GIS in Engineering

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Integrating GIS in the engineering, planning and design processes. Drawings alone are no longer a sufficient format to manage complex project data. To establish a competitive advantage in a very competitive industry, engineers, planners and designers must embrace the benefits of enterprise wide project data sets. This paper presents an approach that transforms the traditional engineering design project lifecycle by synthesizing drawing data, planning applications based on ESRI's ArcGIS and ArcSDE software, design workflows and methodologies, and applying this approach creatively to the existing process. The result is a centralized and organized data store that may be distributed quickly, efficiently and digitally to reduce project costs and duration.

THE ENGINEERING WORLD

There are many elements to consider that make the design and engineering disciplines, sometimes referred to as Architecture, Engineering and Construction (AEC), inherently different than that of a single utility, municipality or other GIS implementation. The following is a partial list of elements that affect the use of GIS and technology in general in the private engineering industry:

- Projects are multi-disciplinary collaborations which include professionals such as engineers, surveyors, landscape architects, planners, economists, scientists, and architects. All of which play a specific and limited duration role in the project.
- The process is human-centric not data-centric. Reliance on person to person communication prevails in the industry and is how the economics of the industry are structured.
- The fundamental digital infrastructure is not installed. Many firms, particularly small to medium size, do not have the basic computing networks and systems needed to realize value from GIS.
- The legal climate for design work is audit trail intensive. Meta-data is not optional even when you are in a hurry. Design responsibility is feature by feature, person by person.

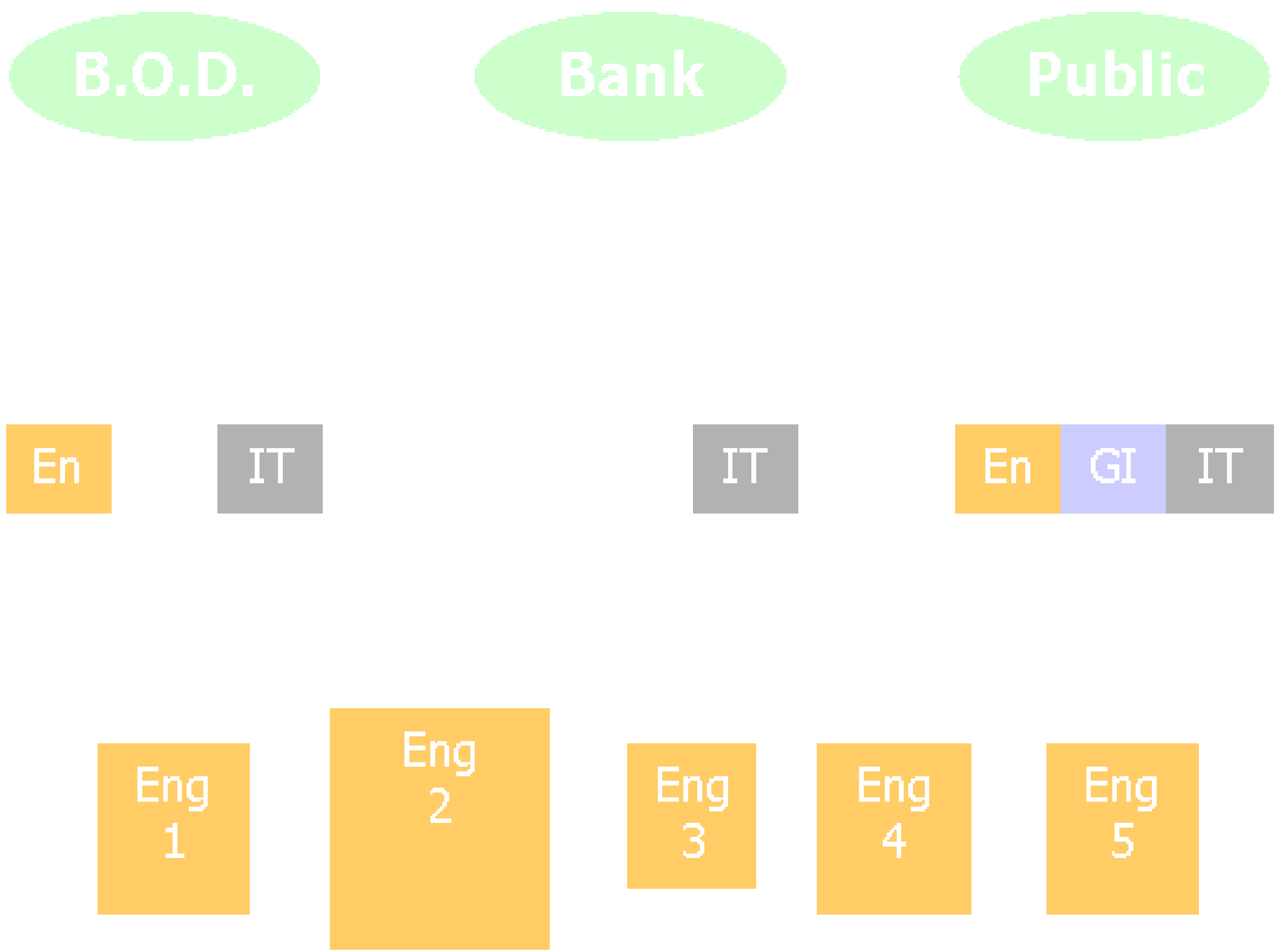
Most of these issues contribute to a setting that is fundamentally incongruous with data centralization and standardization. Historically, communication of design elements between the disparate groups has taken place with drawings. These drawings are still transferred on paper media (engineer's wet stamp) even though the advent of Computer Aided Design (CAD) has made it easier to create them. Paper is the lowest common denominator between disciplines and currently the only acceptable format to establish accountability.

