USETUP Command Set

The following steps are used to complete the horizontal position of the occupied point. Both the backsight and foresight must be known points.

Step 1. Retrieve (X,Y) coordinates of BS and FS, (BS_x,BS_y) and (FS_x,FS_y), respectively
Step 2. Compute the horizontal distance and azimuth between BS and FS
Step 3. Compute horizontal distance(s) from OP to BS and OP to FS
Step 4. Compute the clockwise angle between BS and FS
Step 5. Compute backsight azimuth
Step 6. Compute occupied point coordinates (OP_x,OP_y)

Step 1—Retrieve (X, Y) Coordinates of BS and FS. The known (x,y) points for the BS and FS are retrieved from the control file or input through the POS:USETUP command set.

Step 2—through Step 6. Refer to Figure C-7 for illustration and explanation of POS:USETUP on a step-by-step basis.

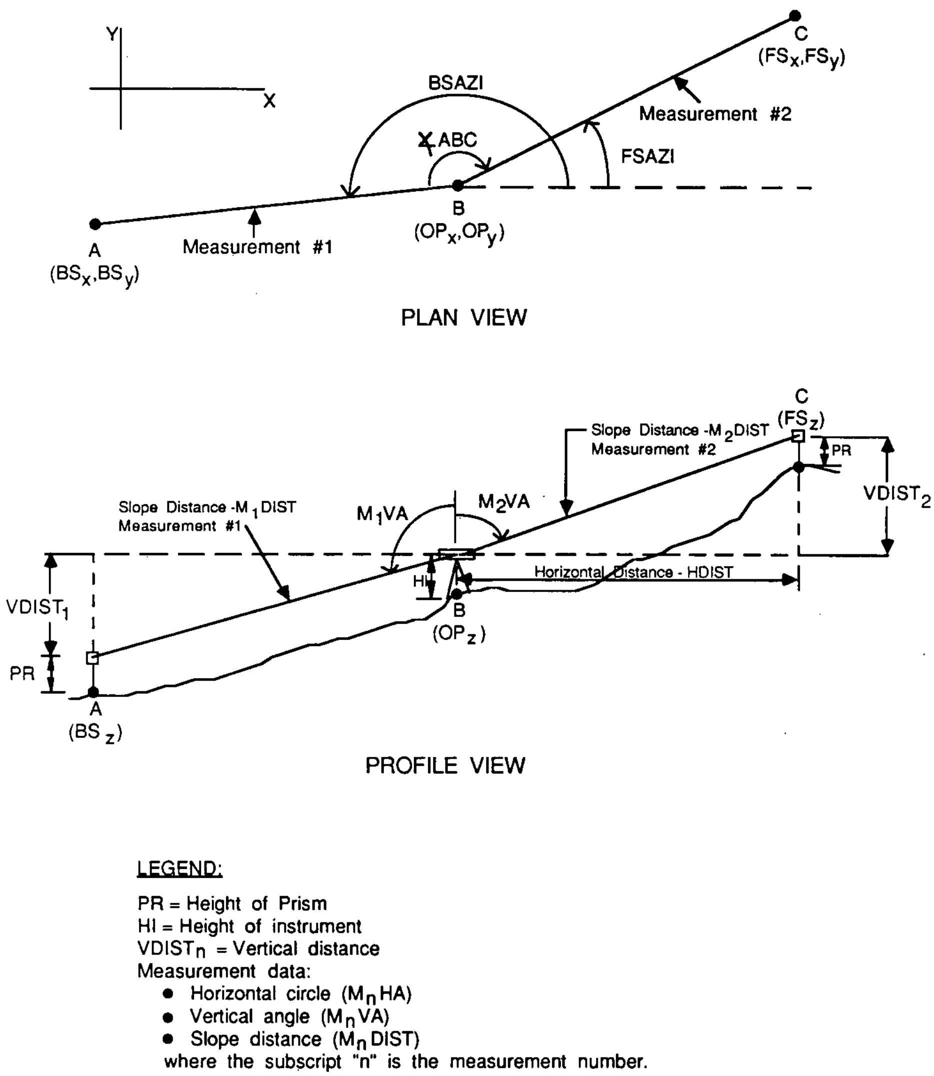


Figure C-5. Compute foresight position.

bHDIST = horizontal distance between BS and FS
ACAZI = azimuth from BS to FS
aHDIST = horizontal distance between OP and FS
cHDIST = horizontal distance between OP and BS
angle(CAB) = angle turning from FS to OP with the BS as the vertex
angle(ABC) = clockwise angle turning from BS to FS with the OP as the vertex
ABAZI = azimuth from BS to OP

Once the occupied point (OP_x,OP_y) is calculated, then subsequent foresight points (FS_x,FS_y) can be calculated for H_V_D: records in FEAT: and HFORE: command sets. The algorithm used is the same as the POS:SETUP algorithm.

POS:HFORE or any H_V_D: Record in a FEAT: Command Set

Refer to Figure C-6 for computational algorithms. The measurement block associated with HFORE is measurement #2 in the formuli.

VERTICAL POSITION

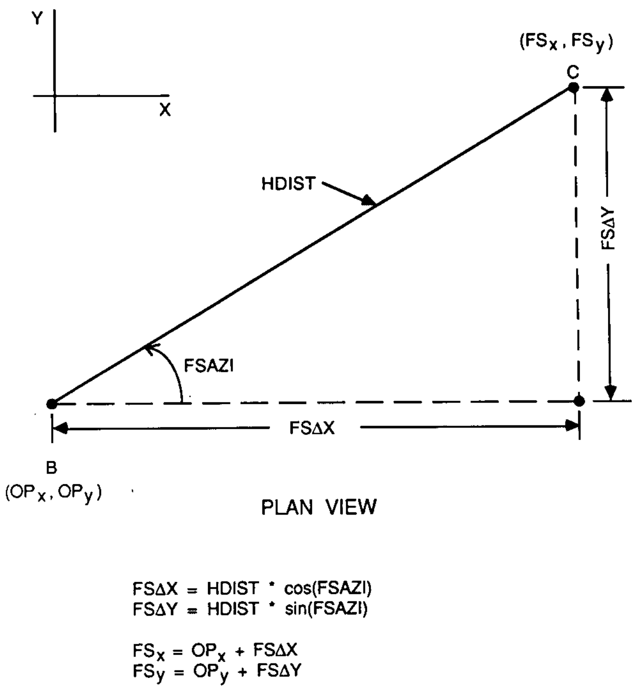
Vertical position can be calculated using either a theodolite or a level. The level is used to measure vertical position only, whereas the theodolite can measure vertical and horizontal simultaneously, or be restricted to one or the other.

To compute the elevation at any foresight, the following steps will occur:

Step 1. Compute the elevation at the instrument (IELEV)
Step 2. Compute the forward or turn-point elevation (PTELEV)

The POS: command sets accomplish step 1. Upon subsequent H_V_D: (or S_O_R:) records for FEAT:, HFORE:, or VFORE: command sets, step 2 is calculated.

To establish elevation of the instrument, the POS:BSLVL and POS:OPLVL command sets are used with levels. POS:BSVERT and POS:OPVERT command sets are used with a theodolite when only vertical position is being calculated. To calculate instrument elevation when a theodolite is being used to measure both horizontal and vertical position, the VERT:, BM:, PR: and



Note: FSAZI is calculated in Step 4 and illustrated in Figure C-5.

Figure C-6. Compute foresight coordinates (FS_x,FS_y).

HI: descriptor records of the POS:SETUP and POS:USETUP command sets are used.

Instrument elevation calculation in POS:SETUP and POS:USETUP mirrors that in POS:BSVERT and POS:OPVERT.

POS:SETUP with VERT:BS = POS:BSVERT
POS:USETUP with VERT:BS = POS:BSVERT
POS:USETUP with VERT:FS = POS:BSVERT
where measurement 2 replaces measurement 1
POS:SETUP with VERT:OP = POS:OPVERT
POS:USETUP with VERT:OP = POS:OPVERT

Similarly, instrument elevation calculation in POS:BSLVL and POS:OPLVL mirrors POS:BSVERT and POS:OPVERT, respectively, where V_nDIST = 0 and prism height (PR) is replaced by backsight rod reading (ROD_1).

PR = prism height
IELEV = elevation of instrument
HI = height of instrument
BM = benchmark elevation (either at BS or OP)
$VDIST_n$ = vertical distance at measurement n
M_nDIST = slope distance at measurement n
ROD_n = rod reading at measurement n
PTELEV = forward or turn-point elevation

POS:BSVERT Command Set

Refer to Figure C-5, PROFILE VIEW.

$$VDIST_1 = M_1DIST \times \cos(M_1VA)$$

$$IELEV = BM + PR - VDIST_1$$

POS:OPVERT Command Set

Refer to Figure C-5, PROFILE VIEW, where BM is the benchmark elevation at OP.

$$IELEV = BM + HI$$

POS:BSLVL Command Set

Refer to Figure C-8, where BM is the known elevation at BS.

$$IELEV = BM + ROD_1$$

POS:OPLVL Command Set

Refer to Figure C-8, where BM is the known elevation at OP.

$$IELEV = BM + HI$$

POS:VFORE, POS:HFORE or Any Unknown Foresight Elevation

When used with BSVERT or OPVERT, the z value or elevation calculations will take the vertical angle and distance measured into consideration. Refer to Figure C-5, PROFILE VIEW, and note that the resulting elevation is computed as:

$$PTELEV = IELEV - ROD_2 - VDIST_2$$

When BSLVL and OPLVL act as the vertical control setup, PTELEV is calculated as above, with $VDIST_2 = 0$.

POSITIONAL ADJUSTMENTS

Both horizontal and vertical positions may be adjusted according to PADJ:vv command tags. These tags and algorithms used to adjust a point are as follows:

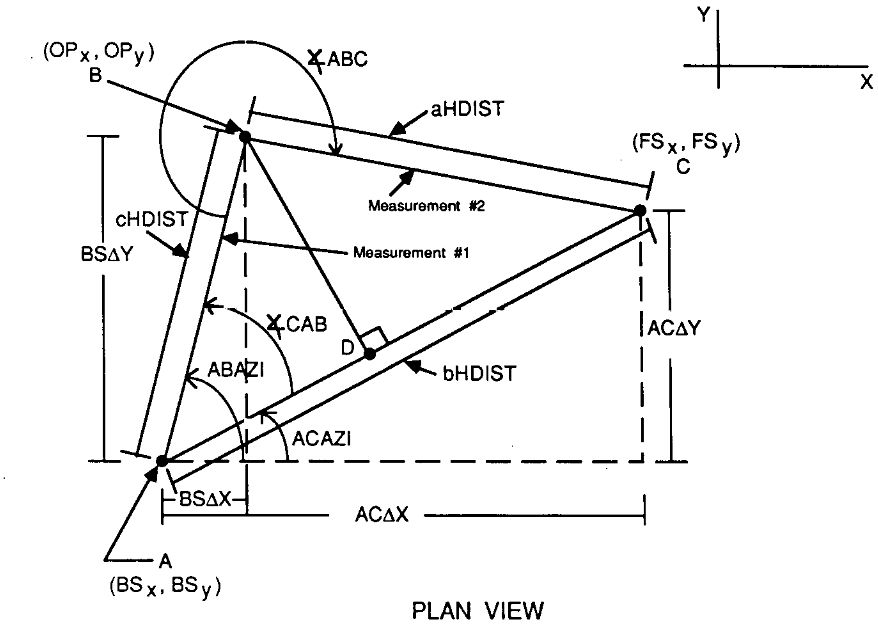
PADJ:OFFSET

The horizontal position is adjusted by the PADJ:OFFSET command set OFFDIST and ANG are given through values of the command set. The following steps are taken:

Step 1. Compute the (x,y) position of the offset point (0)
Step 2. Compute offset azimuth (OFFAZI)
Step 3. Compute actual feature coordinates (F_x,F_y)

Step 1—Compute Position of the Offset Point. See Figure C-9. See Figures C-4, C-5, and C-6 for algorithms to locate a foresight position (FS_x,FS_y).

Step 2—Compute Offset Azimuth—OFFAZI. OFFAZI = FSAZI + 180° − ANG



STEP 2

$AC\Delta X = FS_x - BS_x$
$AC\Delta Y = FS_y - BS_y$

$bHDIST = \sqrt{(AC\Delta X)^2 + (AC\Delta Y)^2}$

For calculations of ACAZI refer to Figure C-5, where:
P1 = A
P2 = C
AZI = ACAZI
$(X_1, Y_1) = (BS_x, BS_y)$
$(X_2, Y_2) = (FS_x, FS_y)$

STEP 3

$aHDIST = \sin(M_2VA) * M_2DIST$

$cHOIST = \sin(M_1VA) * M_1DIST$

STEP 4

$\measuredangle ABC = M_1HA - M_2HA$

STEP 5

$\measuredangle CAB = \arcsin\left(\frac{\sin(\measuredangle ABC) * aHDIST}{bHDIST}\right)$

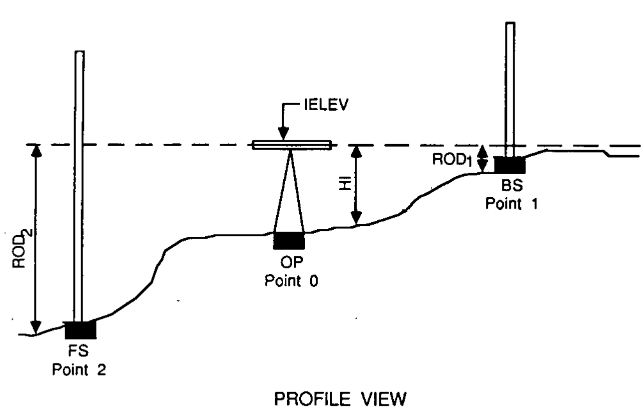
$ABAZI = ACAZI - \measuredangle CAB$

STEP 6

$BS\Delta X = cHDIST * \cos(ABAZI)$
$BS\Delta Y = cHDIST * \cos(ABAZI)$

$OP_x = BS_x + BS\Delta X$
$OP_y = BS_y + BS\Delta Y$

Figure C-7. Compute the coordinates of an unknown control point.



LEGEND: IELEV

IELEV = elevation of instrument
HI = height of instrument
ROD_n = rod reading at measurement point n
$PTELEV_n$ = elevation at measurement point n

Figure C-8. SOR UFF convention.

Step 3—Compute Feature Position. See Figure C-6.

$$F_x = FS_x + OFFDIST \times \cos(OFFAZI)$$

$$F_y = FS_y + OFFDIST \times \sin(OFFAZI)$$

where: (F_x, F_y) is the feature coordinate pair, and OFFDIST is the horizontal distance between feature and prism.

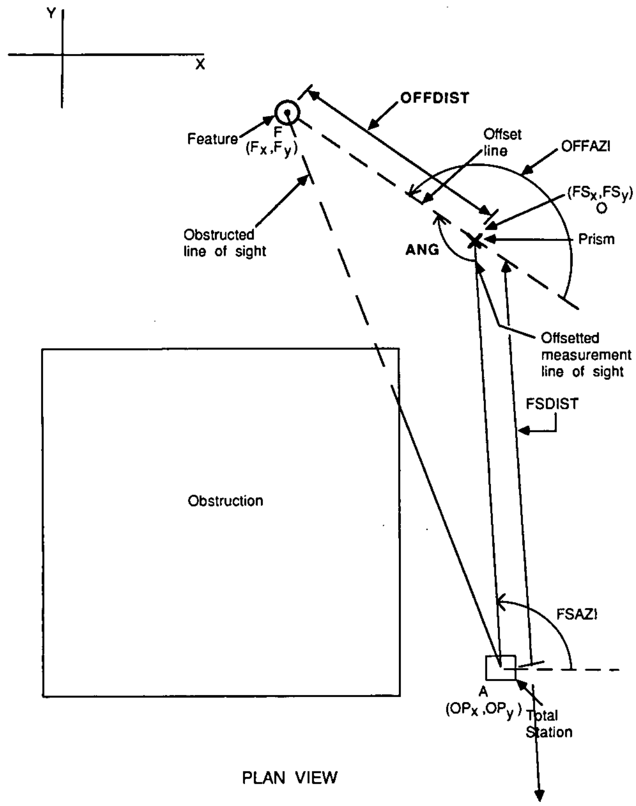


Figure C-9. Horizontal position adjustments.

APPENDIX D

ISIMS FEATURE DESIGN AND INSTALLATION GUIDELINES

INTRODUCTION

One of the objectives of this project is to provide a system that will allow a transportation agency to install an automated survey system and to develop that survey system centered around their own equipment and procedures. ISIMS accomplishes this objective and allows each agency the capability to incorporate its own set of features and their associated information.

This appendix provides an agency with the guidelines needed to incorporate agency feature-specific information into ISIMS. When an agency elects to use ISIMS as the primary survey system, the developer using ISIMS will need to:

- Know the agency's surveying equipment, survey tasks, and data processing capabilities and limitations.
- Know the universal file format (UFF) and control file capabilities and syntax.
- Define an agency-specific ISIMS, maintaining compatibility across data collection procedures, data collectors, and the UFF.
- Incorporate, design, write and/or embellish ISIMS software modules.

To assist in satisfying these needs, a set of suggested tasks has been devised to accomplish the development and implementation of ISIMS. These tasks are as follows:

A. Know the agency's surveying equipment, survey tasks, and data processing capabilities and limitations.
   A.1. Become familiar with agency survey equipment and system.

A.2. Determine survey tasks to be implemented.
A.3. Identify data processing facilities.

B. Know the universal file format (UFF) and control file capabilities and syntax.

C. Define an agency-specific ISIMS, maintaining compatibility across data collection procedures, data collectors, and the UFF.
C.1. Establish control file procedures.
C.2. Establish data collection procedures for POS:vvv command sets.
C.3. Prepare a feature/activity code list.
C.4. Establish data collection procedures for FEAT:vvv and INFO:vvv command sets.
C.5. Prepare feature-specific specifications.
C.6. Establish data collection procedures for features.
C.7. Prepare program design for converting each feature from the agency's data collection format to the UFF convention.

D. Incorporate, design, write and/or embellish ISIMS software modules.

A series of worksheets and forms has been developed to support an agency in following the foregoing tasks. These supporting documents will be very helpful when installing ISIMS. Worksheets and forms provided are as follows:

- Feature Description Form (Form D-1)
- Information Description Form (Form D-2)
- Feature Worksheet (Form D-3)
- Info Worksheet (Form D-4)
- Feature Attribute Form (Form D-5)
- Point Attribute Form (Form D-6)
- Data Collector to UFF Worksheet (Form D-7)
- Conversion Program Guidelines Worksheet (Form D-8)

These forms are located at the end of this appendix. In addition, the installer should also refer to Appendixes C and E. Appendix C documents the universal file format (UFF). Appendix E provides illustrations of the use of the procedures and forms used for the demonstration of ISIMS in Louisiana.

The following sections describe the ISIMS installation procedural tasks further. Use of these task-by-task descriptions, together with the blank forms and worksheets, provides a structured approach to implementing an automated survey system.

GUIDELINES TO IMPLEMENT ISIMS—SUGGESTED PROCEDURAL TASKS

Task A.1—Become Familiar with the Agency Surveying Equipment and System

- Step 1. Become familiar with the survey instrument's capabilities and limitations to record data.
- Step 2. Become familiar with the data collector capabilities and limitations, its ability to input and manipulate data collected in the field and the output format of the data collector.
- Step 3. Become familiar with the data transmission capabilities of the data collector, as well as the cabling and interfacing requirements to communicate with another computer using RS-232C protocol.

Task A.2—Determine Survey Task(s) to be Implemented

- Step 1. Access agency survey tasks and determine needs and benefits to prioritize survey task implementation.
- Step 2. Implement a selected system based on needs, implementation time and/or educational requirements.

SURVEY CHECK LIST

I. Control Surveys	B. Utility
A. NGS	C. Topographic
B. Project	1. Natural
1. Horizontal	2. Manmade
2. Vertical	D. Drainage
II. Engineering Surveys	III. Cadastral Surveys
A. Alignment	A. Boundary
1. Horizontal	B. Property
a. Design	a. Design
b. Staking	b. Staking
2. Vertical	IV. Construction Surveys
a. TBM Establishment	A. Staking
	B. Cross-Section
b. Profile	V. Hydrographic Surveys
c. Cross-Section	A. Construction
d. Contour	B. Maintenance
	IV. Bridge Surveys

Task A.3—Identify Data Processing Facilities

- Step 1. Identify computer facilities for editing processors.
- Step 2. Identify computer facilities for maintaining the UFF.

Task B—Know the Universial File (UFF) and Control File Capabilities and Syntax

- Step 1. Read Appendix C.
- Step 2. Execute the generic demonstrator computer program as documented in Appendix G.
- Step 3. Reread Appendix C. Think especially about data collection inferences relative to identifying multipoint feature facilities (e.g., circles, curvature, backwards collections, skip, related feature ID and closure). Understand the significance of control point number and azimuth point number in the control file and the use of control file information in the POS: command sets.

Task C—Define an Agency-Specific ISIMS, Maintaining Compatibility Across Data Collection Procedures, Data Collectors, and the UFF

This task has seven subtasks (C.1 through C.7) which assume that the data collector is not preprogrammed to output UFF. When the data collector does not output the UFF, then read all subtasks C.1 through C.7.

If the data collector is preprogrammed to output UFF, only subtasks C.3 and C.5 need to be completed. At this point, feature description can be verified upon input to the data collector. Use of information compiled in subtasks C.3 and C.5 should be an installation requirement of the data collector.

If the data collector is going to be programmed by the agency to output UFF, all subtasks apply to the data collector program design. The information compiled in subtasks C.3 and C.5 will be used to verify field-inputted feature descriptions.

Task C.1—Establish Control File Procedures

- Step 1. Select one or more of the following procedures for creating the control file.
  - a. An extraction from a statewide control point database selecting known horizontal control points, bench marks, and azimuth markers.
  - b. Manual input into the control file through data entry procedures.
  - c. Survey data collected and processed through ISIMS and the control points created as output into the control file.
- Step 2. Become familiar with the control file format and understand how it operates.
- Step 3. Develop procedures and computer programs necessary to create the control file if steps 1.a and/or 1.b are selected.
- Step 4. If step 1.c is selected, include control point creation as a feature in Task C.7.
- Step 5. Develop computer programs to handle control file record creation and updating.

Task C.2—Establish Data Collection Procedures for POS:vvv Command Sets

- Step 1. Become familiar with UFF specifications (see Appen. C).
- Step 2. Select the POS:vvv command sets that are applicable to the survey task selected in Task A.2.
- Step 3. Complete the Data Collector to UFF Worksheet (Form D-7) for each command set.

Task C.3—Prepare Feature Code List

- Step 1. Select features that are applicable to the survey task selected in Task A.2.
- Step 2. Complete the Feature Description Form (Form D-1) and Information Description Forms (Form D-2). Features differ from information in that measurement points must be associated with features and cannot be associated with information. See Appendix E for examples.

Task C.4—Establish Data Collection Procedures for ISIMS Definition FEAT:vvv Command Sets

- Step 1. Select the FEAT:vvv command sets that are applicable to the survey task selected in Task A.2.
- Step 2. Complete the Data Collector to UFF Worksheet (Form D-7) for each command set.

Task C.5—Prepare Feature-Specific Specifications

- Step 1. Complete a Feature Worksheet (Form D-3) or INFO Worksheet (Form D-4) for every feature tag identified in Task C.3.
- Step 2. Complete the Feature Attribute Form (Form D-5) for the worksheets in Step 1.
- Step 3. Complete the Point Attribute Form (Form D-6) for the worksheets in Step 1.

(See Appendix E for examples of completed Forms D-3, D-4, D-5 and D-6.)

Task C.6—Establish Data Collection Procedures for Features

- Step 1. Detail the X_Y_Z: or S_O_E: file convention for each feature in column 6 of the Data Collector to UFF Worksheet (Form D-7). This represents the feature-oriented data file that will interface to outside applications.
- Step 2. Detail the H_V_D: or S_O_R: file convention for each feature in column 6 of the Data Collector to UFF Worksheet (Form D-7). This will represent command sets as they are input into ISIMS. A good understanding of ISIMS processing is required.
- Step 3. Detail the field survey data collection records for each feature in column 7 necessary to create the H_V_D: or S_O_R: format detailed in Step 2 above.

The H_V_D: or S_O_E: format in Column 6 of the Data Collector to UFF Worksheet (Form D-7) defines *output* specifications for the user's data collection to ISIMS conversion program.

Column 7 of the Data Collector to UFF Worksheet (Form D-7) defines the *input* specifications for the user's data collector to ISIMS conversion program.

