Using GIS in a Large-Scale Transportation Planning Project

Peter E. Harmet P.E. and Lisa J. Sagami P.E.

Abstract

CH2M HILL Inc. is working with the Illinois Department of Transportation (IDOT) to conduct a transportation planning study referred to as the Elgin O'Hare - West Bypass Project. The study, will identify transportation needs, evaluate a full range of multimodal transportation improvement strategies and provide an Environmental Impact Statement (EIS) to comply with the National Environmental Policy Act (NEPA). To facilitate this effort, the Environmental Systems Research Institute's (ESRI) ArcGIS products will and have played a significant role in the process thus far. The strength of using a Geographic Information System (GIS) in a large-scale transportation planning study lies in its versatility and ease of use for both the GIS and non-GIS user. The advantage of using this technology became evident due to the scope of the project, the accelerated schedule, multitude of stakeholders involved and the initiative to develop context sensitive solutions. This paper will discuss how GIS has been used in the development and execution of a large-scale multimodal transportation planning study.

Background

Illinois Department of Transportation

The Illinois Department of Transportation is committed to meeting its multimodal needs by building and maintaining Illinois' extensive transportation network. Illinois has the third largest roadway network overall in the nation with approximately 140,000 miles of highways, streets and roads, and more than 26,400 bridges carrying nearly 300 million vehicle-miles of travel daily throughout Illinois.

CH2M Hill Inc.

CH2M HILL Inc. was contracted with IDOT in 2007 to conduct the Elgin O'Hare – West Bypass Project. CH2M Hill is a multi-discipline full-service engineering consulting firm that provides expert knowledge in planning, engineering, economics, environmental sciences and construction for complex transportation projects.

Elgin O'Hare – West Bypass Project

The Elgin-O'Hare – West Bypass project is a study that is evaluating multi-billion dollar multimodal transportation needs and system alternatives within a study area located in northeast Illinois. The study area is home to more than 500,000 persons and 500,000 jobs in the six-county Chicago metropolitan region. The transportation infrastructure in the study area includes five intersecting interstate highways, hundred of miles of urban arterial roadways, one of the nation's busiest airports, bicycle/pedestrian facilities, and freight rail and freight distribution centers. The area is densely developed with a mix of residential, commercial and industrial land uses.

Exhibit 1 Study Area

In 2005, the Safe and Accountable, Flexible, Efficiency, Transportation Equity Act: A Legacy for Users (SAFETEA-LU) was signed into law. The SAFETEA-LU promotes more efficient and effective Federal surface transportation programs by focusing on transportation issues of national significance, while giving State and local transportation decision makers more flexibility of solving transportation problems in their communities. The Elgin O'Hare – West Bypass project, which is identified as a project of Regional and National Significance, received SAFETEA-LU funding.

The National Environmental Policy Act (NEPA) requires federal agencies to incorporate environmental considerations in their planning and decision-making through a systematic interdisciplinary approach. IDOT and the FHWA are co-lead agencies and are responsible for complying with the requirements of NEPA. The scope of the Elgin O'Hare – West Bypass project will require an Environmental Impact Statement (EIS) which is a detailed analysis of the environmental impacts and project alternatives.

The study is advancing in two phases or Tiers that build upon one another. The first phase (Tier One) of the project consisted of a planning process that included an examination of the transportation needs, evaluation of transportation system alternatives at a broad system planning level. Tier One concluded with the identification of a Preferred Multimodal System Concept Plan complimented by an Environmental Impact Statement (EIS) and a Record of Decision supporting the findings. In Tier Two, currently in progress, additional environmental studies will complete the NEPA process and the transportation system alternative will be further refined to a engineering level of detail which will be the basis for contract plan preparation and full ROW acquisition. During both Tiers, IDOT and the project team has and will engage stakeholders to build a consensus on every major issue.

