DEFINITION OF GIS: THE MANAGER’S PERSPECTIVE

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Abstract

Two perspectives of defining GIS are identified, namely, technological and organisational. The technological perspective is suitable to describe a GIS developed in a local GIS scenario as in the case of a GIS developed for a business process. The organisational perspective is better for a GIS developed in a global GIS scenario as in the case of a corporate GIS. Based on the limitations of the two perspectives identified, a model is developed to highlight the qualities of a corporate GIS from a manager’s perspective. It is suggested that a corporate GIS is multi-element and modular in nature. It comprises four technological elements (data, standards, information technology and people with expertise) and an organisational setting. Each module of the GIS is defined by the role it plays, namely, infrastructure or business process. A corporate GIS is integrated through the development of a module of infrastructure GIS to support the various modules of business process GIS. The development of the different modules of GIS is significantly affected by the organisational settings. The significance of these qualities towards implementation of an integrated corporate GIS is discussed.

1. Introduction

GIS traditionally refers to Geographic Information Systems. In the literature, there are many approaches of defining GIS with each approach reflecting a person’s current perception of GIS. As the person’s experience with GIS changes, the perception of GIS and as a result the definition of GIS will also change, and vice versa. If that person is a GIS manager, the perception of GIS created by a definition will affect the way the manager implements a GIS.

Implementation also can be affected by many factors both inside and outside an organisation. Different combinations of these factors will create different scenarios of GIS implementation. This paper suggests that different definitions of GIS are applicable in different scenarios of implementation. An appropriate definition will help a GIS manager to formulate a realistic implementation strategy. Therefore the two key perspectives (or approaches) of defining GIS are reviewed from a manager’s point of view to determine their applicability to two basic scenarios of implementation. Based on the limitations identified, an alternative model of describing GIS in an organisation (corporate GIS) is developed providing an insight into the qualities of such a GIS.

2. Definition of GIS

Maguire (1991) reviews the various definitions of GIS in its traditional sense up to 1991. In the process, he identifies two perspectives of describing GIS, the technological and organisational/institution (abbrev.
as organisational) perspective. Though potentially a useful framework of describing GIS, Maguire does not pinpoint the characteristics of the two perspectives. In the following section, this paper consolidates and expands on Maguire’s concepts and tries to enrich his framework of describing GIS.

2.1. Technological perspective of GIS

After coining the term ‘technological perspective’ in describing GIS, Maguire (1991) cites four approaches of defining GIS as identified by Cowen (1988) as examples under this perspective:

- Process-/function-oriented – emphasises the information handling capabilities of GIS (eg., storage, retrieval, manipulation, and display of geographic data);
- Application – divides information systems according to the problems they seek to address (eg., soil, land, and planning information system);
- Toolbox – emphasises the generic aspects of GIS as a toolbox to manipulate spatial data;
- Database – regards GIS as a database system, reflecting the influence of database theory and practice on GIS.

On analysing the characteristics of GIS and other information systems including remote sensing, computer-aided design, computer cartography and database management, Maguire develops a model to describe the relationships among them. Based on this model, he identifies three views of GIS with each view focusing on one functional aspect of GIS:

- Map (inventory, such as data querying)
- Database (simple analysis, such as overlaying, buffering etc.) and
- Spatial analysis (modelling, decision making)

By studying these approaches the technological perspective can be seen as a generic way which identifies GIS by the form of the technology (database, application system, or toolbox) and the functional capabilities (process/function-oriented, map, database, and spatial analysis) as perceived by the person defining the technology.

Implementation can be affected by many factors, eg., target, cost-benefit justifications, stakeholders, senior management support, and culture of organisation etc. Based on how certain and well defined these factors are to GIS managers, two basic scenarios of implementation can be identified, namely, local GIS and global GIS.

Local GIS is the scenario characterised by certainty in defining all or most of the key factors of implementation. A typical example is a GIS developed to provide spatial information products for local needs – a project or an existing business process (or part of it) in an organisation. Global GIS is the scenario characterised by uncertainty in defining all or most of the key factors of implementation. A typical example is a GIS developed for a more global community such a corporation, state/province, country, or even an alliance of countries in a region. Discussion on the global GIS scenario in this paper will be confined to a corporate GIS – a GIS to satisfy the spatial information needs of an organisation as a whole in an integrated manner. The two scenarios represent the best and the worst scenarios in GIS implementation in an organisation in terms of the ability to define needs, constraints and limitations. Other scenarios will normally lie somewhere between the two extremes.