Task C.7—Prepare Program Design for Converting Each Feature from the Agency's Data Collection Format to the UFF Convention

- Step 1. Copy column 7 from the Data Collector to UFF Worksheet (Form D-7) to column 1 of the Conversion Program Decision Table (Form D-8).
- Step 2. Copy column 6 from the Data Collector to UFF Worksheet (Form D-7) to column 3 of the Conversion Program Decision Table (Form D-8).
- Step 3. Complete column 2 by describing the correlation between the input in column 1 and the output in column 3 of Form D-8.
- Step 4. Submit Form D-8 for programming.

Task D—Incorporate, Design, Write and/or Embellish ISIMS Software Modules

- Step 1. Review demonstrators 20-21G, 20-21W, and 20-21L (see Appen. G) and corresponding program documentation (Appen. H).

- Step 2. Pick the computer(s) that will do the survey data processing.
- Step 3. Fill modules 1 and 8 (see below) with communications and editor software, respectively.
- Step 4. Rewrite (or possibly modify) programs for modules 2 and 3 to suit agency needs.
- Step 5. Modify module 5 to accommodate the agency's particular plotter.
- Step 6. Embellish any module. For example, module 9 could be modified to delete commands BCK: and ID:. Also, make minor coding changes due to differences in FORTRAN 77/BASIC across computers.
- Step 7. Add modules, specifically, those that transform UFF data to a roadway engineering application or CADD format.

```
        ISIMS - INTEGRATED SURVEY INFORMATION MANAGEMENT SYSTEM
                      GENERAL DEMONSTRATOR MENU

MODULE                     DESCRIPTION

1.              DOWNLOAD THE FIELD DATA
2.              CONVERT DATA COLLECTOR FORMATTED TOPO DATA TO UFF-HVD
3.              CONVERT DATA COLLECTOR FORMATTED X-SEC DATA TO UFF-SOE
4.              PLOT UFF-HVD OR UFF-XYZ
5.              PRINT UFF-HVD OR UFF-XYZ
6.              PRINT UFF-SOE CROSS SECTIONS
7.              CONVERT UFF-SOE CROSS SECTIONS TO RDS FORMAT
8.              EDIT DATA
9.              CONVERT DATA FROM UFF-HVD TO UFF-XYZ
A.              PRINT A FILE
B.              INSTALL NEW SET OF FEATURES
C.              CONTROL FILE DATA
```

BLANK FORMS AND WORKSHEETS

The blank forms and worksheets provided on pp. 39 through 46 are reproduced to a larger scale than warranted for illustrative purposes, for convenience of the user who may wish to utilize them in implementing the procedural tasks described earlier in this appendix.

APPENDIX E

ISIMS INSTALLATION EXAMPLE

INTRODUCTION

The Louisiana Department of Transportation and Development (LaDOTD) uses a centralized design concept at its headquarters in Baton Rouge. The long-term objective of the LaDOTD is to shorten the time frame between project approval and use of the facility by the public. The key to accomplishing this objective is the development of Computer Integrated Design (CID). Conceptually, CID is based on the premise that the creation of a set of plans is the result of an informational database and engineering decisions.

The hub of this plan will be a Plan Preparation System that consists of a database created from computer design systems and engineering decisions. DOTD's initial effort toward the development of the hub, is the surveying module of that system, in particular the digital collection of survey information.

DOTD utilizes a Wild TC2000 and GRE3 as its survey total station and data collector. The data are processed by the DEC VAX computer for editing, a GIS-type database is created from the edited data, and then the graphics and attribute linkage is generated for manipulation and display.

The data collection system has been designed to optimize the field surveyor's ability to collect data and includes location, geometric description, physical characteristics, and ownership data. Although the concept is to "create a field book," present procedures include the use of the field book where the field book provides the optimal solution. The survey development addresses control-type surveys and topographic surveys. Some characteristics of the system are:

1. Features requiring straight-line and curve data (curbs) have their points of curvature noted without interruption of the measurement process.

Form D-1: Feature Description Form

FEAT VALUE*	FEATURE DESCRIPTION

* This is the one to six character alphanumeric name of the feature that the surveyor intends to input into the data collector and that will then be used to identify the feature.

Form D-2: Information Description Form

INFO VALUE*	INFORMATION DESCRIPTION

*This is a one to six character alphanumeric name corresponding to the INFO: tag (a feature without measurement points/general information), that identifies that piece of general information.

FORM D-3: FEATURE WORKSHEET

FEATURE ____________________________________

MANDATORY DATA

FEAT: ______________________________________

GM: SINGLE CIRCLE
MULTI 3PTCIR

ORIGINAL DATA

	USED OFTEN?	
Z?:	YES	NO
CIRD:	YES	NO
PADJ: OFFSET	YES	NO
PADJ: DEPTH	YES	NO

FEATURE DESCRIPTORS

1)	6)
2)	7)
3)	8)
4)	9)
5)	

MEASUREMENT DESCRIPTORS

1)	6)
2)	7)
3)	8)
4)	9)
5)	

FOR GM:=MULTI	USED OFTEN?	
ID:	YES	NO
CR:	YES	NO
SK:	YES	NO
CL:	YES	NO
BK:	YES	NO

FORM D-4: INFO WORKSHEET

INFO ______________________________

MANDATORY DATA

INFO: ______________________________

OPTIONAL DATA

INFO DESCRIPTOR TAGS

1) 6)
2) 7)
3) 8)
4) 9)
5)

Form D-5: Feature or Information Attribute Form

Feature Name	Acceptable Feature Descriptor Tags	Feature Descriptor Descriptions	Acceptable Values		Req'd Y/N	Default
			values	definition		

Form D-6: Point Description Form

Acceptable Point Descriptor Tags	Point Descriptor Descriptions	Acceptable Values		Req'd Y/N	Default
		Values	Definition		

Data Tag: ____________

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Form D-8. Conversion Program Guidelines Worksheet.

FIELD DATA COLLECTION PROCEDURES	CORRELATION	RAW SURVEY UFF DATA FORMAT

2. Continuous-type (curbs) features are integrated into one element over multiple instrument setups.

3. Continuous features can have data collect forwards or "backwards" on any setup.

4. Selected continuous-type features (fences, underground utilities) can be interrupted to collect "secondary" or service lines.

5. Adjacent features that have a common boundary and symmetry (curb and sidewalk) may be collected like a single feature.

6. The horizontal position of selected elements can be located using offset procedures.

7. There is automatic closure between the first and last point of a feature, even when the feature is the continuous type.

The LaDOTD survey subsystem is similar to ISIMS in its objective, but it is vendor specific, using WILD survey equipment as the data collector and their INTERGRAPH VAX as the processor. However, this offered the project an excellent opportunity for validating and demonstrating the generic concept. Through comparing results, the project is able to obtain a reasonable level of quality assurance.

The alpha test collected raw topographic survey data using Louisiana's data collection procedures on their TC2000 total survey station. The same data were processed through the Louisiana survey subsystem and ISIMS. This provided a necessary assurance that ISIMS was meeting not only its conceptual objective but a computational one as well.

LOUISIANA DOTD—ALPHA TEST SITE

This appendix contains an example of ISIMS as it is installed in Louisiana. The procedures outlined in Appendix D have been applied to Louisiana, the project's alpha test site, and should assist other agencies in their implementation.

The completed examples of the Suggested Procedural Task worksheets, in Appendix D and their supporting forms, also in Appendix D, have been grouped together for easier future user reference and immediately succeed the task-by-task discussion that follows.

The following task-by-task discussion contains two types of comments, *LADOTD Example* and *Comments.* The *LADOTD Example* heading deals with information related to completing the task worksheet. The *Comments* heading simply supplies general information concerning Louisiana experiences in implementing a survey system using digital input.

TASK DISCUSSION

Task A. Know Your Surveying Equipment, Survey Tasks, and Data Processing Capabilities

Task A.1—Become Familiar with the Agency Surveying Equipment and System (See Fig. E-1)

LADOTD Example. Refer to the completed Task A.1 worksheet, Figure E-1.

Comments. The limitations of numeric only had less negative impact than expected.

Automated input of the data at the theodolite is definitely a positive factor.

Surveyor response times for instrument inputs in seconds:

• CODE/INFO blocks	20–30 sec
• Azimuth only	1 sec
• Distance and Azimuth	8 sec

Task A.2—Determine Survey Task(s) to be Implemented

LADOTD Example. Refer to completed Task A.2 worksheet, Figure E-2.

Comments. Louisiana expects significant time savings in collecting topographic data.

Terrain data collection has not been adapted to radial type surveying and because of the flat terrain (maximum elevation in Louisiana 400–500 ft), Louisiana is of the opinion that station-offset-rod reading (SOR) type of data collection will slow down the surveying task. However, the downstream benefits of digitally collecting the terrain data has not been evaluated but is scheduled as a future task.

Task A.3—Identify Data Processing Facilities

LADOTD Example. Refer to completed Task A.3 worksheet, Figure E-3.

Plotting computer routines were written using Hewlett Packard's HPGL graphics language.

Comment. Louisiana's survey subsystem will presently be downloaded to their Intergraph VAX computer, edited, displayed, and maintained on that system. A Plan Preparation database is the eventual home of the UFF like data.

Task B. Know UFF/Control File Capabilities and Syntax

Refer to completed Task B, Figure E-4.

Task C. Define an Agency-Specific ISIMS, Maintaining Compatibility Across Data Collection Procedures, Data Collectors and the UFF

Task C.1—Establish Control File Procedures

LADOTD Example. Refer to completed Task C.1 worksheet, Figure E-5.

Control survey points were manually input for the Louisiana alpha test site. Additional topography control points were established during the data collection process.

Identify the topographic control points as features so that they can be defined on Form D-1. Refer to Figure E-6.

Task C.2—Establish Data Collection Procedures for POS:vvv Command Sets

LADOTD Example. Refer to completed Task C.2 worksheet, Figure E-7.

Refer to the completed Form D-7, Figure E-8.

Louisiana has decided against the use of x,y coordinates as field input. The state-plane coordinate system is the basic coordinate system used and the x,y value of control points will be established in the office or collected as field data. These points will be identified by point numbers in the field, the coordinates calculated during processing and placed in the Control File.

Task C.3—Prepare Feature Code List

LADOTD Example. Refer to completed Task C.3 worksheet, Figure E-10.

The list of fifty (50) features is a subset of the feature activity list in Appendix F.

Task C.4—Establish Data Collection Procedures for ISIMS-Defined FEAT:vvv Command Sets

LADOTD Example. Refer to completed Task C-4 worksheet, Figure E-13. Refer to completed Form D-7, Figure E-14.

The definition of these command sets will be similar to the specifications for Task C.2. When the UFF record layout is determined for a feature in Task C.6, it will require primarily that the appropriate FEAT:vvv command set be copied and the proper descriptor values selected. Thus, this completed form can act like a "spec" sheet when working on Task C.6.

Task C.5—Prepare Features-Specific Specifications

LADOTD Example. Refer to completed Task C.5 worksheet, Figure E-15.

A feature or info worksheet was filled out for each feature identified in Task C.3. Refer to Figure E-16 for five (5) completed examples of features.

The feature descriptor tags are then defined in detail by filling out the feature descriptor tag table for each feature. Figure E-17 provides an example of the same five sample features completed on Form D-5. Refer to the Louisiana Alpha Test Site ISIMS Implementation document for remaining features.

Any point descriptor tags needed are also defined in the point descriptor tag table. These measurement tags are not feature-specific, but apply across all applicable features. Recall there is a limit of nine (9) and Figure E-18 represents those that would apply to Louisiana's selected features.

Task C.6—Establish Data Collection Procedures for Features

LADOTD Example. Refer to completed Task C.6 worksheet, Figure E-19.

Louisiana establishes additional control points for collecting topography to supplement the control points of the Project Control points. These points are established to allow the extension of control from a known control point and to establish an unknown point as a control point. The normal setup code for establishing topography and these two control type codes were added as features in Task C.1. The ISIMS definition for these activities has been documented as Figure E-20, using Form D-7. Note that the inclusion of the ACC:vvv command sets increases the accuracy requirements of establishing an unknown point as a control point.

Task C.6 continues to document the five (5) sample feature codes from Louisiana example in Task C.5. These five features have been documented using an alternate Form D-7 and follow the outlined steps. Refer to Figures E-21 and E-22 for the five (5) completed examples.

An alternate type form has been used for Form D-7 to describe the X_Y_Z, H_V_D and the data collector format for features. Special feature codes describing topographic control points have been defined and use Form D-7 for defining the feature design.

After Task C.6 has been completed, the user should have a complete understanding of both the data collection record sequence and the HVD record layout to be established for each feature, as well as how these relate to each other. A program can then be written to convert the data collector formatted records to the HVD record format.

For additional documentation on the full complement of features implemented in Louisiana, refer to NCHRP Project 20-21 Document "Louisiana Alpha Test Site ISIMS Implementation."

Task C.7—Prepare Program Design for Converting Each Feature from the Agency's Data Collection to the UFF Convention

LADOTD Example. Refer to completed Task C-7, Figure E-23.

This task is more complex than has been previously indicated. There will necessarily be some system and program design done by the computer programming staff. However, the engineer can detail each feature's design information. The programming staff should be able to code and test from the information outlined. Form D-8, Figure E-24, may be sufficient for use as a computer design document from the surveyors to the computer programmers.

Task D—Incorporate Design, Write and/or Embellish ISIMS

LADOTD Example. Refer to Figure E-25 for Task D in Louisiana.

SUGGESTED PROCEDURAL TASKS AS APPLIED TO LOUISIANA DEPARTMENT OF TRANSPORTATION'S AUTOMATED SURVEYING

Task A.1 - Become familiar with the agency surveying equipment and system.

Step 1. Become familiar with the survey instrument's capabilities and limitations with respect to recording data.

Step 2. Become familiar with the data collector capabilities and limitations, its ability to manipulate data collected in the field and the output format of the data collector.

VENDOR: WILD
PRODUCT: TC2000 - Surveying Total Station
GRE3 - Data Collector

CHARACTER ENTRY: Integer only
NUMBER OF CODE BLOCKS: 1
NUMBER OF INFO BLOCKS: 4/CODE BLOCK
NUMBER OF CHARACTERS ALLOWED IN CODE BLOCK: 7
NUMBER OF CHARACTERS ALLOWED IN INFO BLOCK: 7

RECORDING CONCEPT - The GRE3 records blocks of data. There are two types of data blocks: Measurement blocks, code blocks.

MEASUREMENT BLOCK - Measurement blocks are designed primarily for recording measurement information, e.g. angles and distances.

Format and content of a measurement block:

Point number	Hz-circle	V-circle	Slope distance

CODE BLOCK - Code blocks are designed primarily for recording identification codes, data-processing codes and information. However, they can also be used for recording measurement information, e.g. staff readings when leveling, check distances etc.

Format and content of a code block

Word 1	Word 2	Word 3	Word 4	Word 5
Code number	Information 1	Information 2	Information 3	Information 4

Figure E-1. Task A.1—Become familiar with agency survey equipment.

SUGGESTED PROCEDURAL TASKS AS APPLIED TO LOUISIANA DEPARTMENT OF TRANSPORTATION'S AUTOMATED SURVEYING

Task A.2 - Determine survey task(s) to be implemented.

Step 1. Access agency survey tasks and determine needs and benefits, then prioritize survey task implementation.

Step 2. Implement a selected system based on needs, implementation time and/or educational requirements.

SURVEY CHECK LIST

I. CONTROL SURVEYS
  A. NGS
  B. Project
    1. Horizontal — Priority 2
    2. Vertical

II. ENGINEERING SURVEYS
  A. Alignment
    1. Horizontal
      a. Design
      b. Staking
    2. Vertical
      a. TBM Establishment
      b. Profile
      c. Cross-Section
      d. Contour
  B. Utility — Priority 3
  C. Topographic — Priority 1
    1. Natural
    2. Manmade
  D. Drainage

III. CADASTRAL SURVEYS
  A. Boundary — Priority 5
  B. Property — Priority 4
    a. Design
    b. Staking

IV. CONSTRUCTION SURVEYS
  A. Staking
  B. Cross-Section

V. HYDROGRAPHIC SURVEYS
  A. Construction
  B. Maintenance

IV. Bridge Surveys

Figure E-2. Task A.2—Determine survey tasks to be implemented and system.

SUGGESTED PROCEDURAL TASKS AS APPLIED TO LOUISIANA DEPARTMENT OF TRANSPORTATIONS'S AUTOMATED SURVEYING

Task A.3 - Identify data processing facilities.

Step 1. Identify computer facilities for editing processors.
Step 2. Identify computer facilities for maintaining the UFF.

Alpha Test

GRE3 raw survey data was dumped to and edited on an IBM PC-AT compatible using a Hewlett Packard 7475A x-y plotter. Data was converted from H_V_D file convention into X_Y_Z file convention on the same PC. Data was then transferred to LADOTD host IBM mainframe for inputs into RDS.

See Appendix introduction for LaDOTD computer facilities.

Figure E-3. Task A.3—Identify data processing facilities.

SUGGESTED PROCEDURAL TASKS AS APPLIED TO LOUISIANA DEPARTMENT OF TRANSPORTATIONS'S AUTOMATED SURVEYING

Task B - Learn the UFF/Control File capabilities and syntax.

- If the output is in UFF format the users should perform the procedural tasks in the following sequence:
  - Task C.1
  - Task C.3
  - Task C.5 thru Task C.7
  - Task D
- If the output is not in UFF format then the user must develop the conversion program based on his data collector and collection procedure for ISIMS.

Output of GRE3 is not UFF. See Task A.1 for format description.

Figure E-4. Task B—Learn the UFF/control file capabilities and syntax.

SUGGESTED PROCEDURAL TASKS AS APPLIED TO LOUISIANA DEPARTMENT OF TRANSPORTATION'S AUTOMATED SURVEYING

Task C.1 - Establish Control File procedures.

Step 1. Select one or more procedures for creating the Control File.
  a. An extraction from a statewide control point database selecting known horizontal control points, bench marks and azimuth markers.
  b. Manual input into the Control File thru data entry procedures.
  c. Survey data collected, processed thru ISIMS and put into the Control File.

Step 2. Become familiar with the Control File format and understand how it operates.

Step 3. Develop procedures and computer programs necessary to create the control file if subtasks 1.a and/or 1.b are selected.

Step 4. Include control point creation as a feature in Task 7 if subtask 1.c is selected.

Step 5. If output of data collector is in UFF, skip to Task C.3.

Select 1.b and 1.c to create Control File.

Place topographic control points on form D-1, Feature Description Form, Figure E-6.

The FEAT:vvv code for the topographic control points will define the type of surveying being done. If greater accuracies are required then use the ACC:vvv command sets. See Appendix C for specification details on the ACC:vvv command set.

Figure E-5. Task C.1—Establish control file procedures.

Form D-1: Feature Description Form

FEAT VALUE*	FEATURE DESCRIPTION
50	Setup on known point for topographic surveying.
51.	Create a control point from a known point - Topographic Survey.
55	Create a control point from an unknown point - Topographic Survey.

* This is the one to six character alphanumeric name of the feature that the surveyor intends to input into the data collector and that will then be used to identify the feature.

Figure E-6. Topographic control points.

SUGGESTED PROCEDURAL TASKS AS APPLIED TO LOUISIANA DEPARTMENT OF TRANSPORTATION'S AUTOMATED SURVEYING

Task C.2 - Establish data collection procedures for POS:vvv, position, command sets.

Step 1. Become familiar with ISIMS command set specifications.

Step 2. Select the POS:vvv command sets that are applicable to the survey task selected in Task A.2.

Step 3. Complete the Data Collector to UFF Worksheet (Form D-7) for each command set.

Select POS:vvv command sets.
Initiate a definition of Terms/Variables sheet, Refer to Figure E-9.

SELECTED POS:vvv
SETUP
USETUP
EFORE
BSVERT

Figure E-7. Task C.2—Establish data collection procedures for position command sets.

Form D-7. Data Collector to UFF Worksheet

Data Tag: POS

TAG VALUE	DESCRIPTOR: TAG	DESCRIPTOR: DEFAULT SYSTEM	DESCRIPTOR: DEFAULT DOT	DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
SETUP	-	-	-	Set up instrument on known point	POS:SETUP	CODE BLOCK
				Identify occupied point	OS:OSPTNO	INFO1
				Identify BS	BS:BSPTNO	INFO2
				Record Horizontal circle sighted on BS	XXX: ppp hhh	MBHC hhh
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.
** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-8. POS:vvv command set.

Form D-7. Data Collector to UFF Worksheet

Data Tag: POS

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
USETUP				Set up instrument on unknown point	POS:USETUP	CODE BLOCK
	OS			Store occupied point in control file	OS:OSPTNO	INFO1
				Do not store occupied point in control file	OS:	INFO1
	BS			Back sight on known point	BS:BSPTNO	INFO2
	FS			Foresight on known point	FS:FSPTNO	INFO3
				Measure distance and azimuth to backsight	XXX: ppp hhh vvv sss	MB1
				Measure distance and azimuth to foresight	XXX: ppp hhh vvv sss	MB2
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-8. Continued

Form D-7. Data Collector to UFF Worksheet

Data Tag: POS

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
HFORE	-	-	-	Pre-conditions SETUP command set for backsight azimuth	POS:SETUP BSVERT XXX:	CODE BLOCK MBHC
				Foresight establishes a new control point from a known point	POS:HFORE	CODE BLOCK
				Measure distance and angle to foresight	XXX: ppp hhh vvv sss	INFO1 MB
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-8. Continued

Form D-7. Data Collector to UFF Worksheet

Data Tag: POS:

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
BSVERT:				Prerequisite is POS:SETUP or POS:USETUP must be active Establish vertical control for computing elevations	POS:BSVERT	CODE BLOCK
	BM			Identify backsight elevation	BM:BMELEV	INFO1
	PR			Prism height	PR:PRHT	INFO2
				Record BS elevation	XXX: ppp hhh vvv ddd	MBVC hhh vvv ddd
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-8. Continued

SUGGESTED PROCEDURAL TASKS

Task C.3 - Prepare feature code list

Step 1. Select features (Figure E-11) that are applicable to the survey task selected in Task A.2.

Step 2. Complete the Feature Description Form (Form D-1) and Information Description Form (Form D-2).

Feature selection is based on the priority 1 and 2 type surveys noted in Task A.2, Figure E-2.

Figure E-10. Task C.3—Prepare feature code list.

DEFINITION OF TERMS/VARIABLES

1. BS = Backsight
2. FS = Foresight
3. OSPTNO = Occupied station point number value
4. BSPTNO = Backsight point number value
5. FSPTNO = Foresight point number value
6. XXX = UFF measurement block
7. MB = data collector measurement block
8. MBn = Sequential set of data collector measurement blocks where n identifies a particular MB in the set
9. ppp = point number
10. hhh = horizontal circle value
11. vvv = vertical angle value
12. sss = slope distance
13. dv = data value
14. INFO1 = Information field from the code Blockrecord from the WILD GRE3 data collector
15. INFO2 = Information field from the code Blockrecord from the WILD GRE3 data collector
16. INFO3 = Information field from the code Blockrecord from the WILD GRE3 data collector
17. INFO4 = Information field from the code Blockrecord from the WILD GRE3 data collector
18. MBHC = The measurement block that records the horizontal circle
19. MBVC = The measurement block that records the distance and azimuth to a backsight BM.
20. BMELEV = The elevation value of the benchmark.
21. PRHT = The prism height value.

Figure E-9. Definition of terms/variables.

SURVEY FEATURES AND ACTIVITIES AS ADOPTED FROM THE
LOUISIANA DEPARTMENT OF TRANSPORTATION'S
AUTOMATED SURVEYING

Feature/Activity	Survey Type	Class
System Information		
Equipment	All	Info
Date	All	Info
Crew	All	Info
Weather	All	Info
Project Information		
Project ID	All	Info
Horizontal Control		
Vertical Control		
Start Vrt Ctrl on known	Control	Vertical
Start Vrt Ctrl on unknown	Control	Vertical
Stop Vertical Control	Control	Vertical
Depth	Control	Vertical
Probe Length	Control	Vertical
Topographic Control		
Setup on known TCP	Topo	Control
Establish New TCP from known	Topo	Control
Triangulation	Topo	Control
Horizontal Alignment		
Vertical Alignment		
Cross Sections		
Cadastral		
Property Corner	Cadast	Property
Topography		
Box Culvert	Topo	Structure
Building	Topo	General
Curb	Topo	Road
Drop Inlet	Topo	Drainage
Fence	Topo	General
Gate	Topo	General
Guard Post	Topo	Road
Headwall	Topo	Structure
Light Post	Topo	General
Pipe Culvert	Topo	Structure

Figure E-11. Selected feature list.

