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INTERACTIVE GRAPHICS INTERSECTION DESIGN SYSTEM (IGIDS)

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16. Abstract

The Interactive Graphics Intersection Design System (IGIDS), a software package that operates on personal computers and workstations, has been developed to assist engineers in the analysis and design of isolated, at-grade intersections. This report serves as the project's final summary report.

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Project Summary Report

by

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and
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Research Project 0-1291
Interactive Graphics Intersection Design System (IGIDS)

Conducted for the

TEXAS DEPARTMENT OF TRANSPORTATION

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by the

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January 1998

IMPLEMENTATION RECOMMENDATIONS

Results of this project can be put into immediate use by Texas Department of Transportation (TxDOT) personnel who perform intersection design and improvement tasks. The IGIDS may be utilized by both division and district personnel of the Department, as well as by engineers in other governmental agencies. Although the IGIDS is not a substitute for sound engineering analysis and judgment, it provides engineers with powerful computational and graphical tools that can be used to develop and evaluate feasible alternative solutions to intersection traffic problems and thereby make sound engineering decisions. The authors certify that IGIDS is fully Y2K compliant.

This report was prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

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DISCLAIMERS

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation.

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PROJECT SUMMARY

RESEARCH PROBLEM STATEMENT

Recently completed Research Study 0-1308, "Interactive Graphics Intersection Design System (IGIDS)" (Ref 2), produced computer-aided design software for intersection design, redesign, and modification. At an April 1994 presentation of that project's research results to Texas Department of Transportation (TxDOT) Area 3 Committee, TxDOT members requested that the software incorporate two additional features. These features included: (1) supplement the already provided sight distance checks based on horizontal alignment with vertical-alignment-based sight distance checking, and (2) allow the designer to easily place signs, pavement markings, and signalization layout features into a graphics file that can be plotted from IGIDS or from the TxDOT Automated Plan Preparation System (APP) to automatically generate a current bill-of-materials file as traffic control features are placed.

Because IGIDS has been designed to operate on a variety of hardware platforms, including workstations and personal computers, the software is technically available to most individuals having computing hardware access. At the same time, however, TxDOT should provide user training to ensure that these individuals are realizing the full potential of the software's many capabilities. Such training should be developed and offered as soon as possible. Finally, we should note that IGIDS is Y2K compliant.

BACKGROUND

This research team and TxDOT's Departmental Project Director have (PD) recently completed the initial version of the IGIDS program. The IGIDS software has been designed to facilitate extension and expansion. Significant effort has been devoted to designing and implementing an intricate foundation for an evolving, fully featured IGIDS. The system that has evolved operates upon this foundation, which has been carefully configured to permit the addition of capabilities that will ultimately make the IGIDS an extremely efficient and valuable engineering tool. Previous TxDOT research projects that developed IGIDS at the Center for Transportation Research (CTR) at The University of Texas at Austin included the following:

(1) Project 0-1139 (Ref 1), conducted from September of 1988 to September of 1991. This project undertook the initial design and development of IGIDS using MicroStation Clix Version 4 (Refs 4-6) (Unix only) and the C programming language.

(2) Project 0-1308 (Ref 2), conducted from September 1991 to September 1993. This effort added additional features using MicroStation Clix Version 4 (Refs 4-6) (Unix only) and the C programming language.

(3) Project 0-1308 Extension (Ref 2), conducted from September 1993 to September 1994. This project converted IGIDS to MicroStation DOS Version 4 (Refs 4-6) using the MicroStation Development Language (MDL) programming language (Ref 7).

(4) Current Project 0-1291 (Ref 3), conducted from September of 1995 to September of 1997. This project, as described in this report, added vertical sight distance checking, striping, and traffic inventory reporting. It also developed training material using MicroStation 5 (Refs 8-10) and MicroStation 95 (Refs 13-15) and the MicroStation Development Language (MDL) programming language (Refs 11-12).

Over the past two decades, many computer-aided engineering and design tools (e.g., the Roadway Design System, or RDS) have been developed to handle an ever-increasing share of the computational and graphical work required for highway design. Such tools offer the potential for significant improvement in the efficiency and effectiveness with which engineers' time and expertise can be utilized. These aids, when applied to both routine and complex design tasks, relieve engineers of the burden of computing coordinate geometry, permit visual imaging of proposed geometry, and aid significantly in the timely preparation and revision of plans and specifications.

Although many aspects of highway design are currently handled by RDS, much of the detailed effort required for analyzing, designing, and modifying at-grade intersections is not included. The technology that has been developed through the evolution of RDS, particularly interactive graphics, is now available for application in the design and modification of at-grade intersections.