It is suggested that the technological perspective is suitable for GIS implementation in the local GIS scenario. In this scenario, GIS is often conceived locally by business professionals, technicians, or managers specifically to provide a solution/ improvement to a local business process (see elements of success cited by Obermeyer and Pinto (1994)) The purpose of the GIS is well defined and focused; the participants and stakeholders are often relatively few in number and closely involved in the project. They often know the job and each other’s needs well, and share a common set of visions or objectives. Their behaviours can be predicted with greater certainty. So are the various constraints and limitations. The specific nature of the project means that the costs and benefits are often quite straightforward, well
defined and understood. When senior management provide the necessary funding, support is considered secured for the project. Once the hardware and software are chosen based on costs, familiarity, and capabilities, the project team’s main concern is to develop the databases and the applications to deliver the spatial information needed to achieve the target of the project within budget and deadline. These are the characteristics of the local GIS scenario of implementation.

Under these circumstances, irrespective of the application area in question, many factors of implementations are well defined early on either by experience of the local managers, or in a de facto manner once funding is secured and the hardware and software combination is chosen. The main effort of the project team is the development of an information system that serves the purpose. The technological perspective of GIS describes that information system – a narrow view of a system or toolbox that has the necessary capabilities to manipulate spatial data and their relationships to serve a particular purpose. The perspective provides the manager of the GIS project a simple yet sufficiently accurate picture of what should be developed.

2.2. Limitations of the Technological Perspective

In the local GIS scenario there is often a specific target, eg., ‘to identify all the potential habitats for an endangered species of bird in the forests in region X to meet the requirements of a government environmental policy’. A corporate GIS which emphasises integration have a target that is less specific, eg., ‘to develop a GIS to serve the information needs of all the business functions of the organisation’. Further, when formally surveyed to develop a corporate GIS, the stakeholders (users) in different business functions are often not very sure of what their GIS needs are. This is due to the different levels of awareness and expertise of GIS, the dynamic functional requirements of business functions, the vast number of stakeholders involved and their potentially heterogeneous background in the organisation. Their expectations will change with time and as they get more familiar with the technology. Stakeholders’ perceptions of GIS may vary from highly supportive to highly sceptical or even antagonistic. This often results in organisational political behaviours (Pinto and Azad 1994).

Not only must a project team grapple with the different functional views and needs of stakeholders with regard to what a corporate GIS can do, they must also consider other issues which may also affect implementation. Typical examples are:

1. Different types of spatial and attribute data needed
2. Different scales, formats and quality of data needed
3. Different hardware platforms, proprietary software, and communication technology capabilities
4. Different levels of expertise – Information Technology and GIS
5. Different types of information products needed
6. Different knowledge and understanding of GIS resulting in different attitude towards GIS adoption and utilisation
7. Different levels of resource available for development, financial or otherwise
8. Different cultures of conducting business, and thus different emphases on innovation and technology, cooperation and sharing of resources
9. Different mechanisms for communication, coordination, and conflict resolution in general

These issues point to a list of elements that are common to all the functional GIS capabilities required by different business functions and their stakeholders. The elements serve as building blocks that must be worked through, agreed, designed and assembled before the integrated corporate GIS can be realised.

Further the time scale required to build a corporate GIS is often longer than a local GIS project. As a result, success of implementation of the technology also will be subject to a whole host of environmental factors, political, economic, technological or even financial, which can change over the life cycle of the project. While these factors may reasonably be ignored in local GIS projects, they can significantly affect
the outcome of implementation of a corporate GIS.

Therefore in a global GIS scenario such as a corporate GIS, it is difficult to determine the full scope and scale of the project, the full GIS capabilities required, the full range of costs and benefits involved, and the final outcomes expected of the project, at least not in the short term. Chan and Williamson (1995b, 1996a) have reviewed these issues in relation to a State government GIS in Australia.

If the GIS project team recognises only the technological perspective of GIS but not the other broader issues, it may be tempted to develop an information system that provides a range of ‘generic’ GIS functions, hoping that once available the users will adopt the technology with open arms. Almost inevitably, the project team will encounter problems of a totally different scale and nature. These problems are well documented (Chan and Williamson 1996a, Croswell 1989, Tulloch, et al. 1996).

