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Measurement Tools of the Maturity Model for Cloud Management and Governance in Higher Education Institutions

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***Abstract*— Cloud computing is a new model for provisioning and consuming IT services on a need and pay-per-use basis which allows the IT systems to be more agile and flexible. Cloud computing complements both IT services provided internally in organizations and outsourced IT services. This study proposes the applicability of a new holistic maturity model based on standards ISO/IEC 20000 and ISO/IEC 38500, and the frameworks and best practices of ITIL and COBIT, with a specific focus on external provision of cloud-based IT services. The model adapts MM-2GES to cloud-based services provided externally, from the point of view of the customer.**

This model allows independent validation and practical application in the field of higher education. In addition, this study allows to achieve an effective transition to a model of good governance and management of cloud-based services provided externally which, aligned with the core business of higher education institutions, affect the effectiveness and efficiency of its management, optimizes its value and minimizes risks.

***Keywords*— Cloud computing; IT governance; IT management; IT services; Maturity model; Outsourcing**

I. INTRODUCTION

In recent years a set of methodologies, best practices and standards, such as ITIL, ISO 20000, ISO 38500 and COBIT, have been developed to facilitate IT governance and management in a more effective and efficient way. These methodologies, which are appropriate and necessary to move from infrastructure management to service management, see a lack of academic research. For this reason, it is inadvisable to use these frameworks on their own, and it is advisable to consider other existing frameworks in order to extract the best from each for university level [5].

Currently, and in the years to come, organizations that achieve success are and will be those who recognize the benefits of information technology and make use of it to boost their core businesses in an effective strategic alignment, where delivery of value, technology, risk management, resource management, and performance measurement of resources are the pillars of success.

IT has become ubiquitous in almost all organizations, institutions and companies, regardless of the sector to which they belong. Hence, effective and efficient IT management to facilitate optimal results is necessarily essential. IT managers take a long-term, global view about their service-oriented architecture implementation projects. They also need to understand the potential organizational traps and prepare appropriate strategies to deal with the challenges [7]. Furthermore, IT groups in organizations can help improve learning-based outcomes by developing processes and systems that enable a firm to improve outsourcing procedures in a cumulative manner and also to coordinate and collaborate with the vendor [10].

In this environment of total IT dependency in organizations using ITs for the management, development and communication of intangible assets, such as information and knowledge [13], organizations become successful if these assets are reliable, accurate, safe and delivered to the right person at the right time and place, according to the IT Governance Institute (ITGI). In addition, knowledge integration mechanisms are important in helping knowledge utilization in client firms [15]. Also, user firms in information-intensive outsourcing will tend to adopt governance structures that facilitate an enhanced informational response to diverse contingencies and reduce the information states that decision makers have to contend with in the relationship [9].

Futhermore, Cloud computing is the latest trend to outsource some or complete IT operations to run a business from the public cloud that provides a flexible highly scalable technology platform for an organization's business operations [1]. In addition, Cloud computing poses serious challenges to traditional business process outsourcing and have a profound impact on how IT outsourcing is done [16].

Cloud computing represents a fundamental shift in how organizations pay for and access IT services. It has created new opportunities for IT service providers and the outsourcing vendors. Cloud computing will have significant impact on outsourcing vendors, who

must adopt new strategies to include Cloud services as part of their offerings to keep up with profound changes in the IT service industry. They should experiment with Cloud services and understand which models are suitable for their clients. This will help them to identify new business opportunities that arise from cloud computing. In addition, the deployment of new innovative Cloud services with attractive business models will lead to high level of customer satisfaction and unprecedented adoption of Cloud services in the organizations [3].

In addition, a maturity model is a method for judging whether the processes used, and the way they are used, are characteristic of a mature organization [4].

Models by phases or levels allow us to understand how IT management strategies based on computing evolve over time [8]. According to these models, organizations progress through a number of identifiable stages. Each stage or phase reflects a particular level of maturity in terms of IT use and management in the organization.