IDOT is applying a Context Sensitive Solutions (CSS) approach when working with communities within the traditional project development process. They are moving beyond the typical "public involvement" approach to create new collaborative partnerships with stakeholder groups. The CSS approach for this project will develop, build and maintain cost effective transportation solutions which fit into and reflect the project's surroundings, its "context". Through early, frequent and meaningful communication with stakeholders and a flexible and creative approach to design, the resulting project goal is to propose a system of transportation solutions that will improve the quality of life for surrounding communities and to sustain the region's future economic health and growth while seeking to preserve and enhance the scenic, historic and natural qualities of the setting through which it passes.

Schedule

A schedule that takes gradual steps and sincerely reaches out to stakeholder ideas and input was needed to develop trusting community relationships and to build consensus. IDOT chose a Tiered EIS process for this study which is the first Illinois highway project to use a tiered approach. Accordingly, a quick paced two-year process to develop broader answers of what are and where are the elements of the transportation solution within the project study area was initiated during Tier One. Once a transportation planning decision was made, the process then focused on the engineering details of the Preferred Alternative in Tier Two.

Three events occurred that influenced the project during Tier One: first, there was a heightened interest to enhance access to a new West Terminal at O'Hare International Airport that is part of the airport's Modernization Plan. Second, fallout from the financial meltdown of 2008 hit the region hard resulting in a depressed job forecast and stressed public budgets. However, the project was seen as a mechanism to create and revitalize the local economy and to retain and expand the job base for the region which is currently the second largest concentration of jobs in Illinois. In the third event, the project and the airport's modernization plan offered opportunities for land-use enhancements such supporting regional Transit Oriented Development in neighboring communities.

The Role of GIS

From the beginning, the project team believed that the success of the project hinged on the ability to develop an effective well-balanced transportation solution which reflects the perspectives and goals of a diverse group with many interests. The blend of complexities, diverging views and goals for the region required an approach that, in itself, was unique.

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The CH2M Hill project team proposed an approach rooted in the principles of integrated system planning and context sensitive design. Project execution would rely on the innovative use of technology tools that provide decision makers and stakeholders with the right information to support the decisions made.

A challenging part of the project was determining what tools were needed to address the well defined needs of the project. A technology tool to answer questions and solve problems by looking at data in a way that was quickly understood and easily shared was needed. More specifically, a tool was sought that would:

- **Handle large amounts of information**
- **Make complex issues easy to understand**
- **Operate in a framework in a relatively short period of time 24-36 months**
- **Provide an innovative means to develop alternatives and engage stakeholders**
- **Provide an efficient means to test alternatives logically and defensively**

GIS was chosen as that tool; it proved a good fit for the project because it is a computer-based technology that could manage change and could quickly run multiple scenarios and options efficiently. The appeal of using GIS stemmed from its ability to handle great quantities of information while providing a powerful arsenal of analytic tools to explore, understand, and visualize the problems that plague the study area that is over 127 square miles.

However, the true success of GIS in this project was not in the application of its use but in the ability to extract and communicate meaningful information from the data. This step should not be taken lightly but should be tasked only to those who have both the analytical skills needed to structure the data and to those that have expert knowledge in interpreting what the data means. Too often, those tasked lack one or both skill sets. What often results, is either the wrong data is provided which does not answer the questions asked or the right data is provided but the wrong conclusion are drawn. In the Elgin O'Hare – West Bypass Project, the CH2M Hill project team possessed both skill sets. What resulted was a recommendation of a system of transportation solutions that address the questions asked, was quickly understood and easily shared.

