

# A Framework for Designing Performance Indicators for Spatial Data Infrastructure Assessment

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**Abstract.** This chapter introduces the approach of performance-based management for assessing the Spatial Data Infrastructure (SDI). It also presents and explores the paradigm of a guide for aiding the SDI community in the design of Performance Indicators (PIs) as a metric to measure performance when conducting an accountability assessment of an SDI. Within this paradigm the following notions are discussed and analysed: the need for accountability assessment of an SDI; the continuous assessment of an SDI and the methodologies to facilitate it; the application of PIs to SDI assessment; factors affecting the design of PIs and the development and application of a framework to serve as a guide in the design of PIs.

## 11.1 INTRODUCTION

Chapter 5 highlighted the need for a *Multi-view Framework* for assessing SDIs and discussed the need for the application of different assessment techniques based on the purpose of the assessment, along with the complex nature of an SDI. In support of this concept, the author researched specialised techniques to aid in the assessment of SDIs for *recapitalisation* and *reengineering* purposes (that is for assessing accountability). Specialised techniques are required for assessing SDIs, within the realms of reengineering and

recapitalisation, because the performance of an SDI cannot simply be measured in terms of profitability or its generic financial viability. In their current format, these generic tools are not suitable for SDI assessment because SDIs are in nature complex with monopolistic tendencies and therefore, will have complex performances (Lawrence, 1998; Rajabifard, 2002; Giff and Coleman, 2003b; De Man, 2006).

The solution to this problem may be applying a technique — widely used in infrastructure evaluation — of assessing performance through the relationship amongst inputs, outputs and outcomes (Lawrence, 1998). This relationship can be illustrated with the help of Performance Indicators (PIs); that is, the application of metrics to a program in order to provide performance information pertaining to its outputs, outcomes and impact with respect to its inputs and objectives. However, for SDI assessment these PIs must be customised in order to capture and represent the complex and intriguing performance of an SDI.

Exploring the above concept further, the author developed a framework to guide the SDI community in designing PIs specifically for SDIs. The concept behind the development of the framework, its implementation within a performance based management style and its application to the design of PIs for GeoConnections program is presented in this Chapter. It is expected that presenting this information will increase the awareness of the application of PIs as a capable tool for supporting the assessment of SDIs.

## **11.2 APPLICATION OF PERFORMANCE BASED MANAGEMENT TO SDI ASSESSMENT**

Assessing the performance of an organisation is one of the most systematic means of differentiating success from failure, and therefore identifying the strengths and weaknesses of the organisation. In the context of an infrastructure, this implies that the activities of an infrastructure must be assessed and managed if it is to operate at an optimum level (CMIIP, 1995). Performance Based Management (PBM) is one technique that facilitates infrastructure managers to operate an infrastructure in such a manner that its strengths and weaknesses are constantly identified, analysed and managed (GSA, 2000). PBM SIG (2001a) defines Performance Based Management (PBM) as:

“...a systematic approach to performance improvement through an ongoing process of establishing strategic performance objectives; measuring performance; collecting,

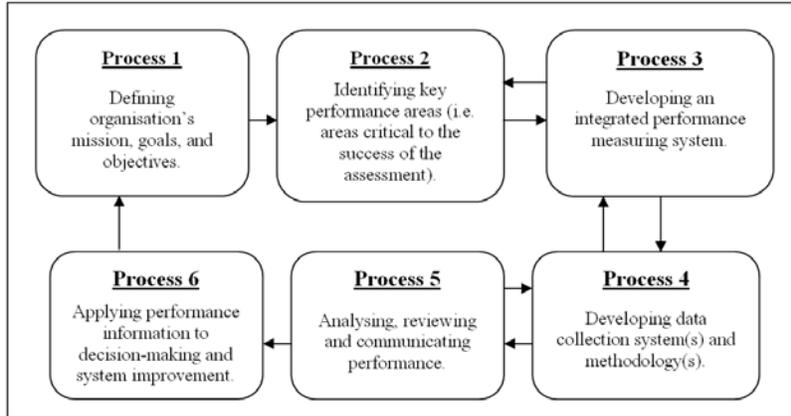
analysing, reviewing, and reporting performance data; and using that data to drive performance improvement.”

To achieve this, PBM uses management processes that translate business strategies into actions at the operational level (where they can be assessed for best value), develop and apply measuring tools, analyse and report the results and apply these results to improve performance (Blalock, 1999 and GSA, 2000). These characteristics make the PBM style an ideal tool for managing an SDI in a manner that facilitates regular assessment of its components, as well as supporting effective and efficient implementation of these components. For additional information on the PBM style and its application to infrastructure management, see Hale, 2003; PBM SIG, 2001a; GSA, 2000; McNamara, 1999; and NPR, 1997.

### 11.2.1 Processes of the PBM Style

The PBM style is an iterative operation that involves at least six key processes capable of facilitating the monitoring of — strengths and weaknesses — an infrastructure in a systematic manner (Environment Canada, 2000) (Figure 11.1). The information gained from processes is then used to constantly improve the quality of the program, as well as justifying continuous investment in the program. That is, the PBM style provides the information to support reengineering and recapitalisation.