There are many maturity models in the literature, and they are applied to various fields, such as project management, data management, help desk, systems safety engineering. Most of them refer to either Nolan's original model [11] or the Capability Maturity Model of Software Engineering Institute (Carnegie Mellon Software Engineering Institute). The latter model describes the principles and practices underlying software processes, and is intended to help software organizations evolve from ad-hoc chaotic processes to mature disciplined software processes.

Nolan was the first to design a descriptive stage theory for planning, organizing and controlling activities associated with managing the computational resources of organizations. His research was motivated by the theoretical need for the management and use of computers in organizations. From 1973 until today, technology and the way it is used has changed a lot, but Nolan's original idea is still valid, and it will remain as long as the quality of services provided internally in organizations, or by external suppliers, is essential.

In the following study, the measurement tools of a new holistic maturity model with a specific focus on cloud-based IT services are proposed, taking into account the general characteristics that define IT outsourcing and external provision of cloud-based services, but also bearing in mind the nuances outlined on service models and deployment models. These measurement tools allow independent validation and practical application in the field of higher education, using a questionnaire, metrics tables, and continuous improvement plan tables as part of the continuous measurement process. Guidelines and standards are proposed in the model for facilitating adaptation to institutions and achieving excellence in the IT services provided externally from the cloud.

II. Maturity Model Proposed

MM-2GES is a new holistic maturity model based on standards ISO/IEC 20000 and ISO/IEC 38500, and the frameworks and best practices of ITIL and COBIT, with a specific focus on IT outsourcing. The model allows independent validation, practical application, and an effective transition to a model of good governance and management of outsourced IT services. The maturity model and its applicability are subject of two papers published in International Journal of Advanced Computer Science and Applications (IJACSA).[1]

In order to design the model, we studied in detail every reference on the provision of IT services that there is in the ISO 20000 and ISO 38500 standards and ITIL and COBIT methodologies, with a specific focus on IT outsourcing.

The model follows a stage structure and has two major components: maturity level and concept. Each maturity level is determined by a number of concepts common to all levels. Each concept is defined by a number of features that specify the key practices which, when performed, can help organizations meet the objectives of a particular maturity level. These characteristics become indicators, which, when measured, determine the maturity level.

MM-2GES defines five maturity levels: initial or improvised; repeatable or intuitive; defined; managed and measurable; and optimized. The model proposes that organizations under study should ascend from one level of maturity to the next without skipping any intermediate level. In practice, organizations can accomplish specific practices in upper levels. However, this does not mean they can skip levels, since optimum results are unlikely if practices in lower levels go unfulfilled.

The applicability of the model and the measurement tools, allow organizations to meet the goal of effective transition to a model of good governance and good management of outsourced IT services.

The model has been tested successfully on an intentional non-probabilistic sample, under the schema of positivist research, one of the three approaches there are in qualitative research. This kind of research assumes that reality is given objectively and it can be described by measurable properties (characteristics or indicators of the model) that are independent of the observer and the instruments used. Positivist studies try to test the theory in an attempt to increase the predictive understanding of a phenomenon. In line with this Orlikowski and Baroudi [12] labeled research in information systems as positivist if there was evidence of formal propositions, quantifiable measures of variables, tests of hypothesis, and draw conclusions

[1] Cf. Valencia, V., Fernández, E., & Usero, L., "Maturity Model for IT Service Outsourcing in Higher Education Institutions", (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 4, No. 10, 2013; Valencia, V., Fernández, E., & Usero, L., "Applicability of the Maturity Model for IT Service Outsourcing in Higher Education Institutions", *(IJACSA)* International Journal of Advanced Computer Science and Applications, Vol. 5, No. 7, 2014

about a phenomenon from a sample of a population estimated.

On the other hand, the external provision of cloud-based services appears as a natural evolution of traditional outsourcing, due to the emergence of emerging technologies related to the provision of IT services. Cloud computing is considered a form of outsourcing [2][6][16]. As a result of technological developments, traditional outsourcing and external provision of cloud-based services, share common characteristics such as reduced costs, increased flexibility, simplified IT and release of resources, among others. But the external provision of cloud-based services has some characteristics that are distinct from traditional outsourcing, from the point of view of the customer, such as shorter contracts, more transparent costs, less project management, less government and less coordination, among others.

