14. A CIO Perspective on Integrating Geo-Information Systems into IT

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I. Introduction

As an everyday part of their jobs, CIOs of large county and city governments must integrate an ever-growing and evolving variety of capabilities and technologies to ensure the effective management of computer systems serving the needs of their jurisdictions. Over the past years, CIOs have had to contend with rapidly advancing Internet services, new generations of software and programming languages, high speed telecommunications technologies, wireless communications, cloud computing, making sense of social media generated "big data", cyber security, building information management (BIM), smart infrastructure, and a proliferation of mobile devices and PDAs. Also, ever since microcomputers sparked an explosion of computer use outside the jurisdiction of the centralized mainframe world, CIOs have had to deal sensitively with a complex environment where agency-based IT managers who did not come under the CIO's direct control have a major hand in implementing departmental systems. Into this challenging environment, CIOs are also increasingly contending with geospatial information systems (GIS), trying to find the optimal balance between central control and laissez faire policies. The purpose of this chapter is to explore the synergies between central IT and GIS, and the role of the CIO in maximizing and measuring their benefits.

II. Geospatial Information Systems hit the mainstream

Geospatial services are in the news. Millions of Internet users are flocking to Google Earth and Bing, adding to those who regularly utilize Expedia.com and similar travel and direction-finding services on their desktops. Many cars and boats come from the dealers with vehicle location systems installed. Many municipal and state Internet portals feature detailed, interactive mapping applications. Smart phones and other PDAs are now routinely equipped with a global positioning system (GPS) capabilities which when linked to social networking applications like Facebook and Twitter are producing an explosion of geo-tagged data in almost unimaginable volumes that can be mined for intelligence. Add to this the miniaturization revolution of sensors that can be placed within smart phones – one dimension of the "internet of things" - and you get even greater volumes of data. The world of big data is upon us and GIS is playing a leading role through its inherent ability to organize vast amounts of information by its location. These developments show that the public has an appetite for and increasing understanding of location-oriented services, heightening their expectations of government. Moreover, following the extensive use of geospatial systems to support response and recovery operations following 9/11 and subsequent disasters, GIS is being taken seriously as a strategic technology critical to national security. Geospatial systems have entered the mainstream, and there is no looking back. Consequently, the posture taken by the CIO toward these systems is of increasing importance.

III. A very brief and impressionistic history of location

Beginnings: The science of geography evolved from the human need to know where important resources could be located, how dangers could be avoided, and the best route to take when traveling from one place to another. The first maps were undoubtedly drawn on the ground with a stick and on the walls of caves with charcoal. They capitalized on the human genius to visually

organize information as an aid to memory and as a means to grasp relationships and patterns. Ancient Egyptians, Greeks and Romans, through their development of mathematics and geometry increased their understanding of the curved surface of the earth, and refined the art and science of map making. Navigational aids, from the compass to the sextant and the chronometer, revolutionized travel and exploration and opened up the oceans for commerce.

Geography in combination with geology, the science of the structure and composition of the earth, were used to exploit important mineral deposits and other natural resources. Land survey methods and technologies were developed to precisely demarcate property boundaries, delineate administrative districts and national borders, and plan the layout of roadways and cities. Geography was used in war time to "map" battlefield terrain, pinpoint the location of one's own forces and those of the enemy, and design strategies for attack and defense. As large bureaucracies came into existence, geographical functions served many agencies in support of property and asset management, taxation, zoning, engineering, and many kinds of service delivery operations. In short, practical and valuable applications of the science of geography predate the development of the computer by thousands of years.

Geography and the computer age: As the value and importance of the IT function grew through the 1960s and 1970s, and as mainframe systems became increasingly essential, local governments began consolidating their IT operations into centralized departments with executive status. During that period, the application of computer technology to most geographic functions lagged because of the difficulty in digitally representing geographic information types, and because standard query languages could not accommodate critical spatial functions, such as measuring distances and dimensions, and calculating areas of overlap. Although addresses, parcels and similar location-oriented attribute data easily became fields within most databases, coordinate systems, photographic imagery and the digital representations of map features—such as points, lines and polygons—were not amenable to early computerization. Finally, in the 1980s, pioneering engineers and geographers created breakthrough software that could digitally represent and manipulate map and other graphical features, such as building structural elements. Those capabilities were designed to work on newly emergent stand-alone workstations and microcomputers and thus, GIS and Computer Assisted Design and Drafting (CADD) systems played an important role in the PC revolution that shook the IT world.

