

# Survey on Maturity Models for the Geospatial Domain

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## Abstract

Maturity models have been designed to assess the maturity (i.e. competency, capability, level of sophistication) of a selected domain based on a more or less comprehensive set of criteria. Although a great number of maturity models have been introduced for different purposes, only few of them are pertinent to the geospatial domain. The present paper lays the foundations for extending the current research on geospatial-related maturity models by conducting a survey on existing models developed for the geospatial domain. In the context of this paper, three maturity models are presented: the 'Maturity Model for Enterprise GIS' assessing the level of a comprehensive GIS approach within an organization, the 'Model for assessing GIS maturity of an Organization' that evaluates how mature an organization is in utilizing spatial data to reach its business objectives, and the 'GIS Capability Maturity Model' where the subject of the assessment is any enterprise environment that recognizes the need to evaluate its GIS operations vis-à-vis a theoretical model that is proposed as a framework. The three models contain many commonalities but as they measure GIS maturity from different perspectives, if used complementary the value and the outcomes for the assessed organizations increase significantly. Nevertheless, there are many directions for extending the existing research in the usage and applicability of maturity models at the geospatial domain and opening the way for their broader utilization across the GI community.

*Keywords:* Maturity models, geospatial, assessment.

## 1 Introduction

Maturity models have been designed to assess the maturity (i.e. competency, capability, level of sophistication) of a selected domain based on a more or less comprehensive set of criteria [1]. One of the first well-known maturity models was the Capability Maturity Model (CMM) created by the Software Engineering Institute (SEI) of the Carnegie Mellon University, originally developed for evaluating and improving the ability of government contractors in the USA to perform contracted software projects [7, 8]. Based on the widely accepted CMM, the SEI published a number of extended models and in 2001 it released its successor, the CMM Integration (CMMI) [2] which integrated and standardized some of these into one maturity model.

Despite the fact that a great number (approx. more than 150) of maturity models have been introduced for different purposes [1], only few of them are pertinent to the geospatial domain. In this paper, we present a literature review of three maturity models [4, 6, 10] in the area of geographic science and geographic information systems by exploring what type of relevant research on maturity models has been undertaken. According to our search in scientific databases and journals, the selected models are the main maturity models purely related with the geospatial domain with any other relative work to be considered as their predecessor.

The paper is structured as follows: we start our analysis with the 'Maturity model for enterprise GIS' which can be regarded as the first maturity model developed specifically for the geospatial domain. In Section 3 we present the 'Model for assessing the GIS maturity of an organization', an evolution of a maturity enhancement model [5] in which competence management has a fundamental and critical role in improving the GIS maturity of an organization. Next we focus on the

'GIS Capability Maturity Model', a tool to assess maturity against a variety of GIS capabilities, originally created for local government agencies and extended to cover any enterprise environment that recognizes the need to evaluate its GIS operations. In Section 5 we present our conclusions based on the scope, the behaviour and the main features of the models, followed by the proposed future work.

## 2 Maturity model for Enterprise GIS

By Enterprise GIS, the proposed model defines a GIS that 'provides a comprehensive suite of capabilities, integrated into operational workflows that support and help attain enterprise priorities' and the subject of the assessment is the level of a comprehensive GIS approach within an organization. It is a self-assessment model currently available in paper format, mainly used by small and large size enterprises in order to integrate their geospatial-technology related investments into the overall enterprise priorities.

The execution of the 'Maturity model for Enterprise GIS' requires very good knowledge of how the GIS operations are implemented within the organization together with a high level understanding of the organization's strategic priorities and overall environment. The intended audience of the assessment results includes executive and management teams that need to have a clear but still high-level picture of the current level of GIS in the organization in order to identify and adopt potential improvement steps that will increase the level of the GIS integration within the organization.

Analysing its structure, we deduce that the proposed model assesses enterprise GIS maturity in five domain areas, namely: enterprise alignment, data, accessibility, integration and sustainability and it examines in total sixteen different

characteristics which form the basis for determining the maturity stage of the assessed organization.

The model identifies five maturity stages as shown in Table 1 with each level to be accompanied by the benefits and the required investments for migrating to that.

Table 1: Maturity levels for the 'Maturity model for Enterprise GIS'.

