Cost-Benefit Analysis for Geographic Information System

Implementation Justification

(Literature Review)

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GIS Success Stories

A Geographic Information System (GIS) is an electronic information system that analyzes, integrates, and displays information based on geography. GIS systems have powerful visual display capabilities that present the results of analysis on maps on a wide variety of scales, ranging from very large (accurate to within inches) to very small (accurate only in broad overview). GIS is regarded as the best technology to understand and solve problems associated with government information which has a geographic dimension--a street address, a transportation corridor, a river, a city line. Some examples of how GIS has been used to increase government efficiency are:

- In 1995, the city of Philadelphia (CA) used GIS to optimize their garbage truck routes. In the following year the city saved over $1 million in overtime. (Koutnik, 5)
- The state of Wyoming used its GIS to audit the mass appraisal process and found that approximately 250,000 parcels were not on the tax rolls. (6)
- The city of Ontario (CA) generated $190,000 per year in lost business license fees by using GIS to audit their billing files.(8)
- In 1996, the city of Scottsdale (AZ) had only 3 weeks in which to respond and challenge the numbers provided by the Census Bureau's mid-decade census. Due to the city's GIS database the challenge was approved, resulting in increased per capita revenues to the city of $1.8 million per year for the next five years - a total of $9 million. This response was possible because the city had GIS available.(Ledbetter, 64)
- The city of Redlands (CA) has used ArcView for crime analysis. They have been able to determine crime patterns which allows them to focus police activities in target areas to reduce crime. They were also able to justify altering police beats to focus their resources.(Koutnik, 8)
- The Metropolitan Sewer District (Cincinnati, OH) used GIS to find parcels with sewer connections which were not being billed. The District generated thousands of dollars of missing revenue that more than covered the cost of their GIS. (5)
- In Portage County (WI) an assistant in the county clerk's office typically would spend over 4 days to prepare the documentation required for rezoning hearing. Using GIS, the process gets done in about half a day. (6)
- The Los Angeles County Assessors Office has reduced their yearly overtime hours from 1200 to zero, while at the same time reducing staff from 55 to 45. The cost and staff saving have been generated by a more automated assessor map creation and reproduction methodology with GIS. (8)

GIS Benefit/Cost Ratios

Despite all the difficulties in quantifying major GIS benefits, there is a particularly useful study that presented examples of the productivity improvements and cost savings produced by GIS -- the Joint Nordic Project Report. This report presented information on costs, benefits, and applications of 16 well established GIS projects in North America and two in Italy. This study is considered by many authors as the best single reference for detailed Benefit/Cost ratio data.(Korte, 49) The project findings were:

- If a system is used only for computer-aided mapping and updating, it gives a full return on investment (**B/C 1:1**).
- If the system also is used for planning and engineering purposes, the investment will be doubled (**B/C 2:1**).The ratio would rise to **4:1** where all commonly used data sets have been automated.
- Research reports publish in Norway and Sweden show that the B/C ratio for automating conventional maps is greater than **3:1**.
- If a common system is created in which information can be shared among different relevant organizations, the investment will come back four times (**B/C 4:1**).
- For organizations with a poor system for manual map production, the automated system has given B/C ratios up to **7:1**.(49)

Alternatives for GIS Investment Justification

Rigorous economic evaluations in GIS purchase justification are rare.(Prisley, 30) The dominant approach is to justify GIS investment based on the following reasons: improve efficiency of services, respond to regulatory requirements, and accomplish a stated goal, mission or

objective.(Koutnik, 3)

There are some important aspects of a GIS project that can make the process of justifying investment in GIS technology (GISt) quite complex. First, in many instances a geographic information system can create an opportunity for a department or organization to perform new data analysis that is not possible without GIS technology and, consequently, not comparable with any of the department pre-GIS operations. Generally, these new capabilities are usually hard to express in financial terms (intangible benefits). However, a literature review revealed that these new capabilities are frequently considered as the strongest arguments for having a GIS.(Stutheit, 69) Second, a GIS can range from one single, well-defined application in one department to an enterprise-wide GIS. In addition, the strongest arguments may also be the ones that often would arise many years after project initiation.

GISt is sought for many governments to improve their operational efficiencies on providing services to the public. Nonetheless, this is also an restraint in the justification process since there is no market prices for services that are consumed within government. Tomlinson (1992) emphasized two alternatives to address this issue. One is to use the standard approach which assumes that "products consumed within government have a value or benefit equal to their cost of production."(248) The second alternative is through comparison. Government staff might identify government services that are provided by the private sector in similar jurisdictions.

The first part of this GIS justification analysis effort would be to determine who will benefit from having GISt available. The user group is broken into two different categories: user and *potential user.* The first is, in general, defined "as a person who uses the system for production, or who works with the products developed by the system.[...] [*Potential user*] is someone who cannot use the present system because of some constraint, but could become a user of the system if it were converted." The city of Ottawa, Canada, in its process of GISt justification considered that the following groups would benefit directly or indirectly from its new services.