The wider the scope and scale of the project is and the longer term it is, the more people will be affected and the less likely the various aspects of the project can be clearly defined or be predicted accurately at an early stage. While the technological perspective of GIS can sufficiently describe a GIS in a local GIS scenario for which many aspects are certain or at least predictable, it is too restrictive to describe a corporate GIS in full. As discussed earlier, a perspective that describes a list of elements or building blocks that underpin the development of the corporate GIS, may be more appropriate.

2.4. Organisational Perspective of GIS

Describing GIS in terms of a list of elements is not new. A collection of such an approach is listed in table 1, including Carter’s definition based on which Maguire (1991) coined the term ‘organisational perspective’. Like the technological perspective, Maguire does not describe the characteristics of the organisational perspective. By comparing Carter’s definition with other definitions described in table 1, two characteristics of the organisational perspective are identified:

1. Describing GIS in terms of its generic elements or building blocks,
2. Taking into consideration the organisational setting in the guise of organisational/ institutional structure/ context (note that the earlier definitions tend not to include this element).

Carter (1989) defines ‘institutional entity’ in terms of the organisational structure and continued financial support. Burrough (1990) describes ‘organisational context’ in terms of new business operations, new staff and new organisational units created to manage GIS, reliable funding and proper legal and political support. Maguire (1991) does not describe what he means by ‘institutional context’. Up until the time Maguire writes his article, the concepts of organisational perspective in general and the organisational setting in particular remain vague and piecemeal. The organisational setting remains a context rather than an integral element until 1993 when the Mapping Science Committee of the US National Research Council (1993) reports its findings on National Spatial Data Infrastructure (NSDI). The Committee identifies NSDI as making up of databases, metadata and sources, data networks, technology, institutional arrangements, policies and standards, and users. McLaughlin and Anderson (1994) later highlight that "the institutional arrangements, policies and standards are required to co-ordinate all of the various parts". The institutional arrangements and policies mentioned constitute the organisational setting and are considered integral elements of the NSDI. The discussions by the US Mapping Science Committee and McLaughlin and Anderson together help establish the organisational setting as an integral element of GIS.

Table 1. Definitions of GIS in terms of its elements.

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<tr>
<th>Authors</th>
<th>Definitions</th>
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<tr>
<td>Dangermond (1988)</td>
<td>GIS consists of five basic elements: &quot;data, hardware, software, procedure and people&quot;.</td>
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Dickinson and Calkins (1988) GIS is made up of three components: "GIS technology, GIS data base, GIS infrastructure".

Carter (1989, p.3) GIS is "an institutional entity, reflecting an organizational structure that integrates technology with a database, expertise and continuing financial support over time."

Burrough (1990) GIS has three components: "computer hardware, sets of application software modules, and a proper organisational context".

Maguire (1991, p.15) GIS comprises "four basic elements which operate in an institutional context: hardware, software, data and liveware".

The development of the NSDI concept and its acceptance by governments worldwide gives significance to the organisational perspective of GIS, and confirms the organisational setting as an integral part of the NSDI. Since then, researchers looking at the management of GIS also make organisational setting an integral part of GIS (Huxhold and Levinsohn 1995).

Based on the experience of the development of the Bangkok Land Information System (Williamson and Mathieson 1993) and the development of GIS in the State of Victoria, Australia, Chan and Williamson (1995a) have identified five elements of GIS. They are considered a good mix that reflect the key elements described by other researchers and a good illustration of the organisational perspective of GIS. The five elements are: data, information technology, standards, people with GIS expertise, and the organisational setting and are described in table 2.

The first four elements can be categorised as a group of technological elements – those related directly or indirectly to the technology. In any case, the technological elements are the building blocks that underpin the technological perspective of GIS. Together with the organisational setting, they form the organisational perspective of GIS and serve as the link between the technological and organisational perspectives of describing GIS.