Feature/Activity	Survey Type	Class
Polygon	Topo	Geometric
Road Edge	Topo	Road
Row Marker	Topo	Road
Shoulder Edge	Topo	Road
Sidewalk	Topo	General
Storage Tank	Topo	General
Track	Topo	Railroad
Traffic Control Box	Topo	Road
Tree	Topo	General
Water Well	Topo	General
Wood Line	Topo	General
Utility		
Appurtenance	Utility	General
Casing	Utility	
Cleanout	Utility	Sewer
Cross Connect Box	Utility	Tele
Fire Hydrant	Utility	Water
Guy Wire	Utility	Power, Tele
Junction Box	Utility	Power Tele
Line	Utility	Gas Petro Sewer Tele TV
Manhole	Utility	Sewer Storm Tele
Meter	Utility	Gas Water
Pole	Utility	Power Tele
Regulator	Utility	Gas Petro
Test Box	Utility	Gas
Underground Transformer	Utility	Power
Valve	Utility	Gas Water
Vent	Utility	Petro
Feature Dependent Activities		
Continue	All	General
Owner	All	General
Offset	All	General
Secondary line	All	General
Start/Stop Curve	All	General
UID	All	General

Figure E-11. Continued

Form D-1: Feature Description Form

FEAT VALUE*	FEATURE DESCRIPTION
102	Edge of pavement
103	Shoulder Edge
104	Curb
106	Guard post
107	Right-of-way
109	Traffic control box
115	Railroad tracks
130	Fence line
131	Gate
137	Sidewalk
140	Storage tank
150	Trees
151	Wood line
173	Storm sewer manhole
174	Drop Inlet
200	Gas line
201	Gas valve
202	Gas meter
203	Gas test box
209	Gas regulator
214	Vent
219	Pipeline regulator
224	Power Junction Box
225	Power Pole
226	Power Pole with Dead Man

* This is the one to six character alphanumeric name of the feature that the surveyor intends to input into the data collector and that will then be used to identify the feature.

Figure E-12. Selected features—Form D-1.

Form D-1: Feature Description Form

FEAT VALUE*	FEATURE DESCRIPTION
227	Underground Transfer
233	Sanitary Sewer Manhole
234	Sanitary Cleanout
253	Telephone Manhole
254	Telephone Junction Box
255	Telephone Pole
256	Telephone Pole With Dead Man
257	Telephone Cross Connect Box
270	Water Line
271	Water Valve
272	Water Meter
274	Fire Hydrant
895	General Polygon
139	Light Post
145	Water Well
160	Pipe Culvert
161	Box Culvert
162	Headwalls
170	Storm Sewer Line
208	Pipeline Casing
210	Petroleum Pipeline
230	Sewer Line
250	Underground Telephone Line
302	Property Corner
135	Building

* This is the one to six character alphanumeric name of the feature that the surveyor intends to input into the data collector and that will then be used to identify the feature.

Figure E-12. Continued

SUGGESTED PROCEDURAL TASKS

Task C.4 - Establish data collection procedures for ISIMS defined FEAT:vvv command sets.

Step 1: Select the FEAT:vvv command sets that are applicable to the survey task selected in Task A.2.

Step 2: Complete the Data Collector to UFF Worksheet (Form D-7) for each command set.

All FEAT:vvv command sets are applicable.

Single Shot Features
Shoot only one point per feature.

1. Actual Single Shot

   Used to locate simple single point features such as control points.

2. Symbolic Single Shot

   Used to locate multiple shot features which will be represented by a predefined symbol.

Multiple Shot Features

Shoot more than one point per feature.

1. Simple Multiple Shot

   Shoot all required points from a single setup.

2. Continuous Multiple Shot

   Shoot as many of the required points as possible from each setup, before moving to the next setup. Assign related ID activity code

   Reference the related activity code, ID, for interrupting the shooting of multiple shot features to:
   (1) move the instrument
   (2) shoot another feature.

3. Closed Multiple Shot

   Feature Characteristic

Figure E-13. Task C.4—Establish data collection procedures for ISIMS defined FEAT:vvv command sets.

4. Primary Multiple Shot with Secondary Extensions

   Reference the secondary and skip activity codes for shooting secondary extensions off of primary features.

5. Multiple Shot with Curves
   a. Arcs - 3 point definition
      - Angle only measurement
      - Angle and distance measurement
   b. Arcs and Smooth Curves - multipoint
      - START/STOP switch
        - Angle and distance measurement
        - Angle and distance measurement
      - ARC or smooth curve is feature characteristic

Circles

1. 1 Shot

   Shoot the center of the circle and measure the diameter and define as feature characteristic.

2. 2 Shot

   Shoot the center of the circle and one point on the circumference of the circle.

3. 3 Shot

   Shoot three points on the circumference of the circle. ISIMS will calculate the center.

Reverse Direction Marker

A double measurement marker is recorded at the beginning of the feature when the surveyor intends to collect the data points in the reverse order from the direction of the survey.
a. Distance measurement ----------------------------[ALL]
b. Distance measurement ----------------------------[ALL]

Figure E-13. Continued

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
FEAT:	-	-	-	Identify feature	FEAT:vvv	
GM:	SINGLE	-	-	Measurement record to point must include distance and azimuth	GM:SINGLE XXX: ppp hhh vvv ddd	Feature specific ISIMS defined ISIMS generated Measurement block
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. FEAT:vvv command set.

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
FEAT:	-	-	-	Identify feature	FEAT:vvv	
GM:	MULTI	-	-	Measurement record to each point along feature; distance and azimuth required	GM:MULTI XXX: ppp hhh vvv ddd XXX: ppp hhh vvv ddd ⋮ XXX: ppp hhh vvv ddd	Feature specific ISIMS defined ISIMS generated Measurement block #1 ISIMS Generated Measurement block #2 ⋮ ISIMS Generated Measurement block #n
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
FEAT:	-	-	-	Identify feature	FEAT:vvv	
				Method #1		
GM:	CIRCLE	-	-	Measurement to center of circle must include distance and azimuth.	GM:CIRCLE CIRD:vvv	Feature specific ISIMS defined
					XXX: ppp	ISIMS generated
					hhh vvv ddd	Measurement block #1
				Diameter of circle input		Code block - info number
				Method #2 Measurement to center of circle and to a point on circumference	GM:CIRCLE CIRD:vvv	Generated in conversion program
					XXX: ppp	ISIMS generated
					hhh vvv ddd	Measurement block #1
					XXX: ppp	ISIMS generated
					hhh vvv ddd	Measurement block #2
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.
** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
FEAT:	-	-	-	Identify feature	FEAT:vvv	
GM:	3PTCIR	-	-	Measurement blocks are at 3 points along the circumference of the circle.	GM:3PTCIR	Feature specific ISIMS defined
					XXX: ppp	ISIMS generated
					hhh vvv ddd	Measurement block #1
					XXX: ppp	ISIMS generated
					hhh vvv ddd	Measurement block #2
					XXX: ppp	ISIMS generated
					hhh vvv ddd	Measurement block #3
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.
** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT SYSTEM	DEFAULT DOT			
FEAT:	-	-	-	Identify feature	FEAT:vvv	CODE BLOCK - CODE NO.
ID:	-	-	-	Give arbitrary ID to continuous type features over multiple setups	ID:vvv	CODE BLOCK - INFO NO.
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT SYSTEM	DEFAULT DOT			
FEAT:	-	-	-	Identify feature	FEAT:vvv	CODE BLOCK - CODE NO.
SK:	-	-	-	To recognize skips in continuous features or to return from secondary line measurements	SK:	Method #1 Code block - Code no. Note: Info blocks to take on characteristics of Feature Code Info Blocks Method #2 Double Measurement blocks showing same x,y coordinates. The PADJ: command set will also be required.
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Form D-7. Data Collector to UFF Worksheet

Data Tag: POS

TAG VALUE	DESCRIPTOR TAG	DEFAULT SYSTEM	DEFAULT DOT	DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
FEAT:		-	-	Identify feature Locate an arc that will be defined by 3 points	FEAT:vvv	CODE BLOCK - CODE NO. Measurement Blocks
CR:	START ARC	-	-		CR:START ARC	MMM:hhh vvv ddd
						MMM:hhh vvv ddd
	END ARC				CR:END ARC	MMM:hhh vvv ddd
				Generally applicable to small curves on turnouts, medians, etc.		
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Form D-7. Data Collector to UFF Worksheet

Data Tag: POS

TAG VALUE	DESCRIPTOR TAG	DEFAULT SYSTEM	DEFAULT DOT	DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
FEAT:				Identify feature	FEAT:vvv	CODE BLOCK - CODE NO. Measurement Blocks
CR:	START CURVE	-	-	Locate a curve that will have multiple points generally applicable to long alignment curves.	CR:START CURVE	XXX:hhh vvv ddd
						XXX:hhh vvv ddd XXX:hhh vvv ddd
	END CURVE	-	-		CR:END CURVE	XXX:hhh vvv ddd
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
FEAT:	-	-	-	Identify feature	FEAT:vvv	CODE BLOCK - CODE NO.
CL:	-	-	-	To identify that a feature is a closed back to point #1	CL:	CODE BLOCK - INFO
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.
** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
FEAT:	-	-	-	Identify feature	FEAT:vvv	CODE BLOCK - CODE NO.
BK:	-	-	-	Take measurement data backwards during a setup	BK:	Double Measurement block where the x,y coordinates are equal. The use of the PADJ: command set will also be required.
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.
** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
FEAT:				Identify feature	FEAT:vvv	CODE BLOCK - CODE NO.
Z:	YES	-	-	Take elevations	Z:YES	Method# 1
	NO	-	-	Do NOT take elevations	Z: NO	Absense of Code block - system default
						Method #2
						Feature specific
						Sequence of:
					XXX: hhh	Measurement block producing an azimuth only
					XXX: hhh vvv ddd	Measurement block distance and azimuth.
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.
** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

Data Tag: POS

Form D-7. Data Collector to UFF Worksheet

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
FEAT:		-	-	Identify feature	FEAT:vvv	CODE BLOCK - CODE NO. Feature specific
CIRD:		-	-	Define the diameter of a circle	CIRD:vvv	Method #1 Code Block - Info
						Method #2 Computation in conversion program
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.
** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-14. Continued

SUGGESTED PROCEDURAL TASKS

Task C.5 - Prepare feature specific specifications.

Step 1. Complete a Feature Worksheet (Form D-3) INFO Worksheet (Form D-4) for every feature tag identified in Task C.4.

Step 2. Complete the Feature Attribute Form (Form D-5) from the worksheets in Step 1.

Step 3. Complete the Point Attribute Form (Form D-6) from the worksheets in Step 1.

See attached worksheets and forms.

Figure E-15. Task C.5—Prepare feature specific specifications.

FORM D-3: FEATURE WORKSHEET

FEATURE PROPERTY CORNER

MANDATORY DATA

FEAT: 302

GM: **SINGLE** MULTI CIRCLE 3PTCIR

ORIGINAL DATA — USED OFTEN?

Z?: **YES** NO
CIRD: YES **NO**
PADJ: OFFSET YES **NO**
PADJ: DEPTH YES **NO**

FEATURE DESCRIPTORS

1) TYPE CORNER MARKER
2)
3)
4)
5)
6)
7)
8)
9)

MEASUREMENT DESCRIPTORS

1)
2)
3)
4)
5)
6)
7)
8)
9)

FOR GM:=MULTI — USED OFTEN?

ID: YES NO
CR: YES NO
SK: YES NO
CL: YES NO
BK: YES NO

FORM D-3: FEATURE WORKSHEET

FEATURE EDGE OF PAVEMENT

MANDATORY DATA

FEAT: 102

GM: SINGLE MULTI CIRCLE 3PTCIR

ORIGINAL DATA — USED OFTEN?

Z?: **YES** NO
CIRD: YES **NO**
PADJ: OFFSET YES **NO**
PADJ: DEPTH YES **NO**

FEATURE DESCRIPTORS

1) TYPE SURFACE
2)
3)
4)
5)
6)
7)
8)
9)

MEASUREMENT DESCRIPTORS

1)
2)
3)
4)
5)
6)
7)
8)
9)

FOR GM:=MULTI — USED OFTEN?

ID: **YES** NO
CR: **YES** NO
SK: **YES** NO
CL: YES **NO**
BK: **YES** NO

FORM D-3: FEATURE WORKSHEET

FEATURE WOODLINE

MANDATORY DATA

FEAT: 151

GM: SINGLE **MULTI** CIRCLE 3PTCIR

ORIGINAL DATA — USED OFTEN?

Z?: **YES** NO
CIRD: YES **NO**
PADJ: OFFSET YES **NO**
PADJ: DEPTH YES **NO**

FEATURE DESCRIPTORS

1) TYPE WOODLINE
2)
3)
4)
5)
6)
7)
8)
9)

MEASUREMENT DESCRIPTORS

1) ORIENT
2)
3)
4)
5)
6)
7)
8)
9)

FOR GM:=MULTI — USED OFTEN?

ID: **YES** NO
CR: YES **NO**
SK: **YES** NO
CL: **YES** NO
BK: **YES** NO

Figure E-16. Sample completed feature worksheet—Form D-3.

FORM D-3: FEATURE WORKSHEET

FEATURE FENCE

MANDATORY DATA

FEAT: 130

GM: SINGLE (MULTI) CIRCLE 3PTCIR

ORIGINAL DATA

	USED OFTEN?	
Z?:	(YES)	NO
CIRD:	YES	(NO)
PADJ: OFFSET	YES	(NO)
PADJ: DEPTH	YES	(NO)

FEATURE DESCRIPTORS

1) CLASS OF FENCE LINE
2) FENCE HEIGHT
3) FENCE TYPE
4)
5)
6)
7)
8)
9)

MEASUREMENT DESCRIPTORS

1) JUNCTION POINT
2)
3)
4)
5)
6)
7)
8)
9)

FOR GM:=MULTI	USED OFTEN?	
ID:	(YES)	NO
CR:	YES	(NO)
SK:	(YES)	NO
CL:	(YES)	NO
BK:	(YES)	NO

Figure E-16. Continued

FORM D-4: INFO WORKSHEET

INFO ENVIRONMENT

MANDATORY DATA

INFO: 3

OPTIONAL DATA

INFO DESCRIPTOR TAGS

1) EQUIP
2) DATE
3) CREW
4) WEATHER
5)
6)
7)
8)
9)

Figure E-16. Continued

Form D-5. Feature or Information Attribute Form

Feature Name	Acceptable Feature Descriptor Tags	Feature Descriptor Descriptions	Acceptable Values		Req'd Y/N	Default
			values	definition		
302	TYCORN	TYPE OF CORNER MARKER	CONMOD	1 = CONCRETE MONUMENT	Y	N
			FEROD	2 = IRON ROD		
			WHELAX	3 = WHEEL AXLE		
			RRTIE	4 = RR TIE		
			RRAIL	5 = RR RAIL		
			WOODP	6 = WOOD POST		
			GBARS	7 = GRATE BARS		
			FEPIPE	8 = IRON PIPE		

Form D-5. Feature or Information Attribute Form.

Feature Name	Acceptable Feature Descriptor Tags	Feature Descriptor Descriptions	Acceptable Values		Req'd Y/N	Default
			values	definition		
102		TYPE OF SURFACE MATERIAL	ASPHALT	11 = ASPHALT	Y	ASPHALT
			CONC	5 = CONCRETE		
			GRAVEL	12 = GRAVEL		
			SHELL	13 = SHELL		
			DIRT	10 = DIRT		
			FBOOK	9999 = FIELD BOOK		

Figure E-17. Sample completed feature attribute form—Form D-5.

Form D-5. Feature or Information Attribution Form

Feature Name	Acceptable Feature Descriptor Tags	Feature Descriptor Descriptions	Acceptable Values		Req'd Y/N	Default
			values	definition		
151	TYWOOD	WOOD LINE TYPE	WOODS HARD LWOODS FBOOK	1 = WOODS 2 = HARD WOODS 3 = LIGHT WOODS 9999 = FIELD BOOK	Y	WOODS

Figure E-17. Continued

Form D-5. Feature or Information Attribute Form.

Feature Name	Acceptable Feature Descriptor Tags	Feature Descriptor Descriptions	Acceptable Values		Req'd Y/N	Default
			values	definition		
130	CLASSL	CLASS OF FENCE LINE	PRIME SECOND	PRIMARY FENCE SECONDARY FENCE	Y	PRIME
	FENCEH	FENCE HEIGHT	1.0 - 15.1	TENTHS OF FT	N	N
	TYPFEN	TYPE OF FENCE	BARBW BARMES HURCAN WOOD	1 = BARE WIRE 2 = BARB WIRE WITH MESH 3 = HURRICANE FENCE 4 = WOOD		

Figure E-17. Continued

Form D-5: Feature or Information Attribute Form

Feature Name	Acceptable Feature Descriptor Tags	Feature Descriptor Descriptions	Acceptable Values		Req'd Y/N	Default
			values	definition		
3	EQUIP	Equipment being used	TC2000	1 = Wild TC2000 and GRE3		
	DATE	Date	YYMMDD	Year Month Day		
	CREW	Field Party	SQUAD	Squad No.		
	WEATHER	Weather conditions	WCOND	1 = Sunny 2 = Cloudy 3 = Partly Cloudy 4 = Rain 5 = Cold		

Figure E-17. Continued

Form D-6: Point Description Form

Acceptable Point Descriptor Tags	Point Descriptor Descriptions	Acceptable Values		Req'd Y/N	Default
		Values	Definition		
JUNCPT	A Junction Point	PNUM SNUM	The last primary line point number The last secondary line point number	N	N
TYPEPT	Point Type	POLE GUYWIR	Pole Guy wire	Y	N
VAULT	Vault	YES	vault exists	N	YES
APPURT	Appurtenance	YES	Exists	N	YES
ORIENT	Orientation	YES	Next measurement point indicates orientation	N	YES
CALC	Calculated point	YES	next measurement point was calculated	N	YES

Figure E-18. Point attribute information—Form D-6.

Task C.6 - Establish data collection procedures for features.

Step 1. Detail the X_Y_Z or S_O_E file convention for each feature in column 6 of the Data Collector to UFF Worksheet (Form D-7). This represents the feature oriented data file that will interface to outside applications.

Step 2. Detail the H_V_D or S_O_R file convention for each feature in column 6 of the Data Collector to UFF Worksheet (Form D-7). This will represent command sets as they are input into ISIMS. A good understanding of ISIMS processing is required.

Step 3. Detail the field survey data collection records for each feature in column 7 necessary to create the H_V_D or S_O_R format detailed in Step 2 above.

Louisiana will use only the H_V_D file convention.

The three topographic survey control points do not require Step 1 definition as they are used by ISIMS in computing x,y,z values.

Refer to the completed Form D-7 for these three data collector to H_V_D conversion definitions.

In Louisiana, an alternate form type was used for detailing the H_V_D and X_Y_Z tag sequences. Figure E-21 describes the H_V_D and X_Y_Z relationship. Figure E-22 describes the H_V_D and data collector relationship.

Figure E-19. Task C.6—Establish data collection procedures for features.

Form D-7. Data Collector to UFF Worksheet

Data Tag: ____________

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
50					H_V_D format only	
				SETUP over known point	POS:SETUP	CODE BLOCK CODE NO. = 50
				Occupied point	OS:SETUP	CODE BLOCK INFO1 = OSPTNO
				BS point	BS:BSPTNO	CODE BLOCK INFO2 = BSPTNO
				Record horizontal circle	H_V_D: ppp hhh vvv ddd	MB BSPTNO hhh
						Acceptable:
					ppp hhh vvv ddd	MB BSPTNO hhh vvv ddd
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-20. Sample of setup code.

Form D-7. Data Collector to UFF Worksheet

Data Tag: ____________

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
51					H_V_D format only	
				Pre-condition Code 50 established	POS:SETUP OS:vvv BS:vvv H_V_D:	
				Establish new control point from known point	HFORE:	CODE BLOCK CODE NO. = 51
				Record distance and azimuth	H_V_D: ppp hhh vvv ddd	MB CODE BLOCK-INFO1 hhh vvv ddd
				Close horizon	ACC:HREPS I_V_D: ppp hhh vvv ddd	MB CODE BLOCK-INFO1 hhh
					H_V: ppp hhh vvv ddd	MB BSPTNO hhh
				Store in Control file	Future Enhancement	Presently Manual
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.

** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-20. Continued

Form D-7. Data Collector to UFF Worksheet

Data Tag: ____________

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
55				Pre-condition Known BS and FS points	H_V_D format only	
				Establish new CP from unknown point	POS:USETUP	CODE BLOCK CODE NO. - 55
				Occupied point	OS:OSPTNO	CODE BLOCK INFO1 - OSPTNO
				BS point	BS:BSPTNO	CODE BLOCK INFO2 - BSPTNO
				FS point	FS:FSPTNO	CODE BLOCK INFO3 - PSPTNO
				Record distance and azimuth	H_V_D: ppp hhh vvv ddd	MB BSPTNO hhh vvv ddd
				Record distance and azimuth	H_V_D: ppp hhh vvv ddd	MB FSPTNO hhh vvv ddd
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.
** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-20. Continued

Form D-7. Data Collector to UFF Worksheet

Data Tag: FEAT

TAG VALUE	DESCRIPTOR			DESCRIPTION OF DATA COLLECTION REQUIREMENTS	UFF DATA FORMAT	FIELD DATA COLLECTION PROCEDURES
	TAG	DEFAULT				
		SYSTEM	DOT			
55 continued				Close Horizon	ACC:HORIZON HTOLR:5.0 ATOLR:5.0 ACC:HREPS I_H_V:	MB
					ppp hhh vvv ddd	hhh
					H_V	MB
					ppp hhh vvv ddd	hhh
				Store in Control File	Future Enhancement	Presently Manual
Column 1	Column 2	Column 3	Column 4	Column 5	* Column 6	** Column 7

* The H_V_D or S_O_E format in Column 6 of the Data Collector to UFF Worksheet defines output specifications for the user's data collection to ISIMS conversion program.
** Column 7 of the Data Collector to UFF Worksheet defines the input specifications for the user's data collector to ISIMS conversion program.

Figure E-20. Continued

FEATURE PROPERTY CORNER

HVD FORMAT

IDENTIFY FEATURE
FEAT: 302

DEFINE GEOMETRY
GM: SINGLE

(1) DESCRIPTOR TAGS
TYCORN:

(2) EACH POINT IS A FEATURE
HVD:

X Y Z FORMAT

IDENTIFY FEATURE
FEAT: 302

DEFINE GEOMETRY
GM: SINGLE

(1) DESCRIPTOR TAGS
TYCORN:

EACH POINT IS A FEATURE
XYZ:

REPEAT (2) FOR MULTIPLE FEATURES WITH SAME TYCORN:
REPEAT (1) FOR MULTIPLE FEATURES WITH DIFFERENT TYCORN:

FEATURE EDGE OF PAVEMENT

HVD FORMAT

IDENTIFY FEATURE
FEAT: 102

DEFINE GEOMETRY
GM: MULTI

DESCRIPTOR TAGS
TYPMAT:

SET USER ID IF FEATURE
REQUIRES MULTIPLE SETUPS
ID: (USER ID)
SET BACKWARE FLAG IF APPLICABLE
BK: YES
TO DEFINE A STRAIGHT LINE
HVD:
TO DEFINE AN ARC
CR: STARTA
HVD:
HVD:
HVD:
CR: STOPA

TO DEFINE A CURVE
CR: STARTC
HVD:
HVD:
HVD:
CR: STOPC

TO NOT CONNECT THE LINE
TO THE NEXT POINT
SK: SKIP
HVD:

XYZ FORMAT

IDENTIFY FEATURE
FEAT: 102

DEFINE GEOMETRY
GM: MULTI

DESCRIPTOR TAGS
TYPMAT:

TO DEFINE A STRAIGHT LINE
XYZ:
TO DEFINE AN ARC
CR: STARTA
XYZ:
XYZ:
XYZ:
CR: STOPA

TO DEFINE A CURVE
CR: STARTC
XYZ:
XYZ:
XYZ:
CR: STOPC

TO NOT CONNECT THE LINE
TO THE NEXT POINT
SK: SKIP
XYZ:

FEATURE WOODLINE

HVD FORMAT

IDENTIFY FEATURE
FEAT: 151
DEFINE GEOMETRY
BM: MULTI
SET USER ID IF FEATURE
REQUIRES MULTIPLE SETUPS
ID: (USER ID)
SET BACKWARD FLAG IF APPLICABLE
BK: YES
DESCRIPTOR TAGS
TYWOOD:
DEFINE WOODLINE FACE
ORIENT: YES
HVD:
DEFINE WOODLINE
HVD:
TO NOT CONNECT THE LINE
TO THE NEXT POINT
SK: SKIP
HVD:
TO CONNECT THE FIRST AND
LAST POINTS
CL: CLOSED

XYZ FORMAT

IDENTIFY FEATURE
FEAT: 151
DEFINE GEOMETRY
BM: MULTI

DESCRIPTOR TAGS
TYWOOD:
DEFINE WOODLINE FACE
ORIENT: YES
XYZ:
DEFINE WOODLINE
XYZ:
TO NOT CONNECT THE LINE
TO THE NEXT POINT
SK: SKIP
XYZ:
TO CONNECT THE FIRST AND
LAST POINTS
CL: CLOSED

FEATURE FENCE

HVD FORMAT

IDENTIFY FEATURE
FEAT: 130

DEFINE GEOMETRY
GM: MULTI

DESCRIPTOR TAGS
FENCEH:
TYPFEN:

SET USER ID IF FEATURE
REQUIRES MULTIPLE SETUPS
ID: (USER ID)

SET BACKWARD FLAG IF APPLICABLE
BK: YES

PRIMARY FENCE LINE
CLASSL: PRIME
HVD:

LEAVE PRIMARY
JUNCPT: PNUM

SECONDARY FENCE LINE
CLASSL: SECOND
HVD:

RETURN TO PRIMARY
CLASSL: PRIME
SK: SKIP
JUNCPT: PNUM
HVD:

TO NOT CONNECT THE LINE
TO THE NEXT POINT
SK: SKIP
HVD:

TO CONNECT THE FIRST AND
LAST POINTS
CL: CLOSED

FORMAT

IDENTIFY FEATURE
FEAT: 130

DEFINE GEOMETRY
GM: MULTI

DESCRIPTOR TAGS
FENCEH:
TYPFEN:

PRIMARY FENCE LINE
CLASSL: PRIME

LEAVE PRIMARY
JUNCPT: PNUM

SECONDARY FENCE LINE
CLASSL: SECOND

RETURN TO PRIMARY
CLASSL: PRIME
SK: SKIP
JUNCPT: PNUM

TO NOT CONNECT THE LINE
TO THE NEXT POINT
SK: SKIP
HVD:

TO CONNECT THE FIRST AND
LAST POINTS
CL: CLOSED

INFO SYSTEM INFORMATION

HVD FORMAT

IDENTIFY INFORMATION
INFO: 3

DESCRIPTOR TAGS
EQUIP:
DATE:
CREW:
WEATHER:

XYZ FORMAT

IDENTIFY INFORMATION
INFO: 3

DESCRIPTOR TAGS
EQUIP:
DATE:
CREW:
WEATHER:

Figure E-21. Sample of feature/information codes in UFF format.