Figure 11.1 illustrates the six key processes involved in applying the PBM style to the operation of an organisation or project. Of importance to this Chapter is the *third process* where what should be measured, and how it is to be measured, is decided. A key output of this phase — the primary focus of this chapter — is metrics to provide information that will assist in the determining the success or failure of the project. Based on extensive research and case studies on infrastructure assessment, the author selected *Performance Indicators* (PIs) as the most suitable metrics to support the assessment of SDIs.



**Figure 11.1: Six Key Processes of the PBM Style (Adopted from NPR, 1997 and PBM SIG, 2001a)**

### 11.3 THE CONCEPT OF SDI ACCOUNTABILITY ASSESSMENT

The different reasons for assessing SDIs were comprehensively discussed in Chapters three and five however, for the purpose of this chapter; SDI assessment will be viewed within the context of accountability. An assessment for accountability (such as mainly for recapitalisation and reengineering) is very significant today because the majority of what Masser 1998 defined as first generation SDIs are now nearing the completion stage. The consequence of this fact is that these SDIs now require reengineered, and therefore recapitalisation, in order to be transformed into the next generation of SDIs capable of providing the services and products demanded by current and future users. Recapitalisation and reengineering of these first generation SDIs in today's stringent economic and political climate will require assessment, in terms of both efficiency and effectiveness. An assessment of efficiency refers to measuring of an SDI to determine if it is achieving its objectives in the most economical manner (input versus output). On the other hand, an effectiveness assessment (output versus outcome/impact) refers to the measuring of n SDI to determine if it is achieving its goals (that is the desired outcome), along with having the predicted impact on society.

#### 11.3.1 SDI Assessment for Reengineering

A reengineering assessment is an evaluation that mainly focuses on the effectiveness of the SDI. That is the assessment focuses on the performance levels of outputs, outcomes and impacts. A reengineering

assessment is important as it informs the stakeholders of whether or not SDIs are achieving what they set out to do, as well as demonstrating their relevance to society.

Again, the transformation of current SDI initiatives towards the next generation of SDIs will require assessment for reengineering. Information from this type of assessment will provide stakeholders with a schema of what aspects of the SDI need to be redesigned to cope with expected demands from the spatial information community. This type of information can also satisfy the demand of the present political climate requiring SDI program coordinators to clearly illustrate to the public that SDIs are providing the services they promised (Stewart, 2006).

A reengineering exercise will require the support of additional investment (such as recapitalisation) and therefore, the challenge is not only for SDI stakeholders to identify the strengths and weaknesses of their SDI to improve on performance, but to also adequately report this performance to the financiers and the public where applicable.

### **11.3.2 SDI Assessment for Recapitalisation**

The first generation of SDIs were funded from the budgets of National Mapping Agencies or through one-time grants from quasi-government agencies and special projects (Rhind 2000; Giff and Coleman, 2003a; and Giff and Coleman, 2003b). However this type of funding arrangement will be inadequate for implementing and maintaining future generations of SDIs (Giff and Coleman, 2002; Giff, 2005). The next generation of SDIs will require structured long-term funding arrangements, which is expected to be provided by mainly the public sector, supported by public-private sector partnership with wholly private sector funding playing a lesser role (Giff, 2005).

To access these structured long-term funding arrangements in today's economic climate, SDI program coordinators must provide information on the performance of the first generation of SDIs; as well as have metrics in place to measure the performance of the next generation of SDIs. This type of information is necessary since both the public and private sectors are now moving towards funding more performance-based initiatives (CMII, 1995; OAG, 1995; PSMO, 1997). Therefore, if the next generation of SDIs are to receive any significant (structured) funding from both sectors they must be capable of measuring and reporting their levels of efficiency and effectiveness, and therefore the need for performance indicators.

#### 11.4 THE APPLICATION OF PIs TO SDI ASSESSMENT

The previous sections introduced the concept of assessing an SDI using indicators as a yardstick to measure performance. Indicators of this nature, used to assess efficiency and effectiveness, are referred to as *Performance Indicators* (PIs) (WHO, 2000). OPM, 1990 defined a PI as:

“...the measurement of a piece of important and useful information about the performance of a program expressed as a percentage, index, rate or other comparison which is monitored at regular intervals and is compared to one or more criterion.”

PIs are usually designed with respect to the organisation’s goals and or objectives and can be either a quantitative or a qualitative measure (Environment Canada, 2000; WHO, 2000). This is in support of the outputs, outcomes and impacts of an organisation, particularly infrastructures which can be either quantitative or qualitative in nature.

Quantitative PIs are composed of numeric values and a unit of measure. The numeric value provides the PI with magnitude (how much), while the unit of measure gives the numeric value meaning (TRADE, 1995). In addition, a quantitative PI can be a single dimensional unit (for instance meters or dollars) or it can be a multidimensional unit of measure (for example a ratio). Single dimensional unit PIs are usually used to compare or track very basic functions of an organisation, while for more complex information collection, multidimensional PIs are used.

