GIS QUALITY MODEL

A Metric Approach to Quality Models

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Abstract: In the past few years organizations and companies have developed new standards which have been proved highly efficient both in the public and private sector. The most important of them is the Quality Management System regulated by the standard ISO 9001. This standard proves how its implementation represents sensitive improvements of the production system, optimizing the product and increasing its quality. This phenomenon is not isolated within software engineering's frame. Many works have been published, like Boehm and McCall, of which have raised many standards among which the ISO/IEC 9126 is highlighted. Regarding this fact, it has been possible to create different solutions for multiple related problems with IT. Nowadays, the Geographic Information Systems' project managers do not have a tool for either selecting the software to implement their projects or supporting this selection in technical criteria. The questions are: which one of the commercial software packages is appropriate to my project? Which one of the software packages follows the requests of the project out? Which one of this software supports the needs of the users? This article presents a quality model to support these decisions. This way, project managers can make their decisions based on a set of metrics which are product of the deep evaluation of characteristics, subcharacteristics and attributes of the software. These metrics has been developed to apply for all models based on ISO/IEC 9126-1 standard. The mentioned elements allow user to know which of the software packages is the best through a GIS Quality Indicator, generated through the model. This indicator allows GIS' project managers to take decisions based on a technical criterion. A model in accordance with international standards related to product quality in software engineering such as ISO/IEC 9126-1.

1 INTRODUCTION

New trends to utilize the cartographic information for evaluating resources and territorial planning emerged in the sixties and seventies. It was noticed that different coverages on the surface of the earth were not independent, rather they kept some kind of interdependence. The need to evaluate them in a more efficient way was self-evident. At first, the used methods were relatively simple namely, transparent copies of maps were superimposed on lit tables and points of coincidence in the distinct maps were found. At a later time, this technique was applied to emerging Information Technologies -IT- and simple maps were created by means of overprint of characters to produce different tones of grey.

Nevertheless, specialists did not find these methods extremely useful and they were not accepted by the professionals that produced, updated or used cartographic information. In the late seventies, the IT to generate cartographic information progressed rapidly and it was tuned many of information-technology systems for distinct cartographic applications. In the same way, progress was being made in related sectors namely: photogrammetry and remote perception. Initially, the fast development meant the duplication of efforts in different areas relating to cartography. With constant improvements to the systems, developers acquired experience and the possibility to use different kind of tools for working with spatial information had been raised. The creation of these systems contributed to the creation of solid Geographic Information Systems -GIS- for general purpose. In

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the early eighties, GIS had become a completely operating system whilst the technology of computers had started to grow and to develop rapidly.

Currently, GIS are being implemented in vertiginous form on public agencies, laboratories, research institutes, pedagogical institutions, private and military industry. This big introduction of the GIS has given rise to a need for the users of the geographic information to know this technology in a better way. Therefore, it is necessary to help them to understand the GIS software through solid and reliable tools which must be based on methodologies created and developed for this specific objective.

This article describes a quality model for selecting and verifying GIS software that will be utilized as a platform for a specific project. This software has to be reliable, fulfil the project requirements analysis and satisfy the needs of both the project and the user. This way, the paper presents an innovative solution to help GIS professionals to support the chose of the platform software on a quality model created for this specific objective. A model that solves a real problem which has not been worked on yet, a problem that is observed in the day-to-day routine of institutions and companies.

2 DESCRIPTION

Models are abstractions of reality and are designed to make process easier. They offer to users the adequate tools to interpret complex realities by isolating and focusing on the principle components and removing elements that do not affect the final results meaningfully. Specifically, quality models offer a series of elements that user must take into consideration to insure that accomplished actions are adequate to obtain the desired results. This way, different kinds of variable are required in order to fit the models up to the intrinsic and extrinsic characteristics of the elements that will get involved within the developed model or models.

Nowadays experts and beginners engaged in development and implementation of information systems, have many problems to select a GIS platform namely: the big supply of GIS products, the multiple versions available of one product, new products or additional extensions to have more tools and specific functions. These are enough causes the users become confused, this way, a simple decision such as to select a GIS platform software turns into a difficult job.