<u>FEATURE</u> PROPERTY CORNER

<u>HVD FORMAT</u>	<u>LOUISIANA WILD TC2000</u>
IDENTIFY FEATURE	
FEAT: 302	CODE BLOCK 302
DEFINE GEOMETRY	
GM: SINGLE	PREDEFINED
(1) DESCRIPTOR TAGS	
TYCORN:	INFO BLOCK 1
(2) EACH POINT IS A FEATURE	
HVD:	MEASUREMENT BLOCK(S)

REPEAT (2) FOR MULTIPLE FEATURES WITH SAME TYCORN:
REPEAT (1) FOR MULTIPLE FEATURES WITH DIFFERENT TYCORN:

<u>FEATURE</u> EDGE OF PAVEMENT

<u>HVD FORMAT</u>	<u>LOUISIANA WILD TC2000</u>
IDENTIFY FEATURE	
FEAT: 102	CODE BLOCK 102
DEFINE GEOMETRY	
GM: MULTI	PREDEFINED
DESCRIPTOR TAGS	
TYPMAT:	INFO BLOCK 1
SET USER ID IF FEATURE	
REQUIRES MULTIPLE SETUPS	
ID: (USER ID)	INFO BLOCK 2
SET BACKWARE FLAG IF APPLICABLE	
BK: YES	DOUBLE MEASUREMENT BLOCKS 1 & 2
TO DEFINE A STRAIGHT LINE	
HVD:	MEASUREMENT BLOCK(S)
TO DEFINE AN ARC	
CR: STARTA	ANGLE ONLY
HVD:	MEASUREMENT BLOCK (PC)
HVD:	MEASUREMENT BLOCK (POC)
HVD:	MEASUREMENT BLOCK (PT)
CR: STOPA	
TO DEFINE A CURVE	
CR: STARTC	ANGLE ONLY + ANGLE ONLY
HVD:	MEASUREMENT BLOCK (PC)
HVD:	MEASUREMENT BLOCK (POC)
HVD:	MEASUREMENT BLOCK (PT)
CR: STOPC	ANGLE ONLY + ANGLE ONLY
TO <u>NOT</u> CONNECT THE LINE	
TO THE NEXT POINT	
SK: SKIP	CLODE BLOCK 990
HVD:	MEASUREMENT BLOCK(S)

<u>FEATURE</u> WOODLINE

<u>HVD FORMAT</u>	<u>LOUISIANA WILD TC2000</u>
IDENTIFY FEATURE	
FEAT: 151	CODE BLOCK 151
DEFINE GEOMETRY	
BM: MULTI	PREDEFINED
SET USER ID IF FEATURE	
REQUIRES MULTIPLE SETUPS	
ID: (USER ID)	INFO BLOCK 3
SET BACKWARD FLAG IF APPLICABLE	
BK: YES	DOUBLE MEASUREMENT BLOCKS 1 & 2
DESCRIPTOR TAGS	
TYWOOD:	INFO BLOCK 1
DEFINE WOODLINE FACE	
ORIENT: YES	
HVD:	MEASUREMENT BLOCK 1
DEFINE WOODLINE	
HVD:	MEASUREMENT BLOCK(S)
TO <u>NOT</u> CONNECT THE LINE	
TO THE NEXT POINT	
SK: SKIP	CODE BLOCK 990
HVD:	MEASUREMENT BLOCK(S)
TO CONNECT THE FIRST AND	
LAST POINTS	
CL: CLOSED	INFO BLOCK 2

Figure E-22. Sample of feature/information code data collector to H_V_D.

<u>FEATURE</u> FENCE

<u>HVD FORMAT</u>	<u>LOUISIANA WILD TC2000</u>
IDENTIFY FEATURE FEAT: 130	CODE BLOCK 130
DEFINE GEOMETRY GM: MULTI	PREDEFINED
DESCRIPTOR TAGS FENCEH: TYPFEN:	 INFO BLOCK 1 INFO BLOCK 2
SET USER ID IF FEATURE REQUIRES MULTIPLE SETUPS ID: (USER ID)	 INFO BLOCK 4
SET BACKWARD FLAG IF APPLICABLE BK: YES	DOUBLE MEASUREMENT BLOCKS 1 & 2
PRIMARY FENCE LINE CLASSL: PRIME HVD:	 PREDEFINED MEASUREMENT BLOCK(S)
LEAVE PRIMARY JUNCPT: PNUM	CODE BLOCK 991
SECONDARY FENCE LINE CLASSL: SECOND HVD:	 CODE BLOCK 991 MEASUREMENT BLOCK(S)
RETURN TO PRIMARY CLASSL: PRIME SK: SKIP JUNCPT: PNUM HVD:	 CODE BLOCK 991 MEASUREMENT BLOCK(S)
TO <u>NOT</u> CONNECT THE LINE TO THE NEXT POINT SK: SKIP HVD:	 CODE BLOCK 990 MEASUREMENT BLOCK(S)
TO CONNECT THE FIRST AND LAST POINTS CL: CLOSED	 INFO BLOCK 3

Figure E-22. Continued

<u>INFO</u> ENVIRONMENT

<u>HVD FORMAT</u>	<u>LOUISIANA WILD TC2000</u>
IDENTIFY INFO INFO: 3	 CODE BLOCK 3
DESCRIPTOR TAGS	
EQUIP:	INFO BLOCK 1
DATE:	INFO BLOCK 2
CREW:	INFO BLOCK 3
WEATHER:	INFO BLOCK 4

Figure E-22. Continued

Task C.7 - Prepare program design for converting each feature from the agency's data collection format to an unprocessed UFF format.

Step 1. Copy column 7 from the Data Collector to UFF Worksheet (Form D-7) to column 1 of the Conversion Program Guideline worksheet (Form D-8).

Step 2. Copy column 6 from the Data Collector to UFF Worksheet (Form D-7) to column 3 of the Conversion Program Guideline Worksheet (Form D-8).

Step 3. Complete column 2 at the Conversion Program Guideline Worksheet (Form D-8), by describing the correlation between the input in column 1 and the output in column 3.

Form D-8 has been completed for the five (5) sample codes used in Task C.5 and Task C.6. Refer to Figure E-24 for completed D-8 forms.

Figure E-23. Task C.7—Convert data collector format to UFF-HVD.

Form D-8. Conversion Program Guidelines Worksheet.

FIELD DATA COLLECTION PROCEDURES	CORRELATION	RAW SURVEY UFF DATA FORMAT
LOUISIANA WILD/TC2000 CODE BLOCK 102	Create FEAT:102 command set	HVD FORMAT IDENTITY FEATURE FEAT: 102
PREDEFINED	Create GM:MULTI command set	DEFINE GEOMETRY GM: MULTI
INFO BLOCK 1 = aaa	Create TYPMAT:aaa feature description command set	DESCRIPTOR TAGS TYPMAT:
INFO BLOCK 2 = bbb	Create ID:bbb feature description command set	SET USER ID IF FEATURE REQUIRES MULTIPLE SETUPS ID: (USER ID)
DOUBLE MEASUREMENT BLOCKS 1 & 2	If MB1xy = MB2xy, Create BK:YES	SET BACKWARD FLAG IF APPLICABLE BK: YES
MEASUREMENT BLOCK(S)	MBn	TO DEFINE A STRAIGHT LINE HVD:
ANGLE ONLY	Create CR:START ARC command set	TO DEFINE AN ARC CR:START ARC
MEASUREMENT BLOCK (PC)	P.C. - MBn	HVD:
MEASUREMENT BLOCK(POC)	P.O.C. - MB(n+1)	HVD:
MEASUREMENT BLOCK (PT)	Create CR:END ARC command set P.T. - MB(n+2)	HVD: CR: END ARC
ANGLE ONLY	Create CR:START CURVE command set	TO DEFINE A CURVE CR: START CURVE
ANGLE ONLY		
MEASUREMENT BLOCK (PC)	P.C. - MBn	HVD:
MEASUREMENT BLOCK(POC)	P.O.C. - MB(n+m)	HVD:
MEASUREMENT BLOCK(PT)	P.T. - MB(n+m+1)	HVD:
ANGLE ONLY	Create CR:END CURVE	CR: END CURVE
ANGLE ONLY		
CODE BLOCK 990	Create SK:SKIP point description set	TO NOT CONNECT THE LINE TO THE NEXT POINT SK: SKIP
MEASUREMENT BLOCK(S)	MBn	HVD:

Figure E-24. Completed conversion program specifications form.

Form D-8. Conversion Program Guidelines Worksheet.

FIELD DATA COLLECTION PROCEDURES	CORRELATION	RAW SURVEY UFF DATA FORMAT
LOUISIANA WILD/TC2000 CODE BLOCK 151	Create FEAT:151 command set	HVD FORMAT IDENTITY FEATURE FEAT: 105
PREDEFINED	Create GM:MULTI command set	DEFINE GEOMETRY GM: MULTI
INFO BLOCK 1 = aaa	Create TYWOOD:aaa descriptor set	DESCRIPTOR TAG TYWOOD:
INFO BLOCK 2 = bbb	Create CL:CLOSED command set	TO CONNECT THE FIRST AND LAST POINTS CL: CLOSED
INFO BLOCK 3 = ccc	Create ID:ccc descriptor set	SET USER ID IF FEATURE REQUIRES MULTIPLE SETUPS ID: (USER ID)
DOUBLE MEASUREMENT BLOCKS 1 & 2	MB1xy=MB2xy create BK:YES command set	SET BACKWARD FLAG IF APPLICABLE BK: YES
MEASUREMENT BLOCK 1	Create ORIENT:YES point descriptor set MB1	DEFINE WOODLINE FACE ORIENT: YES HVD:
MEASUREMENT BLOCK(S)	MBn	DEFINE WOODLINE HVD:
CODE BLOCK 990	Create SK:SKIP command set	TO NOT CONNECT THE LINE TO THE NEXT POINT SK: SKIP
MEASUREMENT BLOCK(S)	MBn	HVD:

Figure E-24. Continued

Form D-8. Conversion Program Guidelines Worksheet.

FIELD DATA COLLECTION PROCEDURES	CORRELATION	RAW SURVEY UFF DATA FORMAT
LOUISIANA WILD/TC2000 CODE BLOCK 130	Create FEAT:130 command set	HVD FORMAT IDENTITY FEATURE FEAT: 130
FEATURE PREDEFINED	Create GM:MULTI command set	DEFINE GEOMETRY GM: MULTI
INFO BLOCK 1 = aaa INFO BLOCK 2 = bbb INFO BLOCK 3 = ccc	Create FENCEH:aaa feature descriptor set Create TYPFEN:bbb feature descriptor set Creates CL:CLOSED command set	DESCRIPTOR TAGS FENCEH: TYPFEN: CONNECT FIRST & LAST POINTS CL:CLOSED
INFO BLOCK 4 = ddd	Create ID:ddd feature descriptor set	SET USER ID IF FEATURE REQUIRES MULTIPLE SETUPS ID: (USER ID)
DOUBLE MEASUREMENT BLOCKS 1 & 2	MB1xy = MB2xy, create BK:YES command set	SET BACKWARD FLAG IF APPLICABLE BK: YES
FEATURE PREDEFINED MEASUREMENT BLOCK(S)	MB2 creates CLASSL:PRIME descriptor set MBn	PRIMARY FENCE LINE CLASSL: PRIME HVD:
CODE BLOCK 991	Creates JUNCPT:ppp point descriptor set and CLASSL:SECOND	LEAVE PRIMARY JUNCPT: PNUM SECONDARY FENCE LINE CLASSL: SECOND HVD:
MEASUREMENT BLOCK(S) CODE BLOCK 991	MBn Creates CLASSL:PRIME feature descriptor set	RETURN TO PRIMARY SK: SKIP JUNCPT: PNUM
MEASUREMENT BLOCK(S)	MBn	HVD: TO NOT CONNECT THE LINE TO THE NEXT POINT
CODE BLOCK 990 MEASUREMENT BLOCK(S)	Creates SK:SKIP command MBn	SK: SKIP HVD:

Figure E-24. Continued

Form D-8. Conversion Program Guidelines Worksheet.

FIELD DATA COLLECTION PROCEDURES	CORRELATION	RAW SURVEY UFF DATA FORMAT
LOUISIANA WILD/TC2000		H_V_D FORMAT
CODE BLOCK 3	Create INFO:3 command set	IDENTIFY INFORMATION INFO:3
INFO BLOCK 1 = aaa INFO BLOCK 2 = bbb INFO BLOCK 3 = ccc INFO BLOCK 4 = ddd	Create EQUIP:aaa information descriptor set Create DATE:bbb information descriptor set Create CREW:ccc information descriptor set Create WEATHER:ddd information descriptor set	DESCRIPTOR TAGS EQUIP: DATE: CREW: WEATHER:

Figure E-24. Continued

SUGGESTED PROCEDURAL TASKS

Task D. Incorporate, design, write and/or embellish ISIMS software modules.

Step 1. Review demonstrators 20-21G, 20-21W and 20-21L (see Appendix G) and corresponding program documentation (Appendix H).

ISIMS - INTEGRATED SURVEY INFORMATION MANAGEMENT SYSTEM
GENERAL DEMONSTRATOR MENU

MODULE	DESCRIPTION
1.	DOWNLOAD THE FIELD DATA
2.	CONVERT DATA COLLECTOR FORMATTED TOPO DATA TO UFF-HVD
3.	CONVERT DATA COLLECTOR FORMATTED X-SEC DATA TO UFF-SOE
4.	PLOT UFF-HVD OR UFF-XYZ
5.	PRINT UFF-HVD OR UFF-XYZ
6.	PRINT UFF-SOE CROSS SECTIONS
7.	CONVERT UFF-SOE CROSS SECTIONS TO RDS FORMAT
8.	EDIT DATA
9.	CONVERT DATA FROM UFF-HVD TO UFF-XYZ
A.	PRINT A FILE
B.	INSTALL NEW SET OF FEATURES
C.	CONTROL FILE DATA

Step 2. Select the computer(s) that will do the survey data processing.

Step 3. Fill modules 1 and 8 (see above) with communications and editor software respectively.

Step 4. Rewrite (or possibly modify) programs for modules 2 and 3 to suit agency needs.

Step 5. Modify module 5 to accommodate the agency's particular plotter.

Step 6. Embellish any module. For example, module 9 could be modified to delete commands BCK: and ID:. Also, make minor coding changes due to differences in FORTRAN77/BASIC across computers.

Step 7. Add modules, specifically, those that transform UFF data to a roadway engineering application or CADD format.

Project 20-21 has developed the above as part of the alpha test site. See Appendix G for Louisiana Demonstration. See Appendix H for software documentation.

Figure E-25. Task D—Incorporate, design, write and/or embellish ISIMS software modules.

APPENDIX F

SURVEY FEATURES AND ACTIVITIES

The types of surveys usually performed by most state DOT's include the following: control, topography, horizontal alignment, vertical alignment, cross-sections, cadastral, and utility. ISIMS has the ability to allow processing of all these types of surveys with appropriate use of Appendix D (ISIMS Feature Design and Installation Guidelines).

As part of the ISIMS installation process for any of these types of surveys, the user should formulate a set of survey features and activities to be incorporated into ISIMS.

Figure F-1 is a set of one hundred and twenty-five (125) survey features and activities, organized by survey type, that can aid the user in the installation of ISIMS for his agency. Additional features or activities can be defined by the user when completing Forms D-1 through D-8. ISIMS is not limited to this list, nor is this list ISIMS-specific. Rather, it can be used as a guide for installing ISIMS for a specific surveying task for a particular agency.

SURVEY FEATURES AND ACTIVITIES

Feature/Activity	SurveyType	Class
System Information		
Equipment	All	Info
Date	All	Info
Crew	All	Info
Weather	All	Info
Data Transmission ID	All	Info
Project Information		
Project ID	All	Info
Accuracy Specs	All	Info
Horizontal Control		
Marker Type	Control	Horizontal
Start on Monument	Control	Horizontal
Start on Azimuth Marker	Control	Horizontal
Setup on known Control Point	Control	Horizontal
Establish new Control Point	Control	Horizontal
End on Monument	Control	Horizontal
End on Azimuth Marker	Control	Horizontal
Side Shot	Control	Horizontal
Reference	Control	Horizontal
Vertical Control		
Start Vrt Ctrol on known	Control	Vertical
Start Vrt Ctrl on unknown	Control	Vertical
Stop Vertical Control	Control	Vertical
Benchmark	Control	Vertical
Temporary Benchmark	Control	Vertical
Side Shot	Control	Vertical
Depth	Control	Vertical
Probe Length	Control	Vertical
Topographic Control		
Setup on known TCP	Topo	Control
Establish New TCP from known	Topo	Control
Triangulation	Topo	Control
Horizontal Alignment		
Center Line	H Align	Design
Vertical Alignment		
Ditch	V Align	Road
Ditch Backslope	V Align	Road
Profile	V Align	Road

Figure F-1. Type and class of feature/activity.

Feature/Activity	Survey Type	Class
Cross Sections		
Originals	X Secs	Road
Drainage	X Secs	Hydro
Cadastral		
Easement Line	Cadast	Property
Property Corner	Cadast	Property
Propery Line	Cadast	Property
Row Line	Cadast	Property
Section Corner	Cadast	Boundary
Topography		
Alignment	Topo	Geometric
Annotation	Topo	Geometric
Bill Board	Topo	Road
Body of Water	Topo	Hydro
Box Culvert	Topo	Structure
Bridge	Topo	Structure
Building	Topo	General
Canal	Topo	Hydro
Catch Basin	Topo	Drainage
Cattle Guard	Topo	General
Circle	Topo	Geometric
Crossing Gate	Topo	Railroad
Crossing Signal	Topo	Railroad
Curb	Topo	Road
Driveway	Topo	General
Drop Inlet	Topo	Drainage
Fence	Topo	General
Fuel Pump	Topo	General
Gate	Topo	General
Guard Post	Topo	Road
Guard Rail	Topo	Road
Headwall	Topo	Structure
Levee	Topo	Hydro
Light Post	Topo	General
Marsh	Topo	Hydro
Mile Post	Topo	Railroad
Orchard	Topo	General
Pipe Culvert	Topo	Structure
Polygon	Topo	Geometric
Retaining Wall	Topo	Structure
Road Edge	Topo	Road
Row Marker	Topo	Road
Running Water	Topo	Hydro
Shoulder Edge	Topo	Road
Sidewalk	Topo	General

Figure F-1. Continued

Feature/Activity	Survey Type	Class
Silo	Topo	General
Slab	Topo	General
Slope Wall	Topo	Structure
Storage Tank	Topo	General
Swamp	Topo	Hydro
Track	Topo	Railroad
Traffic Control Box	Topo	Road
Tree	Topo	General
Topography (cont'd)		
Underground Storage	Topo	General
Utility Line	Topo	Geometric
Water Well	Topo	General
Wood Line	Topo	General
Utility		
Appurtenance	Utility	General
Casing	Utility	
Cleanout	Utility	Sewer
Cross Connect Box	Utility	Tele
Depth	Utility	General
Fire Hydrant	Utility	Water
Guy Wire	Utility	Power, Tele
Junction Box	Utility	Power Tele
Line	Utility	Gas Petro Power Sewer Tele TV
Manhole	Utility	Power Sewer Storm Tele
Meter	Utility	Gas Water
Pole	Utility	Power Tele
Pump Station	Utility	Sewer
Regulator	Utility	Gas Petro
Test Box	Utility	Gas
Transmission Tower	Utility	Power
Underground Transformer	Utility	Power

Figure F-1. Continued

Feature/Activity	Survey Type	Class
Valve	Utility	Gas Water
Vent	Utility	Petro
Feature Dependent Activities		
Continue	All	General
Owner	All	General
Perpendicular Offset	All	General
Restart	All	General
Return	All	General
Start/Stop Curve	All	General
Related Feature Identification	All	General

Figure F-1. Continued

APPENDIX G

USER'S GUIDE TO ISIMS DEMONSTRATORS

INTRODUCTION

One of the results of this project is three demonstrator applications of ISIMS. The applications are:

1. A generic application of ISIMS.
2. A Louisiana (LDOTD)-based application.
3. A Wisconsin (WDOT)-based application.

Each application runs on an IBM-XT compatible microcomputer, has up to 14 modules, has one module written in BASIC, has two modules that are to be filled with off-the-shelf proprietary software, and has FORTRAN 77 as the language for all other modules.

The function of each module is as follows:

Module	Module Description
1	Download data from data collector to data processing microcomputer (IBM-XT compatible)
2	Convert HVD data collector formatted data to UFF-HVD*
3	Convert SOR** data collector formatted data to UFF-SOE***
4	Plot UFF-HVD or UFF-XYZ data on a plotter capable of understanding the HPGL language (an HP 7475A)
5	Print UFF-HVD or UFF-XYZ data
6	Print UFF-SOE cross-section data
7	Convert UFF-SOE cross-section data to RDS format
8	Edit any data
9	Convert UFF-HVD data to UFF-XYZ
A	Print a file
B	Install new set of features
C	Control file maintenance
0	Exit system

*HVD = Horizontal angle, slope angle, distance (comes from field data collection)
**SOR = Station, offset, rod reading (comes from field data collection)
***SOE = Station, offset, elevation

Figure G-1 is a diagram of how field-collected data are converted to the UFF. Path 2 is never used because it is a small computation to get from the data collector to SOR and then SOE. SOR is never used except for archival purposes because it represents the original data. Module 2, Module 3, and Module 9 are the original data processing programs and their positions relative to the data are shown in Figure G-1.

The available demonstrator modules for Louisiana and Wisconsin are shown in Figure G-2. The number of modules (programs) required and their content may need to be modified for a specific surveying task. Usually, as soon as the data are put into a UFF format, modules and programs are available to further process the data.