GIS is adopted for specialty functions: Geospatial capabilities were rapidly adopted for use by professionals in a wide variety of fields for use in specialty systems usually at arms-length from centralized mainstream shops. Geospatial practitioners also were able to utilize global positioning satellites for many non-military functions, from supporting aerial photography to allowing anyone with a GPS receiver to rapidly identify and communicate their exact location on the face of the earth.

Most geospatial practitioners saw themselves as engineers, environmental and health scientists, and planners first, and not as IT professionals. Culturally, it could be seen as crew cuts versus long hairs, sneakers and jeans versus white shirts and ties. (Note: These days CIOs are far hipper than they used to be!)

To many in the IT world, an address remained one field among many, albeit a particularly unreliable one where many errors were often found. To some GIS practitioners, enterprise practices and procedures were burdens to be ignored in pursuit of the cartographically perfect map.

GIS catches on but finds success comes with problems: Yet despite the divide between GIS users and the IT establishment, geospatial systems, often flying under the radar and funded by functional managers, caught on and grew. In particular, municipal agencies that directly delivered public services, managed facilities and infrastructure, or were responsible for planning services across large areas, recognized the importance of manipulating geo-enabled information to support their work.

When a municipal water utility repairs a distribution line, it can be guided by some combination of a unique infrastructure ID, a geographic coordinate, a map or sketch of house connections and customer address. When a local public safety dispatch center (PSAP) receives a distress call, a telephone number must be rapidly matched to the appropriate street address, which is then linked to the position of responders, and the location of travel routes and backup facilities. When a hurricane approaches, emergency managers want to rapidly identify areas likely to flood, at-risk infrastructure, evacuation routes, shelters and the location of vulnerable individuals who may need assistance. When there is a disease outbreak, health scientists examine its geographic distribution to identify patterns that will help in the design of a containment strategy. When devising revenue collection methods, governments need to look across all revenue-related databases to aggregate funds owed at the same address and within specific areas. These are but a few instances where spatial systems, enabling the rapid linking and combining of location information, support essential government operations.

Growing pains: But the growth experienced by geospatial systems also led to problems. GIS application teams—not only in different agencies but often within the same agency—tended not to collaborate, and isolated geospatial data silos proliferated. Different agencies, at great expense, built duplicate and incompatible basemaps to suit their individual needs, then found to their dismay that data could not be easily or accurately related across systems. Moreover, most discovered they could not sustain the continuous flow of funding they required to keep their data up to date. Aware of the inefficiencies, GIS personnel started to band together to address enterprise-wide issues and opportunities, but because few—if any—held executive positions and could not command agency or city resources, it was often impossible for headway to be made. GIS began to acquire an unsavory reputation for producing flashy results in the short term that could not be sustained over time.

IV. GIS' merger with IT—A winning combination

The 1990s saw a combination of factors that led to the rapprochement between GIS committees and CIOs. Astute CIOs, watching the struggles of geospatial initiatives often from afar, recognized the potential of the technology and were looking for opportunities to exert management control while also being wary of invading the turf of agencies with political clout. CIOs with a keen understanding of municipal operations grasped that there were aspects of GIS work that would greatly benefit from centralized authority. They understood that geospatial information, no matter how exotic the object types, broke down into bits and bytes like all other data. They saw the folly of building duplicate networks to support geospatial systems and the inefficiency of acquiring GIS software in small, uncoordinated buys when the price could be significantly lowered through enterprise licensing. They noticed that the same street address might be collected independently by

a dozen different divisions, with significant disparity in field structure, thwarting any hope that the address field could be used to cherry pick data from multiple databases to provide a complete picture of all activities going on at a particular location. They recognized that producing one authoritative ID for every building could solve a multitude of problems experienced by their jurisdiction—from police and fire responders not being able to find a location, to boxes full of returned envelopes containing tax bills rejected by the Post Office because of bad addresses. Indeed, incomplete and contradictory location information introduces significant inefficiency and risk of failure into municipal operations. Many CIOs probably came to believe that the only thing more painful than getting location right was getting location wrong.

