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Towards a Theory of GIS Program Management

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Abstract: After a brief flurry of monographs on business and organizational aspects of GIS in the 1990s, little attention has been paid to a systematic approach in support of GIS Program management. Most existing efforts in both public and private enterprises are based on anecdotal evidence. This chapter outlines a range of research questions and the beginning efforts to study modern GIS management practices and help develop a body of knowledge that can be used for the accreditation of GIS Programs and the certification of GIS Program managers.

Keywords: Enterprise GIS, Strategic Planning, Cost Benefit Evaluation, Human Resources, Funding, Governance, Capability Maturity Model, Management Competency Model.

1 Introduction

GIS has grown up. We do not need to explain the acronym anymore; everybody knows what it is and everybody seems to be using it. Or so they think[i]. Text books of the late 20th century spent a lot of time defining GIS; definitions that show little resemblance to how GIS users in 2015 understand GIS. Many current GIS applications are as easy to use as writing an email on a mobile device and the end user is well-shielded from the 'S' in GIS, the system that was all-important in the definitions of the 1990s. This chapter aims to provide academic support for the people who build and maintain such systems; not the programmers who help us to create ever faster indexes on unstructured data but the people who build the infrastructure that the easy to use applications depend on.

Every organization that has multiple GIS users has *de facto* a GIS Program [1]. If the users get their work done and are not aware of the business unit that allows them to do their work, then this means that the program manager does her job well. If on the other hand every GIS project starts from scratch and the only institutional memory is buried in the heads of those who did other GIS projects before, then the tool that constitutes GIS is clearly not used to its highest potential. This chapter aims to rectify this all-too-common situation by providing an analysis of best practices. Even in organizations that have an official GIS Program manager, this person more often than not has reached their position by seniority and learned by trial and error what works and what doesn't [2]. As mature as GIS is from a technical perspective [3], GIS Program management is still haphazard [4] and the best a GIS Program manager could do up to now is to talk to peers in a social network built over decades of professional experience [5].

The professionalization of GIS has made good progress [6]. GIS certificates, both academic and vendor-driven abound and several professional organizations have developed their own set of certifications for GIS technicians [7-10]; i.e., the bottom strung of a hierarchy of GIS professionals [11]. There is, or at least has not been, a corresponding body of knowledge for higher level GIS professionals or managers, which is surprising given that there are thousands of GIS departments in the United States alone. King County's (Seattle) GIS department, for instance, has 28 staff and spends over $5 million to support some 35 business units throughout the county [12]. Running such a unit could be seen as a public administration [13] or more generally a management science [14] task. But similar to GIScience being different from general information science [15], the body of knowledge in support of a GIS Program is different and needs to be codified. This necessity is underlined by the creation of the GIS Management Institute (GMI) that requires a scientific foundation for its accreditation of GIS Programs and the certification of GIS Program managers [16].

2 The Widening Gap between Bodies of Knowledge

There was a wave of interest in the fledgling GIScience literature on organizational and management aspects of GIS in the late 1990s [17-20] that has barely been kept alive in later years by vendor-sponsored monographs [21, 22]. But things have understandably since changed with respect to technology (from client-server to PC to web services) as well as the role of GIS in many organizations. The better academic departments are doing a good job teaching GIS project management [23] but there is only one school in the United States that offers a degree in GIS Management [24]. In spite of the flurry of publications in the 1990s, GIScience has not been acknowledged in the world of business schools [25].

At the same time, new standards [26 -28] have been widely adopted in the business community but are virtually unknown in the academic world. The PMI defines program management as "the application of knowledge, skills, tools, and techniques to a program to meet the program requirements and to obtain benefits and control not available by managing projects individually", [27, p. 6]. The scope of programs is hence beyond the sum of individual projects and includes training, operations and maintenance activities. All this applied to GIS Programs as well. Two dimensions are useful to keep in mind when there is confusion about the differences between projects and programs:

- Uncertainty; well-managed projects generally have a low level of uncertainty associated with them. This starts with project specification and improves as a project moves towards its goal. Programs, on the other hand do not start out with a well-defined scope and require continuous adjustment. In extreme cases, a successful project may still be abandoned because its program context has changed.
- Change management of projects is usually in form of fixes when the original outcomes seem to become unattainable. Program management, however, anticipates changes and aims to adapt the program to changing contexts.