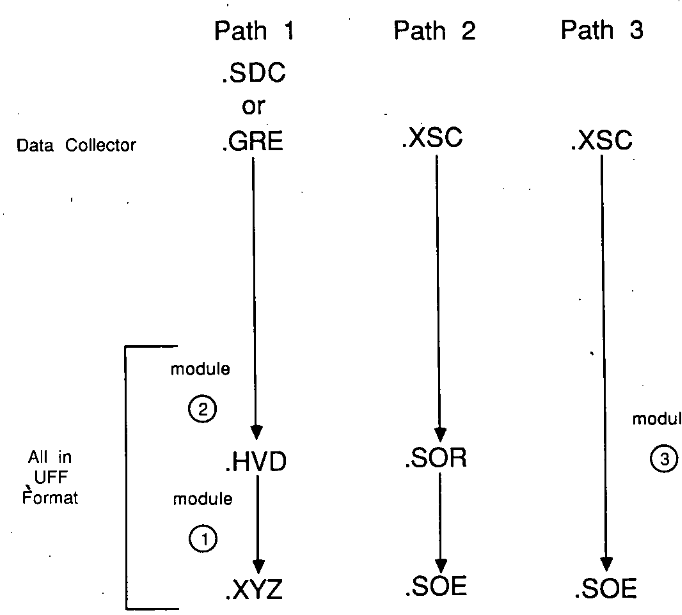


Figure G-1. Survey data file transformation paths to UFF.

```
ISIMS  - INTEGRATED SURVEY INFORMATION MANAGEMENT SYSTEM
                 LOUISIANA DEMONSTRATOR MENU

MODULE              DESCRIPTION
------              -----------
  1         DOWNLOAD THE TC2000/GRE3 FIELD DATA
  2         CONVERT TC2000/GRE3 COLLECTED TOPO TO UFF-HVD
  3         ---- NOT DEMONSTRATED ----
  4         PLOT  UFF-HVD OR UFF-XYZ
  5         PRINT UFF-HVD OR UFF-XYZ
  6         ---- NOT DEMONSTRATED ----
  7         ---- NOT DEMONSTRATED ----
  8         EDIT DATA
  9         CONVERT DATA FROM UFF-HVD TO UFF-XYZ
  A         PRINT A FILE

  0         EXIT THE SYSTEM

FOR ONE SET OF DATA ENTER SEVERAL OF THE NUMBERS ABOVE
IN THE ORDER THAT YOU WANT THESE ACTIVITIES EXECUTED:
```

```
ISIMS  - INTEGRATED SURVEY INFORMATION MANAGEMENT SYSTEM
              WISCONSIN DEMONSTRATOR MENU

MODULE              DESCRIPTION
------              -----------
  1         DOWNLOAD ANY SDC71 FIELD DATA
  2         CONVERT SDC71 COLLECTED TOPO TO UFF-HVD
  3         CONVERT SDC71 COLLECTED CROSS SECTIONS TO UFF-SOE
  4         PLOT  UFF-HVD OR UFF-XYZ
  5         PRINT UFF-HVD OR UFF-XYZ
  6         PRINT UFF-SOE CROSS SECTIONS
  7         CONVERT UFF-SOE CROSS SECTIONS TO RDS FORMAT
  8         EDIT DATA
  9         CONVERT DATA FROM UFF-HVD TO UFF-XYZ
  A         PRINT ANY FILE

  0         EXIT THE SYSTEM

FOR ONE SET OF DATA ENTER SEVERAL OF THE NUMBERS ABOVE
IN THE ORDER THAT YOU WANT THESE ACTIVITIES EXECUTED:
```

Figure G-2. Available demonstrator modules for Louisiana and Wisconsin.

INSTALLING THE DEMONSTRATORS

To execute the demonstrators, it is necessary to install them on a microcomputer with a hard disk. Installation is a two-step process: (1) create a subdirectory called 20-21, and (2) copy the entire contents of each demonstrator disk onto the 20-21 subdirectory.

EXECUTING AN APPLICATION

After installation, there are three applications that can be run. To run an application, first move into the 20-21 subdirectory, then type in 20-21G, 20-21L, or 20-21W for the generic, Louisiana, and Wisconsin demonstrators, respectively, and then press the RETURN key.

At this point, the application is menu driven. By following the menu's instructions all modules can be investigated.

DEMONSTRATOR SIMILARITIES

There are several similarities across the three demonstrators that will apply to any ISIMS application structured in the manner of these demonstrators.

A. Modules 1 and 8 are activated by inserting calls to proprietary computer programs, into the system's driver routine. In the actual October 1986 demonstration in Louisiana, WORDSTAR was used as the editor in Module 8, and XTALK was used as the communications package in Module 1. In these three demonstrators, these modules are not filled, but on-line instructions are given to incorporate off-the-shelf packages into the systems.

B. Modules 2 and 3 are data collector and data collection procedure dependent, and as such, must be rewritten across agencies.

C. The demonstration software in Module 4 is dependent on the plotter's knowledge of HPGL (Hewlett Packard Graphics Language).

D. Software in Modules 4, 5, 6, 7, and 9 all accept UFF as input and so are applicable to any agency using ISIMS (except for the restrictions mentioned in Appen. H).

GENERIC DEMONSTRATOR DESCRIPTION

The purpose of the generic demonstrator is to guide the user who wants to create his own ISIMS application. Executing any module brings up screens that describe what the user needs to do (if anything) in order to make a working module.

Since the generic demonstrator was created as a means of documenting ISIMS implementation, those interested persons should execute 20-21G and read the on-screen documentation.

LOUISIANA DEMONSTRATOR DESCRIPTION

The purpose of the Louisiana demonstrator is to show how the contents of UFF-based data can be entered into a relatively primitive data collector (WILD GRE3-with no programming) and then converted to UFF, printed, and plotted. Relative to this demonstrator, modules 2, 4, and 5 were used. Module 2 is applicable only for users with a WILD GRE3 T2000 who employ the data entry conventions used by Louisiana to collect topo (refer to Appen. E and Appen. H for further information). The data entry conventions applied to the GRE3 allowed entry of data that covers several facets of the UFF-HVD. Because a somewhat complex procedure was applied to a primitive data collector, the programming of Module 2, which converts GRE3-formatted data to UFF-HVD, was a long and complicated process. The level of this programming effort indicates that it may often be better to replace a primitive data collector with a more sophisticated preprogrammed one than to try to apply data collection conventions and write a format translation program for the primitive collector.

In this demonstrator, Modules 2, 4, 5, 9, and A are active; Modules 1 and 8 are to be filled with off-the-shelf software; and Modules 3, 6, and 7 are not applicable to the Louisiana demonstrator. Limitations under which the in-place modules operate are described in Appendix H.

WISCONSIN DEMONSTRATOR DESCRIPTION

The purpose of the Wisconsin demonstrator is twofold. First, it allows processing of topo data when the WILD T2000 is hooked to a second vendor's data collector (SDC71/HP71B from ABACUS). Second, it allows stand-alone use of the SDC71 in collecting cross sections with a rod and level in the standard station and offset method. Once this cross-section data is collected, it can be processed and converted into RDS input format.

Modules 2, 4, 5, and 9 are used to process topo. Modules 3, 6, and 7 are used to process cross sections. For topo, only a very small number of the data collection facilities allowed in the UFF-HVD were implemented. For both topo and cross sections, the survey computer program on the SDC71 was used directly and procedural instructions for data entry were supplied to the survey crew so that the ISIMS application software would properly interpret the data (refer to Appen. H). Limitations under which the in-place modules operate are described in Appendix H.

FILE NAMING IN THE DEMONSTRATORS

The demonstrators have been set up to input specifically named example data files. All Louisiana demonstrator example files are of the form LOUIGRE3.*. The Wisconsin demonstrator example files are named WISCSDCX.*. The file name suffixes for these two demonstrators and associated software conform to the file naming conventions documented in Appendix H.

To allow user-dictated input file naming, minor modifications to programs 20-21W.BAS and 20-21L.BAS are needed.

DEMONSTRATOR 20-21G SCREEN LISTINGS

Examples of the generic demonstrator (20-21G) screen listings describing what the user needs to do to make a working module follow.

ISIMS - INTEGRATED SURVEY INFORMATION MANAGEMENT SYSTEM
GENERAL DEMONSTRATOR MENU

MODULE	DESCRIPTION
1.	DOWNLOAD THE FIELD DATA
2.	CONVERT DATA COLLECTOR FORMATTED TOPO DATA TO UFF-HVD
3.	CONVERT DATA COLLECTOR FORMATTED X-SEC DATA TO UFF-SOE
4.	PLOT UFF-HVD OR UFF-XYZ
5.	PRINT UFF-HVD OR UFF-XYZ
6.	PRINT UFF-SOE CROSS SECTIONS
7.	CONVERT UFF-SOE CROSS SECTIONS TO RDS FORMAT
8.	EDIT DATA
9.	CONVERT DATA FROM UFF-HVD TO UFF-XYZ
A.	PRINT A FILE
B.	INSTALL NEW SET OF FEATURES
C.	CONTROL FILE DATA
0	EXIT THE SYSTEM

FOR ONE SET OF DATA ENTER SEVERAL OF THE NUMBERS ABOVE
IN THE ORDER THAT YOU WANT THESE ACTIVITIES EXECUTED:

1. DOWN LOAD THE FIELD DATA

Survey data is collected in the field using a data collector. This device must have the ability to transfer data through a cable into a computer. RS-232 protocol is the recommended method of communication.

To transfer data from a data collector to a computer one needs:

1) a data collector loaded with data
2) the data collector must have software and a port to transfer data to the computer
3) RS-232 cabling, or similar equipment, between the data collector and computer (possibly including an interface converter to RS-232).
4) software on the computer that can receive data, and a port from which to receive it.
5) compatible RS-232 protocol between the devices sending and receiving data.

* usually available on all data collectors, but may have to be written.

PRESS ANY KEY TO CONTINUE

The protocol for RS-232 connections includes compatibility relative to

- baud rate,
- number of data bits,
- parity, and
- number of stop bits.

The above four (4) parameters must be the same for the equipment being utilized.

On the receiving computer proprietary software is often used to perform this function. At this project's demonstration CROSSTALK XVI software was used on an IBM-PC. The communication software has been replaced by this document for the demonstration model.

2. CONVERT DATA COLLECTOR FORMATTED TOPO DATA TO UFF-HVD

This module is designed to take TOPO data (or any data) collected in angle, angle, distance notation and convert it to UFF-HVD. This module is necessary when the output from the data collector is in a format different than UFF. The user must define a procedure for the collection of TOPO data and then always conform to its format. This procedure will then act as a specification for the creation of the corresponding software module. This software module is dependent upon both data collector and data collection procedure. When coding this module, data checking on FEAT: feature names and feature descriptor tags is recommended. Incorporation of the Louisiana demonstrator TAG file concept is suggested. See Module B for more information.

Configuring a data collection procedure and associated software is a large task. It can be avoided by using a UFF-based data collector.

PRESS ANY KEY TO CONTINUE

3. CONVERT DATA COLLECTOR FORMATTED CROSS SECTION DATA TO UFF-SOE

This module is designed to take cross section data (or any data) collected in station, offset, rod reading notation and convert it to the UFF-SOE. The module is necessary when the output from the data collector is in a format different than UFF. When collecting cross sections in this fashion, a collection procedure can be easily devised to gather appropriate data. The design and coding of the conversion routine will be a small task. This software module is dependent upon both data collector and data collection procedure.

Alternatively, this module could convert data into UFF-SOR. In this case, a UFF-SOR to UFF-SOE conversion program would also be necessary.

The output file for this module in the Wisconsin demonstrator shows how cross section data can be configured in the UFF-SOE. Also, see Appendix H program CNVRTW documentation.

PRESS ANY KEY TO CONTINUE

4. PLOT UFF-HVD OR UFF-XYZ

Plotting survey data facilitate editing. This routine accepts either UFF-HVD or UFF-XYZ as input. The output is a plot with:

1) points and their corresponding point numbers (should density permit).**
2) lines connecting points in a multipoint feature.
3) curves, not necessarily drawn, but at least, indicated by line typing or line color.

The demonstrator software is plotter specific. It requires a plotter with the Hewlett-Packard Graphics Language (HPGL).

** In high density areas the point will be plotted but its corresponding point number will not appear. You may have points with no numbers beside them.

PRESS ANY KEY TO CONTINUE

5. PRINT UFF-HVD OR UFF-XYZ

Print-outs of survey data facilitate editing. This routine accepts either UFF-HVD or UFF-XYZ as input. Its output is a listing of the data. Due to the design of the UFF, out demonstrator makes a multi-columnar listing. For UFF-HVD input, corresponding X, Y, and optionally Z are calculated and printed.

PRESS ANY KEY TO CONTINUE

6. PRINT UFF-SOE CROSS SECTIONS

Print-outs of survey data facilitate editing. This routine accepts either UFF-SOR or UFF-SOE as input. Its output is a listing of the data. Due to the design of the UFF, our demonstrator makes a multi-columnar listing. For UFF-SOR input corresponding elevations are also calculated and printed. This module can apply to all UFF-SOE and UFF-SOR data rather than just cross sections.

A plot routine for this data has not been included because cross section data can be quickly transformed into RDS format for generation of cross-section plots. Optionally, module 4 can be expanded to plot station and offset and another module added to plot cross sections.

PRESS ANY KEY TO CONTINUE

7. CONVERT UFF-SOE CROSS SECTION DATA TO RDS FORMAT

ISIMS can have several translation routines depending upon users' needs. In this demonstrator, cross section data was translated into RDS format (including job control for an IBM mainframe installation). This RDS formatted data can be used without modification in the RDS system. Other candidate translator routines can be written for:

1. INTERGRAPH
2. COGO
3. IGRDS

PRESS ANY KEY TO CONTINUE

8. EDIT DATA

For this module off-the-shelf proprietary software can be used. In the projects' October 1986 demonstration in Louisiana, WORDSTAR was used. This demonstrator contains a non-proprietary editor. We recommend that the user substitute an editor with which he is familiar. The user must know the file-name of the data he wants to edit.

PRESS ANY KEY TO CONTINUE

9. CONVERT DATA FROM UFF-HVD TO UFF-XYZ

This routine takes angle, angle, distance data and transforms it into coordinates (X,Y, and optionally Z). In this process all POS: and PADJ: command sets are lost. Although not required, we recommend that ID: and BK: commands also be filtered out in this conversion. Our demonstrator software does not do this ID: and BK: filtering.

Data in the UFF-XYZ format is in a form most likely to be used for transfer into applications.

A UFF-SOR to UFF-SOE conversion routine is an optional module that could be included by the user. It is not available in this demonstrator.

PRESS ANY KEY TO CONTINUE

A. PRINT A FILE

This routine allows printing of any file whose file name is known. This is a useful module, especially in the demonstrators. Here the user can print and compare any or all example data files. Comparison of the same data in different formats is a good exercise in learning the UFF. These example files show the same data.

Louisiana TOPO	Wisconsin TOPO	Wisconsin Cross Sections	Control
LOUIGRE3.GRE	WISCSDCX.SDC	WISCSDCX.XSC	LOUI.CNT
LOUIGRE3.HVD	WISCSDCX.HVD	WISCSDCX.SDE	WISC.CNT
LOUIGRE3.XYZ	WISCSDCX.XYZ	WISCSDCX.RDS	

PRESS ANY KEY TO CONTINUE

B. INSTALL A NEW SET OF FEATURES

The UFF design allows the user to define his own set of features, associated feature descriptors, and a small number of measurement point descriptors. Guidelines for this exercise are shown in Appendix D and Appendix E shows Louisiana as an example. Once this information is defined, it can be incorporated into ISIMS. ISIMS checks for user compliance when field data is examined. In the Louisiana demonstrator this information has been compiled in the TAG file and used in module 2 for input data checking. Since module 2 is data collector and data collection procedure dependent, the TAG file concept could be used by any user recoding module 2. Module 8 can be used to edit the TAG file.

Alternatively, the TAG file and its data checking facility can be incorporated directly on the data collector. This would be practical for a programmable data collector with software configured to output UFF.

PRESS ANY KEY TO CONTINUE

C. CONTROL FILE DATA

In order to process UFF-HVD data and convert it to UFF-XYZ, the coordinates of the control points are necessary. In this demonstrator, it is assumed that the control survey has already been done and the control points have been adjusted. At this point all control points for the project are put into a control file for use in any module addressing a UFF-HVD data file. During the course of a project, as new control points are established, they should be added to the control file (*.CNT).

Processing of control surveys, automatic inclusion of control points in the control file and traverse adjustments are not modules in this demonstrator, but can be added at the users' discretion. The control file record layout is described in Appendix C.

PRESS ANY KEY TO CONTINUE

LISTINGS OF FILES USED IN DEMONSTRATION

The following example UFF files, as well as data collector files, are found in the demonstrators.

	Louisiana TOPO	Wisconsin TOPO	Wisconsin Cross Sections
Data Collector Files	LOUIGRE3.GRE	WISCSDCX.SDC	WISCSDCX.XSC
Unprocessed UFF Files	LOUIGRE3.HVD	WISCSDCX.HVD	
Processed UFF Files	LOUIGRE3.XYZ	WISCSDCX.XYZ	WISCSDCX.SOE
Application Program Files			WISCSDCX.RDS
Control Files	LOUI.CNT	WISC.CNT	
Feature name and descriptor file	TAG.		