Qualitative PIs are usually used to measure the socio-political outcomes or impact of an organisation (such as the user’s satisfaction). However, although the outcomes or impact of infrastructures are usually qualitative, it is quantitative information that is required by governments and funding agencies in order to ensure that cognitive decisions are made regarding investment (CMIIP, 1995; WHO, 2000). That is, PIs are normally required for a comparative purpose and therefore, researchers recommend that where possible a quantitative value be placed on a qualitative PI (CMIIP, 1995; Lawrence, 1998). This value is an important aspect for SDI assessment since a significant number of the outcomes and impacts of an SDI are qualitative in nature. The transformation of a qualitative PI to a quantitative PI is an intricate task, even more so in SDI

assessment, which is very dependent on the process or processes to be measured.

Other characteristics PIs should have if they are to be considered as proficient PIs are as follows (PSMO, 1997; WHO, 2000; CHN, 2001; Jollette and Manning, 2001):

- **Specific** — Clearly define and easy to understand
- **Measurable** — Should be quantifiable in order to facilitate comparison with other data
- **Attainable/Feasible** — Practical, achievable, and cost-effective to implement
- **Relevant** — True representation of the functions they intend to measure. Should be capable of providing factual, timely and easy understandable information about the function(s)
- **Timely and Free of Bias** — Information collected should be available within a reasonable time-frame, impartially gathered, and impartially reported
- **Verifiable and Statistically Valid** — Should be scientifically sound with possibilities to check the accuracies of the information produced based on sample size
- **Unambiguous** — A change in an indicator should result in clear and unambiguous interpretation. For example, it should be clear whether or not an increase in the value of PI represent an improvement or reduction in the item measured
- **Comparable** — Information should show changes in process over time or changes between processes. This may require quantification of the PI

PIs with the majority of the above characteristics — specifically SMART — are referred to as robust, proficient indicators and are therefore more likely to be intelligible for their intended use (Audit Commission, 2000). See highlighted letters in the list above for the definition of SMART. However, in real life situations it may be difficult to create PIs that precisely fulfil all the criteria listed above, therefore a trade-off may be necessary when designing PIs. Although trade-offs are expected, PIs can still be effective if they are developed within the organisation's mission, goals and management style.

In general, SMART PIs that are designed to measure key processes or functions within an organisation are classified as *Key Performance Indicators* (KPIs) (OAGA, 1999; PBM SIG, 2001b). KPIs are those PIs used to measure the critical success factors of an organisation (PSMO, 1997; Reh, 2005). They provide comprehensive

information about strategic or key areas of an organisation and are vital to decision-makers when it come to recapitalisation and reengineering.

Although PIs (from here on the term PIs refers to both general PIs and KPIs) may have their drawbacks, when it comes to measuring the qualitative aspect of an SDI their other useful qualities makes them applicable to SDI assessment. However, for PIs to have any significant impact on SDI assessment their design must ultimately be based on the complexity of an SDI and not be simply implanted from other industries.

## **11.5 DESIGNING PIs FOR SDI ASSESSMENT**

Increasingly the financiers of SDIs are demanding that PIs are included in the business plan of an SDI. PIs have now become one of the main criteria for leveraging funds for SDIs from both public and private sectors (Giff, 2006). However the designing of PIs for SDI accountability assessment is proving to be an ominous task due to the nature of the performance of an SDI. That is, an SDI is a complex integration of socio-technical components and therefore produces outputs, outcomes, and impacts that are, in turn, complicated to measure. For more details on the complexity of an SDI, and infrastructures in general, see Cilliers, 1998; Eoyang, 1996; Coleman and McLaughlin, 1997 and 1998; Rajabifard et al., 1999; Chan, 2001; Rajabifard, 2002; Williamson, 2002; Giff, 2005; van Loenen, 2006; De Man, 2006; Grus, 2006.

Therefore the challenge for the SDI community is to design PIs that are capable of measuring the complicated performance of an SDI. These PIs must be capable of measuring the direct qualitative and quantitative performance of an SDI, as well as the externalities (qualitative or quantitative) produced. Consequently, PIs to assist in the comprehensive assessment of an SDI must incorporate in their design the variables that contribute, and affect, the complexity of an SDI's performance.

### **11.5.1 A Conceptual Framework for Designing PIs for SDIs**

Working on the paradigm that designing PIs for SDI assessment is an intricate task, the Netherlands' research group on SDI assessment 'RGI-005' agreed that there should be in place a guide to assist members of the SDI community when designing PIs. The author is of the opinion that this guide should be in the form of a framework that provides clear, concise steps for designing PIs that are capable of

effectively measuring an SDI's intricate and complicated performance.

The creation of a framework of this nature will require methodologies that use clearly designed, logical steps. These logical steps can be viewed as a series of flow models tailored to capture the key functions and activities that relate to the purpose of the assessment (GSA, 2000). That being said, this framework would be in part high-level (conceptual) and would require fine-tuning by an individual organisation before its actual execution.