The practice of GIS Programs would be categorized in management science as a portfolio, a higher level management structure that has temporal bounds and combines multiple programs to achieve an organization's strategic objectives [25]. In addition, portfolio projects do not need to be related to each other. Both of these characteristics (no temporal bounds and possible non-relatedness of the projects) are characteristic for GIS Programs. It follows that GIS Programs then combine the components of traditional programs and portfolios, namely: strategic planning, governance, benefits management, and stakeholder engagement. GIS Programs, like portfolios, manage recurring activities (producing values) as well as projectized activities that are aimed at increasing value production capability.

3 Contents of a GIS Program Management Body of Knowledge

3.1 Strategic Planning

Following Crosswell [29], the GIS Program roadmap has to fit with the larger organization strategy of the institution. This requires the identification of geographically oriented business processes to arrive at a GIS assessment and planning workflow. The program manager needs to determine internal and external influences to identify the benefits for stakeholders (see sub-sections beneath). That task itself is based on the recognition of assumptions, some SWOT analyses and feasibility studies. Fortunately, a number of county and state governments have published their GIS Strategic Plans [30-34], which form nice case study objects.

3.1.1 Program Benefits Management

Program benefits management aims at focusing stakeholders on the outcomes and benefits. The latter include internal improved financial performance and operational efficiencies as well as external customers (other business units) or intended beneficiaries such as a particular demographic of the general population. The challenge often lies in realizing that new or improved capabilities to consistently deliver and sustain program products, services, or capabilities are usually fast taken for granted and their continuing benefit is hard to quantify or monetarize. Some benefits such as access to building permit data show immediate results, while others such as improvement in school graduation rates may only become apparent when the program itself is completed. The program roadmap will help in managing expectations in this context.

3.1.2 Program Stakeholder Engagement

The importance of managing perceptions across stakeholder groups cannot be overemphasized. A stakeholder map (see Figure 1) helps to keep oversight as to how tight the communication with each stakeholder (group) should be managed.

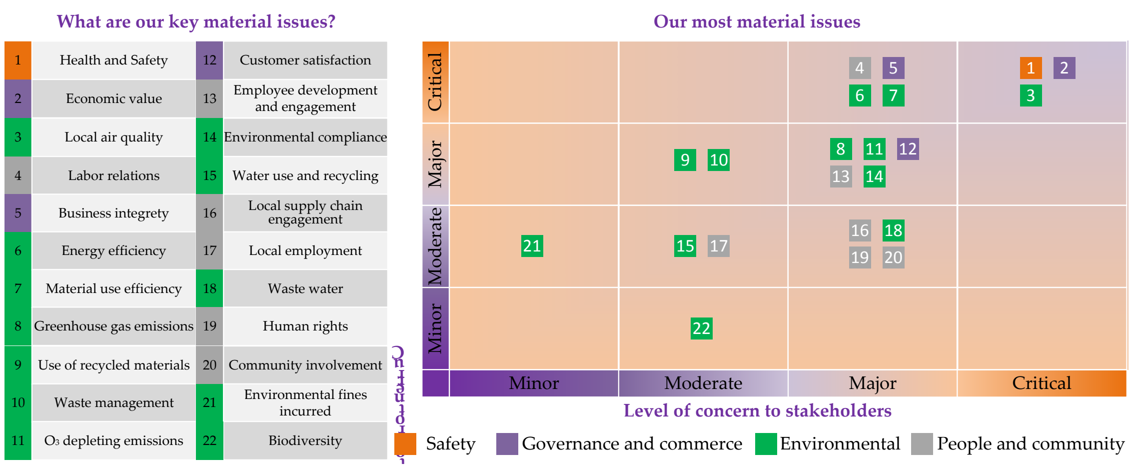

Figure 1: Stakeholder map (adopted from [34, p. 4])

Stakeholder engagement planning should include questions of organizational culture and acceptance of change, expectations of program benefits, degree of support or opposition to the program, and an estimation of the stakeholder's ability to influence the outcome of the GIS Program. The result of such work is a stakeholder engagement plan that should contain quantitative and qualitative measures of stakeholder engagement. Although it is discussed here as part of strategic planning, it should be noticed that stakeholder engagement planning like the strategic plan as a whole is a continuous effort and not limited to the beginning stages of a GIS Program.