File formats and content for the data collector files can be found in the GRE3 and SDCH user manuals and by reading the source code for programs CNVRTL.FOR, CNVRTW.FOR and CRSSEC.FOR found on the demonstrator disks. File format and content for UFF files are included in Appendixes C and H. Listings of these files are provided in the remainder of this appendix.

```
*-----------------------------------------------------------------------*
!  File: A:LOUIGRE3.GRE                                                 !
! Saved: 10-02-86 at 11:29:13 am                               Page  1 !
*-----------------------------------------------------------------------*

410001+00000001 42....+08001704 43....+00000017 44....+00000002 45....+00000001
410002+00000055 42....+00000130 43....+00000006 44....+00000007       00000000
110003+00000758 21.104+35959597 22.104+09009084 31..01+00342580 51....+0012+000
110004+00000759 21.104+14332539 22.104+09016134 31..01+00142280 51....+0012+000
110005+00000760 21.104+32332542 22.104+26950303 31..01+00000000 51....+0012+000
110006+00000761 21.104+18000003 22.104+26958052 31..01+00000000 51....+0012+000
410007+00000050 42....+00000130 43....+00000006        00000000       00000000
110008+00000762 21.104+35959599 22.104+09012384 31..01+00000000 51....+0012+000
410009+00000137 42....+00000000 43....+00000000 44....+00000000 45....+00013701
110010+00000763 21.104+16554147 22.104+08955396 31..01+00172300 51....+0012+000
110011+00000764 21.104+16558368 22.104+08956466 31..01+00000000 51....+0012+000
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POS:USETUP
OP: C  130
BS: C    6
FS: C    7
H_V_D:   3  359 59 59.7  090 09 08.4      342.5800
H_V_D:   4  143 32 53.9  090 16 13.4      142.2800
ACC:HREPS
I_V_D:   5  323 32 54.2  269 50 30.3         .0000
I_V_D:   6  180 00 00.3  269 58 05.2         .0000
POS:SETUP
OP: C  130
BS: C    6
H_V_D:   8  359 59 59.9  090 12 38.4         .0000
FEAT:SIDEWK
GM:MULTI
ID:13701
SK:SKIP
H_V_D:  10  165 54 14.7  089 55 39.6      172.3000
H_V_D:  12  165 58 36.9  089 56 46.0      176.3800
H_V_D:  13  159 57 57.7  090 00 34.2      173.1900
H_V_D:  14  155 18 18.9  090 17 04.5      155.9100
H_V_D:  16  357 10 40.5  090 22 57.5      286.8100
H_V_D:  17  354 47 36.0  090 18 37.7      316.5200
H_V_D:  18  351 43 47.7  090 20 51.3      320.6100
H_V_D:  19  345 17 39.7  090 29 22.1      321.3100
FEAT:TREE
GM:SINGLE
TYPE:000004
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H_V_D:  23  160 16 31.0  089 38 58.8       70.8900
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H_V_D:  26  173 25 03.4  089 47 50.0      135.8100
H_V_D:  27  191 54 57.1  089 09 40.5      164.4100
H_V_D:  28  191 36 06.0  089 18 36.8      163.5900
H_V_D:  29  191 11 30.3  089 21 28.7      164.3700
FEAT:CURB
GM:MULTI
ID:10401
SK:SKIP
BK:START
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H_V_D:  34  352 09 36.2  090 26 12.4      323.8000
H_V_D:  35  354 48 05.5  090 24 40.1      320.0700
H_V_D:  36  357 28 04.2  090 22 54.5      298.0700
H_V_D:  38  154 06 51.8  090 14 25.4      155.9400
H_V_D:  39  158 15 51.2  090 00 42.5      173.3800
H_V_D:  40  165 25 33.2  089 51 55.9      179.4900
BK:END
H_V_D:  41  165 26 59.7  089 56 17.1      180.0600
FEAT:DROPIN
GM:SINGLE
H_V_D:  43  154 08 51.1  090 12 51.3      155.5200
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H_V_D:  44  155 02 56.7  090 11 21.3      154.7900
H_V_D:  45  154 36 09.8  090 12 59.0      150.4400
H_V_D:  46  036 02 30.3  090 51 13.8       52.9500
H_V_D:  47  032 32 26.9  090 49 26.9       56.4200
H_V_D:  48  034 29 39.8  090 47 27.2       58.2800
H_V_D:  49  055 47 49.0  090 45 44.0       90.9600
H_V_D:  50  053 11 45.0  090 46 30.3       92.8600
H_V_D:  51  053 52 31.7  090 42 06.3       95.1000
H_V_D:  52  357 35 22.8  090 20 04.2      293.2500
H_V_D:  53  357 06 26.7  090 19 49.8      293.0200
H_V_D:  54  356 59 36.5  091 05 46.7      297.5700
H_V_D:  55  005 32 40.8  090 21 51.3      301.9400
H_V_D:  56  005 17 37.0  090 21 50.8      306.3500
H_V_D:  57  005 45 46.7  090 21 49.3      307.0900
H_V_D:  58  008 28 28.0  090 11 57.1      342.1900
H_V_D:  59  009 11 53.9  090 11 56.2      343.8600
H_V_D:  60  009 21 18.8  090 10 42.8      341.4200
FEAT:CURB
GM:MULTI
ID:10402
SK:SKIP
BK:START
H_V_D:  63  015 33 11.3  090 05 29.0      360.1400
H_V_D:  65  008 30 06.2  090 11 33.6      342.2700
H_V_D:  66  005 48 48.6  090 09 41.0      330.1400
H_V_D:  67  005 17 40.2  090 22 11.5      306.3200
H_V_D:  69  140 24 02.7  090 10 27.7      171.3900
H_V_D:  70  141 14 51.9  090 06 31.2      194.5500
H_V_D:  71  137 56 31.2  089 18 26.5      209.9800
BK:END
H_V_D:  72  138 02 03.4  089 22 08.4      210.4000
FEAT:SHOULD
GM:MULTI
ID:    0
TYPE:000003
SK:SKIP
H_V_D:  74  138 13 57.4  089 50 30.7      175.1200
H_V_D:  75  007 08 54.5  090 14 04.0      299.8000
POS:EFORE
OP: C  130
BS: C    7
FS: C  131
H_V_D:  77  359 59 59.7  089 55 52.3         .0000
H_V_D:  78  193 14 19.9  090 35 54.1      388.5900
H_V_D:  79  013 14 29.4  269 32 44.3         .0000
H_V_D:  80  180 00 01.9  270 26 46.4         .0000
POS:SETUP
OP: C  131
BS: C    6
H_V_D:  82  359 59 59.7  089 13 35.5         .0000
FEAT:CURB
GM:MULTI
ID:10402
H_V_D:  85  355 20 36.4  089 15 58.2      283.6000
FEAT:CURB
```

```
GM:MULTI
ID:    0
SK:SKIP
BK:START
H_V_D:  88  347 47 05.3  089 12 40.9     278.8700
H_V_D:  89  349 11 53.8  089 08 34.0     127.6700
H_V_D:  91  151 46 41.4  092 11 11.1      54.2000
H_V_D:  92  160 48 36.7  091 57 54.4      72.2800
H_V_D:  93  175 32 34.1  091 58 24.1      82.6200
BK:END
H_V_D:  94  185 01 08.6  091 57 13.9      86.6100
FEAT:SIDEWK
GM:MULTI
ID:    0
SK:SKIP
H_V_D:  96  160 05 42.6  091 58 30.0      65.7100
H_V_D:  97  156 35 09.3  092 03 00.2      65.8900
H_V_D:  98  347 52 04.9  089 16 09.1     127.5700
H_V_D:  99  347 13 00.1  089 15 39.9     244.2800
FEAT:SIDEWK
GM:MULTI
ID:    0
TYPE:000004
SK:SKIP
H_V_D: 101  346 18 18.7  089 07 57.2     244.3700
H_V_D: 102  347 55 21.0  089 18 58.5     244.3500
H_V_D: 103  347 17 05.6  089 08 50.1     236.2000
H_V_D: 104  347 57 05.8  089 11 28.3     236.3300
H_V_D: 105  348 32 11.2  089 10 19.6     170.4700
H_V_D: 106  347 30 08.6  089 07 56.8     170.4800
H_V_D: 107  347 29 39.5  089 07 56.0     174.9300
H_V_D: 108  348 27 41.6  089 10 54.9     174.9900
FEAT:SIDEWK
GM:MULTI
ID:    0
TYPE:000003
SK:SKIP
H_V_D: 110  346 08 44.5  089 13 12.4     175.0000
H_V_D: 111  319 31 11.3  089 39 22.7     191.8700
H_V_D: 112  319 13 18.3  089 39 19.8     194.6900
H_V_D: 113  320 49 55.5  089 41 11.4     207.4500
H_V_D: 114  315 57 38.7  089 41 18.1     216.0500
H_V_D: 115  313 15 20.2  089 39 22.8     198.6800
H_V_D: 116  327 10 20.9  089 37 11.5     178.3500
H_V_D: 118  326 34 16.5  089 36 54.9     172.7500
H_V_D: 119  329 44 25.0  089 41 34.9     169.9100
H_V_D: 120  330 13 25.3  089 36 27.8     174.8200
H_V_D: 121  346 07 50.8  089 10 06.2     169.8600
FEAT:LPOST
GM:SINGLE
H_V_D: 123  343 44 22.1  088 52 15.9     147.3600
H_V_D: 124  342 28 48.5  088 57 01.3      47.8800
FEAT:CURB
GM:MULTI
ID:    0
```



```
CL:CLOSED
SK:SKIP
H_V_D: 126  004 18 16.0  089 16 22.6     100.7000
H_V_D: 128  004 32 06.5  089 06 45.6     100.9700
H_V_D: 129  005 10 13.1  089 08 29.9     103.8100
H_V_D: 130  006 44 59.6  089 06 43.7     102.4700
H_V_D: 132  124 43 25.7  091 52 32.1      62.6100
H_V_D: 133  128 00 11.2  091 58 35.8      63.7500
H_V_D: 134  128 18 09.0  091 54 02.2      61.0200
FEAT:TCBOX
GM:SINGLE
H_V_D: 136  166 11 32.8  090 21 15.0      63.2200
FEAT:SSMAN
GM:SINGLE
H_V_D: 139  339 16 32.1  089 25 47.2       6.5000
H_V_D: 140  339 44 14.6  089 28 08.4       7.4800
FEAT:TMAN
GM:SINGLE
H_V_D: 142  113 02 42.2  091 28 36.7      83.6700
FEAT:WMETER
GM:SINGLE
H_V_D: 144  053 25 03.1  089 59 10.8     113.3400
H_V_D: 145  055 36 45.7  089 50 02.0     134.2600
FEAT:WVALVE
GM:SINGLE
H_V_D: 147  058 48 32.0  089 50 05.8     145.8400
H_V_D: 148  099 26 30.7  090 48 53.1      98.7900
FEAT:WMETER
GM:SINGLE
H_V_D: 150  098 38 55.7  090 57 02.2     101.5200
H_V_D: 151  099 38 02.7  090 55 04.7     102.4500
FEAT:WVALVE
GM:SINGLE
H_V_D: 153  092 43 52.4  090 53 43.9     147.3800
FEAT:FHYD
GM:SINGLE
H_V_D: 155  101 13 45.0  089 31 55.3     108.6000
FEAT:WLINE
GM:MULTI
ID:    0
DIAM:000002
MATL:000005
SK:SKIP
H_V_D: 161  034 23 06.3  089 36 31.6     105.1500
H_V_D: 162  051 58 51.4  089 38 17.2      88.4100
ID:   -1
SK:SKIP
H_V_D: 163  051 58 51.4  089 38 17.2      88.4100
H_V_D: 164  056 04 26.0  090 00 51.0     112.0400
ID:   -9
SK:SKIP
H_V_D: 165  056 06 10.2  090 00 52.7     112.1200
H_V_D: 167  053 25 55.1  089 36 32.0     113.3600
ID:   -1
H_V_D: 169  058 05 07.1  089 53 10.9     133.5900
```

```
ID:   -9
SK:SKIP
H_V_D: 170  058 05 06.7  089 53 11.5     133.6200
H_V_D: 172  055 36 50.4  089 32 01.9     134.2900
ID:   -1
H_V_D: 175  058 50 52.0  089 49 51.2     145.6500
ID:    0
H_V_D: 178  093 17 19.8  091 17 45.2      90.0100
H_V_D: 179  100 11 51.9  091 10 35.9      95.6200
ID:   -9
SK:SKIP
H_V_D: 180  100 13 21.8  091 10 35.0      95.6900
H_V_D: 182  099 26 05.8  091 05 37.8      98.8900
H_V_D: 184  098 36 04.5  091 14 32.6     101.5500
ID:    0
H_V_D: 186  101 17 14.2  091 16 57.5      96.6600
ID:   -9
SK:SKIP
H_V_D: 187  101 17 14.1  091 16 58.5      96.6500
H_V_D: 189  099 40 22.0  091 11 24.0     102.4800
ID:    0
H_V_D: 191  105 48 18.5  091 06 29.1     101.2200
H_V_D: 192  102 32 48.1  091 14 39.0     110.1100
ID:   -9
SK:SKIP
H_V_D: 193  102 32 48.3  091 14 39.9     110.1000
H_V_D: 195  101 04 27.1  091 49 52.3     108.5000
ID:    0
H_V_D: 198  092 45 26.1  090 53 19.7     147.4000
FEAT:CURB
GM:MULTI
ID:10401
H_V_D: 201  059 22 46.7  090 55 58.4      57.5600
H_V_D: 202  067 39 46.5  091 06 11.9      56.9000
H_V_D: 203  077 07 19.8  091 05 51.1      58.0600
FEAT:CURB
GM:MULTI
ID:10401
TYPE:000001
FEAT:SIDEWK
GM:MULTI
ID:13701
TYPE:000001
H_V_D: 208  081 00 34.1  091 17 53.7      59.0800
H_V_D: 209  096 03 36.2  091 28 42.4      67.6700
H_V_D: 210  108 52 02.9  091 41 38.5      89.8000
H_V_D: 211  110 23 38.5  091 27 47.5     115.1700
H_V_D: 214  106 43 50.0  090 59 20.9     148.8100
FEAT:CURB
GM:MULTI
ID:10401
H_V_D: 217  106 12 09.3  090 55 42.3     152.7100
H_V_D: 218  103 54 39.2  090 51 11.8     167.2200
H_V_D: 219  102 19 17.5  090 48 55.5     177.2000
FEAT:CURB
```



```
GM:MULTI
ID:    0
SK:SKIP
H_V_D: 221  102 35 03.9  090 47 51.9     178.1100
H_V_D: 222  102 16 36.0  090 46 22.3     177.6200
H_V_D: 223  099 09 14.8  090 37 35.5     198.9500
FEAT:SIDEWK
GM:MULTI
ID:13701
H_V_D: 225  099 00 23.0  090 37 53.5     192.8000
```

```
FILE:X_Y_Z
FEAT:SIDEWK
GM:MULTI
ID:13701
SK:SKIP
X_Y_Z:  10   1000217.7735   249971.4768   .00
X_Y_Z:  12   1000214.5393   249973.9740   .00
X_Y_Z:  13   1000207.6502   249956.6936   .00
X_Y_Z:  14   1000217.2153   249937.0531   .00
X_Y_Z:  16   1000559.6662   249668.1976   .00
X_Y_Z:  17   1000589.6299   249656.2737   .00
X_Y_Z:  18   1000604.0430   249666.2236   .00
X_Y_Z:  19   1000626.3476   249694.5291   .00
FEAT:TREE
GM:SINGLE
TYPE:000004
X_Y_Z:  21   1000298.9294   249910.0647   .00
X_Y_Z:  22   1000299.2768   249908.3759   .00
X_Y_Z:  23   1000297.6617   249908.0743   .00
X_Y_Z:  24   1000260.5752   249966.4498   .00
X_Y_Z:  25   1000260.6853   249964.9461   .00
X_Y_Z:  26   1000258.8626   249964.7630   .00
X_Y_Z:  27   1000278.8711   250016.9519   .00
X_Y_Z:  28   1000278.4918   250015.7996   .00
X_Y_Z:  29   1000277.0851   250015.8904   .00
FEAT:CURB
GM:MULTI
ID:10401
SK:SKIP
BK:START
X_Y_Z:  32   1000629.0291   249693.0737   .00
X_Y_Z:  34   1000604.8904   249662.3138   .00
X_Y_Z:  35   1000592.1745   249653.8030   .00
X_Y_Z:  36   1000566.4320   249659.0764   .00
X_Y_Z:  38   1000215.9036   249934.0895   .00
X_Y_Z:  39   1000205.0865   249952.2268   .00
X_Y_Z:  40   1000211.0063   249974.3142   .00
BK:END
X_Y_Z:  41   1000210.5760   249974.6962   .00
FEAT:DROPIN
GM:SINGLE
X_Y_Z:  43   1000216.3255   249934.0102   .00
X_Y_Z:  44   1000217.9587   249935.9661   .00
X_Y_Z:  45   1000221.4765   249933.1442   .00
X_Y_Z:  46   1000364.6450   249821.1012   .00
X_Y_Z:  47   1000368.3878   249818.0713   .00
X_Y_Z:  48   1000366.7054   249815.9615   .00
X_Y_Z:  49   1000337.0721   249785.7297   .00
X_Y_Z:  50   1000340.7040   249782.9332   .00
X_Y_Z:  51   1000339.1422   249780.9770   .00
X_Y_Z:  52   1000562.6407   249662.1159   .00
X_Y_Z:  53   1000564.2549   249663.9959   .00
X_Y_Z:  54   1000567.8195   249661.1867   .00
X_Y_Z:  55   1000536.4762   249629.0257   .00
X_Y_Z:  56   1000540.1444   249626.2386   .00
```



```
X_Y_Z:  57   1000538.5411   249624.1673   .00
X_Y_Z:  58   1000545.5995   249586.5141   .00
X_Y_Z:  59   1000542.8444   249582.7752   .00
X_Y_Z:  60   1000540.7531   249584.3432   .00
FEAT:CURB
GM:MULTI
ID:10402
SK:SKIP
BK:START
X_Y_Z:  63   1000516.5974   249549.6389   .00
X_Y_Z:  65   1000545.5062   249586.3583   .00
X_Y_Z:  66   1000551.7295   249605.2551   .00
X_Y_Z:  67   1000540.1227   249626.2602   .00
X_Y_Z:  69   1000190.4552   249900.6997   .00
X_Y_Z:  70   1000168.0535   249907.1695   .00
X_Y_Z:  71   1000151.1353   249897.8242   .00
BK:END
X_Y_Z:  72   1000150.7545   249898.2091   .00
FEAT:SHOULD
GM:MULTI
ID:    0
TYPE:000003
SK:SKIP
X_Y_Z:  74   1000185.8558   249894.7220   .00
X_Y_Z:  75   1000528.3541   249625.9410   .00
FEAT:CURB
GM:MULTI
ID:10402
X_Y_Z:  85   1000495.5074   249522.5280   .00
FEAT:CURB
GM:MULTI
ID:    0
SK:SKIP
BK:START
X_Y_Z:  88   1000524.8192   249499.3461   .00
X_Y_Z:  89   1000623.3104   249614.1455   .00
X_Y_Z:  91   1000734.3362   249755.9067   .00
X_Y_Z:  92   1000752.0264   249766.4354   .00
X_Y_Z:  93   1000773.6129   249760.6902   .00
BK:END
X_Y_Z:  94   1000784.9907   249751.6613   .00
FEAT:SIDEWK
GM:MULTI
ID:    0
SK:SKIP
X_Y_Z:  96   1000747.5990   249761.5104   .00
X_Y_Z:  97   1000744.2927   249763.8160   .00
X_Y_Z:  98   1000625.5573   249612.2122   .00
X_Y_Z:  99   1000549.6927   249523.5133   .00
FEAT:SIDEWK
GM:MULTI
ID:    0
TYPE:000004
SK:SKIP
X_Y_Z: 101   1000552.5811   249520.9117   .00
```

```
X_Y_Z: 102    1000547.3940    249525.4570    .00
X_Y_Z: 103    1000554.8131    249529.7778    .00
X_Y_Z: 104    1000552.6710    249531.5058    .00
X_Y_Z: 105    1000595.4380    249581.6253    .00
X_Y_Z: 106    1000597.7166    249579.5585    .00
X_Y_Z: 107    1000594.7845    249576.2116    .00
X_Y_Z: 108    1000592.5487    249578.1421    .00
FEAT:SIDEWK
GM:MULTI
ID:    0
TYPE:000003
SK:SKIP
X_Y_Z: 110    1000597.8507    249573.4621    .00
X_Y_Z: 111    1000665.7809    249520.6289    .00
X_Y_Z: 112    1000666.1051    249517.6527    .00
X_Y_Z: 113    1000657.5233    249506.6490    .00
X_Y_Z: 114    1000673.2490    249494.3838    .00
X_Y_Z: 115    1000685.5371    249510.0808    .00
X_Y_Z: 116    1000646.2339    249540.8836    .00
X_Y_Z: 118    1000649.9531    249545.4574    .00
X_Y_Z: 119    1000642.2517    249551.6634    .00
X_Y_Z: 120    1000638.9256    249547.7720    .00
X_Y_Z: 121    1000601.2020    249577.3619    .00
FEAT:LPOST
GM:SINGLE
X_Y_Z: 123    1000620.5020    249590.6970    .00
X_Y_Z: 124    1000682.2660    249668.6764    .00
FEAT:CURB
GM:MULTI
ID:    0
CL:CLOSED
SK:SKIP
X_Y_Z: 126    1000625.0451    249654.3000    .00
X_Y_Z: 128    1000624.6061    249654.5068    .00
X_Y_Z: 129    1000621.5878    249654.0109    .00
X_Y_Z: 130    1000621.3270    249657.1432    .00
X_Y_Z: 132    1000709.3973    249769.7125    .00
X_Y_Z: 133    1000713.0187    249770.8224    .00
X_Y_Z: 134    1000713.2401    249768.0863    .00
FEAT:TCBOX
GM:SINGLE
X_Y_Z: 136    1000751.5808    249755.4169    .00
FEAT:SSMAN
GM:SINGLE
X_Y_Z: 139    1000707.1824    249701.7189    .00
X_Y_Z: 140    1000706.5940    249700.9332    .00
FEAT:TMAN
GM:SINGLE
X_Y_Z: 142    1000692.0515    249788.6756    .00
FEAT:WMETER
GM:SINGLE
X_Y_Z: 144    1000602.6299    249741.1445    .00
X_Y_Z: 145    1000584.3100    249752.2951    .00
FEAT:WVALVE
GM:SINGLE
```



```
X_Y_Z: 147    1000576.3521    249763.7704    .00
X_Y_Z: 148    1000666.6420    249795.5351    .00
FEAT:WMETER
GM:SINGLE
X_Y_Z: 150    1000664.1719    249797.3381    .00
X_Y_Z: 151    1000665.3168    249798.9600    .00
FEAT:WVALVE
GM:SINGLE
X_Y_Z: 153    1000629.9908    249830.4114    .00
FEAT:FHYD
GM:SINGLE
X_Y_Z: 155    1000665.3127    249805.7836    .00
FEAT:WLINE
GM:MULTI
ID:    0
DIAM:000002
MATL:000005
SK:SKIP
X_Y_Z: 161    1000605.6444    249704.2530    .00
X_Y_Z: 162    1000625.7756    249731.5440    .00
ID:   -1
SK:SKIP
X_Y_Z: 163    1000625.7756    249731.5440    .00
X_Y_Z: 164    1000605.5423    249745.6720    .00
ID:   -9
SK:SKIP
X_Y_Z: 165    1000605.4867    249745.7526    .00
X_Y_Z: 167    1000602.6220    249741.1769    .00
ID:   -1
X_Y_Z: 169    1000586.9957    249757.4558    .00
ID:   -9
SK:SKIP
X_Y_Z: 170    1000586.9678    249757.4669    .00
X_Y_Z: 172    1000584.2864    249752.3067    .00
ID:   -1
X_Y_Z: 175    1000576.5656    249763.7877    .00
ID:    0
X_Y_Z: 178    1000662.1699    249782.8965    .00
X_Y_Z: 179    1000669.1943    249793.2453    .00
ID:   -9
SK:SKIP
X_Y_Z: 180    1000669.2014    249793.3265    .00
X_Y_Z: 182    1000666.5902    249795.6120    .00
X_Y_Z: 184    1000664.0879    249797.3173    .00
ID:    0
X_Y_Z: 186    1000670.4063    249794.9613    .00
ID:   -9
SK:SKIP
X_Y_Z: 187    1000670.4105    249794.9522    .00
X_Y_Z: 189    1000665.3695    249799.0095    .00
ID:    0
X_Y_Z: 191    1000675.8752    249802.1521    .00
X_Y_Z: 192    1000667.0013    249808.1674    .00
ID:   -9
SK:SKIP
```

File: A:LOUIGRE3.XYZ
Saved: 01-29-87 at 11:26:16 am


```
X_Y_Z: 193   1000667.0054   249808.1583   .00
X_Y_Z: 195   1000665.1100   249805.5226   .00
ID:    0
X_Y_Z: 198   1000630.0357   249830.4650   .00
FEAT:CURB
GM:MULTI
ID:10401
X_Y_Z: 201   1000657.9392   249730.0216   .00
X_Y_Z: 202   1000662.3491   249737.0433   .00
X_Y_Z: 203   1000667.0467   249745.3551   .00
FEAT:CURB
GM:MULTI
ID:10401
TYPE:000001
FEAT:SIDEWK
GM:MULTI
ID:13701
TYPE:000001
X_Y_Z: 208   1000669.0198   249748.9488   .00
X_Y_Z: 209   1000677.0262   249765.7916   .00
X_Y_Z: 210   1000684.3635   249792.9449   .00
X_Y_Z: 211   1000679.8482   249818.0580   .00
X_Y_Z: 214   1000661.7379   249847.6336   .00
FEAT:CURB
GM:MULTI
ID:10401
X_Y_Z: 217   1000659.1262   249850.8483   .00
X_Y_Z: 218   1000647.9728   249862.1187   .00
X_Y_Z: 219   1000639.6962   249869.4607   .00
FEAT:CURB
GM:MULTI
ID:    0
SK:SKIP
X_Y_Z: 221   1000640.0803   249870.6210   .00
X_Y_Z: 222   1000639.3997   249869.7913   .00
X_Y_Z: 223   1000621.0237   249884.7041   .00
FEAT:SIDEWK
GM:MULTI
ID:13701
X_Y_Z: 225   1000623.3542   249878.9906   .00
```

File: A:LOUI.CNT
Saved: 01-21-87 at 00:19:10 am

1	M	0.0000	0.0000	0.0000
2	M	0.0000	0.0000	0.0000
3	M	0.0000	0.0000	0.0000
4	M	0.0000	0.0000	0.0000
5	M	0.0000	0.0000	0.0000
6	M	1000586.1660	249616.7520	0.0000
7	M	1000220.6820	249903.7710	0.0000
8	M	0.0000	0.0000	0.0000
9	M	0.0000	0.0000	0.0000
10	M	0.0000	0.0000	0.0000
11	M	0.0000	0.0000	0.0000
12	M	0.0000	0.0000	0.0000
13	M	0.0000	0.0000	0.0000
14	M	0.0000	0.0000	0.0000
15	M	0.0000	0.0000	0.0000
16	M	0.0000	0.0000	0.0000
17	M	0.0000	0.0000	0.0000
18	M	0.0000	0.0000	0.0000
19	M	0.0000	0.0000	0.0000
20	M	0.0000	0.0000	0.0000
21	M	0.0000	0.0000	0.0000
22	M	0.0000	0.0000	0.0000
23	M	0.0000	0.0000	0.0000
24	M	0.0000	0.0000	0.0000
25	M	0.0000	0.0000	0.0000
26	M	0.0000	0.0000	0.0000
27	M	0.0000	0.0000	0.0000
28	M	0.0000	0.0000	0.0000
29	M	0.0000	0.0000	0.0000
30	M	0.0000	0.0000	0.0000
31	M	0.0000	0.0000	0.0000
32	M	0.0000	0.0000	0.0000
33	M	0.0000	0.0000	0.0000
34	M	0.0000	0.0000	0.0000
35	M	0.0000	0.0000	0.0000
36	M	0.0000	0.0000	0.0000
37	M	0.0000	0.0000	0.0000
38	M	0.0000	0.0000	0.0000
39	M	0.0000	0.0000	0.0000
40	M	0.0000	0.0000	0.0000
41	M	0.0000	0.0000	0.0000
42	M	0.0000	0.0000	0.0000
43	M	0.0000	0.0000	0.0000
44	M	0.0000	0.0000	0.0000
45	M	0.0000	0.0000	0.0000
46	M	0.0000	0.0000	0.0000
47	M	0.0000	0.0000	0.0000
48	M	0.0000	0.0000	0.0000
49	M	0.0000	0.0000	0.0000
50	M	0.0000	0.0000	0.0000
51	M	0.0000	0.0000	0.0000
52	M	0.0000	0.0000	0.0000
53	M	0.0000	0.0000	0.0000
54	M	0.0000	0.0000	0.0000
55	M	0.0000	0.0000	0.0000

56	M	0.0000	0.0000	0.0000
57	M	0.0000	0.0000	0.0000
58	M	0.0000	0.0000	0.0000
59	M	0.0000	0.0000	0.0000
60	M	0.0000	0.0000	0.0000
61	M	0.0000	0.0000	0.0000
62	M	0.0000	0.0000	0.0000
63	M	0.0000	0.0000	0.0000
64	M	0.0000	0.0000	0.0000
65	M	0.0000	0.0000	0.0000
66	M	0.0000	0.0000	0.0000
67	M	0.0000	0.0000	0.0000
68	M	0.0000	0.0000	0.0000
69	M	0.0000	0.0000	0.0000
70	M	0.0000	0.0000	0.0000
71	M	0.0000	0.0000	0.0000
72	M	0.0000	0.0000	0.0000
73	M	0.0000	0.0000	0.0000
74	M	0.0000	0.0000	0.0000
75	M	0.0000	0.0000	0.0000
76	M	0.0000	0.0000	0.0000
77	M	0.0000	0.0000	0.0000
78	M	0.0000	0.0000	0.0000
79	M	0.0000	0.0000	0.0000
80	M	0.0000	0.0000	0.0000
81	M	0.0000	0.0000	0.0000
82	M	0.0000	0.0000	0.0000
83	M	0.0000	0.0000	0.0000
84	M	0.0000	0.0000	0.0000
85	M	0.0000	0.0000	0.0000
86	M	0.0000	0.0000	0.0000
87	M	0.0000	0.0000	0.0000
88	M	0.0000	0.0000	0.0000
89	M	0.0000	0.0000	0.0000
90	M	0.0000	0.0000	0.0000
91	M	0.0000	0.0000	0.0000
92	M	0.0000	0.0000	0.0000
93	M	0.0000	0.0000	0.0000
94	M	0.0000	0.0000	0.0000
95	M	0.0000	0.0000	0.0000
96	M	0.0000	0.0000	0.0000
97	M	0.0000	0.0000	0.0000
98	M	0.0000	0.0000	0.0000
99	M	0.0000	0.0000	0.0000
100	M	1000359.7522	249873.7895	0.0000
101	M	1000710.7484	249707.1369	0.0000
102	M	0.0000	0.0000	0.0000
103	M	0.0000	0.0000	0.0000
104	M	0.0000	0.0000	0.0000
105	M	0.0000	0.0000	0.0000
106	M	0.0000	0.0000	0.0000
107	M	0.0000	0.0000	0.0000
108	M	0.0000	0.0000	0.0000
109	M	0.0000	0.0000	0.0000
110	M	0.0000	0.0000	0.0000