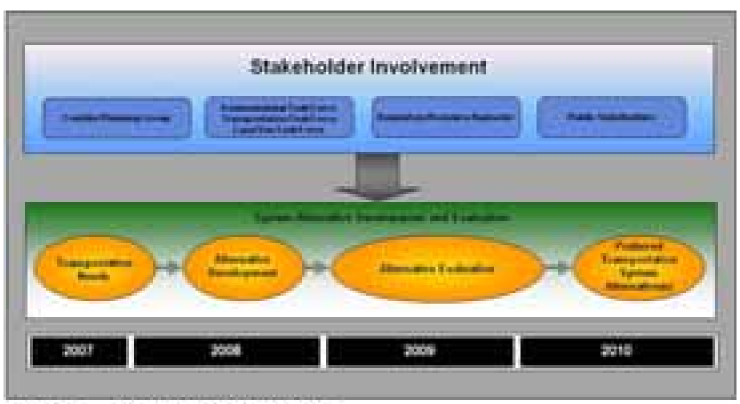

Exhibit 2 Tier One Planning Process

The Tier One Planning Process was broken down into four phases. Each phase used GIS data in a way different than the other. What resulted was a versatile and robust database that provided a variety of ways to explore and extract data needed to make the decisions sought as well as a means to visualize and share information with the project team, transportation agencies, and stakeholders who are both familiar with GIS data and those who are not.

The following are examples of how GIS was used during each of the four phases of the Tier One Planning Process.

Alternatives Development

An early step in the project development was identifying transportation problems within the study area in order to generate the Purpose and Need statement. This step was fundamental for the overall alternative study process; it provided the framework for developing alternatives that would address the identified transportation problems plaguing the area and the Purpose and Need Statement was required to comply with NEPA project development procedures. Transportation problems were identified in a two-part approach. First, extensive stakeholder coordination activities began with an exercise where stakeholders identified transportation problems and identified its location based on their familiarity with the study area or their day-to-day activities relating to traffic patterns and travel behavior.

Stakeholder input was solicited with one-on-one meetings, written audit questionnaires; and a public meeting forum where stakeholders were invited to comment on locations and a range of transportation problems that were observed, reported or experienced. During this activity event, stakeholders wrote the transportation problem or constraints on a post-it note and placed it on a large study area exhibit. By the meetings end, the large study area exhibits were covered with post-it notes. From the exercise, the project team extracted spatial features and associated attributes such as a descriptor of the issue or constraint, as well as any stakeholder's problem definition comment written on the post-it note to a project-specific GIS database then prioritized stakeholder concerns.

Exhibit 3 Transportation Issues/Problems Activity Event

A Travel Demand Model was used to support a technical analysis of the travel issues/problems. The purpose and need statement was then formulated from analyzing and interpreting the Travel Demand Model results which fit well with stakeholder concerns cited. Consequently, the Purpose and Need Statement not only identified the objectives and goals for the project but it provided the framework for developing alternatives that would address the identified transportation problems plaguing the area.

The development of the alternatives, based on technical analysis, stakeholder input and environmental constraints, were developed to optimize travel distribution and flow throughout the transportation system. Given the nature of transportation issues in the study area, it was concluded that no single improvement or travel mode would address the diverse transportation needs in the area. Rather, a comprehensive system of improvements to roadway and transit networks, coupled with effective operating and travel demand management strategies were needed.

Exhibit 4 Modal Strategies

As a first step in developing alternatives to address the project's key transportation issues, another stakeholder activity event was held. Given the broad range of transportation improvements available, the size and complexity of the study area, stakeholders were asked to identify the type of improvement that would best solve the transportation problems in the area and to identify its location on large exhibits of the study area.

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The improvement type and location identified by stakeholders were then translated to a GIS database. What resulted, were a collection of modal strategies which consisted of improvements to roadways, transit, bicycle/pedestrian facilities and freight services, as well as various operating and demand management strategies. From a trend analysis, it was determined that the modal strategies consisted of three elements to address the complex transportation issues in the study area; 1) improve capacity and travel service along major transportation corridors; 2) construct new regional roadway and transit corridors in order to complete linkages in the area's major roadway and transit systems, and 3) construct both new roadway and transit corridors and improve capacity and travel service on existing facilities.