### 2.4. Limitations of Organisational Perspective

Organisational setting is no longer considered just the context that imposes a range of constraints. It is an integral part of the GIS and like all its other elements, will need to be actively nurtured, assembled/created and maintained. Unlike the early days in GIS development, people now are more knowledgeable of what constitutes organisational setting. Based on experience in United States and other countries, some developers of spatial data infrastructures know specifically what kind of organisational setting they want to create (ANZLIC 1996). Using concepts from organisational theory, Huxhold and Levinsohn (1995) list the many aspects of organisational setting (refer as state of the organisation) for GIS – a corporate GIS.

### Table 2. Elements of a GIS (Chan and Williamson 1995a).

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<tr>
<th>Elements of a GIS</th>
<th>Scope of Each Element</th>
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<tr>
<td>Data</td>
<td>all accessible data, both geographical and attribute, required to meet the geographical information needs, identified or latent.</td>
</tr>
<tr>
<td>Information Technology</td>
<td>all computer hardware, software (including applications) and the associated communication technology required to meet the geographical information needs, identified or latent.</td>
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</table>
Standards | all agreed practices required to facilitate the sharing of the other four components of a GIS.
---|---
People with GIS Expertise | all knowledge, skills, procedures, and systems, technical or otherwise, acquired by the stakeholders, that are required for the smooth functioning of the GIS to meet the information needs, both identified or latent.
Organisational Setting | all the operating environments, technical, political, or financial, created by the interaction among stakeholders, in which the GIS is to function.

The identification of the aspects of organisational setting is an important step towards the successful implementation of a corporate GIS. However, it only allows more systematic planning and implementation of the GIS. It does not clarify the relationships between technological elements of GIS and the organisational setting, which is important in the formulation of realistic implementation strategies. In her research into GIS diffusion, Campbell (1996) recognises that diffusion of GIS is affected by the nature of GIS, the structure of an organisation, and the interplay of the two. Her finding highlights the current limited understanding of how the technological elements of GIS interact with their organisational setting. Perhaps instead of looking at the derived knowledge from the organisation literature, a look at the fundamentals of organisation theory may be more beneficial.

3. GIS in an Organisation

To better understand how the technological elements of GIS interact with the organisational setting, it is necessary to establish a link between the two. To do that it is important to consider what constitutes an organisation first.

3.1. Organisation

Broom, et al. (1981) identify the four elements of formal structure as "division of labour, delegation of authority, channelled communication, and coordination" of which division of labour and delegation of authority (hierarchical structure) are key elements. From the five main types of organisational structures identified by Mintzberg (1979), a basic combination of hierarchical structure and division of labour can be identified, separating an organisation into two functional parts as shown in figure 1. The two parts are:

1. Business – a functional part of the organisation representing all the business functions,
2. Administration – a functional part of the organisation representing central administration and the associated functions of staff departments.

Broom, et al. (1981) also define formal structure as "the official rules, goals, powers, and procedures that determine how the organisation’s work is done". Further, to Handy (1993) organisations are "first and foremost, fascinating collections of people". Therefore the two functional parts come to represent the people and the associated rules, regulations, procedures, power/authority, and communication channels that allow business to be carried out and changes to be made when necessary.
Broom, et al. (1981) also consider that "Informal structure is the patterned interactions of persons and groups within the organisation" and together with formal structure, "they make up the social structure of the organisation. The interplay of the two is a basic characteristic of organisations". By adding an informal structure to the formal structure of an organisation, a model of the social structure of organisation is formed as in figure 2.

Like other forms of information technology, GIS is employed to facilitate decision making in business processes. Broom et al.'s definition of the formal structure of an organisation also suggests that the organisation undertakes processes to produce something as determined by its goals. If both GIS and an organisation can be viewed in terms of business processes that they are involved, it may be easier to identify their relationships.