Level	Name	Description
5	Enterprise	The GIS Strategic Plan is aligned with the overall Enterprise Strategic Plan
4	Integrated	The GIS organization looks beyond its internal workflows to how it can enhance operational workflows
3	Centralized	The organization establishes a centralized GIS unit to serve the GIS needs across all of the other departments
2	Department Based	Specific departments or agencies recognize the value of building GIS capability for their internal use
1	Enthusiasts	Individuals with interest obtain tools and use the GIS technology on an ad-hoc basis

The output is mainly qualitative since it is not in the form of an overall average score and the nature of the model is both descriptive and prescriptive meaning that apart from providing an indication on the here-and-now situation, it also gives emphasis on how to improve the maturity stage of the assessed organization [9].

### 3 Model for assessing GIS maturity of an Organization

The 'Model for assessing GIS maturity of an Organization' evaluates how mature an organization is in utilizing spatial data to reach its business objectives. It was developed as a tool to reinforce the utilization of spatial data and spatial solutions when it was observed that despite the availability of well-implemented, comprehensive Spatial Data Infrastructures (SDIs), the exploitation of spatial datasets in public and private organizations was very limited due to the fact that much more attention had been given in the producers and publishers of spatial datasets of SDIs than the user organizations that practically should benefit from the outcomes of SDIs [5].

The proposed maturity model assesses the current state of an organization's ability to materialize the benefits from SDI's development and provides improvement guidelines to achieve a higher maturity stage. It addresses a twofold need: on one hand, it is organizations that seek to strengthen their effectiveness and productivity by leveraging SDIs, and on the other hand, it is SDIs that need a tool to measure how successfully they have been used so far by various user

organizations in order to identify their further potential requirements.

Currently the model is available only in spreadsheet format but an open web application is planned to be implemented in the future to facilitate the execution of the assessments and the analysis of the results. Conducted assessments have shown that a combination of GIS user groups and management staff needs to be involved in order to achieve more accurate results while the target audience of the output is twofold: a) executive and management teams having a very critical and important role in the exploitation level of spatial data and b) SDIs as they should be interested in the real utilization and application of their implementations by the user organizations.

Concerning the key areas covered by the proposed model, these are three: architecture, services and processes and capabilities and for each key area there is a number of sub areas that are examined forming a model that in all evaluates fifteen different characteristics. The different maturity levels foreseen are six (Table 2).

Table 2: Maturity levels for the 'Model for assessing GIS maturity of an Organization'.

Level	Name	Description
6	Innovativeness	The organization is agile and quick to utilize the new possibilities offered by spatial data sets and spatial technology
5	Strategically optimized	Concrete measures from the evaluation guide the development of the use of spatial data towards strategic goals
4	Comprehensively managed	Evaluation of the use of spatial data provides information about problems and subjects that need development but the information does not always end in action
3	Concentrated coordinated	The use of spatial data is coordinated but the organization is not yet able to react to exceptional cases
2	Separately governed in each branch	Spatial data are used in certain branches but the ensemble does not work yet
1	Decided case-specifically	Spatial data are used but the ensemble is disjoint and does not assume a coherent form

The assessment can be used for: a) determining the as-is situation of the GIS maturity of an organization (descriptive), b) identifying next steps towards improving its maturity status and c) for benchmarking since the proposed model can be used as a common model for assessing the GIS maturity of multiple user organizations in order to measure the success of the implementation of a SDI.

### 4 GIS Capability Maturity Model

Although at the beginning the 'GIS Capability Maturity Model' was focused on cities, counties or other local government entities [3], currently its target audience includes any enterprise environment that recognizes the need to evaluate its GIS operations vis-à-vis a theoretical model that is proposed as a framework for an effective enterprise.

The development of the model was initially driven by the discordance between GIS investments and their effectiveness to realize their potential benefits for local government agencies as depicted in financial return of investment reports. It is a self-assessment model offered in the form of an electronic survey where the respondents, who must be knowledgeable about the organization's GIS operations, have the opportunity to provide their answers through a relative questionnaire. The output of the assessment, although depend on GIS capabilities of both GIS management and professional staff, it mainly concerns the GIS management level.

The questionnaire used by the proposed model to measure the GIS capability maturity of an organization is divided in two areas: enabling capability and process execution capability. Enabling capability includes questions related to technology components, data, resources and related infrastructure while process execution gauges the ability of the GIS management and professional staff to maximize the utilization of the available enabling capability. The total number of questions is 45 and it is worth noting that the assessment scale used in the two areas is not the same. For questions belonging to the enabling capability area, a seven-level scale is introduced (Table 3) whereas execution capability is measured against the typical five-level scale (Table 4).