- City and its departments for both existing and new products;
- Taxpayers who will benefit from new services;
- Private sector organizations, including construction firms, planners, architects, real estate firms and a wide variety of others who would have a willingness to pay for GIS products;
- Other related government organizations, such as school boards, that will benefit from some GIS products.

Ottawa successfully justifies GIS investment by quantifying benefits of GIS' products through a ranking scheme. The ranking scheme requires that each department assess the value of its services and determine how each GIS information product that could be generated for that department would affect what the department could do. Most of this evaluation would involve savings in direct costs (staff time, material, and timely provision for products now produced manually) with minimal subjective judgment. Nevertheless, it is recommended that estimates be reviewed by relevant department heads, and in some situations an external consultant can be hired to confirm their validity.

The departments of the city of Ottawa that participated of the interviewing process were Engineering and Works, Housing and Property, Planning and Development, Economic Development, Office of the City Clerk, Fire, Recreation and Culture, Legal and Police. The benefits of 100 information products were quantified through these interviews. Interviewees were asked to provide the following information for each product that was part of the department list of applications:

1. the nature of the programmed activity;
2. the extent to which information products are used currently;
3. the costs of producing current products, and
4. the estimated benefits of products not currently available that would be produced with a GIS.

In this list of information products there are a number of "new" information products that are likely to be unmanageable if addressed manually. The city of Ottawa called these products *desired additional information*. The Ottawa study based on the information provided by each department estimates the current baseline cost (material and personnel time) of making products manually and the costs of making the *desired additional* information products if existing manual methods were used. The savings of both information products (already produced and desired) were calculated by assessing how much would be saved if GISt were available.

However, in this study dollar values were assigned "only to savings made by replacing information products already produced manually, or to savings in staff time or improvements in operational efficiencies or other direct benefits by city staff."(251) It is important to emphasize that costs of producing desired additional information manually were considered as an *avoided cost.*

As a result of this GIS feasibility study, Ottawa's staff could successfully present GIS as an attractive public investment. They estimated that "tangible benefits to the city's operations from 1990 to 2000 will be in excess of $30 million expressed in discounted 1991 dollars (...) over this ten-year-period, we [city of Ottawa] estimate savings of over 439000 person hours valued at over $11 million from GIS efficiencies." (251) "The net result is a discounted excess of benefits over costs of more than $17.5 million." (252)

There are occasions where government needs to respond to regulatory (mandated) requirements, in which case an advanced technology investment could be comfortably justified. An example is the Florida's 1985 Planning and Development Act that required that local governments provide detailed information available in the form of maps and map overlays. Governments in a similar situation could use a less time consuming and more flexible approach.

Therefore, GISt justification could be accomplished through a system of weighing the intangible benefits to what is called "excess tangible cost."(Prisley, 33) In this approach the "hard" benefit data (tangible benefits) is deducted from the total system cost. Then, the cost left without justification is compared to a list of GIS intangible benefits. The intangible benefits (improved decision making, customer satisfaction, improved access to information, more effective communication and data sharing between offices, etc...) values will be estimated through judgement. (Liteck, 16)

In this justification process the probability of achieving these intangible benefits are subjectively assessed. Liteck explains that if a manager determines that the probability of achieving a particular benefit is about one in ten, then it is necessary to shown $10 of potential benefits for every dollar of excess tangible costs in order to be convinced of a project's merit.

For this approach it is crucial to identify what would could change in the department operations due to GIS implementation. It is clear that this approach involves some subjectivity, but the outcome can be highly positive if the in-house personnel involved in the project proposal make a "brainstorm" effort to list all the possible benefits that GIS could bring to each of the departments involved. Despite the fact that some of these benefits would be abstract in nature, the *Excess Tangible Cost* approach would set a framework for future system performance evaluation. And, based on the "brainstorm" discoveries GIS might become a very attractive investment.

- Simplified Excess Tangible Cost - Example

  Tangible Costs ..... $ XXX

  - Tangible Benefits XX

  Excess Tangible Costs XX

  Intangible Benefits

  Benefit 1 x discount factor 1 = YY

  Benefit 2 x discount factor 2 = YY

  Benefit 3 x discount factor 3 = YY

  Benefit 4 x discount factor 4 = YY YY(total)

  NET (figure of merit)..... XX

Benefits

The "hard" benefit data frequently involves labor savings, material cost savings, and minimization of current out-house expenditures. The bulk of these savings are usually labor cost savings. Labor savings are the dollar value assigned to personnel work time saved through GIS use. Each department should estimate how much time its employees spend on any of the tasks related to the data sets available for each of these two alternatives: proposed GIS (automated) and non-GIS (manual). In order to assess the value of labor savings, the time saved by using the automated alternative is multiplied by the salary and any other economic benefit of the personnel whose time is saved.(Korte, 49) The material cost savings are tools and consumable resources such as drafting supplies necessary in the manual map production process. Minimization of out-house expenditures occurs when a department no long needs to hire consultants to perform tasks that are now available through its GIS.