When applying the above theory to SDIs, the author explored the hypothesis that by using analogies from infrastructures and organisations producing public goods a conceptual framework for the design of PIs for SDI assessment (here after referred to as The Framework) can be formulated. Research into this hypothesis indicates that applying this concept to an SDI will not be as straightforward as it is for other sectors due to the complex nature of an SDI. The research also indicated that the methodology(s) selected for including in The Framework must be capable of encompassing knowledge of the complexity of an SDI; that is, the frameworks used in other sectors require customisation to cope with the complicated and long-term performance of an SDI. This particular methodology can be achieved by injecting knowledge of the complexity of an SDI, its complicated performance and the implementation environment into the selected generic framework(s) at appropriate points. The use of this knowledge will ensure that the PIs produced are sensitive to the complicated performance of an SDI.

Using the results of the investigation into the hypothesis as a base, the author developed a framework to aid in the design of SDI PIs, which is presented in the next section. It should be noted that the framework was developed within the broader context of the PBM style.

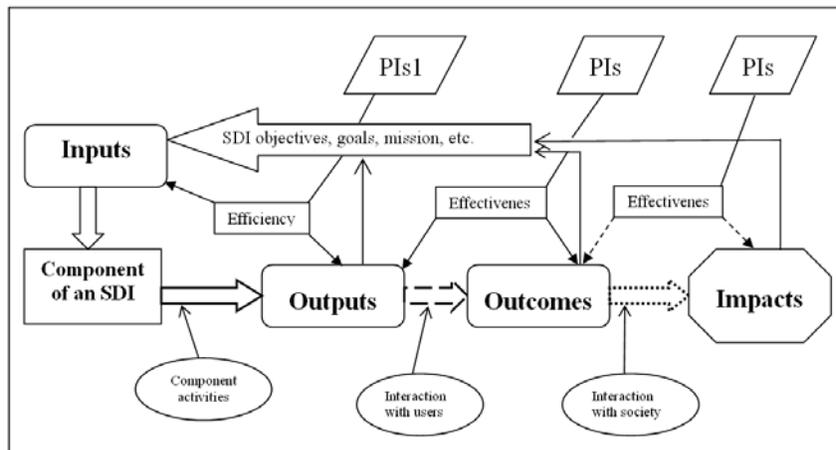
### ***The Framework***

The framework was developed mainly to support the design of PIs in order to measure the efficiency and effectiveness of an SDI. In researching the design methodologies of these types of PIs, the author identifies a key tool that ought to be included in the design procedure. This tool, a *logic model*, serves the purpose of connecting an organisation's activities with its performance and should be created

before embarking on the actual design of PIs of this nature (Innovation Network, 2005; Taylor-Powell, 2005).

In summary, a logic model is a graphic representation of the theory of change of an organisation, so far as it illustrates how the inputs and activities connect to the results (Taylor-Powell, 2005; Coffman, 1999); that is, this visual schema conveys explicitly the assumed relationships (activities and interactions) amongst inputs, outputs, outcomes and impacts (Schmitz and Parsons, 1999). These relationships are conveyed by using boxes, connecting lines, arrows (double directional in some cases), feedback loops and other visual metaphors (Schmitz and Parsons, 1999). See Figure 11.2.

Once the logic model is completed then PIs to measure the critical success areas of an organisation, identified by the logic model, can be designed (Coffman, 1999). Applying this concept to assessing the accountability of the SDI resulted in the identifying three categories of PIs for this type of assessment. The formulation of the three categories was based on the accountability relationships among an SDI's inputs, outputs; outcomes and the expected impact, as illustrated by the logic model (see Figure 11.2).



**Figure 11.2: Example of a Logic Model of a Component of an SDI**

With reference to Figure 11.2, the efficiency relationship that is illustrated by the logic model gives rise to the need for a set of PIs (referred to as PIs1) to measure this aspect of performance. Similarly, the two sets of effectiveness relationships, key to assessment of this nature, promote the need for two additional categories of PIs referred to in the Chapter as PIs2 (output vs. outcomes) and PIs3 (outcomes vs.

impacts) respectively. Analysis of a number of logic models produced for SDI assessment leads to the conclusion that a framework for designing accountability PIs should be capable of addressing at least these three categories of PIs.