However entrenched these issues are, they can be overcome by providing tools that provide the needed functionality, but ultimately change will occur mostly through training and evangelism of digital concepts and processes.

Multi-disciplinary Collaborations

Typically, discipline specific GIS implementations such as seen in water utilities or Assessor's departments are built on single purpose databases. These databases may be complicated and have multiple layers, but they are usually highly focused. For example, the Assessor's database is solely about parcels and ownership, other layers may be only coincidental or supporting. Additionally, typical GIS implementations usually document the "as-built" condition, describing infrastructure that exists with data in a standing database that is updated only after construction. Finally, these implementations are managed and populated by personnel from a common background or discipline reflective of the specific mission.

These conditions rarely exist in a design or engineering project scenario. In every design/engineering project all of the individual elements that make up our environment are present from roads to parcels to wet and dry utilities and even many other non-traditional layers are present. In each and every design/engineering project, whether it be a public road or private residential development, an entire "city" of data is created. There are some elements of an engineering project database that describe existing features, but most describe only proposed changes to the environment.



As described in the graphic above, multidisciplinary teams are created on a project by project basis. Many different firms play different roles throughout the project. Making the situation even more difficult is the fleeting nature of the project for the participants. Unlike a standing GIS, the project will have a known and deliberate duration for each of the contributing firms. This becomes an issue when attempting to figuratively and physically place the server or centralized database. Currently, the prime consultant or a dedicated data management consultant provides this function.

Thus paper drawings, while in and of themselves are considerably less functional for storing and managing spatial data than GIS databases, are the media of choice because of their portability. Drawings are passed indescriminantly from consultant to consultant like passing notes during class. The key to overcome this obstacle is to train participants to publish their data to the central database for all to view simultaneously.