GIS comes to the table: On the other hand, astute geospatial practitioners, with increasing amounts of professional training and a broader perspective, recognized the inefficiencies of stand-alone and departmental systems, and understood the enormous benefits that could come from enterprise GIS (E-GIS). They imagined one most accurate basemap of the entire jurisdiction that was kept up to date and that everyone used, making all the information registered to the base fully compatible, and capable of being combined for analysis and operations support. They conceptualized a unified digital infrastructure that made it possible for bandwidth-intensive GIS data to be easily shipped between offices and even extended out to the field using wireless communications. They imagined a comprehensive address database incorporated into a geocoding engine that would ensure that the location information needed by all production databases was drawn from one, well-maintained source that guaranteed accuracy and compatibility between data sets. They hoped for a powerful, highly placed champion willing to fight for their priorities.

While some dreamed about how that could come about through a totally independent GIS organization, many understood that integration with IT and the acceptance of the CIO as their leader made the most sense. Where reason did not prevail, there were instances where budget managers, fed up with waste, failure and duplication of effort, wielded the shotgun at the marriage of IT and GIS.

A new environment emerges: Fortunately, the IT organizations in the 1990s were different than the ones in the 1980s. Dealing with the proliferation of microcomputers and networked systems had taught CIOs that there needed to be a balance between centralized and decentralized systems management. Central control was needed to guarantee standards, efficient procurement, compatible architectures and the implementation of enterprise services and applications. Departments, if acting within enterprise guidelines, could then be given autonomy to develop systems that met specific business requirements and depended upon agency subject-matter expertise. That model worked when applied to GIS systems, especially when a CIO recognized the importance of hiring a highly qualified Geospatial Information Officer (GIO) as high-ranking deputy, who could serve as an expert champion for enterprise GIS efforts.

V. Key elements in building enterprise GIS

While the nitty gritty of enterprise GIS development ought to be managed by the GIO, the CIO should have a clear understanding of some of the major elements that a successful effort must include.

Building and maintaining the basemap: One key to the development of enterprise GIS, and perhaps the most expensive, is the building of a spatial data infrastructure that encompasses the total area of a jurisdiction and includes all important physical and legal elements. Assuming that capable in-house or consultant staff is available for the up-front technical design work, building E-GIS usually begins with the acquisition of digital aerial photography with a pixel size of one foot to as small as three inches. All the features seen in the imagery product—buildings, curblines, streets, water features, street furniture—will be in an accurate relationship with both the earth and with each other.

Concurrently, a jurisdiction should be developing a unified and comprehensive street name and address database, and assembling parcel maps for digital conversion and registration to the aerial basemap. Making sure that each structure and each parcel is tagged with its correct address and parcel ID ensures that all legacy databases containing address and parcel data can now be linked to the common basemap and, through the use of their location fields as indexing keys, to each other. Once base data has been built, data maintenance operations must be properly staffed. As basemap products including a geocoding engine are distributed to municipal agencies, standards must be set to govern each department's data and application development activities. Also useful is an internal consulting service to help agencies harmonize their GIS development with the enterprise.

Infrastructure upgrades: CIOs, upon overcoming the sticker shock associated with building an E-GIS data infrastructure, will then be confronted with huge geospatial data sets that threaten to overwhelm IT infrastructures. Once more, it will be necessary for CIOs to take a big breath and push for the funds necessary to upgrade capacity. Fortunately, technology advances, such as the move toward high bandwidth fiber; the implementation of service-oriented, web-based architectures; cloud services; exponential increases in processing power and memory; compression software, which can shrink the footprint of imagery and feature files; and new generations of database software that come with spatial extensions; are combining to keep costs in check while vastly expanding capabilities.

Organizing, planning and financing: Successful enterprise GIS requires the organization of a steering committee of agency GIS managers to help set GIS policies and priorities, and to promote data sharing and collaboration. The GIO must be an active member of the community if not its leader. The CIO will play a key role in being the overall champion for GIS initiatives with the clout to fight for new initiatives and funding for system and data maintenance.