3.2. Organisation as a Mechanism of Production

Alford (1993) develops a framework called the Public Production Process that can help create a view of organisation in terms of its business process. He regards public sector activity as a production process that makes up of four integrated components: Organisational Capabilities, Production, Value, and Environment (figure 3). Organisational Capabilities refer to the productive capabilities of the organisation such as staff, equipment, buildings etc. Production is the procedures whereby the Organisational Capabilities and other resources are converted to something of value. Value refers to something of value produced, such as goods, services, market failure remedies, and equity etc. Environment is the citizens and stakeholders for whom the Value is produced; and from whom authority and funds (taxes) to conduct the business are received.
The Public Production Process is distinct from the private one in four ways. Very briefly, first, public sector managers produce non-market values (also referred by some researchers as public value) in addition to market values. Second, the range of actors in the Environment is more complex involving stakeholders other than clients and tax-payers. Third, public sector managers use public power, including persuasion, convenience and power itself, in addition to public money as a resource to carry out their tasks. Fourth, they make use of public power to tap production capabilities from other external organisations through a process called Co-Production. These distinctions make the elements in Alford’s Public Production Process more comprehensive and generic in describing production processes in general, not just public processes. Chan and Williamson (1996b) first apply Alford’s model to develop a model of internal production process (figure 4) which in turn is used to describe the decision process for GIS diffusion in a government organisation.
Through the introduction of the concept of an internal production process, Chan and Williamson effectively view an organisation as a mechanism of production to generate products and services that meet the requirements of stakeholders in the external environment. This is a convenient concept as GIS is considered by Chan and Williamson as part of the production infrastructure used in the organisation to facilitate the production process. The view of organisation as a mechanism of production may provide a window of opportunity to analyse the quality of GIS in respect to an organisation. However, the concept of internal production process has one major limitation – its emphasis is on describing the different elements of a production process, not the organisation. The solution is to incorporate the concept into the structure of an organisation previously developed from basic organisational theory (figure 2). This results in a view of organisation as a mechanism of production as shown in figure 5.

In figure 5, the production process is represented by the formal and informal structure of the organisation. Based on the definition of the functional parts of an organisation, i.e., Business and Administration as identified in sub-section 3.1 above, the formal and informal structure can be regarded as the organisational setting in which people function to generate the product mix required of the organisation. The production infrastructure is the collection of non-human capabilities and resources such as buildings, machineries, information technology (including GIS), and other raw materials that support the work of these people in both functional parts of the organisation.

3.3. GIS as a Mechanism of Production

Having given GIS a foothold in structure of an organisation, it is time to develop a view of GIS in terms of the business processes an organisation undertakes. The concept of infrastructure in GIS in terms of NSDI was well spelled out in the Executive Order issue by the US President in 1994 (Clinton 1994) and was subsequently embraced by many governments world wide. In 1994, Weill, et al. first develop a model that expands the concept of infrastructure and business process to IT in an organisation. Due to unexpected delays, their paper (1996) is published at a later date. Through personal communication and based on Weill, et al.’s model, Chan and Williamson (1995a) develop a model that matches the roles of GIS to IT’s roles as infrastructure and business process in an organisation (figure 6). The respective roles of GIS are:

1. Business process – serves as an integral part of business processes to improve their efficiency and effectiveness; and
2. Infrastructure – facilitates the development of business process GIS-tech.

Distinguishing GIS from IT using the convenient concept of GIS paradigm (georeferencing, geocoding and topology) introduced by Huxhold and Levinsohn (1995), figure 6 illustrates the business view of GIS showing the corporate GIS as making up of business process and infrastructure GIS. With a business view for each of GIS and organisation, we can now put the
two types of GIS in place of Production Infrastructure in figure 5 to give a model of GIS in an organisation as in figure 7.

3.4. GIS in an Organisation

In figure 7, each functional part of an organisation is a potential location for GIS. It is possible to identify two basic modules of a GIS in an organisation: infrastructure GIS in the Administration part, and business process GIS in the Business part. There is no GIS in Product Mix which is not operational. A module is made up of a set of technological elements of GIS playing the role of either infrastructure or business process in the Administration or Business part of the organisation respectively. The role and the location of each module of GIS in an organisation give each set of the technological elements of the module a unique organisational setting which is represented by the corresponding social (formal and informal) structure of the organisation. The organisational setting gives the GIS in an organisation its modular nature. The common purpose of all the modules of GIS is to produce the product mix as dictated by the stakeholders outside the organisation (see figure 4).
The model in figure 7 represents an integrated GIS in an organisation – a simplified corporate GIS in this case. Integration is achieved by the development of a module of infrastructure GIS which provides common technological elements, i.e., standards and shared GIS capabilities such as data, technology, and expertise to support the various modules of business process GIS. Technically speaking, the more similar the technological elements in any two modules of business process GIS are, the easier it is to develop the module of infrastructure GIS; the less similar, the more difficult. However, this is not always true.