Human-centric vs Data-centric processes

Historically, professional design firms have vested all of the project knowledge and recording of thoughts and ideas in the project manager's head and in their physical office space. If the client calls the firm to ask a project related question the project manager must be located to respond. The project manager is primarily the repository for all of the project information. If the project manager cannot be located, an assistant or other staff person may try to locate the required information. Each project manager stores information differently, thus the lack of standardization, and usually keeps most of the details in their head. This historic system is not only inefficient but also has a high negative "bus factor". The "bus factor" is the amount of negative impact a project will undergo in the event the project manager is "hit by a bus". While this may seem macabre, if all of the project details are stored in the project manager's head and that person is removed from the project or disabled, the project information goes with them. While it is unusual that a project manager would literally be "hit by a bus", project managers do retire, change firms or leave the company for many reasons which effectively removes them from the project.

In a data-centric atmosphere, it is policy that all thoughts, ideas and communications related to a project be stored in the centralized digital database on the central server. Professional activities such as designs, emails, studies and results are not stored on sticky notes, in personal daybooks or in paper files in a particular project manager's office. They are placed within a specifically designated framework and file system.

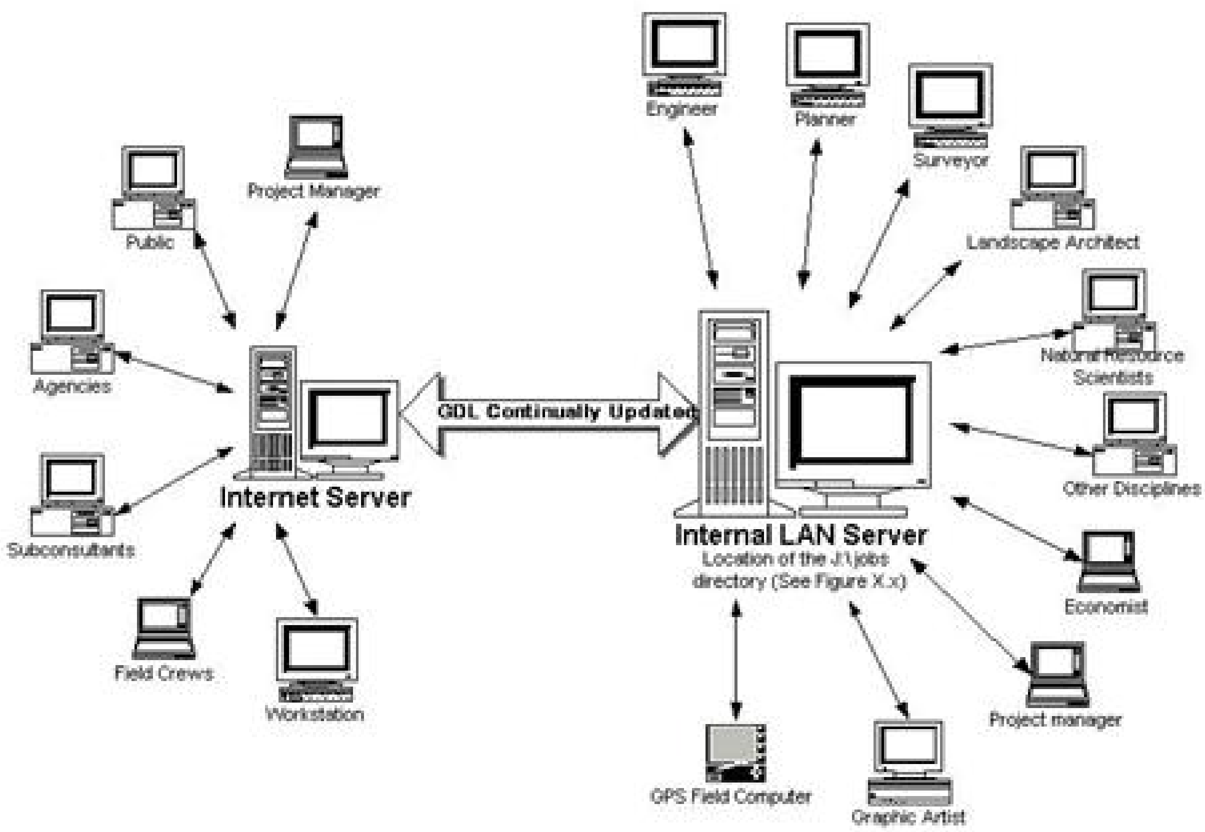
Traditionally, design/engineering project tasks are subdivided by discipline. Planners do their work, engineers do their work, and architects do their work etc. Each of the disciplines has their own traditional process for completing their work, none of which actually correlate to each other. A data-centric process leaves this traditional discipline based arrangement behind in favor of an integrated approach. Each project is comprised of only three different components of work;