Table 3: Maturity levels for the 'GIS Capability Maturity Model' – Enabling capability.

Level	Value	Description
7	1.00	Fully implemented
6	0.80	In progress with full resources available to achieve this capability
5	0.60	In progress but with only partial resources available to achieve this capability
4	0.40	Planned and with resources available to achieve this capability
3	0.20	Planned but with no resources available to achieve this capability
2	0.00	This desired, but is not planned
1	Not Applicable	Out of scope

Table 4: Maturity levels for the 'GIS Capability Maturity Model' – executing capability.

Level	Name	Description
5	Five	Optimized processes
4	Four	Managed and measured processes
3	Three	Defined processes
2	Two	Repeatable processes
1	One	Ad-hoc processes

The proposed GIS Capability Maturity Model is considered both qualitative and quantitative since each level of the maturity scale corresponds to a specific value. Therefore, the model does not provide only a detailed picture of weak points and development priorities for the assessed organization but also it can be used for benchmarking purposes.

## 5 Conclusions

The existing maturity models for the geospatial domain are self-assessment methods that can be used by any organization to measure its GIS-related maturity. The present survey shows that these models contain many commonalities in their domain and sub-domain areas and all of them use the entity type 'Organization' as the subject of the assessment. Nevertheless, they measure GIS maturity from different perspectives and therefore, if used complementary the value and the outcomes for the assessed organizations increase significantly.

Among them, the 'GIS Capability Maturity Model' focuses primarily on the GIS operations as such and it can be considered as the most extensive model, requiring in principle the involvement of GIS experts with deep and broad knowledge of the GIS environment inside the organization. To the contrary, the 'Maturity model for Enterprise GIS', as it focuses on how much the organization's GIS world is integrated into the overall enterprise environment, demands the involvement of professionals who combine both profiles: they should know very well how the GIS technology is implemented inside the organization but also be aware of the enterprise strategic vision and business priorities.

Another common element is the adoption, with some minor extensions or variations, of the typical five-stage scale as the basis for presenting the assessment results and in all cases, as the assessed organization matures, it moves from a lower maturity level to a higher one.

Also, all models focus more on the qualitative nature of the measurement and less on the quantitative one but still, they give a clear indication to the assessed organization of the improvement steps and the prerequisites for achieving a higher maturity performance.

## 6 Future work

Maturity models have been widely used in many different domains in order to assess the maturity level of an assessed entity vis-à-vis a predefined set of capabilities. Their main advantage is that they do not remain descriptive, providing only feedback about the as-is situation, but they can also be used as a tool to: a) obtain concrete recommendations for future improvement and b) compare or analyze the assessment results in order to identify best practices, lessons learnt and so on.

The present paper attempts to survey the existing maturity models related to the geospatial domain. The models presented can be considered complementary tools offered to any organization interested in assessing its maturity level from different point of views, providing a more holistic picture of

how various GIS operations and capabilities are implemented and integrated into the overall enterprise environment.

It is unequivocal that there are many directions for extending the existing research in the usage and applicability of maturity models at the geospatial domain and opening the way for their broader utilization in the GI community.

For example, the development of all existing models followed a general methodological approach [1, 9]. Therefore, we are planning to conduct a thorough analysis of existing design frameworks and principles for creating maturity models and develop a new methodology tailored to the needs and particularities of the geospatial domain.

Furthermore, as our analysis showed that all geospatial-related models use the entity type 'Organization' as the subject of their assessment, we envisage the development of a model for assessing a dissimilar entity type (e.g. the 'Geographic Service') or the extension of general-purpose maturity models to cover the specific nature of the geospatial domain. This will happen in parallel with an extensive analysis of the characteristics currently covered by the domain and sub-domain areas included in the existing geospatial-related maturity models, in order to identify aspects that either are missing or could be assessed in more detail.

Moreover, the release of existing models only in paper or spread sheet format is undoubtedly a barrier for their utilization across the intended target groups. For that reason, our future plans include the investigation of additional delivery channels such as an online application that will facilitate not only the diffusion of geospatial maturity models but also the analysis of the collected assessment results.

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