The elements in each module are developed by the people functioning in the organisational setting. As the organisational setting affects the behaviour of people in it, it will have significant influence over the rate and direction of development of the GIS elements, including the organisational setting itself. Therefore, if the technological elements of two business modules of GIS are similar but the people in the two business functions are not talking with each other, it will be very difficult to develop a module of infrastructure GIS to integrate the two business modules. On the other hand, a receptive and willing organisational setting in each business function will encourage people to communicate with one another resulting in faster and focused development of a module of infrastructure GIS. However, not all organisational settings are as receptive and willing. It will be the job of a GIS manager to carefully cultivate the right settings to support the integrated corporate GIS. In general, the more business functions are involved, the more stakeholders and their organisational settings will have to be catered for, and the more time consuming it is to develop a module of infrastructure GIS.

As discussed in sub-section 2.2. and 2.3., the organisational perspective of GIS is more suitable for a corporate GIS in a global GIS scenario. This suggestion is confirmed by the concept of integration of a corporate GIS as discussed in the last two paragraphs and illustrated in figure 7. The discussions and the model emphasis the multi-element nature of GIS and the importance of organisational setting as an integral element of GIS – the characteristics of the organisational perspective.

If development is not coordinated, the GIS in an organisation may simply consist of one or more independent modules of business process GIS. Each module of business process GIS has its unique organisational setting represented by a smaller and more homogeneous group of people in a particular business function. It is more likely that the behaviours of the people involved are certain or predictable, and as a result, factors of implementation of each business process module are more likely to be certain or predictable and match those of the local GIS scenario. Under this circumstances, based on discussions under sub-section 2.2., the technological perspective of GIS is more appropriate in describing a module of business process GIS. Individual GIS in the various business functions can be viewed as independent information systems providing spatial data handling and analysing capabilities.

Therefore based on the model in figure 7 a corporate GIS can be seen as a collection of all the modules of business process GIS integrated through the creation of a module of infrastructure GIS. The various
modules of GIS in the corporation are multi-element in nature and depending on the organisational settings concerned, can be developed at different times, play different roles, and be located in different parts of the organisation. Therefore different perspectives of describing GIS will be applicable depending on the stage of implementation of the corporate GIS. The technological perspective is suitable to describe a module of business process GIS while the organisational perspective is best for the corporate GIS.

4. Conclusions

Two perspectives of defining GIS have been identified, namely, technological and organisational. The technological perspective gives a pragmatic and tangible definition to GIS emphasising its forms and functional capabilities. It is sufficiently simple and accurate for GIS implementation in the local GIS scenario in which many of the factors affecting implementation are certain or well defined. However it is too specific to be useful in a global GIS scenario.

The organisational perspective recognises the multi-element nature of GIS and defines it in terms of its generic technological elements (data, information technology, standards and people with expertise) and its organisational setting. This paper argues that this perspective is better suited to a global GIS scenario as in the case of an integrated corporate GIS, in which many factors affecting implementation are vague and uncertain. However, the lack of understanding of the relationship between the technological elements and the organisational setting means that, in its current form, the organisational perspective at best provides a framework for planning the systematic development of a GIS in an organisation (a corporate GIS in this case). It does not provide new insights into the nature of a corporate GIS which can have fundamental influence on the formulation of implementation strategy. By means of an inference process using concepts from basic organisational theory, public administration, and information technology management, a model is developed to describe a corporate GIS, showing the relationships between the technological elements of GIS and its organisational setting.

Based on the model, a corporate GIS is multi-element in nature, making up of two basic modules of GIS in an organisation – infrastructure GIS in the Administration part, and business process GIS in each business function in the Business part. While the technological perspective of describing GIS is more appropriate for a module of business process GIS, the integrated corporate GIS is best described by the organisational perspective. Integration is achieved by developing a module of infrastructure GIS which links various modules of business process GIS together.

Integration of GIS, like its utilisation is significantly controlled by the people in each participating module of business process GIS. These people will only be able to come together to discuss, to iron out differences and to come to agreements to develop the infrastructure module if the organisational settings are receptive and willing and provides the necessary means for communication. Implementation of a corporate GIS therefore requires a set of strategies to nurture the right organisational settings within the organisation to develop different modules of GIS that play different roles in a timely manner.

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