When GIS projects are planned, objectives are defined and user's requirements are identified; one of the most important stages for their design and development is to select the platform which it will be implemented over. This decision implicates investment of resources, run times, accomplishment of requirements and needs, adequate functionality and the customer satisfaction. For GIS' domain, it does not exist a tool, methodology or model that permits professionals to solve this problem. They neither have enough support to bear his decision in theoretic well-grounded concepts. Therefore, it is evident the need of creating some method in order that this decision is not based exclusively on project manager's experience or, as it occurs for the most of the cases, taking into account the most popular GIS software without evaluating more alternatives.

The mentioned deficiency constitutes a problem that needs to be solved. This solution has to support one of the most relevant processes in the project cycle, due to the fact that it affects deeply the success or failure of the project.

Taking into consideration what's been said up to this point, it is possible to define the main objective of this article. Of course, it is to define a quality model for GIS software packages, that permits identifying through robust metrics which is the best GIS software for an specific project and its implementation within a frame of specific conditions and under a set of specific requirements. Three fundamental points would be mitigated with this model: (i) speeding up the process of selection of platforms and tools of the system, (ii) offering a safe methodology to guarantee that the selected tool fulfils the minimal requirements of system and user, (iii) bearing the development of information systems on standards and quality models designed and developed specifically for this objective.

2.1 Quality Models

The first topic that must be discussed in this article it is what quality means and how this characteristic is integrated in information systems and software packages. Just as quality has evolved, its concept has borne several transformations over the time. Thus, different definitions have been emitted by working groups dedicated to its study. Formal meanings that take into account the human dimension are suggested by Dr. Joseph M. Juran (Juran, 1995): quality consists in freedom after deficiencies; quality refers to the absence of deficiencies itself; quality consists in the product's characteristics that are based on the customer's needs. Other important definitions are (Crosby, 1991), (Feigenbaum, 1991), (Taguchi, 2004) and (ISO, 2000), that defines quality as "set of properties or characteristics of something (product, service, process) that made it apt to satisfy needs." This definition not only refers to the characteristics of the product or services itself, rather introduces other aspects that can be shown in the final service.

Analyzing the above definitions the quality concept that will be taken into account to develop the model exposed in this paper is the set of product or service's characteristics that have the ability to satisfy the user's needs and expectations, permitting to judge its value based in a set of attributes and intrinsic properties, within a frame of reference well defined.

2.1.1 Software Quality

Nowadays it is clear how computers and software are utilized for a wide range of fields and applications. That is why, development and selection of high-quality software products are relevant, even though it is considered that its development and implementation in a right way implies the success or failure of the processes that are borne on these tools. Thus, the specification and the extensive evaluation of the software quality is a key factor to ensure an adequate quality and the success of the tasks based on software products.

ISO (ISO & IEC, 2001) suggests that it is important that each relevant characteristic of software quality be specified and evaluated, using valid and widespread metrics as far as possible. Software producers are responsible for that these characteristics are identified in order to define the metrics that will permit to know whether an element or attribute of the product is acceptable. Thus, several elements will be considered both in the process of development and the use of software.

ISO/IEC 9126 and ISO/IEC 14598 have been developed considering these characteristics; in addition associated metrics can be used not only for evaluating software products but also to define quality requirements and other uses. ISO/IEC 9126 was created for the specification and extensive evaluation of the software product quality taking into account metrics, specifying relevant quality characteristics and describing a model for production of software products from the point of view of internal and external use. ISO/IEC 14598 is related with the software product evaluation.

Considering that the proposed model aims supplying a tool that permits users to select among the different bidding of the market, the software which adjusts to specific user needs and fulfils the entire quality requirements for GIS projects in a specific domain. The developed model relies on the ISO/IEC 9126 family standard and specifically in the ISO/IEC 9126-1 quality standard due to the fact that it lets to create hierarchies of quality features, which are essential for building structured quality models besides that it is a widespread standard.

Table 1: Standard ISO/IEC 9126.