MM-2GES is a good basis in order to use in this new scenario and new business model based on external provision of cloud computing services. The model has been designed to be applied in any scenario where an organization has the ability to hire IT services to external service providers. However, there are some significant differences between traditional IT outsourcing and external provision of services based in the cloud. Therefore, the model allows some adjustments to be made in the metrics tables where each characteristic in the model is rated. The adjustments in the model have been made depending on the differences mentioned above.

In addition, when discussing cloud computing we must take into account there are three different service models, each of which has specific characteristics, and also there are four deployment models with specific characteristics. Thus, when discussing the external provision of services in the cloud, the characteristics of services depend on the type, design and nature of the service, studied in a personalized way.

Therefore, MM-2GES has been adapted to external provision of cloud-based services. These kinds of services have been analysed from a general and theoretical angle, taking into account the general characteristics that define them, but also bearing in mind the nuances outlined on service models and deployment models.

The differences between traditional IT service outsourcing and IT services provided externally from the cloud are the following, extracted from different publications [2], [3], [6], [14]:

1. No advance costs. Simpler and more transparent costs;
2. Shorter, less complex and more important contracts;
3. Rapid scaling on demand. Greater flexibility with respect to the increase and decrease of IT resources needed due to the existence of services and infrastructure deployed in the cloud;
4. Less customization of services and greater difficulty of integrating legacy systems;
5. Less project management, less government and less coordination. Less interaction;
6. Few legal guarantees on security and data privacy;
7. Greater uncertainty about business continuity;
8. Greater uncertainty and importance of service availability; and
9. Less guarantee of getting a certain performance.

Taking into account the differences between IT outsourcing and the external provision of cloud-based services, it is been necessary to make a number of adjustments in MM-2GES. These adjustments allow to apply the maturity model in an environment where external cloud-based services are provided. This way, a new characteristic that define both traditional outsourcing and cloud computing will be added to the maturity model, flexibility. This requires identifying which concepts of MM-2GES would be affected by the differences between traditional IT outsourcing and the external provision of cloud-based services. Table I shows the concepts affected by the differences. The first column of the table shows all key areas that form the basis of the maturity model designed for IT outsourcing. The second and successive columns show the differences between IT outsourcing and external provision of cloud-based services.

TABLE I. KEY AREAS AFFECTED BY THE DIFFERENCES BETWEEN IT OUTSOURCING AND EXTERNAL PROVISION OF CLOUD-BASED SERVICES

Key areas or determinants	**Differences between IT outsourcing and external provision of cloud-based services**								
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
Formal Agreement		X	X						
Service Measurement									X
Quality Management									
Monitoring and Adjustments					X				X
Alignment IT-Business				X					
IT Governance Structure					X				
Service Level Agreement (SLA)		X	X					X	X
IT Service Registration									

Incident and Problem Management									
Changes									
Testing and Deployment									
Control of External Providers								X	
Business Risk							X		
Financial Management									
Legislation						X			
Demand and Capacity Management			X				X		
Formal Agreement Management		X							
Knowledge Management									
Guidelines on outsourcing an IT service (life cycle)	X	X							

The concepts that are not altered by the differences between IT outsourcing and external provision of cloud-based services are the following:

- Quality Management;
- IT Service Registration;
- Incident and Problem Management;
- Changes;
- Testing and Deployment; and
- Knowledge Management.

The concepts altered by the differences between IT outsourcing and external provision of cloud-based services are the following:

- Formal Agreement;
- Service Measurement;
- Monitoring and Adjustments;
- Alignment IT-Business;
- IT Governance Structure;
- Service Level Agreement (SLA);
- Control of External Providers;
- Business Risk;
- Financial Management;
- Legislation;
- Demand and Capacity Management;
- Formal Agreement Management;
- Knowledge Management; and
- Guidelines on outsourcing an IT service (life cycle).

After analysing all the differences, extracted from different publications [2], [3], [6], [11], between traditional IT service outsourcing and IT services provided externally from the cloud, the necessary adjustments have been made in the indicators of the model in order to adapt it to a new model (henceforth MM-CBS) with a specific focus on the external provision of cloud-based IT services.