The modal strategies and improvement locations identified served as a foundation for advancing the development of system strategies. As a result, fifteen initial roadway system strategies started to take shape using ESRI's Arcview software. They were developed through an iterative process that integrated stakeholder input, technical considerations, and CSS design principles. First, corridors and their connections to existing major roadway facilities were identified. Attributes were added such as number of lanes, improvement limits and improvement type. The initial roadway system strategies which progressed to roadway system alternatives were designed at a conceptual level of detail to establish a representative layout and to allow a comparative evaluation of the alternatives.

Exhibit 5 Initial Roadway System Strategies

Through an iterative step the alternatives were refined and evaluated based on travel performance and environmental, socioeconomic/land use and financial criteria to compare and differentiate the performance of each alternative. The roadway system strategies were screened from fifteen alternatives to ten based on the ability to address the Purpose and Need statement, from ten alternatives to seven based on disproportionate environmental impacts, and seven to two and two to the selection of the Preferred Roadway System Alternatives based on stakeholder input, travel performance and financial, environmental, socioeconomic/land use criteria.


Exhibit 6 Evaluation and Screening

Transit improvements were also considered on a parallel track in the development of the comprehensive transportation solution for the study area. A total of fifteen transit improvements were incorporated into the Preferred Transit System Alternative which was a mix of light rail, commuter rail, bus rapid transit, arterial rapid transit, express bus, local bus, and local circulators.

In addition, the comprehensive transportation solution included a complementary set of bicycle/pedestrian system improvements as a means to enhance modal opportunities by improving connections between transit stations, park and ride facilities, community activity centers, regional trail systems and employment areas.

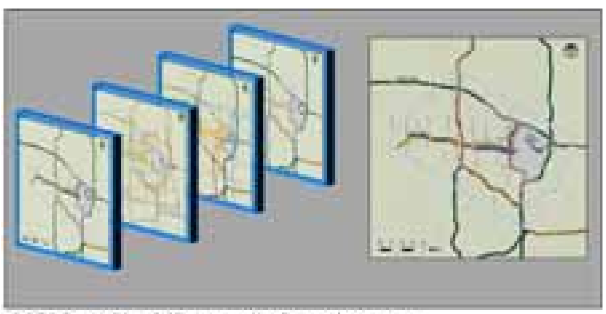
Exhibit 7 Multimodal Transportation System Components

By the end of Tier One, a multimodal system of transportation solutions was developed. Throughout the Alternative Development process using GIS proved to be an efficient means to develop and test alternatives and was invaluable in conveying a message and telling the story.

Travel Demand Modeling

GIS was also used as a decision-support tool in Travel Demand Modeling. The approach took full advantage of the existence and capabilities of the region's Planning Agency, known as the Chicago Metropolitan Agency for Planning (CMAP), and the agency's Travel Demand Model to develop a sub-model specifically for the project study area. The intent of the Travel Demand Model was to help better understand travel patterns and origin-destination trip exchanges within the area and to evaluate multimodal traffic movements for the project.

The basic modeling platform for all model operations was TransCAD software. TransCAD was chosen because of its superior data and database management capabilities, its GIS interface, and tools provided to speed and facilitate development of the model. The basic network inputs for the model came from two sources; the first and basic source is the master highway network maintained in an ArcGIS environment. This was used to provide spatial and attribute definition for the majority of the regional transportation network and specifically in the project study area. Specific time period links in the 2007 base year transportation network were identified and flagged using time period attributes in the master highway network. Changes and additions needed to represent future transportation networks were derived in a similar fashion and supplemented by updates from the CMAP Transportation Improvement Program database.

The model was robust in that it provided distinctive modeling and simulation tools that were applied to "if-then" or "what-if" scenarios. The challenge to this task was in the interpretation of the data. Because the transportation system is dynamic, an understanding of the environment, travel behavior and expertise in the nuances of the Travel Demand Modeling was needed to find, extract and interpret trends and tendencies from the Travel Demand Model results.