In a hub/spoke organization design, a sensible division of labor between central and decentralized efforts will be required. Central IT must have sufficient staff and resources to develop enterprise applications serving everyone and maintain many of the common framework data sets, including regularly capturing new aerial photography, designing and enforcing standards, and ensuring that GIS requirements are part of the jurisdiction's IT planning and budgeting processes.

Many CIOs chronically strapped for funding often find themselves having to balance funding for their traditional systems with the insatiable appetite of geospatial systems for more. In the past, when the CIO asked the earnest GIS managers for a rationale for such expenditures, about all they received was a shrug of the shoulders that seemed to say, "We create maps, not business cases." That answer is no longer adequate. GIS priorities must compete with all other IT initiatives and

deserve to be funded only if their worth can be proven. The following section provides a path for creating a cost benefit rationale for enterprise GIS and for individual GIS projects.

VI. The payoff: New capabilities impact the bottom line

The build-out of an enterprise GIS will provide GIOs and CIOs with a number of capabilities that can have significant impact on municipal operations that can be shown to more than offset expenditures. GIS promotes **enterprise data integration** by making it possible for information from different datasets to be related to one another by keying on common spatial fields. The GIS capacity for **visualizing** information makes it easier for employees to organize and operationalize their field work, and for citizens to rapidly obtain useful information via highly intuitive mapping interfaces delivered over the Internet. The geocoding application made possible by enterprise GIS allows universal **address normalization and validation**, which guarantees the accuracy of address information upon which depends the efficient and timely delivery of critical services. GIS-based analysis enables **pattern recognition**, which allows government managers to identify trends, detect problems and find solutions in areas, including infrastructure protection, crime reduction and disease control. The **routing and distance calculation** capabilities of GIS permit more effective allocation of work and the more efficient design of work routes.

However, the true measure of benefits that can be realized by those and other geo-capabilities will remain unknown unless the CIO makes a conscious effort to quantify them. The next section outlines the specific kinds of quantifiable benefits achievable by GIS-enabled operations that can be documented and used to more than justify expenditures on E-GIS.

VII. Return on investment: Proving that GIS is worth the extra price

The following are excellent areas to start looking for significant and measurable returns on your enterprise GIS investments.

Improved revenues: Many counties and cities depend upon property tax revenues based on the assessed value of land and structures. Although property tax operations have always been geospatial in nature, aerial photography, including oblique angle photos, can be used to identify property improvements missed by field inspectors. Benefits can range from a 0.5% to 2% or larger gain in assessed value. While seemingly small, when computed against the entire tax base, that benefit alone can totally offset the cost of building and maintaining an enterprise GIS. Similarly, if all revenue oriented databases can be geo-enabled, jurisdictions can aggregate all outstanding taxes, fines and fees by individual, property and address, which can greatly assist collection efforts, a tactic used by Arlington County, Virginia, among others, with great success. Additionally, comprehensive and up-to-date GIS information about streets and houses supplied to the U.S. Census Bureau can increase population counts by 5% or more. If a jurisdiction of 100,000 receives $200 per capita in federal and state grants, a 5% census increase can result in an additional $1 million annually.

Public safety: E-911 emergency dispatch operations save thousands of lives annually and are supported by systems that depend on location information. At the core of these systems is the ability to pinpoint where an incident has occurred by matching phone number to address (or cell phone provided coordinate), identify the nearest potential responder, and direct the responder to the scene by the shortest possible route. E-GIS can ensure that address and routing errors are kept

to an absolute minimum. Efficient dispatch lowers response time, which is highly correlated to reduced deaths and injury.

GIS also is the key component of crime pattern analysis applications and aids the design of crime fighting strategies. CompStat applications, a key component of the intelligence-led policing movement, have helped to dramatically reduce crime levels in a number of major counties and cities, including New York, which over the past 18 years has seen its murder rate reduced by more than 75 percent. Benefits measured in lives saved can have a significant impact on how GIS and IT funding requests are perceived by budget offices and CEOs.