Standard	Objective
ISO/IEC 9126-1	Quality model
ISO/IEC 9126-2	External metrics
ISO/IEC 9126-3	Internal metrics
ISO/IEC 9126-4	Quality in use metrics

2.1.2 ISO/IEC 9126 Quality Standard

ISO/IEC9126 is a family of standards that regulates the software product quality taking into account: models which are conformed by, internal and external characteristics, the method to measure these characteristics and the functionality of the proposed model. The standard is conformed by four parts that share the same general title: Information technologies – Software engineering – Product quality.

Xavier Franch (Franch, 2003) says that ISO/IEC 9126-1 specifically addresses quality model definition and its use as a framework for software evaluation. A 9126-1 quality model is defined by means of general software characteristics, which are further refined into subcharacteristics, which in turn are decomposed into attributes, yielding a multilevel hierarchy. At the bottom of the hierarchy are measurable software attributes, whose values are computed using some metrics, which are defined and regulated by ISO/IEC 9126-2 and ISO/IEC 9126-3 standards. Internal metrics quantify the software's characteristics, while external metrics measure the general behaviour and performance implicating the system in which the software is implemented. Finally, quality in use quantifies the effects of using a software package in a specific context; this is regulated by the standard ISO/IEC 9126-4 taking into consideration characteristics and subcharacteristics.

The proposed quality model has been developed exclusively taking into account the external quality elements, because it is there where the end user interacts directly with the final product and it is from this that the user defines his quality perception. In other reference frames, this perception can feed back to the internal quality and create an ever improving cycle of product. Nevertheless, this element was not considered within the development of this work due to the fact that it is focused exclusively on the end user. The objective is to reach the necessary quality to satisfy the real users' needs.

2.2 Referenced Models

The software product quality should be evaluated using a well defined quality model. In practice it is not possible to measure all the software's internal and external subcharacteristics due to the fact that software products are normally too big. Also, it is not practical to measure the quality in use for all of the possible user-task scenarios. The resources for evaluation must be assigned to the different kinds of measurements depending on the objectives of the business and the nature of the product or the design process. ISO proposes evaluating the software products quality based on a set of characteristics and subcharacteristics of general interest.

Table 2 shows the six quality characteristics defined in the ISO/IEC 9126-1 quality standard and their decomposition into subcharacteristics. In addition, subcharacteristic compliance is included for all of the characteristics. These elements support the proposed model. Combining this model with the one proposed by Franch, it is possible to define an adequate evaluation frame for GIS.

Quality models considered for the development of this article are the ones that for its aim permit to evaluate the performance of any application or to create some kind of metric.

In the study accomplished by Chirinos (Chirinos *et al*, 2003), he intends a requirements classification which takes into account the quality views from the first stages of development to provide the quality requirements identification. The authors develop a requirements classification model based on views of quality with the aim of providing the quality requirements identification.

Another interesting work is developed by (Losavio, 2002). She proposes a form to specify the relevant quality attributes implicated in the design of architectonic process. An additional model to take into account was carried out by (Calero *et al,* 2004), whom developed the Web Quality Model –WQM–.

The main referenced model is developed by Franch and Carvallo (Franch, 2003), quality models in software package selection. This work proposes a specific methodology to make structured quality models to select software package involving software's description and functionality. The model comprises six steps: defining the domain, determining quality subcharacteristics, defining a hierarchy of subcharacteristics, decomposing subcharacteristics into attributes, decomposing derived attributes into basic ones, stating relationships between quality entities and determining metrics for attributes.

Table 2: ISO/IEC 9126-1 standard.

Characteristics	Subcharacteristics
Functionality	Suitability, Accuracy, Interoperability, Security.
Reliability	Maturity, Fault tolerance, Recoverability.
Usability	Understandability, Learnability, Operability, Attractiveness
Efficiency	Time behaviour, Resource utilization.
Maintainability	Analyzability, Changeability, Stability, Testability.
Portability	Adaptability, Installability, Coexistence, Replaceability

It is in the determination of metrics for attributes where the proposed model focuses its develop and underlies one of the main contributions (since current methodologies does not define real metrics), and further on, a global quality indicator which defines an absolutely quantification for the package software quality evaluation.