The framework developed to assist in the design of the three categories of PIs mention above consisted of ten fundamental steps all aimed at capturing the unique relationships amongst the inputs, outputs, outcomes, and impact of an SDI (see Figure 11.3). It should be noted that the steps recommended by the author (listed below) are not linear but represent iterative or circular processes that require regular revisiting (see Figure 11.3). The ten customised steps in the framework for abetting the design of PIs for assessing the efficiency and effectiveness of an SDI are:

1. Based on the objectives, (program level and strategic) and the purpose of the assessment, create a logic model to assist in identifying key performance areas (that is critical aspects of the program to be measured).
2. With the aid of logic models, identify inputs and the main activities/functions of the critical areas of the program.
3. Clearly define, in operational and measurable terms, the expected outputs, outcomes and where possible impacts. At this stage decisions on milestone targets and measures can also be made.
4. Identify factors (internal and external) that are likely to influence the outputs, outcomes and impacts and therefore affect the assessment. These factors should then be encapsulated in the PIs.
5. Design a set of efficiency indicators (PIs1) based on the expected outputs. The aim of this step is to determine whether the program is operating at its optimal level. The PIs in this category should be capable of capturing the amount of input units that are involved in the production of a specified output. In terms of an SDI, some of the challenges in developing this category of PIs are defining inputs in monetary terms and defining what is to be classified as output. For example, are the components of an SDI outputs, or are the datasets facilitated by the components the output?
6. Select KPIs from the list of efficiency PIs developed in the previous step. Again the logic model(s) and the SMART concept can be used to assist in the selection of the KPIs. That is, relate the KPIs to the logic model(s) to determine

whether or not they are providing information pertaining to critical success areas.

7. Design a set of *effectiveness indicators* (PIs2 and PIs3). Effectiveness represents the influence outputs are having on the users and to a lesser extent its impact on the wider community. For an SDI it is expected that the PIs in this category will be more qualitative than quantitative. An example of a quantitative PI for an outcome is the percentage of users that were capable of efficiently using the datasets from the SDI in their decision-making process. A qualitative PI for outcome could be the level of satisfaction a user derives from the metadata provided by a data supplier. However the development of PIs in this category will require extensive investigation into the medium to long-term effects of an SDI on the society, the inclusion of a number of external variables and the possible quantification of qualitative PIs.
8. Select KPIs from the list of effectiveness PIs developed in the previous step (see step 6 for details).
9. Analyse KPIs to determine for example, if they pass the SMART test, are cost effective to implement, data is readily available for these PIs, personnel are in place to collect and analyse the required data and that they will actually measuring the performance of critical success areas of the SDI.
10. Combine the sets of KPIs capable of measuring and reporting the performance of the critical success areas (or desired areas) of the SDI.

The above ten steps components of the framework only serve the purpose of providing a skeleton for the design of PIs. That is the steps are conceptual (they do not provide, in detail the handling of a number of the variables that affect the design of PIs) and will therefore require greater analysis of variables specific to the particular SDI to be assessed. Therefore the application of the above ten steps to the design of PIs (in particular PIs2 and PIs3) may require the inclusion of additional variables to facilitate the capturing of assessment features specific to the SDI in question. These variables will be predominantly external to the SDI and largely dependent on the implementation environment.

Figure 11.3 is a schematic representation of the application of the framework that clearly shows the iterative processes involved in the

design of PIs. To assist with the application of the framework the author recommends the usage of tables. The application of tables, in support of the framework, provides users with a schematic aide to the design process. In addition, using tables is important as they facilitate the collection and structuring of decisive information on the design variables, as well as the PIs themselves. Therefore an analysis of the tables should provide PI designers with information that will greatly enhance their ability to produce good quality SMART PIs.

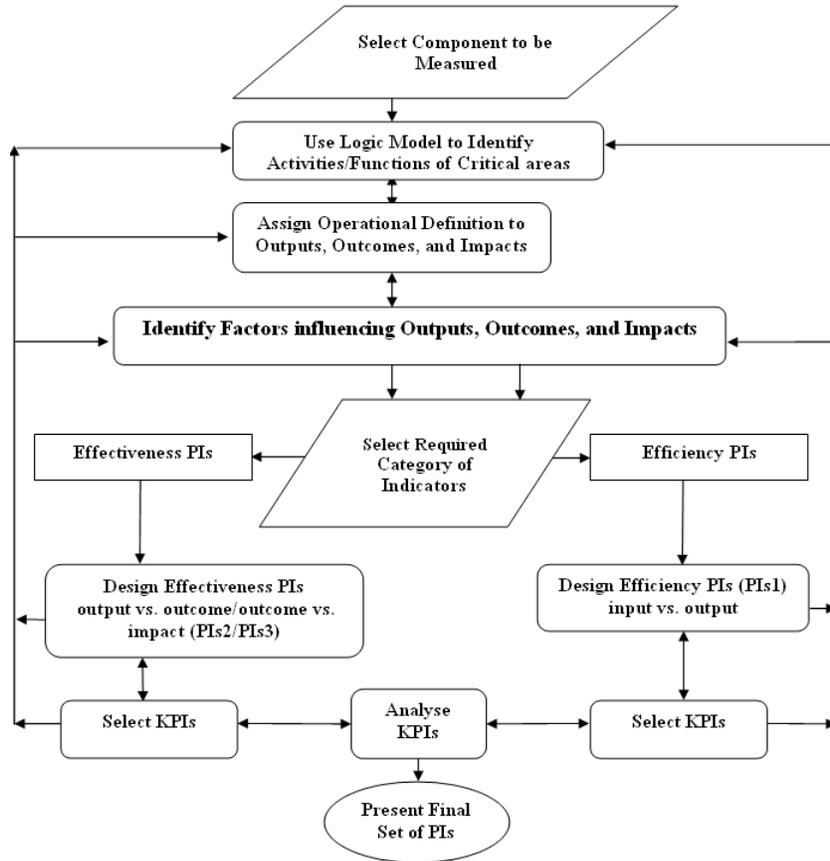


Figure 11.3: Flow Diagram of the Ten Steps Involved in Designing PIs for SDI Assessment