The applicability of MM-CBS can be implemented in organizations that have cloud-based services provided externally. In order to apply the new model we must use the adapted tools used in the maturity model for IT service outsourcing. The tools are the following: a questionnaire, metrics table, and continuous improvement plan tables as part of the continuous measurement process.

Therefore, the procedure to follow is to put into practice the continuous measurement process by implementing the continuous improvement plan, and using the assessment tool, which is composed of the questionnaire results, metrics table and continuous improvement plan tables.

III. Objectives of the Maturity Model

The main purpose of MM-CBS is to fulfill as many requirements of an ideal maturity model for cloud management and governance of cloud-based IT services as possible. With the identification and definition of some key concepts and an assessment tool, the model allows a systematic and structured assessment of organizations. Although the assessment instrument has a lot of qualitative responses, it also has quantitative responses, such as the degree of compliance with certain characteristics that define the maturity model (e.g. the degree of influence of the KPIs and KGIs in the penalties for breach of agreements).

The identification of key areas and concepts specifying its characteristics to constitute the underlying structure of the model, complements the necessity to refer to governance and management concepts tested and backed by standards and methodologies. Moreover, the model advocates continuous learning and improvements in governance and good management of cloud-based IT services provided externally, from the point of view of the customer, even when organizations have reached the maximum level (5).

IV. Measurement Tools of the Maturity Model Using the Template

We have designed an assessment tool along with the maturity model that allows independent validation and practical application of the model. Therefore, the maturity of an organization indicates how successfully all practices that characterize a certain maturity level have gone fulfilled. The questions used in the questionnaire consider the basis of the assessment instrument. They were extracted from each of the indicators defining each of the general concepts and key areas of the maturity model. These general concepts and defining characteristics have been extracted from the following standards and methodologies:

- Standard ISO/IEC 20000 and methodology of good practices ITIL. Both provide a systematic approach to the provision and management of quality IT services.
- Standard ISO/IEC 38500:2008 provides guiding principles for directors of different organizations to manage, evaluate, and monitor the use of information and communication technologies effectively and efficiently.
- COBIT business-oriented methodology provides good practice through a series of domains and processes, as well as metrics and maturity models in order to measure the achievement of the objectives pursued.

In addition, new indicators have been developed based on the proposed model in order to assess appropriate aspects not reflected either in previous methodologies and standards or in the existing literature (e.g. the inclusion of service performance in the SLA and the use of user-satisfaction surveys in IT-business alignment).

TABLE II. METRICS TABLE AND QUESTIONNAIRE

Level	Code – Indicator – Question of Questionnaire	Source
	Concept: Formal Agreement: contract, agreement or similar (FA)	***ISO 20000, Cobit, ITIL***
3	FA1 - Procedures and processes – Are there clear documented procedures to facilitate the control of cloud-based IT services with clear processes for negotiating with external providers?	Cobit
	FA2 - Elements of FA - Formal agreements (contracts, agreements or the like) of every cloud-based IT service include:	ISO 20000, ITIL, Cobit
3	FA2a - Scope of work	
2	FA2b - Services / deliverables to be provided	
3	FA2c - Timeline	
2	FA2d - Service levels	
2	FA2e - Costs	
3	FA2f - Billing Agreements	
2	FA2g - Responsibilities of the Parties	
	FA3 - Requirements of FAs - Formal agreements meet the following requirements:	Cobit
3	FA3a - Legal (compliance with current regulations)	
3	FA3b - Operational (proper delivery and management of services in operation)	
3	FA3c - Control (for the measurement and analysis of the services)	
2	FA4 - Revision frequency of FAs - Formal agreements are reviewed periodically at predefined intervals	ISO 20000
3	FA5 - Penalties in FAs - There are penalties for breach of formal agreements, including termination of agreements	Self developed
345	FA6 - Enforcement of penalties in FAs - Degree of enforcement of penalties for breach of agreements	Self developed
	Concept: IT Governance Structure (EOG)	***IT Governance Study 2007, ISO/IEC 38500***
2	EOG1 - Board of Directors and CIO – There is a Board of Directors where CIO is a member	
2	EOG2 - IT Strategy Committee - There is an IT Strategy Committee (CIO is a member) that designs the strategy and high-level policies of the university on IT	
3	EOG3 - Audit Committee (external and internal) - There is an Audit Committee (external and internal) that oversees the IT governance and provides support to auditors in their duties	
2	EOG4 - IT Steering Committee - There is an IT Steering Committee led by CIO that designs and implements IT projects that meet IT strategic planning	
3	EOG5 - Commission on Technology and / or IT Architecture - There is a Committee on Technology and / or IT architecture led by CIO that advises and coordinates IT management issues	
2	EOG6 - Projects Office - There is a Projects Office led by CIO that manages IT projects	
2	EOG7 - Services Commission - There is a User Services Commission representing all end users of cloud-based IT services	