3 MODEL DEFINITION

Through the proposed model, it is possible to know which of the available software packages fulfil minimal and necessary requirements in desired conditions, and which of they get the higher evaluation for each characteristic (dimensions) defined in the model. This evaluation will permit discarding those tools that not fulfil minimal conditions, as well as reducing the possibilities to determine a final decision based on another kind of criteria like the cost-benefit ratio, because it is possible that tools with a huge difference in their cost, supply the same functionalities and guarantee the same reliability in some designing conditions.

3.1 Characteristics & Subcharacteristics

The flexibility of the methodology proposed by 9126-1 standard is unequivocal, their components are not a straightjacket for the definition of the model in a specific dominion but they constitute a good starting point. This way, when the components

Table 3: Modified characteristics and subcharacteristics.

Characteristics	Subcharacteristics
Functionality	Compatibility. Availability.
Reliability	Quality data verification. Scalability.
Usability	Complexity of personalization. Usability compliance.
Efficiency	Data protection. Efficiency compliance.
Maintainability	Maintainability compliance.
Portability	Portability compliance.

and the modifying dimensions are examined according to the needs of GIS software, some subcharacteristics have been eliminated, others have changed its meaning and others have been created defining new concepts according to GIS software packages. The result is showed in Table 3.

In general all the subcharacteristics definitions are according to what is indicated by ISO/IEC 9126-1. The subcharacteristics compliance for usability, efficiency, mantainability and portability are eliminated for being considered irrelevant for GIS software. The six new incorporated elements try to refine the model for a complete evaluation.

For the dimension functionality, the subcharacteristic compatibility is defined like the capability of the software to interchange data and to maintain projects with others software package of the same type. The subcharacteristic availability evaluates the licenses and license administrator to verify if the software guarantees the license service. Data verification permits to verify input and output of data quality. Scalability checks the software capability to be adapted without problems to a harder work as a result of new users addition, increment of the traffic or execution of new transactions. An important GIS subcharacteristic is the complexity of personalization, defined like the set of software attributes that determine the capability and facility of software's personalization for specific tasks. Finally, data protection compiles the attributes for users' administration and how the data access is administrated in the main system.

3.2 Definition of Types of Measures

Once the model's dimensions have been defined and before defining the attributes that describe them, it is necessary to indicate the types of measures that the user will use to quantify attributes. For its definition some points must have considered:

- Types of measures have to be represented by quantitative elements to be able for operations.
- If the type of measure is represented by qualitative elements, it has to be changed to quantitative elements.
- For some types of attributes it is not enough to express the measure of his behaviour with single elements like *boolean* or *integer*, in this case the attribute require a function to express in a best-suited form its behaviour.

Table 4: Type of measures for attributes quantification.

Measure	Type	Dominion	Unit	Symbol
Eyewitness	Boolean	0-1		P
Time	Integer		s/d/m	T
Level	Integer	0-4		N
Ratio	Integer	0-100	%	R

Taking into account Vallecillo and Bertoa's work (Vallecillo & Bertoa, 2002), the proposed model will use the types of measures defined in Table 4. Each one of these types will be utilized to quantify the model defined attributes in following cases:

- Eyewitness (P) indicates if an attribute exists.
- Time (T) measures spans.
- Ratio (R) expresses a specific percentage.
- Level (N) indicates a grade of effort, ability.

The model establishes a five-level classification method for the Level type according to Table 5. The Eyewitness type is defined through a *boolean* value.

Table 5: Measures description.

Measure	Value	Scale
Level	0	Very low
	1	Low
	2	Medium
	3	High
	4	Very high
Eyewitness	0 – False	Exist
	1 – True	Not exist

Time and Ratio types are expressed in seconds and percentage respectively. The percentage shows how much the software gets close to the fulfilment of a requirement. In cases like installation times and configuration as well as capacitating and learning can change the time unit second to day or month.

For operations of attributes quantified through Time type, it is necessary to transform from Time to Level, this way the metrics operation becomes more efficacious. This transformation is done according to Table 6. Each attribute needs to be transformed in a different way. The attributes A, B, C & D correspond to: duration of the product in the market, efficient use, adequate configuration and efficient administration. The values correspond to the same scale defined in the Table 5.