The results of the Travel Demand Model and the ability of GIS to illustrate and provided quantifiable results proved beneficial in validating or not validating what occurs as one travels in, out and through the area to support the decisions made.

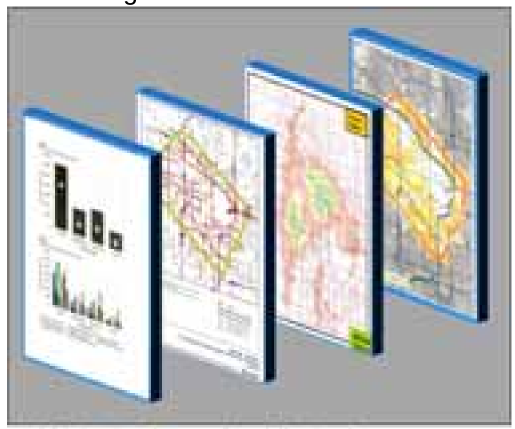

Exhibit 8 Travel Demand Modeling Results

Environmental Analysis

Because the project is being conducted pursuant to the National Environmental Policy Act (NEPA) regulations and both the Federal Highway Administration (FHWA) and IDOT agreed to conduct the study in two tiers, the level of detail and the timeframes associated with the project must meet NEPA requirements for a two-step tiered process. This process allowed a system-level study that included a macro-level engineering and environmental analysis performed under Tier One with the traditional level of detail studies conducted as part of Tier Two project development.

As part of the process, each of the environmental resource issues pertaining to transportation system improvements were evaluated for potential impacts. A GIS database served as the key tool for estimating and comparing direct impacts located within the boundary of preliminary construction footprints developed for each alternative. Indirect impacts to environmental resources located outside the preliminary construction footprint were evaluated based on their proximity to the footprint on a case-by-case basis. Using GIS allowed the assessment of the environmental effects of many alternatives, spread over a large study area, to an equal level of detail. Evaluation considerations include federal/state regulated resources, displacements and community resources. The challenge of this task was conducting the analysis for a study area that is over 127 square miles. In view of that, the GIS database contained over 130 data layers such as wetlands, floodplains, threatened and endangered species, buildings structures, parcel boundaries, special waste sites, land use, greenways, parklands and forest preserves to name a few. Local agency data was supplemented by project-specific data. For example, building displacements were identified by first digitizing the building footprints from aerial photography. All structures were then field

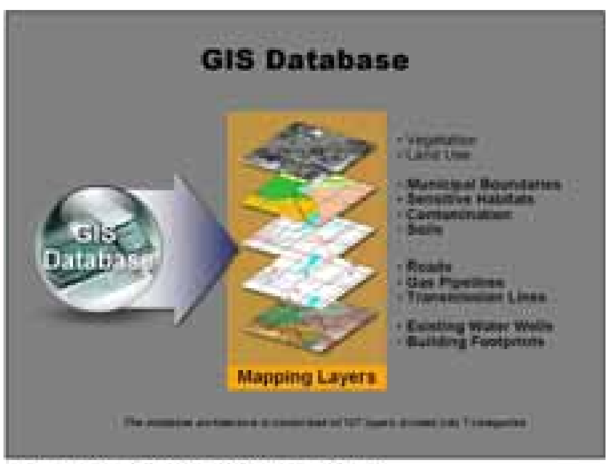

Exhibit 9 GIS Database Architecture

verified for ancillary structures such as garages or sheds. Boundaries and attribute information such as building classification, number of employees, and number of business within the building were added to the GIS database. Interpretation of the data was critical when determining impacts on properties, structures and to employees. As noted previously, working with data should be tasked only to those who have both the analytical skills needed to structure the data and are knowledgeable with interpreting what the data means. In view of that, the project team implemented a two-step process: screen using GIS overlay analyses and verify the results with professional interpretation of data. For IDOT this step proved beneficial; what can take 7-8 years to complete an EIS was accomplished in 2½ years as well as IDOT receiving a “Lack of Objection” rating from the USEPA.