Intersection design involves not only the geometric, structural, and drainage features of the roadway that are now handled by RDS, but also many traffic operational aspects. Detailed analyses must be made concerning capacity, level of service, delay, channelization, type of traffic control devices, physical siting of traffic control devices, safe approach speeds, emissions, fuel consumption, and other factors before a set of plans can be finalized. While a number of computer aids for evaluating these factors have already been developed, others are still needed. These aids need to be consolidated into a package that can allow easy access by an engineer through an interactive-graphics workstation at the office desk.

The capability of the desktop workstation has now reached a level such that many intersection analysis and design tasks can be performed quite efficiently by engineers equipped with appropriate software and relatively inexpensive computer hardware. Communications technology is also available to permit reliable, low-cost transfer of design files from micro to micro and, when design tasks dictate the need for more extensive computing power, to main-frame computers.

It is also feasible to develop computer software that permits interactive graphical presentation of all important aspects of at-grade intersection design on a variety of computer hardware configurations. Interchangeability of software components and design files among

these hardware systems will provide a very flexible and efficient working environment for design engineers involved in intersection design and modification.

OBJECTIVES

The primary objectives of Project 0-1291 were (1) to incorporate two functional features to the Interactive Graphics Intersection Design System (IGIDS); and (2) to develop appropriate training resources that can acquaint potential users with IGIDS and its capabilities. Explicit objectives included the following:

1. Add a feature to IGIDS that will permit vertical-alignment-based sight distance checking.
2. Add to IGIDS a capability allowing users to graphically place signs, signals, and pavement markings that are captured into a graphics file that can be plotted from IGIDS or TxDOT's Automated Plan Preparation System (APP).
3. Generate a current bill-of-materials file as traffic control features are graphically placed by a user.
4. Develop concepts and materials for IGIDS-user training course(s).

IMPLEMENTATION

Results of this project can be put into immediate use by Texas Department of Transportation (TxDOT) personnel who perform intersection design and improvement tasks. IGIDS may be utilized by both division and district personnel, as well as by engineers in other governmental agencies. Although IGIDS is not a substitute for sound engineering analysis and judgment, it nonetheless provides engineers with powerful computational and graphical tools that can be used to develop and evaluate feasible alternative solutions to intersection traffic problems.

BENEFITS

Effectiveness and efficiency of intersection geometry, traffic control, signage, and channelization are of growing importance to all traffic engineering agencies within the state of Texas. User costs associated with traffic delays and their concomitant fuel consumption and auto emissions are directly related to intersection operations.

The additional IGIDS features developed in this research project can help ensure appropriateness and efficiency of intersection design and improvement programs. The IGIDS training resources resulting from the research will also instruct potential users on how best to employ the software's many features.

IGIDS DEVELOPMENT

METRICATION

The first task undertaken in this project was the metrication of IGIDS. It was decided that IGIDS should work in either English units or in metric (SI) units. After a project is started in IGIDS, the units cannot be changed. During startup, IGIDS tests the MicroStation master unit character description for the design file. If the units cannot be determined, an IGIDS Units Definition dialog box is displayed so the user can choose either English or metric units.

All calculations within IGIDS were evaluated to determine whether English units were involved. Where appropriate, the equivalent metric design value was given as an alternative. In other cases, the English unit value was converted to metric. Some dialog boxes include both English units and metric units in the name (e.g., vehicle type for vehicle turn templates and a width for striping). This version of IGIDS was made available to TxDOT when the metrication process was completed.

VERTICAL-ALIGNMENT-BASED SIGHT DISTANCE CHECKING

IGIDS commands were renamed and added to accommodate vertical-alignment-based sight distance checking. IGIDS horizontal sight distance calculations are performed for no control, stop sign controlled, and yield sign controlled lanes. The distance from the conflict point within the intersection to the front bumper position of the car on the inbound lane and to the car on the conflicting leg is calculated based on the speeds specified and on the procedures in *A Policy on Geometric Design of Highways and Streets 1990* (Ref 27) and in *A Policy on Geometric Design of Highways and Streets 1994* (Ref 28). The vertical sight distance calculations use the same procedures to determine the 2D horizontal sight triangle and to then check for sight obstructions within the 2-D horizontal sight triangle from the driver's 3-D eye position to the object's 3-D position as the object moves toward the stop line of the conflicting path.