Table 6: Attribute reclassification for Time measures.

Value	Atributte A (Year)	Atributte B (Mth)	Atributte C (Day)	Atributte D (Mth)
0	< 5	< 7	> 5	< 4.5
1	5 - 10	6 - 7	5	4 - 4.5
2	11 - 20	5 - 6	4	3.5 – 4
3	21 - 30	4 - 5	3	3 – 3.5
4	> 30	< 4	<= 2	< 3

Once the dimensions and types of measure have been defined it is possible to start the definition of attributes, the main component of the GIS quality model. The attributes correspond to the way that the model's characteristics are described and a quality property which is possible to assign a measure. Through an analysis of GIS tools, compiling GIS experts' concepts and experiences as well as the observation of projects, 370 attributes have been defined for the dimensions. The complete list can be consulted in the physical model or (Siabato, 2005).

3.3 Metrics Definition

The measures, which rate the attributes that describe the dominion defined for the characterization of the model, are computed through metrics. Two kinds of metrics have become established in the model: specific and general metrics. Specific metrics are defined to deliver a general evaluation of the evaluated software, in this sense, it will be a metric which will compute not measured but other metrics derived of the model such as general metrics, which are defined as the elements that will be utilized to quantify each one of the dimensions of the model.

3.3.1 GIS Quality Indicator

As was said, the model intends to show an indicator that represents in a simple way the GIS software quality evaluated, a specific metric is established (1).

$$I = \sum_{i=1}^{6} N_i W_i \qquad (1)$$

Where *Ni* represents each one of the dimensions which conforms the model and *Wi* is their weight. In order to define the *Wi* weights a group of GIS experts replied to an opinion poll which tried to classify the level of the dimensions. From the obtained values and pondering the results the *Wi* weights are described in Table 7.

Considering that grades granted by experts are rated in the range 0–10 and they must be normalized to the model's dominion (0-1); it is necessary to use the relation described in (2).

Table 7: Weights for dimensions.

Dimension	Value	Weight
Functionality	0.26	W_1
Reliability	0.21	W_2
Usability	0.17	W_3
Efficiency	0.10	W_4
Maintainability	0.16	W_5
Portability	0.10	W_6

$$W_i = \overline{\chi_i} \Big/ \sum_{i=1}^{6} \overline{\chi_i} \qquad (2)$$

3.3.2 Subcharacteristics Evaluation

To define the metrics of the dimensions it is necessary to take into account each one of the subcharacteristics which compose them. Unlike the definition of the indicator *I*, each subcharacteristic will be calculated with the same weight.

A method according to the type of measure P, T, N or R is determined for the evaluation of each subcharacteristic. The dominion of evaluation is established in the range 0 -1, 1 represents a total fulfilment of the subcharacteristic and 0 represents its absence. Taking into account these premises, metrics M_{TP}, M_{TT}, M_{TR} and M_{TN} are defined according to the type of measure.

For evaluation of the type P attributes the expression (3) has been defined, where *Xi* is the grade P established by the user and *n* corresponds to the number of attributes for the evaluation of each subcharacteristic. With this metric is possible to evaluate attributes such as applicability, accuracy, interoperability, security and availability.

$$M_{TP} = \sum_{i=1}^{n} \chi_i \Big/ n \qquad (3)$$

For quantification of type R measures, the previous method is valid if it is considered that the dominion of evaluation R: 0-100 is comparable with P: 0-1. The expression (4) defines the metric for the evaluation of type R attributes. Subcharacteristics such as compatibility and functionality compliance are quantifiable with this method.

$$M_{TR} = \frac{\sum_{i=1}^{n} \chi_i \big/ n}{100} \qquad (4)$$

For type N measures, the method to calculate the grades is more complex. Due to the evaluation scale (Table 5) it is possible to define the work dominion in R5. Therefore, the best-suited the way of quantifying attributes related to this type of measure is applying the Euclidean rule. The expression (5) represents the metric for type N measures. Where, *Xi* represents the grade N established by the user between 0-4 and the element *n*, just like (3), is the number of attributes for each subcharacteristic.

$$M_{TN} = \sqrt[2]{\sum_{i=1}^{n} \chi_i^2} \Big/ 4\sqrt{n} \qquad (5)$$

Finally, for the quantification of type T measures and keeping in mind the reclassification showed in Table 6, which the dominion of evaluation for N is homologate to type T measure, it is also possible to apply the expression (5) to type T measures, taking into account the respective reclassification process.