3.2 Cost Benefit Evaluation

The purpose of a cost benefit evaluation is to get senior management support and secure funding. The business case for the GIS Program has to be developed in collaboration with key sponsors and stakeholders. Obermeyer [35] provided a general overview with examples for a range of benefits from GIS Programs across North America but until recently, the only methodological description was a very hands-on ten-step process developed for ESRI in 2008 [36], which was followed by individual studies reported on in the URISA Journal [12, 37]. A first detailed and systematic methodology is currently being developed and tested for a range of organizations at the University of Washington by Zerbe [38]. For smaller organizations, so-called cost-effectiveness analysis, balanced score card, total cost of ownership, or even basic payback period value-added approaches have been proposed [29, 39].

3.3 GIS Human Resources

One of the main differences between a GIS Project (even a big one) and a GIS Program is the issue of staff recruitment and hiring, which would usually be left to a personnel or human resource department. However, a GIS Program manager has to determine how to distribute workloads across full- and part-time positions, student interns, contract personnel, or using overtime of existing personnel. The Urban and Regional Information Systems Association (URISA) published a useful booklet about model GIS job descriptions [40] that illustrates the range of responsibilities, and a salary survey [41] that in addition to mere dollar figures also provides a wide range of tables that can be mined for how GIS tasks are distributed throughout different types of organizations. One of the unresolved issues of GIS human resources is the question of gender balance [42].

3.3.1 From Geospatial Technology Competency to Geospatial Management Competency

The US Department of Labor released in 2010 a nine-tiered geospatial technology competency model that specifies foundational, industry-wide, industry sector-specific, and finally occupation-specific competencies [43] (see Figure 2). It then contracted with URISA to develop a geospatial management competency model for the top tier of this pyramid [44]. It specifies 74 essential competencies and 18 competency areas that characterize the work of most successful managers in the geospatial industry. Its purpose is to guide individual professional development, to help people in move up or over in an organization or industry, to help educators and trainers develop curricula that address workforce needs, to inform development of interview protocols, as requirements for professional certification, and as criteria for academic program accreditation and articulation.

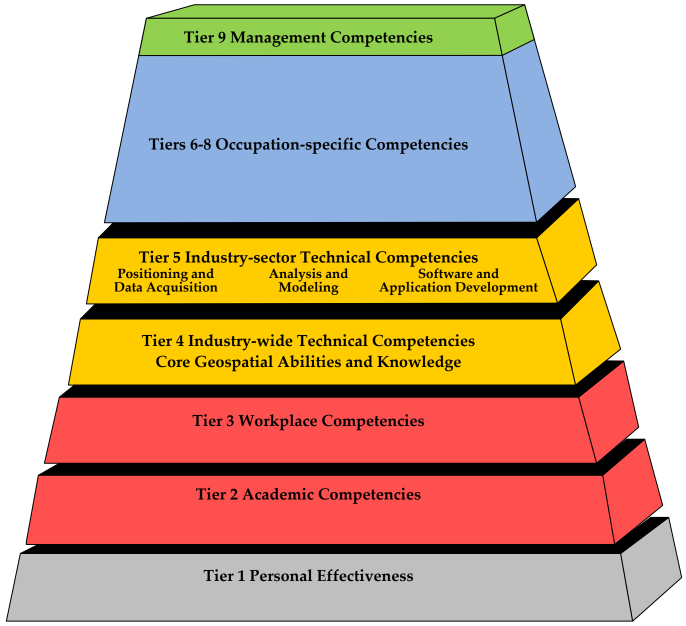

Figure 2: Geospatial competency model (adopted from [43, 44])