The IGIDS was originally designed using 2-D. The coordinates of a point were represented by the x and y coordinates of the point. To implement vertical sight distance checking, the elevation of a point needs to be input or calculated. The goal was to minimize the input required from the user while providing at the same time a reasonably accurate definition for elevation. Since the intersection of two paths in the intersection is at a single point, the elevation of that single point would be the same. The legs of an intersection are generally planar near the intersection such that a single elevation point somewhere on the leg centerline plus the grade information could specify the longitudinal elevation while the cross slope could define the transverse elevation of the points along a leg. This technique would allow each leg to have independent grade information and would allow the user to easily change the elevation information without changing the 2-D plan coordinates. The sight line

spacing is the 2-D distance between points along the conflicting path from the object's initial position to the stop line. In addition, the user may input the driver's eye height and the object height. Also, the traffic control cabinet sometimes represents a significant sight obstruction; therefore, the user may enter the elevation of the top of the traffic control cabinet. The sides of the traffic control cabinet are extended to the terrain so that a driver's view is blocked under the traffic control cabinet.

The other major consideration for vertical sight distance calculations was the representation of the ground terrain and other elevation features. Virtually all Digital Terrain Model (DTM) programs, including GEOPAK (Ref 32), have the capability to produce a triangle file that represents the 3-D terrain. This triangle file is a 3-D file containing 3-D triangles where the x, y, and z coordinate of each vertice of the triangle is specified. The ground terrain and other elevation features, such as buildings, may be represented by the DTM. It is up to the user to create the triangle file with their DTM package to represent all terrain and man-made features that may restrict vertical sight distance. The user may attach the triangle file as a reference file to the IGIDS file.

To perform the vertical sight distance checks, a 3-D line is drawn from the driver's eye position, using the driver's leg's station, elevation, grade, cross slope, and driver eye height, to the object's position, using the object's leg's station, elevation, grade, cross slope, and object height. The 3-D line is checked against all triangles, terrain, and traffic control cabinet, to determine the position closest the driver's eye position where the 3-D line goes under the terrain traversing from the driver's eye position, to the object's position and the position closest the object's position where the 3-D line goes under the terrain traversing from the object's position to the driver's eye position. If the 3-D line does go under the terrain, it is considered an obstructed line; otherwise it is considered an unobstructed line. The obstructed lines may have a color different from the unobstructed lines. In addition, the portion of the obstructed line from the driver's eye position to the position closest the driver's eye position where the 3-D line goes under the terrain is referred to as the "line before obstruction;" the portion of the obstructed line from the position closest the driver's eye position where the 3-D line goes under the terrain to the position closest the object's position where the 3-D line goes under the terrain is referred to as the "line through obstruction;" and the portion of the obstructed line from the position closest the object's position where the 3-D line goes under the terrain to the object's position is referred to as the "line behind obstruction." No attempt is made to determine whether the line through the obstruction is visible at any time between its beginning and ending point. The line before obstruction, the line through obstruction, and the line behind obstruction may each have a different color and may be displayed or not displayed. The traffic control cabinet may also have a different color and may be displayed or not displayed. The position of the object is moved from its initial position toward the stop line for the lane by an amount specified by the user as "Sight Line Spacing;" the checking process is then performed again. The procedure ends when the position of the object is beyond the stop line for its lane.