### 11.6 IMPLEMENTATION OF THE FRAMEWORK

To determine the suitability of the framework, it was applied and analysed within three case studies on PI development for Geomatics organisations in Canada (The GeoConnections Secretariat, The

GEOIDE Network and Land Information Ontario). The case studies involved the investigation of performance related activities of these organisations, the usage of PIs in measuring performance, the methodology(s) used to design PIs and the problems encountered when designing PIs to name a few. All three organisations investigated were well aware of the need to measure performance and the advantages of using PIs when assessing performance. Also of significance to the research was that these organisations had PI design as a key focus of their assessment activities.

This section presents examples of the applying the framework to assess selected areas of the GeoConnections Secretariat program. GeoConnections is the Federal Government organisation responsible for coordinating the implementation of the Canadian Geo-spatial Data Infrastructure (CGDI). GeoConnections was chosen for the examples as of the three agencies investigated, it was the only one performing its assessment activities within a management style similar to the PBM and, during the time of the case study, GeoConnections was at the stage of actually designing PIs. Another criteria considered was that GeoConnections was using a logic model — a tool recommended by the author for the design of PIs — in their assessment activities.

The GeoConnections' logic model identified four critical areas of the program that required assessment (such as User Capacity, Content, Standard and Technical Infrastructure, and Policy and Coordination). That is, analysing the program, with the aid of the logic model, indicated that these four areas were critical to the success or failure of the program and therefore, their performances should be evaluated when assessing the program. The logic model also identified three categories of PIs for assessing the critical areas; these categories are similar to those recommended by the author previously (including PIs 1, PIs 2 and PIs 3) (see Appendix A). For User Capacity, 22 sets of category PIs1 were required to assess the quality of its deliverables. Similarly, for Standard and Technical Infrastructure 20 sets of category PIs2 were required to assess this aspect of the program. For Policy and Coordination, the logic model indicated that there should be four sets of category PIs3 to assist with measuring the performance of this section (see Appendix A).

Therefore the test for the framework was applying it to the design of the 46 sets of PIs (22 outputs, 20 outcomes, and four impacts) required for measuring the critical areas of the GeoConnections' program. Applying the framework to this task would assist the author

to determine its suitability (by analysing its strengths and weakness) when employed in the design of PIs of this nature.

The application of the framework using the iterative concept, to assist in the design of PIs for the GeoConnections’ program, was carried out as recommended using tables. The design process was divided into two segments. Firstly, the designing of efficiency PIs (PIs1) by including in the framework factors affecting the measurement of efficiency (Table 11.1). Secondly, the designing of effectiveness PIs (PIs2 and PIs3) through the analysis of variables specific to measuring the effectiveness levels of the program’s performance (Table 11.2).

**Table 11.1: A Snapshot of the Activities Involved in the Development of Efficiency PIs**

<b>Variables used in the development of PIs to Measure efficiency</b>			
<b><i>Goals/Objectives</i></b>	<b><i>Inputs</i></b>	<b><i>Outputs</i></b>	<b><i>Efficiency PIs</i></b>
To increase user capacity by creating an environment where Geo-Information is easily accessible for reuse	Datasets with metadata, standards, web portals, awareness activities, policies, etc.	New applications that use Geomatics and the CGDI to meet user requirements	1. The number of new applications that uses the CGDI datasets 2. The number of new applications using CGDI datasets that satisfies users’ requirements
<b>Second Iteration</b>			
<b><i>Outputs</i></b>	<b><i>User Communities</i></b>	<b><i>Externalities</i></b>	<b><i>Efficiency PIs</i></b>
New applications that use Geomatics and the CGDI to meet user requirements	Knowledge of the users’ demands (e.g., type and quality of products)	Product information from application developers and their willingness to participate	The number of new relevant applications that uses the CGDI datasets

Table 11.1 illustrates the iterative processes involved in applying the framework to the design of PIs for the GeoConnections program. The first iteration involves including in the tables the objectives of the component to be assessed, all the inputs used to achieve the objectives, the outputs of the component and all the possible PIs that could be used to measure the efficiency of the outputs. The PIs are then refined, based on internal and external influences. This process is repeated with each iteration, reducing the number of PIs. The n-1 and n<sup>th</sup> iterations then address the cost and expertise required to used these PIs in the assessment process. The ultimate and penultimate iterations will further customise the PIs based on their economic effectiveness. Using Table 1 as an example, from the table it is evident that the

initial application tracked the effects of goals, inputs and outputs on the design of efficiency PIs. In the second iteration, other influential factors are considered and the PIs subsequently refined. The iterative process repeats this procedure until the most feasible PIs (measurable, cost effective KPIs) are designed.