Productivity: E-GIS data, when combined with automated vehicle location (AVL), mobile computers and wireless communications, can increase productivity of inspectors, social service workers and service crews by 10% or more. Geospatially equipping the mobile worker also can significantly increase the speed and improve quality of information collected in the field. Accurate field information can impact revenues by ensuring that data collected to support violations issuance and associated fines will stand up to challenge in court. Benefits can be quantified as time saved and in improved revenue collections.

Greater information availability: Many governments are starting to embrace the concept of Open Data. Municipalities, counties and state recognize that the data they have built with public funds should be returned to the public in forms that they can use as long as highly sensitive information such as detailed infrastructure designs remains restricted. E-GIS gives a jurisdiction the ability to publish easy-to-understand information over the Internet to serve a variety of functions. Internet maps allow citizens and visitors to quickly locate key facilities, and identify services and areas of importance to them. Government applications based on GIS information can enable citizens to perform a variety of tasks that might otherwise require a long trip to a municipal office. During an emergency, maps posted to the Internet can direct the public to evacuation routes and to shelters. Additionally, a well-designed web site can highlight available sites that might be of interest to developers from across the county or around the world. The geo-tagged big data from social media sites when mashed together with municipal E-GIS allows business to operate with great insight and effectiveness. CIOs should understand that the economic viability of a municipality is at least in part determined by the public availability of data for these business support services.

Guidelines to coming up with numbers: CIOs interested in coming up with solid numbers that document the benefits of enterprise GIS can utilize a number of tools. Public Technology Institute (PTI) has published guidelines, which include an ROI methodology to systematically identify and calculate benefits. These tools have been used successfully in a number of jurisdictions to justify GIS investments. The Geospatial Information Technology Association (GITA) also has come out with a rigorous manual that guides ROI calculations with a focus on increased worker productivity.

VIII. An international, national, regional, state, county, and municipal context

With GIS in their portfolios, CIOs now find themselves in a position not only to enable major improvements in their own jurisdictions but also to play a significant role in their region, their state and their nation. For as it turns out, the enterprise data built for municipal E-GIS has important applications beyond local boundaries. The same data architectural factors needed to consolidate GIS within a single governmental entity also enable geo-data integration and data-based collaboration

across counties, regions, states, and the nation as a whole. When data is developed to common standards, there is no reason why it cannot be combined—LEGO®like—across jurisdictional borders to provide a common operational picture, solve large scale problems and support regional and national services. These purposes have taken on added importance following 9/11 because information sharing can support vital national security and infrastructure protection missions. As your jurisdiction's CIO you should explore with you GIO the opportunities and advantages of integrating your data with that of bordering and encompassing governmental entities.

The New York State Total Integration Effort – A Case Study: The State of New York contains 57 counties and 1543 general purpose governmental jurisdictions (929 Towns, 614 cities and villages). Based on a grant from the Fund for the City of New York, the New York State GIS Association investigated the status of GIS in local governments across the State using surveys and interviews. The findings and recommendations coming out of those efforts are instructive. Results show that there is significant penetration of GIS in many of the State's counties, and its more populous and prosperous cities and towns. At the municipal level geo-enabled data and applications were being used for operations that range from 911 emergency response and crime pattern analysis, to parcel mapping and assessment, water and sewer maintenance, roadway sign management, health and human services field work and many others. At the same time results show that there are many hundreds of jurisdictions that do not current use GIS. The NYS GIS Association found:

- Municipal level governments were largely responsible for the collection of accurate and detailed information about the physical characteristics and ongoing activities of their jurisdictions. This field collected information needed to be accurately located to be reliable.
- County governments also collected geo-enabled information of its own, but additionally needed a great deal of information from their municipalities. Ideally the exchange of data between county and municipality needs to go both ways.
- Many state agencies also depended upon data rolled up from municipalities and counties to create state wide data sets for planning, regulatory compliance and operations support. In addition, Federal agencies often request this data from State agencies to support Federal work processes.
- To the extent municipalities, counties and states used standardized GIS framework data layers such as imagery, streets, and addresses and parcels, many of the data sharing functions described above were able to take place seamlessly and efficiently with significant savings in time. The silos that normally plague the sharing and combining of information across jurisdictional boundaries could be significantly reduced by a well-designed cross-governmental GIS data exchange design.