Public Outreach

The Elgin O’Hare – West Bypass Project required an extraordinary and sustained public involvement program that formed a fundamental and collaborative partnership between IDOT and stakeholders that continued through the project development. Because IDOT was committed to applying a Context Sensitive approach to this project, flexibility in project development/design and public trust was imperative in order to make headways in reaching a consensus.

This project was stakeholder driven, outreach events allowed stakeholders a means to actively participate in the process and take ownership or pride in their role in developing the system of transportation solutions. Using GIS as a communication and collaboration tool integrated technology into the process; it assembled and shared information in a way that the project team, external stakeholders needed to make informed decisions.

One interesting observations occurred during an outreach event when stakeholders were asked to identify where and what type of improvements should be implemented on large study area exhibits. At their disposal was an arsenal of information in the form of exhibits, tables, even an ArcReader application that housed attribute information on existing transportation facilities within the study area. However, the stakeholders were drawn to the large maps and often times ignored other information provided even if it contained valuable information; thus, reinforcing the value and versatility of using an information system to model and share spatial information.

Exhibit 10 Public Outreach Effort

However, the challenge of this task was the shear quantity of information that was relayed to stakeholders, local agencies, media and citizen’s groups. As a result, the GIS Public Outreach effort was almost a full-time task but resulted in many satisfying Public Outreach moments for IDOT during the project. Among them are stakeholder interests that had evolved from diverse interests to a unified objective. Others include stakeholders demanding to be heard in a positive and constructive way, and to get their point across over 900 people attended a Public Meeting and submitted more than 30,000 comments stating a preference for a particular alternative.

Future

At the conclusion of Tier One, Tier Two will commence. During this phase the project team will address the issues that are now ripe for consideration; this will include the detailed engineering layout, environmental mitigation requirements, construction sequencing, and financing strategies. Tier Two will be largely completed by the end of 2012 and will set the stage for the preparation of the final design and construction documents.

The actual implementation of the project, like the planning process, will likely bring together diverse funding organizations that may further brand the uniqueness of this project. The challenge of this phase will be integrating the detailed level of design from independent projects into the process, sharing information with the stakeholder yet tempering the effort so that information overload does not occur.

Lessons Learned

After the completion of Tier One, the GIS goals of the project were revisited to gage its success in the execution of the planning process.

- **Was the tool able to handle the amount of information required?**
- **Were complex issues successfully communicated?**
- **Did spatial analytics produce results that were logical and defensible?**
- **Did the tool engage stakeholder in active participation in the public process to identify a system of transportation solutions?**

For the most part the answers to these questions were yes but with any project, problems will be encountered; it is part of the process. Fortunately, none of the problems encountered were detrimental to the fate of the project.

First, the project was plagued with the usual data needs problems such as locating relevant sources of data in a timely manner, working with obsolete data before project closeout thus requiring data updates, overcoming the release of data dilemma and the usual availability of data for the project scale. However, the project team persevered and worked through these problems, manually filling in data gaps, “made due with the data that was available” or “brainstormed work-arounds.”

However, not seeing the big picture was one of the more severe problems encountered. Because the project area is so expansive and unique it required experts from various fields to develop the comprehensive transportation solutions. Accordingly, many were so focused on their own particular area of interest they failed to see the “bigger picture”; in essence, operated as if blinders were on. However, this should not be considered an error on their part but it is more likely attributed to being unfamiliar with working on a large-scale planning project. Hence, evidence of conflict was observed. For example, in order to create a workable GIS database the needs of the Environmental Team differed from the needs of the Travel Demand Modeling or the Public Outreach group. To many, it looked as though we had either redundant or extraneous data which to many was confusing and distractive when it was more a lack of understanding the “big picture” and being accustomed to working on smaller-scale projects. Looking back, what was required was better communication so that everyone understood the “bigger picture” as well as the understanding of each area’s particular data needs.