3.4 Financial Planning and Management

3.4.1 Costs

GIS Programs are often funded through line-items in the general fund—allocated through the organization's budgeting process. In addition to funds allocated through the normal budgeting process in an organization, there are often other funding sources such as special funds or capital funds (for road or utility improvements) that are managed separate from the general fund. Among program management one can distinguish traditional project costs from those that are more often seen as "fixed costs" such as system infrastructure, tech support, application development, or finance management. We are used to projects to have costs overruns. These will have to be buffered in the larger context of the GIS Program – something that puts GIS Program managers into a difficult position, where she has to defend herself in all directions. Flexibility gained from a wider range of staffing options (including the secondment of employees from other departments) goes a long way to create such buffers.

3.4.2 Outsourcing

An increasingly popular option for minimizing long term costs is the notion of outsourcing and contracting. Web services cover potentially more and more of the above mentioned fixed costs. In addition, needs assessment, field work, and many data maintenance tasks are now seen as areas that do not require in-house expertise. The difficult part here is that outsourcing does not relinquish the organization from its role to manage and oversee the work, and to take overall responsibility for it.

With increased reliance on outside vendors and contractors comes the issue of procurement. Traditionally the realm of a purchasing department, this is a prime example for where spatial is special, i.e., the expertise for running the complete workflow from the preparation of specifications and requests for information / qualifications / proposals / bids to review and contract preparation should lie within the GIS Program [29]. The need to incorporate legal counsel may cause this externalization of costs to become a rather drawn-out process. It is therefore the responsibility of the GIS Program manager to develop and maintain a good working relationship with the vendor/contractor.

3.5 The Technological Environment

3.5.1 Enterprise GIS

GIS Program management and enterprise GIS go hand in hand. An enterprise GIS without GIS Program management is unconceivable and the latter would be overkill if there is no wide adoption of GIS throughout the organization. The notion of an enterprise GIS assumes that multiple if not many business units are using GIS.

3.5.2 Components of a GIS Architecture

Although many businesses do not have a formal GIS architecture, enterprise GIS benefit immensely from an organized conceptual framework that enables the description and guides the construction and operation of complex GIS implementations. There is a large body of literature on architectural reference models and best practices [45, 46].

A solid architectural design is robust enough to cope with ever changing environments and demands. Examples for relatively recent demands that distinguish GIS architectures from general IT trends are: wireless data acquisition including real-time GPS/GNSS, "Open GIS" from desktop clients to web portals, web services and crowd-sourcing, coping with big data like LiDAR, CAD-GIS integration. Compared with most other business applications, GIS puts a much higher demand on the expertise and computational prowess of the IT infrastructure, which may in some instances cause the general IT department to be subsumed under the GIS Program.

Given the above mentioned demands, enterprise GIS tend to put a much higher strain on security, database administration, and user support than traditional IT departments are used to. Even the development of technical standards (in-house as well as outside all the way up to the International Standards Organization (ISO)) requires faster training and continuing education cycles.

3.5.3 Maintaining the In-house GIS Database

GIS projects are usually not expansive enough to warrant the development of guidelines for data quality. It is therefore at the GIS Program level, that organization-wide data quality specifications should be developed and enforced. The FGDC has developed a widely accepted base standard [47], which may, however, have to be expanded to fit the mission of the enterprise. It is in this context worthwhile to consult further standards developed by ISO [48] and the Open Geospatial Consortium.

The GIS Program manager is responsible for defining an enterprise-wide set of automated and manual checks both during (quality control) and after data editing (quality assurance). In some instances, this still involves data capture itself, but for most GIS programs, standardized procedures will have to be developed that ascertain that editing and analysis procedures are documented well enough to be reproducible.

3.6 GIS Program Governance

3.6.1 Reporting Structures and Responsibilities

Following directly from the previous section, a well-managed GIS Program has policies and practices for each of the categories listed in Table 1. These should be developed on a consensus basis and reviewed/revised on a regular basis.