The vision of compatible and integrated data across entire States and including all local governments can happen only if CIOs at all government levels have a common vision and only if GIS has been made a significant part of their efforts. The NYS GIS Association has also found:

- Robust geospatial systems were often found in jurisdictions with a strong and centralized IT, where the CIO had embraced GIS and made it an important component of their operations.
- Strong municipal GIS is often found in those counties with effective GIS leadership, where county and municipal data managers worked closely together.

- State agencies are the source of valuable state-wide data, with dozens and even hundreds of layers. Respondents recognized that there was the potential for great value should this data be put together in a central repository that was easy to access and use. State wide data layers stuck in State agency silos greatly inhibited collaboration and slowed the growth of GIS at the local level.
- All levels of government understood the value of capturing accurate, geo-tagged information by field workers – usually from local governments - and realized that smart phones with data collection apps could make this possible. Via internet access the smart phones could also transmit data to central data bases in real time.

Among many other options, the NYS GIS Association is actively encouraging the following:

- New York State should bring together the State-wide GIS layers created by all its agencies, integrate that data using the State's base imagery and street framework layers, and put that information into an easy to access "open" repository that will enable county and municipal governments (and single purpose districts) to use the data with a simple browser. This action alone would likely increase the use of GIS in thousands of jurisdictions across the state.
- Through a collaborative effort of State and local governments, a cheap, generic and customizable data collection application designed for use on smart phones and similar geo-enabled wireless devices, should be made available to all local government workers. This could standardize and automate the collection of geo-tagged field data – a vital and ubiquitous function - at all levels of government, increasing data quality and making many government operations more efficient and effective.

In the opinion of this writer, the way forward for New York municipalities, counties and state agencies (and those of other states as well) is to systematically build out integrated GIS data capabilities by employing cloud technology and mobile devices, all with the collaboration and support of IT.

The Role of GIS In The Smart Cities Movement: "Smart Cities" is the latest expression attempting to encapsulate the idea that the rapidly expanding amount of digital information and successive waves of technological innovation should be harnessed to help make cities work better. Those cities that fail to leverage these IT resources will fall behind, lose their competitive edge and be surpassed by cities that take full advantage of the opportunities presented by this phase of the information technology revolution. Geospatial technology and geo-enabled data play an important if not a central role in these developments. Here are some areas where they are having an impact.

- **Smart Transportation**: Currently our cars are starting to resemble computers on wheels. With the use of navigation systems we can plot the most efficient route between multiple locations. Computers built within vehicles now monitor functions and maximize efficiencies while also predicting dangerous roadway situations and helping drivers make safe driving choices. Sensors tracking traffic volume can adjust lanes and the timing of traffic lights to maximize flow. In the future, cars that function more like robots may take us from one place to another without the need for driver intervention. The benefits will include faster travel times, safer trips, more productive time for work and reduced energy costs. Critical to

achieving these advances is the ability for the car to know where it is in space at all times and to also know where other vehicles, streets, curbs and buildings are as well.