- data collection
- data analysis
- data distribution

All activities undertaken as part of a digital design project can be classified into one of these three efforts. Whether you are a landscape architect or a wetlands biologist or an engineer, each of your activities can be classified accordingly without respect to your discipline. Capturing a wetland boundary with GPS is a data collection effort. Calculating slope to engineer a road is analytical. But perhaps the greatest advantage of a centralized digital project database is the opportunity for data distribution. Hardcopy "drawings" can still be derived from the database to support the traditional requirements, but the same data may be distributed on interactive CD-ROM and over the Internet.

Digital Infrastructure not in Place

A critical component of organizing a digital design office that will maximize the value of GIS in business terms is the use of what is called a "client–server" computer architecture. While it seems second nature to those who are steeped in the GIS tradition, it is not unusual still today in smaller firms to see non-networked or loosely networked computers. Larger offices that use computers for any substantial amount of work are now typically using this client-server system. There are many types of office networks in existence. The client-server configuration is specific and necessary to achieve the value of an integrated digital process. LAN design is fundamental to GIS but is not prioritized in most engineering firms. They may have the physical resources connected but the storage designs and access controls do not support integrated GIS operations. Once the general client–server local area network (LAN) is set up, specific directory formatting and structure elements are needed to support the process.



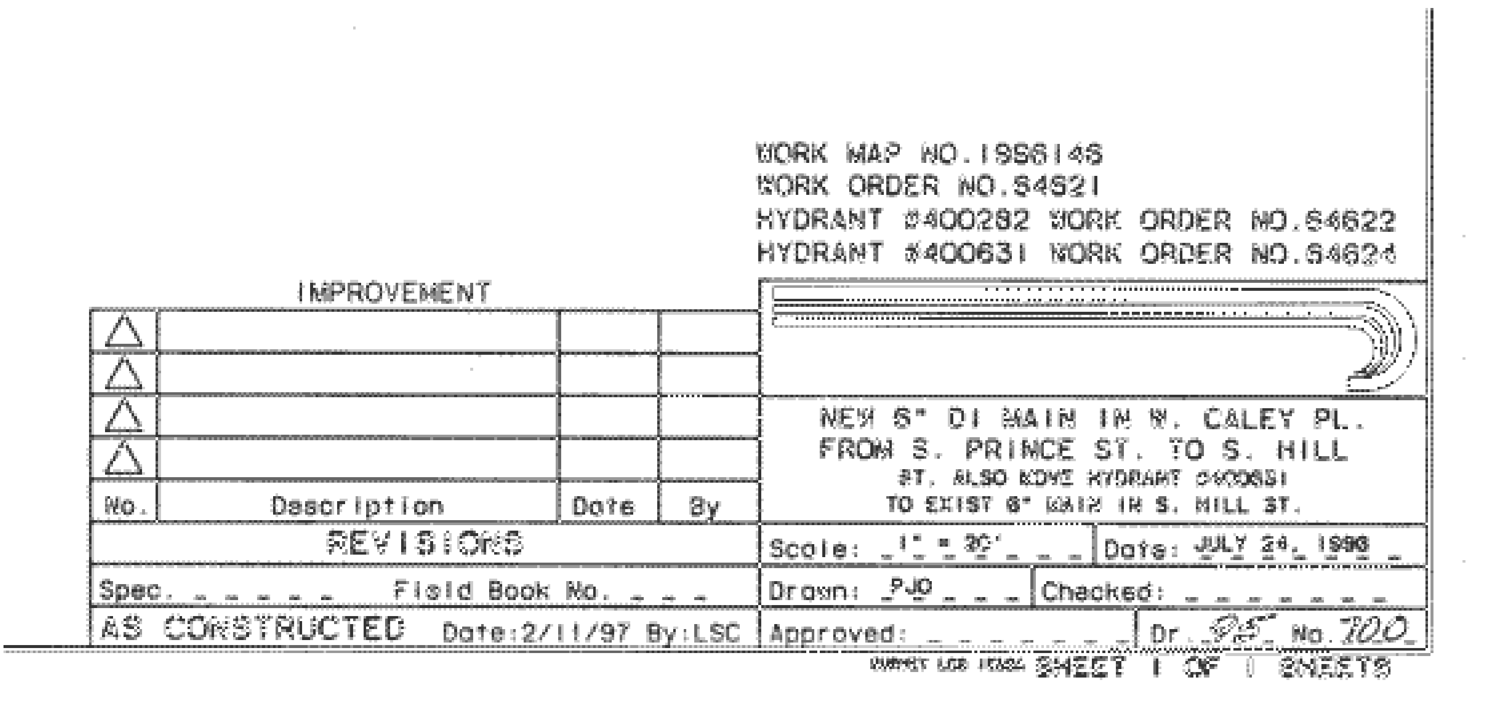
Commitment to an entirely digital process is necessary for the successful GIS implementation in a private firm. These are expensive outlays, and the business model of the firm needs to reflect this commitment to the digital process to be profitable. The adage exists daily that the $2000.00 spent on a computer can buy a lot of pencils and mylar! The return on investment relies on deliberate and correct use of the equipment leveraging (and selling) what paper and mylar cannot do, such as communication around the world instantaneously via the Internet with password protection.