Table 11.2 illustrates a similar concept to that of Table 11.1 however, in Table 11.2 the aim is to design effectiveness PIs and therefore factors influencing these PIs are included in the table. A similar iterative process is applied, as in Table 11.1, with each iteration resulting in a more specific definition of the PIs.

**Table 11.2: A Snapshot of the Activities Involved in the Development of Effectiveness PIs**

<b>Variables used in the development of PIs to Measure effectiveness</b>			
<i>Outputs</i>	<i>Outcomes</i>	<i>Effectiveness PIs</i>	
Authoritative, highly available technical infrastructure for data discovery, data access, data exchange and security (e.g., Discovery portal, data access portals, web services, etc.)	Stakeholders are able to achieve operational efficiencies resulting from using the evolving infrastructure services	<ol style="list-style-type: none"> <li>1. Percentage changes (-ive or +ive) in the cost of production/collection of datasets or specific applications when using the services of the CGDI.</li> <li>2. The number of stakeholders that reports positive changes (greater efficiency) in their business operations due to the services of the technical infrastructure</li> <li>3. The number and types of changes demanded by stakeholders that will facilitate them operating at an optimal level that were implemented</li> </ol>	
<b>Second Iteration</b>			
<i>Outcomes</i>	<i>Stakeholders</i>	<i>Externalities</i>	<i>Effectiveness PIs</i>
Stakeholders are able to achieve operational efficiencies resulting from using the evolving infrastructure services	Stakeholders' activities (e.g., CGDI awareness, retooling, partnerships, benefits of geo-information in decision-making, application development, etc.)	Status of the supporting infrastructure, quality and availability of provincial and local datasets, different access policies of CGDI datasets	<ol style="list-style-type: none"> <li>1. Percentage changes (-ive or +ive) in the cost of datasets for specific applications when using the services of the CGDI.</li> <li>2. Percentage changes (-ive or +ive) in the time it take to acquire datasets when using the services of the technical infrastructure</li> </ol>

### ***Results of the Implementation***

Applying the framework to the design of PIs for the four critical areas of the GeoConnections' program resulted in the production of SMART PIs to assist with measuring the programs' performance. The first iterative process produced an average of ten PIs for each activity assessed. At the end of subsequent iteration, the number of PIs was reduced. PIs were eliminated if the influence of one or more variables in the table renders them unverifiable or difficult to validate. The iterative process is stopped when an activity has a maximum of two SMART, scientifically sound, PIs. An example of the final set of PIs designed for an outcome using the framework in an iterative manner is seen at Table 11.3.

**Table 11.3: Sample Results of the Application The Framework to the Design of PIs for the GeoConnections Program**

<b>Outcomes</b>	<b>Possible Performance Indicators (PI)</b>	<b>Data Collection Methodologies</b>
Stakeholders are able to achieve operational efficiencies resulting from use or existing and evolving technical infrastructure services	<ol style="list-style-type: none"> <li>1. Percentage changes (-ive or +ive) in the cost of datasets for specific applications when using the services of the CGDI.</li> <li>2. Percentage changes (-ive or +ive) in the time it take to acquire datasets when using the services of the technical infrastructure</li> </ol>	Measuring these PIs will require case studies of selected (key) stakeholders to determine how they benefit from the technical infrastructure services. This can be supported by short surveys of the wider community.

## **11.7 CONCLUSIONS**

This chapter presented the concept of assessing an SDI to justify the expenditure on its implementation, and to determine whether it is achieving its objectives. Within this concept, the author recommended the use of the PBM style as a means to facilitate continuous and a more efficient assessment of SDIs. In addition, assessing an SDI requires the usage of metrics to assist with measuring performance and the author recommends PIs as the metrics to measure the performance of an SDI. However the most efficient and effective application of PIs to SDI assessment requires that there is in place a guide to aid in their design.

In support of this, the chapter presented a framework as a guide for designing PIs for SDI assessment. Although the framework is in part conceptual, its application in the case studies indicates that it is a suitable guide to design PIs for the SDIs investigated. This conclusion is formed on the basis that the PIs produced generally met the

requirements of the public sector funding agencies of these SDIs. The case studies also indicated that the framework served the purpose of providing the SDI community with an insight into the steps and intricacies involved designing PIs for evaluating SDIs.

In concluding, the author recommends additional testing of the framework across a wider cross-section of SDIs to determine its suitability to assist with designing PIs for different classifications of SDIs. In addition, more in-depth studies into some of the key/common variables that contribute to the complexity of designing PIs would greatly assist with developing a more comprehensive framework to act as a guide for designing PIs to abet in the assessment of current and future generations of SDIs.