• Personnel and professional development	• System administration and network security
• Standards compliance	• User support and help desk services
• Contract and financial management	• External communications
• Project coordination and management	• Data maintenance procedures and responsibilities
• Data/product access and sharing	

Table 1: Categories of GIS Program Policies (adopted from [29]).

3.6.2 Legal Issues

Except for health and financial institutions, few other IT managers have to deal as many legal concerns as the GIS Program manager. In the widest sense, these have to do with access to and distribution of geographic information. Legal authority for access to public records is granted in the United States by the federal freedom of information act [49] that are augmented by state laws and local regulations such as right-to-know laws and sunshine acts.

This is balanced by both security concerns and the threat of liability suits. A FGDC study [50] showed that security concerns are usually over-emphasized and that most of non-classified information is available through multiple pathways. Liability concerns are more difficult to deal with because the range of possible aggravations is so large. Reliability questions though are easiest to address by placing data into the public domain, which absolves authorities from almost any responsibility for inaccuracies [51] – but this contradicts another tenet of GIS Program management: to cover one's costs through revenues [52]. Interagency agreements for cost and data sharing carry their own rules and should be adhered to if for no other reason than that it would erode trust if partners do not act in sync.

With the transition from product to service delivery, the legal territory becomes ever more uncertain to the GIS manager because service providers usually exclude liability in case of service changes and traditional data backup procedures become obsolete.

4 GIS Capability Maturity Model (GISCMM)

The GIS Management Institute developed a tool to assess levels of capability and maturity of an organization's GIS operations [53]. The model was originally developed with a focus on local governments but is intended to be applicable to any enterprise GIS. The notion of a capability maturity model was originally developed by the Software Engineering Institute [54].

The capability maturity model is based on the characteristics of the organization's approach to individual defined processes. These processes are usually defined as:

Level 1 – Ad hoc (chaotic) processes-typically in reaction to a need to get something done.

Level 2 – Repeatable processes–typically based on recalling and repeating how the process was done the last time.

Level 3 – Defined process–the process is written down (documented) and serves to guide consistent performance within the organization.

Level 4 – Managed process–the documented process is measured when performed and the measurements are compiled for analysis. Changing system conditions are managed by adapting the defined process to meet the conditions.

Level 5 – Optimized processes–The defined and managed process is improved on an on-going basis by institutionalized process improvement planning and implementation. Optimization may be tied to quantified performance goals.

The National States Geographic Information Council (NSGIC) identified in 2010 seven categories for which GIS capability maturity should be measured: (1) people, (2) data, (3) processes, (4) policy, (5) strategy, (6) technology, and (7) legal [55]. Within these seven categories, the GMI chose to assess GIS organizations' maturity on a 7-point scale in 56 specific detailed characteristics based on their current implementation of each characteristic. The GIS Capability Maturity Model assumes two broad areas of GIS operational development: enabling capability and execution ability. Enabling capability can be thought of as the technology, data, resources, and related infrastructure to support typical enterprise GIS operations. Enabling capability includes GIS management and professional staff. However, the ability (execution capability) of the staff to utilize the enabling technology at its disposal is subject to a separate assessment as part of the model.

5 Conclusions

This chapter outlines a range of aspects in which the management of GIS projects and programs differ. The latter is a relatively undeveloped research area. Efforts to build a scientific foundation for program management practices just started with the development of a thorough return on investment study across a multitude of organization types [38]. Similarly, the data created by hundreds of organizations, who are as of 2015 conducting a GISCMM-based assessment will provide the foundation to build a generalizable body of knowledge for GIS Program management. Together with an analysis of best practices as identified, for example, through 35 years of peer review for the Exemplary Systems in Government Award [56], we are inching towards a theory of GIS Program Management.

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[i] GIS is experiencing the same misunderstanding that statistics faced (and is still facing) ten years ago. Just because a function is available at the push of a button does not mean that it is appropriate. The same way that statistical analyses are constrained by measurement scales, geo-spatial analyses are prone to the modifiable area unit problem and uninitiated GIS users often lack the spatial reasoning skills that are necessary to analyze spatial data properly. This is, however, not the topic of this chapter.