111	M	0.0000	0.0000	0.0000
112	M	0.0000	0.0000	0.0000
113	M	0.0000	0.0000	0.0000
114	M	0.0000	0.0000	0.0000
115	M	0.0000	0.0000	0.0000
116	M	0.0000	0.0000	0.0000
117	M	0.0000	0.0000	0.0000
118	M	0.0000	0.0000	0.0000
119	M	0.0000	0.0000	0.0000
120	M	0.0000	0.0000	0.0000
121	M	0.0000	0.0000	0.0000
122	M	0.0000	0.0000	0.0000
123	M	0.0000	0.0000	0.0000
124	M	0.0000	0.0000	0.0000
125	M	0.0000	0.0000	0.0000
126	M	0.0000	0.0000	0.0000
127	M	0.0000	0.0000	0.0000
128	M	0.0000	0.0000	0.0000
129	M	0.0000	0.0000	0.0000
130	M	0.0000	0.0000	0.0000
131	M	0.0000	0.0000	0.0000
132	M	0.0000	0.0000	0.0000
133	M	0.0000	0.0000	0.0000
134	M	0.0000	0.0000	0.0000
135	M	0.0000	0.0000	0.0000
136	M	0.0000	0.0000	0.0000
137	M	0.0000	0.0000	0.0000
138	M	0.0000	0.0000	0.0000
139	M	0.0000	0.0000	0.0000
140	M	0.0000	0.0000	0.0000
141	M	0.0000	0.0000	0.0000
142	M	0.0000	0.0000	0.0000
143	M	0.0000	0.0000	0.0000
144	M	0.0000	0.0000	0.0000
145	M	0.0000	0.0000	0.0000
146	M	0.0000	0.0000	0.0000
147	M	0.0000	0.0000	0.0000
148	M	0.0000	0.0000	0.0000
149	M	0.0000	0.0000	0.0000
150	M	0.0000	0.0000	0.0000

```
*-----------------------------------------------------------------------------*
| File: A:TAG                                                                 |
| Saved: 11-04-86 at 10:27:01 am                                  Page  1     |
*-----------------------------------------------------------------------------*

EDGPV  F1 TYPE N       2   1    2    3    4 9999
SHOULD F1 TYPE N       2   1    2    3    4    5 9999
CURB   F1 TYPE N     1 2   1    2
CURB   F2 MATL N     2 2   1    2 9999
CURB   F3 CLSD N     1 2   1    2
GDPOST                 0
ROW                    0
TCBOX                  0
RR                     0
SIDEWK F1 TYPE N     2 2   1    2    3    4
SIDEWK F2 MATL N     2 2   1    2    3 9999
SIDEWK F3 CLSD N     1 2   1    2
LPOST                  0
WWELL                  0
TREE   F1 TYPE Y     1 2   1    2    3    4    5
CBASIN                 0
DROPIN                 0
GASLN  F1 DIAM N       0
GASLN  F2 OWNR N       0
GVALVE F1 OWNR N       0
GMETER F1 OWNR N       0
GMETER F2 INST N       2   1    2
GTBOX                  0
GSREG                  0
VENT                   0
PREG                   0
PJBOX                  0
PPOLE  F1 DIAM N       0
PPDM   F1 DIAM N       0
UTRAN                  0
SSMAN                  0
SCLEAN                 0
TMAN   F1 DIAM N    24 0
TJBOX                  0
TPOLE                  0
TPDM                   0
TXCBOX                 0
WLINE  F1 DIAM N    .5 1  .38 48.0
WLINE  F2 MATL N       2   2    5    6 9999
WVALVE F1 VALT N     2 2   1    2
WMETER                 0
FHYD                   0
OWNER  F1 OWN1 Y  9999 1 1001 9999
OWNER  F2 OWN2 N       1 1001 9999
OWNER  F3 OWN3 N       1 1001 9999
OWNER  F4 OWN4 N       1 1001 9999
SKIP                   0
SECOND                 0
DEPTH  F1 DPTH Y       0
DEPTH  F2 DECI N    10 2   1   10  100
```

```
*-----------------------------------------------------------------------------*
| File: A:WISCSDCX.XSC                                                        |
| Saved: 01-04-80 at 10:06:07 pm                                  Page  1     |
*-----------------------------------------------------------------------------*

PR:CX
IT:NONE
SN:0
NM:TECH SERVICES
TE:72
BP:30
OB:LEN
RE:GENE
DT:86/10/08
WE:RAIN
TK:XSE
AC:OS
ZC:29.16
AC:BS
RR:2.2520
AC:ST
ST:100
AC:SS
OF:0
RR:3.00
AC:SS
OF:2
RR:3.1
AC:SS
OF:2.5
RR:3.65
AC:SS
OF:25.5
RR:4.04
AC:SS
OF:26
RR:3.58
AC:SS
OF:44
RR:3.18
AC:SS
OF:-2
RR:3.07
AC:SS
OF:-2.5
RR:3.50
AC:SS
OF:-17.5
RR:3.9
AC:SS
OF:-18
RR:3.40
AC:SS
OF:-36
RR:3.38
AC:ST
ST:125
AC:SS
OF:0
RR:3.72
```

AC:SS
OF:2
RR:3.76
AC:SS
OF:2.5
RR:4.23
AC:SS
OF:26
RR:4.63
AC:SS
OF:26.5
RR:4.18
AC:SS
OF:34
RR:3.94
AC:ST
ST:150
AC:SS
OF:0
RR:4.32
AC:SS
OF:2
RR:4.40
AC:SS
OF:2.5
RR:4.83
AC:SS
OF:26
RR:5.3
AC:SS
OF:26.5
RR:4.8
AC:SS
OF:44
RR:4.7
AC:SS
OF:-2
RR:4.30
AC:SS
OF:-2.5
RR:4.83
AC:SS
OF:-18.0
RR:5.15
AC:SS
OF:-18.5
RR:5.73
AC:SS
OF:-34
RR:4.6
AC:SS
OF:-34
RR:4.6
AC:ST
ST:125

AC:SS
OF:-2
RR:3.78
AC:FS
RR:4.132
AC:BS
RR:4.924
AC:ST
ST:125
AC:SS
OF:-2.5
RR:4.914
AC:SS
OF:-17.5
RR:4.8
AC:SS
OF:-18
RR:4.3
AC:SS
OF:-34
RR:4.51
CLOSED:FBOFF

```
+------------------------------------------------------------------------------+
|  File: A:WISCSDCX.SOE                                                         |
| Saved: 01-29-87 at 11:03:12 am                                      Page  1 |
+------------------------------------------------------------------------------+

FILE:S_O_E
FEAT:XSEC
GM:MULTI
SK:SKIP
S_O_E:   11    100.00000  -36.00      28.032
S_O_E:   10    100.00000  -18.00      28.012
S_O_E:    9    100.00000  -17.50      27.512
S_O_E:    8    100.00000   -2.50      27.912
S_O_E:    7    100.00000   -2.00      28.342
S_O_E:    1    100.00000     .00      28.412
S_O_E:    2    100.00000    2.00      28.312
S_O_E:    3    100.00000    2.50      27.762
S_O_E:    4    100.00000   25.50      27.372
S_O_E:    5    100.00000   26.00      27.832
S_O_E:    6    100.00000   44.00      28.232
FEAT:XSEC
GM:MULTI
SK:SKIP
S_O_E:   34    125.00000  -34.00      27.694
S_O_E:   33    125.00000  -18.00      27.904
S_O_E:   32    125.00000  -17.50      27.404
S_O_E:   31    125.00000   -2.50      27.290
S_O_E:   30    125.00000   -2.00      27.632
S_O_E:   12    125.00000     .00      27.692
S_O_E:   13    125.00000    2.00      27.652
S_O_E:   14    125.00000    2.50      27.182
S_O_E:   15    125.00000   26.00      26.782
S_O_E:   16    125.00000   26.50      27.232
S_O_E:   17    125.00000   34.00      27.472
FEAT:XSEC
GM:MULTI
SK:SKIP
S_O_E:   28    150.00000  -34.00      26.812
S_O_E:   29    150.00000  -34.00      26.812
S_O_E:   27    150.00000  -18.50      25.682
S_O_E:   26    150.00000  -18.00      26.262
S_O_E:   25    150.00000   -2.50      26.582
S_O_E:   24    150.00000   -2.00      27.112
S_O_E:   18    150.00000     .00      27.092
S_O_E:   19    150.00000    2.00      27.012
S_O_E:   20    150.00000    2.50      26.582
S_O_E:   21    150.00000   26.00      26.112
S_O_E:   22    150.00000   26.50      26.612
S_O_E:   23    150.00000   44.00      26.712
```

```
+------------------------------------------------------------------------------+
|  File: A:WISCSDCX.RDS                                                         |
| Saved: 01-29-87 at 11:08:14 am                                      Page  1 |
+------------------------------------------------------------------------------+

//FRANK#P JOB (7024,03102),GLENN,CLASS=K,MSGCLASS=9,NOTIFY=C1319
//*** JOB TO PLOT X-SECTIONS THAT COME IN ON AFLOPPY IN RDS
//*** CARD FORMAT FRANK COOPER   08/25/86
//RDS      EXEC RDSGEOM
//CARD.INPUT DD *
FRANK01SYSTEMXXXXXXXXXXXXXXNEWNO NO NO NO NO    XSEC PLOT
FRANK##RTERRAINX        X      TEX
XXXXXX.2  100 0  1L   20   803 36   801 18   751 17   791  2   834  2
XXXXXX.2  100 0  2L   20   841  0
XXXXXX.2  100 0  3R   20   831  2   776  2   737 25   783 26   823 44
XXXXXX.2  125 0  1L   20   769 34   790 18   740 17   728  2   763  2
XXXXXX.2  125 0  2L   20   769  0
XXXXXX.2  125 0  3R   20   765  2   718  2   678 26   723 26   747 34
XXXXXX.2  150 0  1L   20   681 34   681 34   568 18   626 18   658  2
XXXXXX.2  150 0  2L   20   711  2   709  0
XXXXXX.2  150 0  3R   20   701  2   658  2   611 26   661 26   671 44
FRANK##RXSEC                   100 100             X     100L220RX 660
//RDS.FT16F001 DD DSN=&&RDS,DISP=(NEW,PASS),UNIT=WORKPAKS,
//    SPACE=(CYL,1),LABEL=RETPD=0
//PLOTSAS EXEC PLOTSAS,PLOTDSN='&&RDS'
```

PR:ARET
IT:NONE
SN:0
NM:TECH SERVICES
TE:72
BP:30
OB:LEN
RE:GENE
DT:86/09/25
WE:PC
TK:RTO
AC:OS
PN:100
PD:6
HZ:359.99998
VT:90.21067
AC:SS
PN:1
PD:TR
HZ:191.55476
VT:89.13378
DS:164.74
AC:SS
PN:2
PD:TR
HZ:174.2452
VT:89.34118
DS:135.87
AC:SS
PN:3
PD:TR
HZ:162.10156
VT:89.56095
DS:70.58
I1:7777
I2:8888
AC:SS
PN:4
PD:*CU
HZ:346.23495
VT:90.2834
DS:323.93
I3:9999
AC:SS
PN:5
PD:*CU
HZ:352.02393
VT:90.22001
DS:323.86
A2:SKIP
AC:SS
PN:6
PD:*CU
HZ:354.74349
VT:90.22007

DS:320.07
AC:SS
PN:7
PD:*CU
HZ:357.25115
VT:90.25012
DS:298.97
A2:CLOSE
AC:SS
PN:8
PD:*CU
HZ:154.10561
VT:90.13441
DS:155.9
AC:SS
PN:9
PD:*CU
HZ:159.3304
VT:89.58329
DS:175.940
AC:SS
PN:10
PD:*CU
HZ:165.26181
VT:89.59471
DS:179.520
AC:SS
PN:11
PD:*CU
HZ:165.26375
VT:90.03357
DS:180.03
CLOSED:FBOFF

```
*--------------------------------------------------------------------*
|  File: A:WISCSDCX.HVD                                               |
| Saved: 01-29-87 at 11:02:16 am                            Page  1   |
*--------------------------------------------------------------------*

POS:SETUP
OP: C 100
BS: C 6
H_V_D:     0  359 59 59.9    90 12 38.4        .00000
FEAT:TR
GM:SINGLE
H_V_D:     1  191 33 17.1    89  8  1.6    164.74000
H_V_D:     2  174 14 42.7    89 20 28.2    135.87000
I1:7777
I2:8888
H_V_D:     3  162  6  5.6    89 33 39.4     70.58000
FEAT:*CU
GM:MULTI
I3:9999
H_V_D:     4  346 14  5.8    90 17   .2    323.93000
SK:SKIP
H_V_D:     5  352  1 26.1    90 13 12.0    323.86000
H_V_D:     6  354 44 36.6    90 13 12.3    320.07000
CL:CLOSED
H_V_D:     7  357 15  4.2    90 15   .4    298.97000
H_V_D:     8  154  6 20.2    90  8  3.9    155.90000
H_V_D:     9  159 19 49.4    89 34 59.8    175.94000
H_V_D:    10  165 15 42.5    89 35 41.0    179.52000
H_V_D:    11  165 15 49.5    90  2   .8    180.03000
```

```
*--------------------------------------------------------------------*
|  File: A:WISCSDCX.XYZ                                               |
| Saved: 01-29-87 at 11:04:11 am                            Page  1   |
*--------------------------------------------------------------------*

FEAT:TR
GM:SINGLE
X_Y_Z:   1    1000277.8384     250016.6992          .00
X_Y_Z:   2    1000260.1793     249966.2203          .00
I1:7777
I2:8888
X_Y_Z:   3    1000299.0820     249909.8502          .00
FEAT:*CU
GM:MULTI
I3:9999
X_Y_Z:   4    1000625.5518     249688.6445          .00
SK:SKIP
X_Y_Z:   5    1000605.4697     249662.8235          .00
X_Y_Z:   6    1000592.4279     249654.0048          .00
CL:CLOSED
X_Y_Z:   7    1000567.8983     249659.1816          .00
X_Y_Z:   8    1000215.9606     249934.0277          .00
X_Y_Z:   9    1000204.3456     249956.2639          .00
X_Y_Z:  10    1000210.7282     249973.8778          .00
X_Y_Z:  11    1000210.3046     249974.1698          .00
```

```
C:\)MODE LT PT1:132,6 6

Printer error

*--------------------------------------------------------------------*
|  File: A:WISC.CNT                                                   |
| Saved: 01-21-87 at 00:19:10 am                            Page  1   |
*--------------------------------------------------------------------*
   1   M       0.0000        0.0000        0.0000
   2   M       0.0000        0.0000        0.0000
   3   M       0.0000        0.0000        0.0000
   4   M       0.0000        0.0000        0.0000
   5   M       0.0000        0.0000        0.0000
   6   M1000586.1660   249616.7520        0.0000
   7   M1000220.6820   249903.7710        0.0000
   8   M       0.0000        0.0000        0.0000
   9   M       0.0000        0.0000        0.0000
  10   M       0.0000        0.0000        0.0000
  11   M       0.0000        0.0000        0.0000
  12   M       0.0000        0.0000        0.0000
  13   M       0.0000        0.0000        0.0000
  14   M       0.0000        0.0000        0.0000
  15   M       0.0000        0.0000        0.0000
  16   M       0.0000        0.0000        0.0000
  17   M       0.0000        0.0000        0.0000
  18   M       0.0000        0.0000        0.0000
  19   M       0.0000        0.0000        0.0000
  20   M       0.0000        0.0000        0.0000
  21   M       0.0000        0.0000        0.0000
  22   M       0.0000        0.0000        0.0000
  23   M       0.0000        0.0000        0.0000
  24   M       0.0000        0.0000        0.0000
  25   M       0.0000        0.0000        0.0000
  26   M       0.0000        0.0000        0.0000
  27   M       0.0000        0.0000        0.0000
  28   M       0.0000        0.0000        0.0000
  29   M       0.0000        0.0000        0.0000
  30   M       0.0000        0.0000        0.0000
  31   M       0.0000        0.0000        0.0000
  32   M       0.0000        0.0000        0.0000
  33   M       0.0000        0.0000        0.0000
  34   M       0.0000        0.0000        0.0000
  35   M       0.0000        0.0000        0.0000
  36   M       0.0000        0.0000        0.0000
  37   M       0.0000        0.0000        0.0000
  38   M       0.0000        0.0000        0.0000
  39   M       0.0000        0.0000        0.0000
  40   M       0.0000        0.0000        0.0000
  41   M       0.0000        0.0000        0.0000
  42   M       0.0000        0.0000        0.0000
  43   M       0.0000        0.0000        0.0000
  44   M       0.0000        0.0000        0.0000
  45   M       0.0000        0.0000        0.0000
  46   M       0.0000        0.0000        0.0000
  47   M       0.0000        0.0000        0.0000
  48   M       0.0000        0.0000        0.0000
  49   M       0.0000        0.0000        0.0000
  50   M       0.0000        0.0000        0.0000
  51   M       0.0000        0.0000        0.0000
  52   M       0.0000        0.0000        0.0000
  53   M       0.0000        0.0000        0.0000
  54   M       0.0000        0.0000        0.0000
  55   M       0.0000        0.0000        0.0000
```

56	M	0.0000	0.0000	0.0000
57	M	0.0000	0.0000	0.0000
58	M	0.0000	0.0000	0.0000
59	M	0.0000	0.0000	0.0000
60	M	0.0000	0.0000	0.0000
61	M	0.0000	0.0000	0.0000
62	M	0.0000	0.0000	0.0000
63	M	0.0000	0.0000	0.0000
64	M	0.0000	0.0000	0.0000
65	M	0.0000	0.0000	0.0000
66	M	0.0000	0.0000	0.0000
67	M	0.0000	0.0000	0.0000
68	M	0.0000	0.0000	0.0000
69	M	0.0000	0.0000	0.0000
70	M	0.0000	0.0000	0.0000
71	M	0.0000	0.0000	0.0000
72	M	0.0000	0.0000	0.0000
73	M	0.0000	0.0000	0.0000
74	M	0.0000	0.0000	0.0000
75	M	0.0000	0.0000	0.0000
76	M	0.0000	0.0000	0.0000
77	M	0.0000	0.0000	0.0000
78	M	0.0000	0.0000	0.0000
79	M	0.0000	0.0000	0.0000
80	M	0.0000	0.0000	0.0000
81	M	0.0000	0.0000	0.0000
82	M	0.0000	0.0000	0.0000
83	M	0.0000	0.0000	0.0000
84	M	0.0000	0.0000	0.0000
85	M	0.0000	0.0000	0.0000
86	M	0.0000	0.0000	0.0000
87	M	0.0000	0.0000	0.0000
88	M	0.0000	0.0000	0.0000
89	M	0.0000	0.0000	0.0000
90	M	0.0000	0.0000	0.0000
91	M	0.0000	0.0000	0.0000
92	M	0.0000	0.0000	0.0000
93	M	0.0000	0.0000	0.0000
94	M	0.0000	0.0000	0.0000
95	M	0.0000	0.0000	0.0000
96	M	0.0000	0.0000	0.0000
97	M	0.0000	0.0000	0.0000
98	M	0.0000	0.0000	0.0000
99	M	0.0000	0.0000	0.0000
100	M	1000359.7522	249873.7895	0.0000
101	M	1000710.7484	249707.1369	0.0000
102	M	0.0000	0.0000	0.0000
103	M	0.0000	0.0000	0.0000
104	M	0.0000	0.0000	0.0000
105	M	0.0000	0.0000	0.0000
106	M	0.0000	0.0000	0.0000
107	M	0.0000	0.0000	0.0000
108	M	0.0000	0.0000	0.0000
109	M	0.0000	0.0000	0.0000
110	M	0.0000	0.0000	0.0000

111	M	0.0000	0.0000	0.0000
112	M	0.0000	0.0000	0.0000
113	M	0.0000	0.0000	0.0000
114	M	0.0000	0.0000	0.0000
115	M	0.0000	0.0000	0.0000
116	M	0.0000	0.0000	0.0000
117	M	0.0000	0.0000	0.0000
118	M	0.0000	0.0000	0.0000
119	M	0.0000	0.0000	0.0000
120	M	0.0000	0.0000	0.0000
121	M	0.0000	0.0000	0.0000
122	M	0.0000	0.0000	0.0000
123	M	0.0000	0.0000	0.0000
124	M	0.0000	0.0000	0.0000
125	M	0.0000	0.0000	0.0000
126	M	0.0000	0.0000	0.0000
127	M	0.0000	0.0000	0.0000
128	M	0.0000	0.0000	0.0000
129	M	0.0000	0.0000	0.0000
130	M	0.0000	0.0000	0.0000
131	M	0.0000	0.0000	0.0000
132	M	0.0000	0.0000	0.0000
133	M	0.0000	0.0000	0.0000
134	M	0.0000	0.0000	0.0000
135	M	0.0000	0.0000	0.0000
136	M	0.0000	0.0000	0.0000
137	M	0.0000	0.0000	0.0000
138	M	0.0000	0.0000	0.0000
139	M	0.0000	0.0000	0.0000
140	M	0.0000	0.0000	0.0000
141	M	0.0000	0.0000	0.0000
142	M	0.0000	0.0000	0.0000
143	M	0.0000	0.0000	0.0000
144	M	0.0000	0.0000	0.0000
145	M	0.0000	0.0000	0.0000
146	M	0.0000	0.0000	0.0000
147	M	0.0000	0.0000	0.0000
148	M	0.0000	0.0000	0.0000
149	M	0.0000	0.0000	0.0000
150	M	0.0000	0.0000	0.0000

APPENDIX H

PROGRAM DOCUMENTATION

DEMONSTRATOR SOFTWARE SYSTEM OVERVIEW

Software

The ISIMS demonstrator software processes survey data according to UFF specifications. It includes modules that are both data-collector dependent as well as modules that are applicable across a large number of agencies. An earlier version of the software was demonstrated at the second TAC meeting to the NCHRP Project Manager and Technical Advisory Committee. Both then and now, this software takes topological data collected in Louisiana on a GRE3 data collector, converts it to UFF format, and produces a plot of the results. It does the same with Wisconsin topological data collected on an SDC71 data collector. It also processes Wisconsin cross-section data collected on an SDC71 data collector into RDS format.

During the course of this project the UFF was not only defined but also updated on two occasions. Software development necessarily had to lag UFF development. Although these programs now reflect the current UFF, time did not permit incorporating all of its facilities.

The software used in this demonstration is written in Microsoft FORTRAN 77. There are two drivers, one to demonstrate Louisiana survey data processing and the other for Wisconsin data. These drivers activate the appropriate demonstrator software programs. They are written in BASICA.

All software is designed to run on an IBM-PC or an IBM-PC clone using the DOS 2.0 operating system. The system also accommodates off-the-shelf proprietary software for the survey data editing module and the data transfer module (from the data collector to the processing computer). In the project demonstrator, Wordstar and Crosstalk XVI were used. Figure H-1 provides an overview of the entire ISIMS structure showing survey procedure, hardware, software, and data formats.

The demonstration is structured to allow the user to activate any program from the driver main menu. Figure H-2 illustrates all modules in the system and how they apply to Louisiana and Wisconsin data. The typical application program execution sequence is shown in Figures H-3 and H-4 for Louisiana and Wisconsin, respectively. Figure H-5 is a summary depicting the purpose of each program in the system. The program name, description, inputs, and outputs are listed in Figure H-5.

Files

The DOS 2.0 operating system uses certain conventions for naming files. A file name contains a maximum of eight characters plus an optional extension consisting of a period and three characters. The software uses the file name extension to categorize files into types. The eight-character file name prefix consists of a four-character project name followed by a four-character sequence number. Figure H-6 shows the types of files, their file name and/or extension and the purpose of all files in the system.

File layouts describing the exact record format for the file name and feature files are presented in Figures H-7 and H-8. Refer to Appendix C for record layouts for the UFF and the project control files. For data collector record layouts, refer to the SDC71 and the GRE3 users' manuals.

PROGRAM-SPECIFIC DOCUMENTATION

CNVRTL.FOR Program

CNVRTL reads data and performs error checking on a GRE3 data collector input file and a feature file. The program converts the field data to the UFF-HVD format.

Files used as input to CNVRTL are the file name file (FILE.NME), project control file (*.CNT), feature file (TAG), and the GRE3 data collector file (*.GRE3). Procedures for collecting data on the GRE3 data collector based on Louisiana DOTD surveying procedures are listed in Appendix E.

The output of CNVRTL is a UFF-HVD file. The program also sends a listing of the feature file to the printer.

CNVRTL handles only the SETUP, USETUP, and EFORE POS: commands to establish positioning. It does not adjust on PADJ: commands. The user-defined features available to CNVRTL are a subset of the features listed in Appendix E. CNVRTL handles all of these features with the exception of 102, 115, 130, 131, 135, 140, 151, 160, 161, 162, 170, 173, 209, 210, 230, 250, 255, 302, and 895.

PLOT2021.FOR Program

The purpose of PLOT2021 is to draw a plot consisting of points, connecting lines and annotated point numbers. The data for these points can come from the UFF-HVD file, the UFF-XYZ file, or the UFF-SOE file. PLOT2021 is written in FORTRAN 77 and employs HPGL calls to the plotter.

The input files for PLOT2021 are the file name file (FILE.NME), the project control file (*.CNT), and any one of the following files: UFF-HVD, UFF-XYZ, or UFF-SOE.

The output of this program is a plot drawn on an HP7475 plotter. The plot shows a symbol for each point in the file. Control points are drawn using a different symbol. Points in multipoint features are connected. All point numbers are annotated except those that are so close together that they would overwrite one another.

The plotter software and hardware allow the use of two different paper sizes, 8.5 in. by 11 in. or 11 in. by 17 in. The user is prompted to enter the minimum and maximum X value, the minimum Y value, and the paper size. The user can also choose whether or not to annotate point numbers.