The metrics defined until now allows finding values in ideal conditions in which all attributes are graded with the same type of measure. Nevertheless, there are some subcharacteristics that combine three or more types of measures, this force to define a new method for computing a single value for each subcharacteristic. Ad hoc, it must be taking into account that the final result belongs to the dominion of the model, defining a general case that allows finding the final value independently if the subcharacteristic is quantified with two or more type of measures. The expression (6) is the best suitable relation to solve this problem.

$$M_{TG} = \sqrt[2]{\sum_{i=1}^{n} \chi_i^2} \Big/ \sqrt{n} \qquad (6)$$

Where M_{TG}, defined as the metrics of general type, is the general evaluation of the subcharacteristics. *Xi* represents the metrics N, R, T ó P established for the attributes that define the subcharacteristic and *n* is the number of different measures N, R, T ó P implicated in the evaluation.

3.3.3 Quantification of Dimensions

When the defined metrics are applied to the subcharacteristics that compose the dimensions of the model, a value between zero and one is obtained. This value represents the level of quality for each quantified item. This information can be useful for some user that requires comparing a subcharacteristic in particular. However, this information is only an intermediate product utilized for the final purpose, the presentation of the GIS quality indicator (1). Once the sub-characteristics were defined, the last step is to define *Ni*. Keeping in mind that each one of obtained elements has been normalized, in order to obtain each *Ni* it is necessary to average the subcharacteristics which compose it. (7) represents the expression to obtain each *Ni* value.

$$N_i = \sum_{i=1}^{n} \theta_i \Big/ n \qquad (7)$$

Where, u_i represents each one of the dimension subcharacteristics, and *n* is the number of related subcharacteristics. This way, the metric for each dimension is obtained and the user will be able to evaluate the result according to his needs and the ones belonging to the project. In addition, we have all of the elements to calculate the Indicator (I) useful to determine which of the evaluated software adjust better to the project.

3.4 Metrics Representation

The elements that must be represented are the GIS quality Indicator and each one of the metrics which are utilized to evaluate the dimensions. Two methods of presentation have been established in order to show the obtained results to the user:

- Numerical method. A numerical value that will be utilized to represent the GIS Indicator (1) and to compare the general evaluation of each software package evaluated.
- Graphical method. A six-branch graphic that will be utilized to represent each dimension. The user will be able to evaluate which one of the dimensions has the biggest evaluation.

4 SOFTWARE EVALUATION

There are multiple companies which offer different solutions for the implementation of GIS projects. The most outstanding are Intergraph®, MapInfo®, Autodesk®, MicroImages®, Smallworld®, Bentley® and ESRI®. Once the model has been defined, three GIS software will be evaluated in order to validate the proposed model. The three evaluated GIS package are ArcGIS™ ArcInfo 9.0 from ESRI® TNT 6.9 from MicroImages® and Geomedia™ Professional from Intergraph®.

To validate the model the set of metrics have been implemented in a Microsoft® Office Excel book. In this book, the user rates each attribute in the dominion that has been defined for each type of measure. Each sheet has the changes of scale and the necessary operations to generate the metrics.

The results of the finished evaluation for the mentioned software are shown in Table 8 and Figure 1. The showed metrics will permit project managers make the best decision based on the metrics for each subcharacteristic and the GIS Quality Indicator.

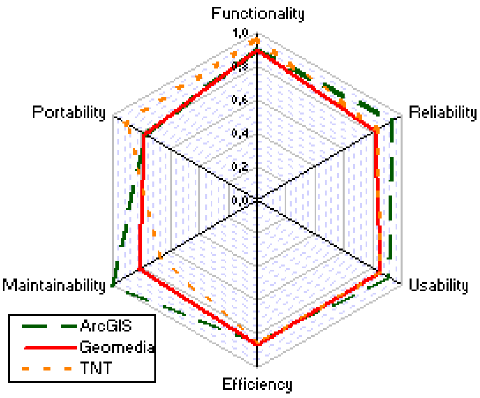

Figure 1: Metrics representation.