TRAFFIC CONTROL DEVICE PLACEMENT

IGIDS commands were added to accommodate striping and traffic inventory reporting. IGIDS provides for the placement and bill-of-materials for the following traffic control devices: yield sign, stop sign, 3 lens signal head, 3 lens protected left signal head, left turn channelization arrow, straight movement channelization arrow, right turn channelization arrow, U-turn channelization arrow, pretimed controller, NEMA controller, solid line striping, broken line striping, dotted line striping, lane drop striping, no passing inbound striping, no passing outbound striping, double solid line striping, and double broken line striping. IGIDS adds graphics to the database and to the graphics file for each type of traffic control device. The graphics are stored on the level for traffic control and thus may be displayed or not displayed. IGIDS provides for the placement, modification, and deletion of striping. The Type of Striping may be (1) solid line, (2) broken line, (3) dotted line, (4) lane drop, (5) no passing inbound, (6) no passing outbound, (7) double solid line, or (8) double broken line. The Width (in/mm) may be (1) 4/100, (2) 6/150, (3) 8/200, (4) 12/300, (5) 18/450, or (6) 24/600. The Color may be (1) White or (2) Yellow. The Shift is a value in decimal master units that defines the distance from the start of the reference object to the start of the solid portion of the stripe in the longitudinal direction. This does not affect the length of the solid portion of the stripe but offers an offset for the start of the pattern. The Reference Object Type may be (1) IGIDS Seg (a single IGIDS segment), (2) IGIDS Edge (all IGIDS segments making up an edge such as leg centerline, leg inner edge [median] curb return, leg outer edge [curb] curb return, lane inner edge, lane outer edge, or lane stop line), or (3) scratch seg (any graphics drawn by MicroStation on the scratch level). The Mode may be (1) Place, (2) Modify Attributes, or (3) Delete. When in Place Mode, the Type of Striping, Width (in/mm), Color, Shift, and the Reference Object Type may be specified. Selecting and confirming a Reference Object Type will cause IGIDS to (1) prompt for the trim length from the start of the reference object (the default will be 0, which means to start at the beginning of the reference object), (2) prompt for the stripe length (the default will be the length of the reference object minus the trim length), and (3) copy the reference object to IGIDS and apply the current attribute settings. When in Modify Attributes Mode, the Type of Striping, Width (in/mm), Color, and Shift may be specified while the Reference Object Type is dimmed and not selectable. The attributes of the selected stripe will be modified to the current values selected. When in the Delete Mode, the Type of Striping, Width (in/mm), Color, Shift, and the Reference Object are all dimmed and not selectable. The selected stripe will be deleted with confirmation. Striping uses MicroStation custom line styles, which are available only in MicroStation Version 5.0 and higher. Custom line styles were developed for each striping type, unit of measurement, and width. The stripe dimensions defined in the *1980 Texas Manual on Uniform Traffic Control Devices for Streets and Highways* with Revision 6, 1996 (Ref 29), were used to create the custom line styles and to define the allowable combinations of striping type, width, and color. The file "igids_ls.rsc" contains the IGIDS custom line style definitions. For inventory purposes, the number of signs, signal heads, channelization

arrows, and controllers is determined while the linear meters or feet of striping of a certain type, width, and color are calculated. The traffic inventory may be a report suitable for printing or a spreadsheet-compatible input file that may be imported into most popular spreadsheet programs (including Microsoft Excel).

TRAINING

An IGIDS Training Manual was developed in printed form, using Microsoft Word, and in HTML, the programming language of the World Wide Web (www). A Microsoft PowerPoint presentation was also developed that follows the "Overview" chapter of the IGIDS Training Manual. The IGIDS Training Manual, in printed or HTML form, may be used in a self-paced individual instruction mode or by a live instructor in a classroom mode. The IGIDS Training Manual consists of three major parts. The first part contains an overview of IGIDS that reviews IGIDS concepts and terminology. The second part, an "Introduction to MicroStation 95," reviews the pertinent MicroStation 95 commands necessary to operate IGIDS and includes a simple MicroStation exercise. The third part contains ten progressively complex exercises that illustrate most functions within IGIDS. Each exercise is scripted in detail so the student knows exactly what is expected. For the student that gains experience quickly, the key commands and user entries are emphasized in bold type. The overview should be read before a formal class begins. The "Introduction to MicroStation 95" and the "Simple Example" must be completed first and in order, since other exercises use files developed during the initial exercises. The training should take approximately two 8-hour days. Numerous screen captures are incorporated and a plot of the final form is provided.

HIGHWAY CAPACITY MANUAL CHAPTER 9 ANALYSIS

At the request of the TxDOT project director, the IGIDS *Highway Capacity Manual* (HCM) Chapter 9 Analysis was updated to the procedures defined in the 1994 *Highway Capacity Manual Special Report 209* (Ref 30). In addition to updating the procedures, a dialog box was developed for HCM Chapter 9 Analysis which allows the user to select numerous options; a Peak Hour Factor option was also added to the turn movement count dialog box. Finally, the SOAP capacity calculations were adapted to use the new HCM procedures.

OTHER FEATURES

A standard MicroStation 95 file name entry dialog box is now used each place where the user is prompted to enter a file name for reading or writing. This gives the user the ability to browse the computer system to locate the device, directory, and file name to be used.

Because the traffic controller timing data entry was complicated and time consuming, a dialog box was developed for the pretimed and NEMA traffic controllers. Phases can be added, resequenced, and deleted, and timing values can be applied to all phases or to a single phase. For the pretimed controller, phase lengths are automatically calculated. For the

NEMA traffic controller, the single ring or dual ring mode of operation may be selected, controller options can be specified for all phases or a single phase, and the dual entry phase option is selectable when in dual ring mode of operation and dimmed when in single ring mode of operation.

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