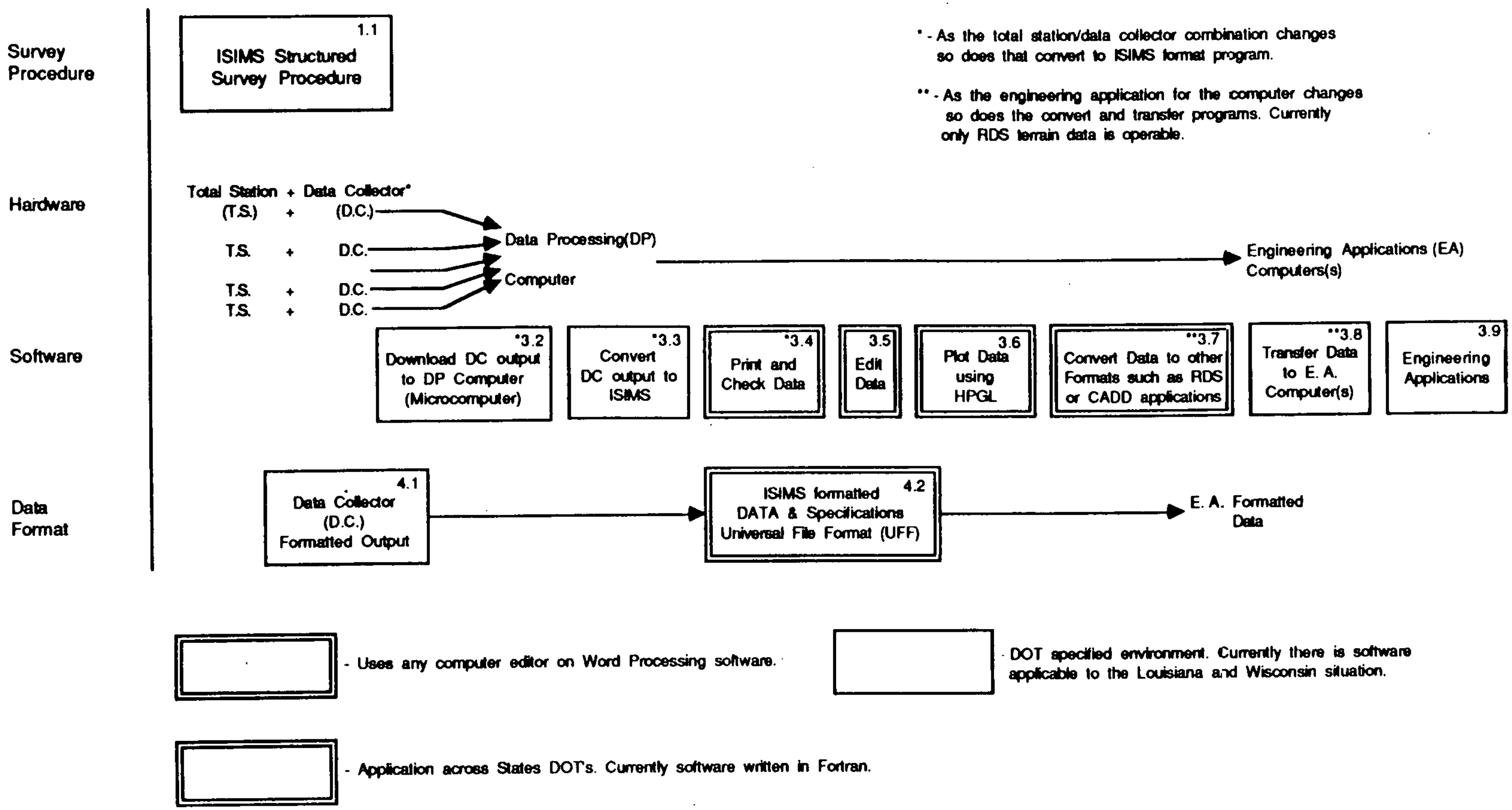


Figure H-1. ISIMS configuration at end of NCHRP Project 20-21.

List of all ISIMS demonstrator modules.

Module	Description
1	DOWNLOAD THE FIELD DATA
2	CONVERT DATA COLLECTOR FORMATTED TOPO DATA TO THE UFF-HVD
3	CONVERT DATA COLLECTOR FORMATTED X-SEC DATA TO THE UFF-SOE
4	PLOT UFF-HVD OR UFF-XYZ
5	PRINT UFF-HVD OR UFF-XYZ
6	PRINT UFF-SOE CROSS SECTIONS
7	CONVERT UFF-SOE CROSS SECTIONS TO RDS FORMAT
8	EDIT DATA
9	CONVERT DATA FROM UFF-HVD TO UFF-XYZ
A	PRINT A FILE
B	INSTALL NEW SET OF FEATURES
C	CONTROL FILE DATA
0	EXIT THE SYSTEM

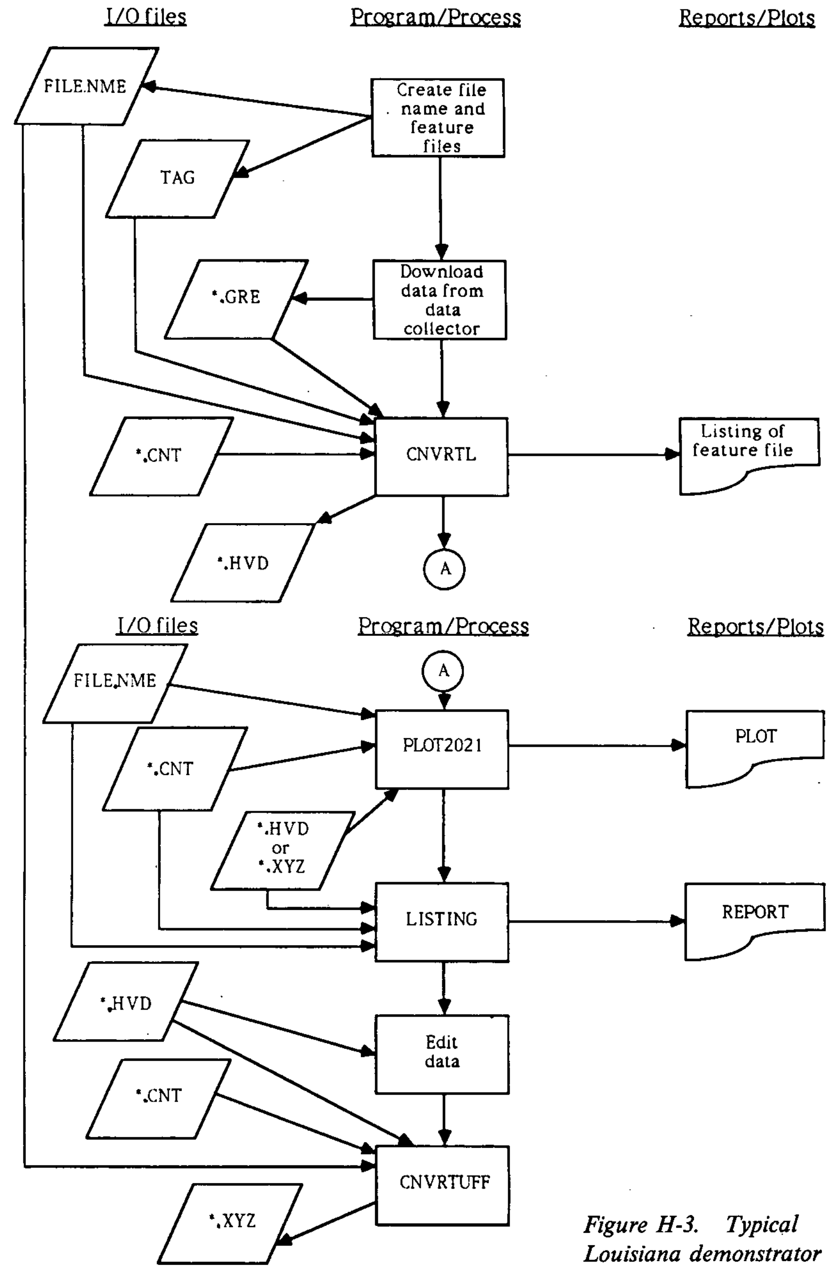
Modules activated in Louisiana demonstrator.

Module	Description	Program Name
1	DOWNLOAD THE TC2000/GRE3 FIELD DATA	1.
2	CONVERT LOUISIANA TC2000/GRE3 COLLECTED TOPO TO UFF-HVD	2. CNVRTL
3	----- NOT DEMONSTRATED	3.
4	PLOT UFF-HVD OR UFF-XYZ	4. PLOT2021
5	PRINT UFF-HVD OR UFF-XYZ	5. LISTING
6	----- NOT DEMONSTRATED	6.
7	----- NOT DEMONSTRATED	7.
8	EDIT DATA	8.
9	CONVERT DATA FROM UFF-HVD TO UFF-XYZ	9. CNVRTUFF
A	PRINT A FILE	
0	EXIT THE SYSTEM	

Modules activated in the Wisconsin demonstrator.

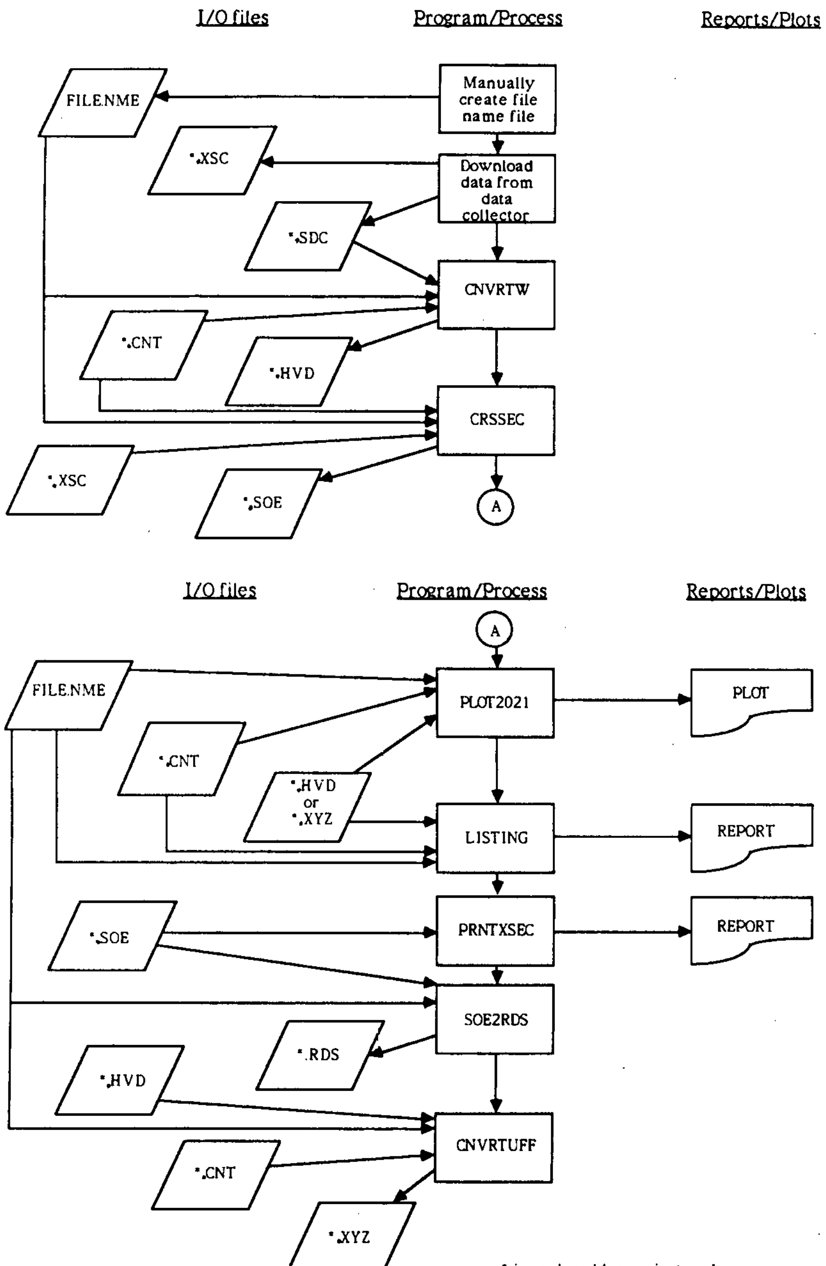
Module	Description	Program Name
1	DOWNLOAD ANY SDC71 FIELD DATA	1.
2	CONVERT SDC71 COLLECTED TOPO TO UFF-HVD	2. CNVRTW
3	CONVERT SDC71 COLLECTED CROSS SECTIONS TO UFF-SOE	3. CRSSEC
4	PLOT UFF-HVD OR UFF-XYZ	4. PLOT2021
5	PRINT UFF-HVD OR UFF-XYZ	5. LISTING
6	PRINT UFF-SOE CROSS SECTIONS	6. PRNTXSEC
7	CONVERT UFF-SOE CROSS SECTIONS TO RDS FORMAT	7. SOE2RDS
8	EDIT DATA	8.
9	CONVERT DATA FROM UFF-HVD TO UFF-XYZ	9. CNVRTUFF
A	PRINT ANY FILE	
0	EXIT THE SYSTEM	

Figure H-2. ISIMS demonstrator modules.



* is replaced by project and sequence number
Refer to Figure H-6 for file descriptions.

Figure H-3. Typical Louisiana demonstrator program execution sequence.



* is replaced by project and sequence number
Refer to Figure H-6 for file descriptions.

Figure H-4. Typical Wisconsin demonstrator program execution sequence.

Program Name	Program Description	Inputs	Outputs
LISTING	Lists the contents of either a UFF-HVD or UFF-XYZ file. For UFF-HVD also calculates and lists appropriate (X,Y,Z) coordinates	1) file name 2) UFF-HVD or UFF-XYZ file 3) project's control file	Listing of the UFF-HVD or UFF-XYZ data
CNVRTUFF	Converts a UFF-HVD file to a UFF-XYZ file	1) file name 2) UFF-HVD file 3) project's control file	UFF-XYZ file
PLOT2021	Reads UFF-HVD or UFF-XYZ and plots points, connecting lines and point numbers	1) file name 2) UFF-HVD or UFF-XYZ file 3) project's control file	Plot
CNVRTL	Reads data in GRE3 format and converts to UFF-HVD	1) file name 2) GRE3 file 3) project's control file 4) feature file	1) UFF-HVD file 2) listing of feature file
CNVRTW	Reads topo data in SDC71 format & converts to UFF-HVD	1) file name 2) SDC71 file 3) project's control file	1) UFF-HVD
CRSSEC	Reads cross-section data in SDC71 format & converts to UFF-SOE	1) file name 2) SDC71 file	1) UFF-SOE
SOE2RDS	Reads UFF-SOE data & converts to RDS format	1) file name 2) UFF-SOE	1) RDS file
PRNTXSEC	Lists the contents of a UFF-SOE file	1) file name 2) UFF-SOE	1) listing of UFF-SOE data
PRNT	Prints any file indicated by the user	1) any file	1) printed listing of file
20-21L.BAS	Louisiana demonstrator driver	-----	name file
20-21W.BAS	Wisconsin demonstrator driver	-----	name file

Figure H-5. Program descriptions.

File	Filename	Purpose
1) File name	FILE.NME	Contains one record with project name, sequence number and date. Project name & sequence number are used as the prefix for file names.
2) UFF-HVD	*.HVD	Contains field data translated into UFF format.
3) Project control file	*.CNT	Contains control points used to establish positioning.
4) Feature file	TAG	Contains user defined features & descriptors.
5) GRE3 data collector file	*.GRE	Contains raw field data from the GRE3 data collector.
6) UFF-XYZ	*.XYZ	Contains processed field data in UFF format with angle and distances replaced by X, Y, and Z coordinates.
7) SDC71 topo data collector file	*.SDC	Contains topo raw field data from the SDC71 data collector.
8) SDC71 cross-section data collector file	*.XSC	Contains cross-section raw field data from the SDC71 data collector.
9) UFF-SOE	*.SOE	Contains cross-section field data translated into UFF.
10)RDS file	*.RDS	Contains processed cross-section data translated into a RDS format.

* Prefix to file name is project name plus sequence number.

Figure H-6. File descriptions.

Variable	Field Description	Type & Size	Comments
PROJ	Name of project	C4	
SEQ	Sequence number	C4	
DATE	Date	C8	MM/DD/YY

Figure H-7. File name file record layout (FILE.NME).

Variable	Field Description	Type & Size	Comments
FNAME	Feature name	C6	
TNUM	Number of descriptor tags	C2	1st character = F or M 2nd character = number
TNAME	Name of descriptor tag	C4	
REQD	Is this descriptor required	C1	"Y" or "N"
DEFLT	Default value for this tag	C4	
TYPE	Type of values	C1	0 = no values 1 = Range (min-max) 2 = distinct numeric values 3 = distinct character values
VALUES	Values for descriptor tags	C4	

Figure H-8. Feature file record layout (TAG.).

The types of positioning in PLOT2021 are limited to SETUP, USETUP, and EFORE POS: commands. The program does not adjust on PADJ: commands.

LISTING.FOR Program

This program lists the contents of either a UFF-HVD or a UFF-XYZ file. If the input is a UFF-HVD file, the program will calculate and list the appropriate X, Y, and Z coordinates.

Inputs to LISTING are the file name file (FILE.NME), the project control file (*.CNT), and either a UFF-HVD or a UFF-XYZ file. The output is a printed listing of the file. Records are listed in five columns across each page. For each H_V_D: record, four additional lines of data are added to show point numbers, X, Y, and Z coordinates.

Positioning in LISTING is limited to the SETUP, USETUP, and EFORE POS: commands. The program does not adjust on the PADJ: command and does not perform error checking.

CNVRTUFF.FOR Program

The purpose of CNVRTUFF is to convert a UFF-HVD file to a UFF-XYZ file. A file in the UFF-XYZ format has all horizontal angles, vertical angles, and distances changed to X, Y, and Z coordinates.

Inputs to CNVRTUFF are the file name file (FILE.NME), the project control file (*.CNT), and a UFF-HVD file. The output of the program is a UFF-XYZ file.

Positioning in CNVRTUFF is limited to the SETUP, USETUP, and EFORE POS: commands. The program does not adjust on PADJ: commands. Currently, there is no grouping of records for the related feature ID, nor does it transpose backwards-collected data into forward.

CNVRTW.FOR Program

This program converts specifically sequenced topo data collected by an SDC71 data collector to UFF-HVD. Converted SDC71 commands are as follows:

SDC71	UFF-HVD	Comments
AC:OS	POS:SETUP	AC:OS is the 1st acceptable command
PN:xxx	OP:xxx	
PD:xxx	BS:rrr	
PN:ppp		Measurement point number of H_V_D command
PD:*xxxx	FEAT:xxxx GEOM:MULTI	The asterisk in 1st position implies a multipoint feature
PD:xxxx	FEAT:xxxx GEOM:SINGLE	
I1:xxxx I2:xxxx I3:xxxx	I1:xxxx I2:xxxx I3:xxxx	Feature descriptors with tags I1, I2, and I3 respectively
A1:START	CR:START CURVE	
A1:STOP	CR:END CURVE	
A2:SKIP	SK:SKIP	
A2:CLOSE	CL:CLOSED	
HZ:aaa	H_V_D:ppp aaa bbb ccc ppp is from the latest PN:	
VT:bbb		
DS:ccc		

Only these SDC71 commands are accepted, with AC:OS being the first acceptable command. The HZ:, VT:, and DS: commands are always input together and are in this sequence.

In this program, only a subset of the UFF-HVD is used. This restricted UFF-HVD has the following characteristics:

Restrictions
1. Only POS:SETUP is used.
2. No Z coordinates.
3. No PADJ: commands.
4. No circles.
5. No related feature ID's.
6. No backwards.

Permissible
1. Curves are acceptable.
2. Single and multipoint features are acceptable.
3. Any feature set and three feature descriptors per feature are allowed.
4. Skip and closure are allowed.
5. H_V_D is the file type.

Inputs to this program are project and sequence numbers plus the SDC71 topo output (*.SDC). The output of this program is UFF-HVD data (*.HVD).

CRSSEC.FOR Program

The purpose of this program is to take cross-section data collected as station, offset, and rod reading on an SDC71 data collector and to turn it into its UFF-SOE data equivalent. Data entry on the SDC71 has been defined to accommodate these functions.

SDC71 input description	SDC71 inputs
1. Benchmark elevation input and corresponding benchmark rod reading	AC:OS ZC: __ AC:BS RR: __
2. Station number input	AC:ST ST: __
3. Offset and rod reading input	AC:SS OF: __ RR: __
4. Adjusting of instrument because of moving the tripod	
a. Foresight to a temporary benchmark	AC:FS
b. Moving of the level and then	RR: __
c. Backsight to the same benchmark	AC:BS RR: __

Figure H-9 shows the proper sequencing of SDC71 records, their description, and acceptable record sequencing.

The UFF-SOE output file consists of all S_O_E: records sorted by station number and offset values. In addition, the first record of the file that is FILE:S_O_E. A FEAT:XSEC and GEOM:MULTI record pair precedes each set of S_O_E: records with the same station number.

The inputs to the CRSSEC.FOR program are project and sequence numbers plus the SDC71 cross-section output (*.XSC). The output of this program is UFF-SOE data (*.SOE).

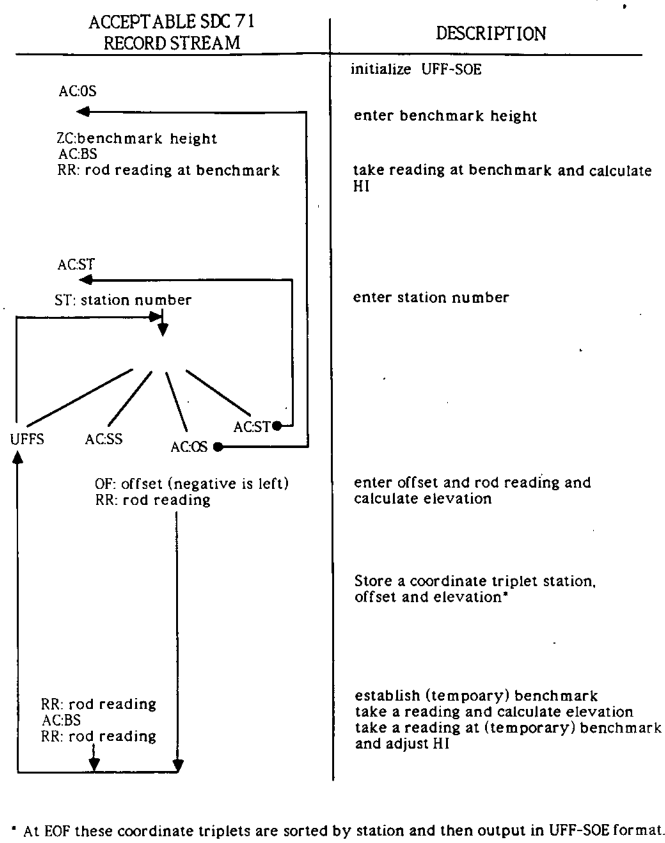


Figure H-9. Program CRSSEC description.

SOE2RDS.FOR Program

This program takes the output of program CRSSEC.FOR (UFF-SOE data), and puts it into a format acceptable for input into RDS. Job control for an IBM mainframe is also part of the output.

In this conversion process, five station/offset combinations are allowed per RDS record, a bias is used relative to elevations, and offsets are termed "R" and "L" (right and left) instead of positive and negative respectively.

Inputs to the program are project and sequence numbers plus the UFF-SOE output of program CRSSEC.FOR (*.SOE). The output of this program is RDS-formatted data including job control (*.RDS).

PRNTXSEC.FOR Program

The purpose of this program is to list the contents of a UFF-SOE file.

Inputs to the program are the name file and a UFF-SOE file. The output is a printed listing of the UFF-SOE file showing records in five columns across each page.

PRNT.FOR Program

This program prints any file indicated by the user. Inputs are from the keyboard and are a file name, and an indication can be given to print extra line feeds. The line feed option should be invoked when the file normally prints over itself or when double spacing is wanted. Output is to the printer. Only the first 127 characters of each record are printed.

20-21L.BAS Demonstrator

This is the Louisiana demonstrator driver. It provides a menu of modules so that the user can easily select and run Louisiana-related demonstrator programs (see Fig. H-2). Appendix G provides guidelines for executing this demonstrator.

20-21W.BAS Demonstrator

This is the Wisconsin demonstrator driver. It provides a menu of modules so that the user can easily select and run Wisconsin-related demonstrator programs (see Fig. H-2). Appendix G provides guidelines for executing this demonstrator.

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