The results indicate that the best performed software is ArcGIS™, followed by TNT and Geomedia™. It is necessary to underline that this is a general evaluation and takes into account the global performance of the evaluated software and it is not an evaluation based on specific conditions. However, offers a good idea about which of the evaluated software has the best performance. But it is not possible to say that ArcGIS™ is better than the other ones. Figure 1 shows such the software with the best functionality is TNT. This implicates that if the user is looking for a package with specific functions and properties to satisfy his needs, the adequate election is TNT. This type of analysis is possible because of the independent evaluation of each dimension, e.g. if the user needs a highly adaptable software the right election is ArcGIS™.

5 CONCLUSIONS

It is evident how any GIS project must select each one of its components in the right way. This project has covered this problem for the software platform on which the project will be implemented. Taking into account that exists many kinds of products, the aforementioned platform must be selected with technical criteria and keeping in mind users' needs. The proposed model constitutes an advance for the definition and selection of GIS software packages, based on international standards and focused on the fulfilment of users and project requirements. This model helps to GIS managers to select the platform based on technical criteria and a safe methodology.
This a pioneer model, even though it is based on existing methodologies, it does not exist quality models related in the GIS dominion. Besides that, this work proposes a set of completely innovative metrics which can be applicable to any quality model derived from ISO/IEC 9126-1.

Table 8: Results of the finished evaluation.

Dimension	ArcGIS™	Geomedia™	TNT
Functionality	0,900	0,892	0,968
Reliability	0,932	0,811	0,840
Usability	0,918	0,850	0,856
Efficiency	0,855	0,862	0,868
Maintainability	1,000	0,809	0,676
Portability	0,772	0,780	0,905
Indicator (I)	0,909	0,840	0,859

The developed model considers the typical evolution between measure, metric and indicator. Each one of the attributes derived from the GIS software analysis is quantified through a measure. These measures are processed through a set of algorithms which let to know an overview of the evaluated software. Finally, each metric generated for each dimensions is processed to generate the GIS Quality Indicator, main objective of this work.

This paper had defined a new methodology which can be used to support the GIS projects design process on international standards, incorporating this type of projects to international quality standards.

REFERENCES

Calero, C., Ruiz, J. & Piattini, M. (2004) "A web metrics survey using WQM", In: *Fourth International Conference on Web Engineering*, Munich - Alemania

Chirinos, L. (2003) "Una clasificación de requisitos basada en vistas de calidad", In: *Jornadas Chilenas.*

Crosby, P. B. (1991) *La organización permanece exitosa*, Mc. Graw Hill, México D.F. – México.

Feigenbaum, A. V. (1991) *Total Quality Control*, Mc. Graw Hill, New York – USA.

Franch, X. & Carvallo, J. (2003) "Using Quality Models in Software Package Selection", *IEEE Software*, 20 (1)

ISO (2000) *International Standard ISO 9001:2000 Quality systems - Model for quality assurance*

ISO, IEC, (2001) *International Standard ISO/IEC 9126-1. Software engineering -Product quality- Part 1: Quality Model*, ISO/IEC 9126.

Juran, J. M. (1995) *Juran y la planificación para la calidad*, Diaz de Santos, Madrid – España.

Losavio, F. (2002) "Quality Models to Design Software Architecture", *Journal of Object Technology*, 1 (4) 165

Siabato, W. (2005) *Modelo de calidad para paquetes de software SIG*, MSc. Tesis. U. Pontificia de Salamanca.

Taguchi, G., Chowdhury, S. & Wu, Y. (2004) *Taguchi's Quality Engineering Handbook*, Wiley-Interscience, New York – USA.

Vallecillo, A. & Bertoa, M. (2002) "Atributos de calidad para componentes COTS", In: *IDEAS 2002*, La Habana - Cuba 352-363