- **Telecommunications**: Smart phones and the imperative to be connected to anyone and everyone 24x7 while certainly having undesirable characteristics, has become a necessity of modern life. The cities with the most available, robust and intelligent telecommunications infrastructures will be most attractive to individuals and businesses that rely upon being connected all the time whether in a park, a building elevator or an underground subway station. Connected municipal work forces with full access to data exchange in the field will be more efficient and effective. Cities that learn to communicate efficiently with their citizens will have harvest free crowd sourced information of great value, while making available municipal information that facilitates business and enhance personal and family life. The GPS capabilities of smart phones and devices enables all the data created or received to have a location component, making that data more intelligent and more easily organized and analyzed.
- **Smart Infrastructure**: Above ground infrastructure such as roads and structures, and underground infrastructure including water and sewer pipes, electric conduit, mass transit systems, gas mains, and telecommunications networks are being equipped with new generations of smart sensors connected to powerful monitoring and management systems with remotely controlled features. These technologies will take the pulse of a City billions of times a day and identify anomalies that require action. With tools to adjust the output and efficiency of infrastructure elements, smart control devices can make adjustments to reduce the expenditure of resources or increase them should demand pick up. The electric grid will accept locally generated power from solar panels and wind turbines, and adjust electric generation based on real time patterns of demand. Damage to infrastructure elements will be detected and result in automatic shutdown and the immediate dispatch of repair crews to minimize damage and restore service. Much of this is contingent on those smart infrastructure elements being able to communicate exactly where they are located.
- **Big Data**: With the proliferation of social media, smart devices, sensors, and smart infrastructure, vast amounts of new data will be generated and there is a danger we can get lost in the variety and volume. We need to be able to zero in on the subset of that information that contains real value. Well managed cities, while protecting the privacy of their citizens, will find creative and useful ways of tapping this data to make smarter planning decisions and to improve the services they deliver to the public. Businesses and jobs will be attracted to cities that use new information tools effectively in ways that help individuals make better decisions and lead fuller lives. By working to ensure that all this information has locational intelligence, as CIO, you can utilize powerful spatial analytic tools that can help you separate data noise from intelligence. And please always bear in mind that "spatial is special." Location is a fundamental component of almost all data and all human activity. GIS can facilitate the organization, analysis and visualization of thousands of layers of information and the orchestration of hundreds of service delivery operations in ways that no other IT component can.

X. Conclusion

If you've gotten this far in the chapter and haven't skipped too many pages, then it is my hope that you have a deeper appreciation for GIS and your role as CIO in advancing its use and realizing its benefits for your jurisdiction. If your curiosity is peaked about GIS and you wish read more about this subject, I can personally recommend "The Mapmakers," by John Noble Wilford. Additionally, you can visit the web site of ESRI (www.esri.com), the world's largest GIS software company, which offers many good publications on geospatial subjects.

As CIO you may never become a black belt in the geospatial sciences, but if you can manipulate a digital map on the Internet, you are well on your way to being able to conceptualize most of the valuable functions that geospatial systems can perform and fit them into your overall vision for IT. What's more, your IT background gives you business management, enterprise architecture and strategic and business planning skills that your GIS operations dearly need.

With the hiring of a GIO as one of your key deputies, and with a firm adherence to the discipline of systematically measuring costs and benefits, you are on course to ensuring that your department will be able to serve your elected and appointed officials, fellow workers and citizens with state-of-the-art geospatial capabilities. You also will be in a position to guarantee that your jurisdiction takes its rightful place in efforts to advance the application of spatial technologies for the benefit of the nation as a whole.

Discussion questions

1. Is the funding level for GIS in your jurisdiction calibrated to the potential ROI that GIS systems can provide?

2. Does GIS factor into your enterprise architecture and portfolio management initiatives?

3. Are the GIS practitioners in your jurisdiction appropriately organized and led to yield the most effective geo-services possible?

4. Is your jurisdiction systematically examining new spatially enabled technologies, like automated vehicle location, to determine which ones will work best for you?

5. When designing and building telecommunications and computer infrastructure, including wireless networks, do you keep in mind the high bandwidth requirements often needed to exchange geo-information, particularly to and from the field and remote offices?

6. Are you using highly expressive and attractive digital maps on your Internet site for a variety of public information, economic development and service delivery applications?

7. Are the key mapping layers in your jurisdiction edge-matched and integrated with those of adjoining jurisdictions to create regional coverages for strategic applications?

8. Is your jurisdiction participating in regional, state and national efforts to utilize geo-data and geo-systems for emergency management and homeland security?

9. Have you built jurisdiction-wide basemap layers and acquired or built a geocoding application to insure that all location information used across the enterprise can be validated, normalized and used for geo-enabled enterprise data integration?

10. Have you investigated how geospatial capabilities can enhance legacy systems by improving the accuracy and completeness of spatial data fields, and promoting data integration and visualization?

11. Have you integrate GIS into your big data and smart cities initiatives, and have you decided to make sure your critical infrastructure is properly mapped?

12. Have you hired a Geospatial Information Officer (GIO) as a high-ranking deputy to ensure the best possible leadership of your geospatial operations.

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