The second problem dealt with those who are involved with design detail; there was a mindset that if the exhibits are simple then it will be ineffective in carrying a message because it is too unrealistic. In many ways this is true but the intent is the gradually expose stakeholder, who may not be familiar with engineering design, to the intricacies of the design detail, to prevent information overload and to use GIS exhibits for as long as possible thus buying time to develop, with limited interruption, the design detail.

Finally, in no manner is the use of GIS more intertwined and prevalent than with the Public Outreach effort. Although use of GIS was successful there was discord which is often experienced with large-scale planning projects. In the event that this might occur, a workflow was set up early in the project in order to provide the support required to handle a project of this size with the limited resources available. Whenever, exhibits were requested those tasked were specifically instructed to consider the request a “typical request”, ask only pertinent information needed to complete the task - what, where, when and how many. Comments on any requests or any revisions were not to be editorialized but completed with no fanfare or delay – “get it done and move on”. If the discord was still present it was likely not due to the quality of work. Often, as is the case, the source is rooted with the interdependence of one effort with the other and the difficulty in acknowledging it.

Summary

One of keys to the project’s success was implementing GIS into the planning process and much of the success of using GIS in the Elgin O’Hare – West Bypass project was attributed strong IDOT leadership who pushed for a new way to deliver transportation planning projects and who recognized GIS as a vital technology tool and orchestrated a sound strategy for its use. In doing so, IDOT was well rewarded when the project outcomes exceeded their expectations in a number of areas including:

- **Successfully identified Travel bottleneck locations and traffic generators, modeled solutions and measured benefits**
- **The environmental impact analysis and the document known as the Environmental Impact Statement was approved and signed six months ahead of schedule.**
- **Successfully engaged Stakeholders with details of the project process as evident by the receipt of over 30,000 comments in favor of one alternative over others.**
- **Received consensus and support for a multi-billion dollar multimodal transportation plan comprised of highway, transit, and non-motorized improvements.**

There was also clear evidence that employing GIS in the process was the right choice:

- **GIS proved to be the right technology tool because it provided decision makers and stakeholders with the right information to support decisions**
- **The versatility of using a GIS as a technology tool grew as stakeholders became more familiar with its capabilities**
- **GIS facilitates the development of project specific databases that support transportation, environmental and community analytics**
- **GIS was a reliable tool that provided quantitative results that were logical, objective and defensible**

A number of conclusions emerge from review of using GIS in this project. GIS communicates spatial information in a manner similar to the way our brain process information and if used correctly, it can illicit a profound impact on the way decisions are made. GIS provides not only spatial information but it provides context so that the connections or relationships between different types information are processed with such clarity that the decisions that must be made are easily deduced and the conclusions are, often times, obvious. The key to telling any “story” is context and from the success of the Elgin O’Hare – West Bypass Project, GIS has proven to be one of the best technology tools out there; using GIS in this project injected needed “context” to the story told and for the decisions made. The system allows a virtually unlimited amount of information to be linked to locations on earth. It is limited only by the quality of data and the expertise of those who analyze and extract its information and interpret its relevance in context to its surroundings. Consequently, using GIS in future transportation planning studies will continue; it will become commonplace and will be the technology of choice due to its effectiveness in providing the right and relevant information to make the needed decisions sought.

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Hardware
- Dell Precision T3500 PC running Windows XP
- HP Designjet 4000ps Color Plotter
- HP color Laserjet 5550 Printer

Software
- Arcview 9.3 – Environmental Systems Research Institute, Inc.
- Microstation V8i - Bentley Systems Inc.
- TransCAD version 4.5

Data

Coordinate System and Geodetic Datum
- State Plane Coordinate System – Illinois East (FIPS 1201 Feet)
- Geodetic Datum – NAD 1983

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