	Concept: Service Level Agreement (SLA)	ISO 20000 & ITIL
2	SLA1 - SLA - There is an SLA for each cloud-based IT service provided by the cloud service provider	ISO 20000 & ITIL
	SLA2 - Elements of SLA - SLAs include:	
2	SLA2a - Service availability	
4	SLA2b - Service performance	Self developed
3	SLA2c - Penalties for breach of SLA	
2	SLA2d - Responsibilities of the parties	
3	SLA2e - Recovery Times	
4	SLA2f - Quality Levels	
5	SLA2g - Security requirements	
2	SLA3 - Frequency reviewing of SLA - SLAs are reviewed periodically at predefined intervals	ISO 20000 & Self developed

To evaluate the maturity model of an organization using MM-CBS and the measurement instruments proposed, it is necessary to obtain a series of data resulting from the responses to the questionnaire based on the indicators that define the general concepts of our maturity model.

Table II shows three of the nineteen key areas or concepts that are the basis of the model. The first column of the table shows the level or levels corresponding to the indicator located in the second column. The second column shows the survey questions and indicators for each of the questions or part of the questions. Finally, the third column shows the source where the indicator or item has been extracted as a feature of the general concept or key area of the model.

Therefore, the maturity level of every higher education institution studied is measured by evaluating its development in each key area or concept, which is indicated by responses to items or indicators in metrics tables (see Table II). In order to qualify for a specific maturity level, the university surveyed must carry out all key practices of that level successfully.

A. Continuous Improvement Plan

Both ISO 20000 and ISO 38500 standards, and ITIL and COBIT methodologies of best practice in IT management and governance, are a good basis for the study and analysis of governance and management of the IT services provided externally in organizations. That is why they allow the design of a new maturity model that facilitates the achievement of an effective transition to a model of good governance and management of cloud-based IT services that, aligned with the core business in higher education institutions, impacts on the effectiveness and efficiency of its management, optimizes its value and minimizes risks.

A questionnaire (survey form) forms the basis of the quantitative study of the maturity model. The questionnaire is based on the attributes or indicators that define the different levels of the model. It contains standard and suitable questions, according to the nature of the research.

Questionnaire responses allow the obtaining or calculation of the level of maturity by applying the scale defined in MM-CBS. In addition, questionnaire responses, after being properly analysed, shed light on the current situation of the different organizations studied in governance and management of cloud-based IT services.

This research also allows case studies to be carried out at some universities. These case studies put the model into practice in order to draw conclusions. The questions used in the questionnaire bring the design of a proposed continuous improvement plan (see Tables III, IV and V) to allow a sequential growth by stages. The growth occurs as a hierarchical progression that should not be reversed, for the aforementioned reasons, and involve a broad range of organizational activities in governance and management of cloud-based services.

Tables III, IV and V show three different levels (there are five tables, one for each level) of the model with the key areas or concepts to be improved in order to allow a sequential growth by stages. The first column of the tables shows the concepts. The second column of the tables shows the objectives to achieve corresponding to the concept in the first column. Finally, the third column shows the actions to accomplish in order to achieve the objectives set in the second column.