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## Appendix A

### Critical Areas of the GeoConnections Program and the Categories of PIs used to Assess Them

Critical Area	Program Deliveries and the Categories of PIs used to Assess Them			
	<i>Efficiency (PIs 1)</i>	<i>Effectiveness (PIs 2)</i>		<i>Effectiveness (PIs 3)</i>
	Output	Outcome (1-3yrs)	Outcome (3-5yrs)	Impact
<i>User Capacity</i>	<ol style="list-style-type: none"> <li>1. Reports on user requirements in key areas.</li> <li>2. New national or inter-provincial portals involve several agencies across levels of government in key priority areas.</li> <li>3. New applications that use Geomatics and the CGDI to meet user requirements.</li> <li>4. Communication and outreach products for conferences and workshops.</li> <li>5. Training tools and materials to leverage the CGDI.</li> <li>6. New sustainable Geomatics clients that are aware of the advantages of using the CGDI</li> </ol>	<ol style="list-style-type: none"> <li>1. User-requirements are well-known before technology and data investments are made.</li> <li>2. New CGDI systems, portals and applications build awareness in decision-makers and other end-users of the benefits of the CGDI.</li> <li>3. Users are aware of and prepared to leverage the CGDI</li> </ol>	<ol style="list-style-type: none"> <li>1. Due to the success and relevance of operational CGDI systems, champions in key priority areas transfer knowledge of the CGDI in their community to encourage take-up (taking ownership)</li> <li>2. Priority user communities have increased their capacity to use the CGDI to meet their decision-making requirements</li> </ol>	<ol style="list-style-type: none"> <li>1. Decision-makers increase their use of location-based information to address issues in priority areas related to public health, public safety/security, sustainable development &amp; the environment, and Aboriginal matters</li> </ol>
<i>Content</i>	<ol style="list-style-type: none"> <li>1. Overall action plan and reports on user and business requirements analyses</li> <li>2. Data maintenance agreements.</li> <li>3. Up to date national framework data and associated metadata.</li> <li>4. New framework data and associated metadata</li> <li>5. Technical and scientific documentation on data standards for integration.</li> <li>6. Non-framework distributed data published from closest point to source and made accessible in an integrated manner.</li> <li>7. Standardised local/regional/provincial data content available through the CGDI.</li> <li>8. Local/regional/provincial data content available through the CGDI</li> </ol>	<ol style="list-style-type: none"> <li>1. Increased awareness by data producing agencies of standard user centric design methodologies and user data requirements.</li> <li>2. Agencies cooperate for data production, reducing duplication.</li> <li>3. Users recognise framework data as an authoritative Geomatics construct to enable priority applications.</li> <li>4. Users are able to use processes to produce data that is derived from other scales or sources.</li> <li>5. Users aware of/are able to use reusable, current and relevant data.</li> </ol>	<ol style="list-style-type: none"> <li>1. Priority user communities are using relevant, authoritative geospatial data in operational CGDI systems from closest point to source.</li> <li>2. Multiple CGDI operational systems access common regionally integrated information, reducing duplication and improving user effectiveness</li> </ol>	<ol style="list-style-type: none"> <li>1. Priority user communities secure access to user-defined and timely required for their business processes</li> </ol>

Critical Area	Categories of PIs			
	<i>Efficiency (PIs 1)</i>	<i>Effectiveness (PIs 2)</i>		<i>Effectiveness (PIs 3)</i>
	<b>Output</b>	<b>Outcome (1-3yrs)</b>	<b>Outcome (3-5yrs)</b>	<b>Impact</b>
<b>Content Continued</b>		6. Users are aware of the value of integrating regional information in provincial/territorial and national information systems. 7. Users recognise the value of regionally integrated information in addressing numerous inter-jurisdictional issues using the CGDI		
<b>Standard and Technical Infrastructure</b>	1. Authoritative, highly available core CGDI technical infrastructure for data discovery, data access, data exchange and security (e.g., Discovery Portal, data access portals, web services etc.). 2. New innovative services, tools for decision support use by priority user communities and applications. 3. Technical standards, common multi-stakeholder architecture documentation. 4. Workshops, collaborative resources and outreach to promote and develop common technical standards	1. Stakeholders are able to achieve operational efficiencies resulting from use or existing technical infrastructure services. 2. Stakeholders recognise the value of and apply national and international standards for access and use of geospatial data through technical infrastructure.	1. Stakeholders evolve their business processes by sharing, jointly developing and using common services, tools and standards of the CGDI as part of their operations.	1. Through a model partnership approach, federal and provincial governments, the private sector, academia and NGOs operate and evolve technical standards and infrastructure to meet common needs
<b>Policy and Coordination</b>	1. Communication and outreach products. 2. Best Practices Policy Guides, policy position papers. 3. Advisory networks, meetings & workshops for advisory networks 4. Discussion papers providing context & options on emerging policy issues (including assessments of policy/cultural barriers to CGDI use)	1. Stakeholders are aware of time, effort and cost savings relative to business transformation using the CGDI approach 2. Stakeholders are aware of key decision/business areas where CGDI can benefit them, key policy/cultural barriers to its uptake and potential approaches to overcoming those barriers.	1. As benefits outweigh costs, organizations transform business processes, including policies and culture to adopt CGDI	1. The F/TP community and other stakeholders avoid duplication and increase benefits by transforming business processes, implement policies that increase information sharing.