The key to a successful purchase justification could be the identification of potential changes GIS technology would yield. The most common examples of intangible benefits or broad categories of benefits expected from GIS are:

- reducing the potential for maladministration and liability,
- more rigorous data management,
- enhanced visualization of graphical data,
- improved analytical procedures,
- improved data security,
- the provision of better information,
- more consistent access to data,
- improved services to customers,
- the ability to integrate data,
- the ability to generate new 'understandings', and easier access to data.

Costs

Costs are much more straightforward to quantify. However, it is stressed by many GIS specialist that costs are highly *front-loaded*.

Consequently, information about all the potential benefits an organization could expect to obtain becomes vital. The dominant approach in cost analysis is to divide costs into two categories, implementation and maintenance. Korte (49) defines maintenance cost as "operations and the maintenance of the digital database following system implementation." GIS database is instrumental only if it provides current information. Also, hardware/software upgrading and replacement should be considered on the assessment of the system ongoing costs. According to Worral, the possible items to be considered in any GIS implementation cost analysis are: (557)

- hardware integration with pre-existing computing infrastructure,
- evaluation, selection, acquisition and installation of software,
- undertaking requirements/needs analysis,
- contractual aspects,
- consultancy support,
- systems customization,
- applications portfolio development (and/or customization),
- interfacing to other 'data servers' and operational systems,
- training, human resources planning, skills development and re-skilling,
- additional vendor services (e.g. possible turnkey development),
- business analysis,
- project management,
- delivery and installation,
- communications,
- business process re-engineering,
- documentation redesign,
- transitional costs (i.e. parallel running of old and new systems),
- on-going revenue implications (i.e. staff costs and consumables),
- data modeling, data flows analysis and redesign,
- data purchase (e.g., Address Point, Census),
- data capture, data conversion, and
- data re-survey and validation.

The city of Ottawa revealed that the costs were distributed among the following categories: maintenance (15,1%), software (8,6%), external data conversion (20%), staffing/training (26,7%), hardware (24,0%), system implementation (5,6%).

Conclusion

The implementation of GIS is a long-term undertaking of time, effort, and money. An organization or department can highly advance its GIS implementation by considering the option of a data sharing cooperative. The Enterprise-wide option (data sharing) has been proven quite successful as a means to minimize costs.

Moreover, this option would enable an organization or department to use existing datasets and/or operational capabilities. This option can bring about major efficiencies and savings to the public sector under increasing performance pressure. GIS data sharing needs to be viewed as a *strategic advantage*.

It is well recognized today that governmental agencies often duplicate data that are already available and in use by other agencies. A GIS sharing program could permit to an agency to "keep pace" with new mandates even when it faces a shrinking budget. Sharing data can build interagency cooperation and expanded use of information created by government agencies.

A financial example is presented by the Kansas GIS Policy Board's briefing paper. It revealed that the board spent a total of $2,2 million to develop a shared database of geographically-related information and to coordinate the use of that information among State, Federal, and local agencies. According to the report this data set would have cost the state $11,3 million considering the usage of the shared geographic information by individual state agencies. That results in a net savings of State tax dollars in the amount of $9 million over four fiscal years (Benefit/ Cost ratio of 4:1).

An in-state example of successful and invaluable GIS data sharing was the one experienced by a number of government agencies when a devastating ice storm hit the northern part of New York State (NYS) on January 6, 1998. As a result of the storm, over 130,000 residents, countless businesses, and 1800 farms were without power. Additionally, phone services were decimated and numerous roads were closed. Six counties were declared eligible for federal disaster relief. Agencies such as Department of Transportation, Office of Real Property Services, Department of State, Public Service Commission, Department of Health, and Department of Environmental Conservation worked together to share GIS data, staff and analysis obtained from it to meet the State's urgent needs.

The NYS Statewide GIS Coordination program quickly facilitated the recovery effort because it has been disseminating an interagency cooperation climate since its establishment 14 months ago. Under the leadership of New York's Office for Technology this program has been able to bring together over 100 volunteers that represent State agencies, local government, academia and private sector. These volunteers have been actively sharing their GIS expertise to address many of the major issues relating to the dissemination of GISt among all levels of government within the State.

The task of justifying the cost of investment in GIS is well acknowledged to be difficult. Organizational resistance can be reduced if an extra

effort is made to educate and involve the people within the organization who will benefit from the technology. Increasingly, the ultimate goal of implementing a GIS system is to improve an organization's performance and to enhance the outlook for new business opportunities.

It is important to emphasize that one of the most useful features of a GIS is its ability to overlay different views of a place. Combinations are limited only by the kinds of questions you need to answer and the kind of spatial data you have available to answer them. This powerful ability to integrate different kinds of information about a place can lead to better-informed decisions about public investments in infrastructure and services. Geographic Information Systems are effective analytical and decision-making tools that organize, compare, and analyze disparate types of information.

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