Building the technical infrastructure for a digital process is only one component of a system. Building the firms business practices such as billing rates, insurance, location and products in support of the new processes are also necessary to create a successful model.

Legal Climate

Another one of the issues impeding the integration of GIS into the design professions is the legal climate within which these professions apply their skills. Unlike public GIS, the managers and technicians using and creating the data for the design professions have very specific licensure requirements. These include primarily Architects, Surveyors and Engineers. With licensure comes very strict and sometimes inflexible requirements for work procedures and documentation to create an audit trail.

All geometry created for the built environment is created by design professionals. They actually make the calculations and decisions about the curve of the road or the diameter of the pipe. These decisions come with responsibility that must be documented. The title block provided below demonstrates some of the documentation that is required for each drawing.



Additionally, this would require a “wet stamp” from and engineer or surveyor. This wet stamp is the signature of the responsible party. These professionals have a liability for failure of their work. They rely on the current drawing format to support this accountability.

While it seems like a difficult obstacle to overcome, these accountability issues are really related to what GIS users call meta-data. Meta-data in the engineering world is not an option, it is a requirement of the profession. The database must be created to support these meta-data needs. The tools must be in place to ensure design integrity including checking and rechecking of calculations, and allowing other professionals to identify source of calculations and geometry.

CONCLUSION

Use of GIS in the private AEC market is still in its infancy. Long held traditions mentioned above and others contribute to a climate not readily conducive to centralized data management and the use of GIS. Deliberate attempts to create tools and workflows that support the legal and embedded practices within the design professions are what is needed to advance the use of these tools in daily production. A shift in philosophy from protecting data to sharing data and specific training will provide the motivation to use geo-spatial software.

REFERENCES OR ACKNOWLEDGEMENTS

Jennifer G. Redmond M.U.R.P. The TSR Group Inc.
Noah Benedict The TSR Group Inc.

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