TABLE III. CONTINUOUS IMPROVEMENT PLAN. LEVEL III

Level III - Defined		
Concept	***Improvement Objectives***	***Improvement Actions***
Formal Agreement: Contract, agreement or similar (FA)	- There are clear documented procedures in order to manage cloud-based IT services, with clear processes in order to negotiate with providers - The formal agreement	- It would be advisable to have well documented procedures in order to facilitate the control of cloud-based IT services, with clear processes in order to negotiate with external providers. Thus it would facilitate to sign formal agreements, in the form

	includes scope of work, timeline, billing agreements, and penalties - Good degree of compliance with legal, operational and control requirements - There are penalties for breach of formal agreements - Low degree of enforcement of penalties for breach of formal agreements	of contracts, agreements or similar - IT Management should demand every formal agreement of every cloud-based IT service to include scope of work, a timeline, billing agreements, and penalties for breach of signed agreements - IT Management, based on signed agreements, should demand a good degree of compliance with legal, operational and control requirements. Legal requirements in order to comply with current regulations, operational requirements for the proper delivery and management of services in operation, and control requirements to facilitate the measurement and analysis of the services in order to improve them in operation - Likewise, IT Management should demand penalties for breach of formal agreements, stipulated in them, even if degree of enforcement of penalties is low. Thus, contractual parties would become aware of the need to comply with signed formal agreements
Monitoring and adjustments (MON)	- Optimized process to supervise the cloud-based IT services, the associated risks and the provision of services. This process measures the performance of services and provides information in order to measure current and future services. - The compliance with operational and legal requirements is monitorized.	- Supervision of external cloud service providers is essential for monitoring. It would be necessary to carry out the supervision of cloud-based IT services, the associated risks and the provision of services. Therefore, the process that allows to carry out this supervision, must be optimized. - IT government should monitorize the compliance with operational requirements (proper delivery and management of services in operation) and legal requirements (compliance with current regulations) of the cloud-based IT services.
Alignment IT-Business (ALI)	- The requirements of the cloud-based IT services are well defined, well implemented and well aligned with business objectives in organizations	- The degree of alignment or integration of the cloud-based IT services with business depends on how the requirements of the cloud-based IT services have been met. Therefore, it would be necessary to have these requirements well defined, implemented and aligned with business objectives in organizations
IT Governance Structure (GS)	- The organizational structure of IT also has an audit committee (external and internal), and a commission on technology and / or IT architecture	- The government team or the management has taken the responsibility to create a structure of decision making related to IT, where CIO must be the protagonist and the backbone and integrator of IT strategy in the organization. In addition to IT Strategy Committee, IT

		Steering Committee, Projects Office and Services Commission, it would be necessary to establish the following: -Audit Committee: supporting committee that reports to the Board of Directors. This committee should supervise the good governance of IT in order to become successful from all points of view, or at least from the point of view of control and compliance with regulations -Commission on Technology and / or IT__Architecture: the commission should advise and coordinate IT management issues, assist the organization in the planning of IT development, coordinate its implementation, monitoring and assess the action plans to implement
Service Level Agreement (SLA)	- SLA includes: penalties for breach of SLA and recovery times (continuity)	- It would be advisable to include in SLAs the corresponding penalties for breach of SLA and recovery times, as part of the continuity
Incident and Problem Management (IPM)	- The degree of optimization of incident management process is very high - Problem Management Process (PMP) is implemented - The degree of optimization of PMP is high - Tools that manage problems are optimized and they allow to investigate the cause of incidents, identify possible solutions, prevent repeat incidents, and minimize the impact of incidents that cannot be avoided - There is an acceptable link between incident management and service level management	- It would be necessary there were a very good degree of optimization of the incident management process, and the IT manager should supervise the degree of optimization - PMP allows to investigate the cause of incidents, identify possible solutions, prevent repeat incidents, and minimize the impact of incidents that cannot be avoided, propose change requests and carry out post implementation reviews. Therefore, it would be necessary there were a good degree of optimization of the PMP, and the IT manager should supervise the degree of optimization - The tools that allow to investigate the cause of incidents, prevent repeat incidents and minimize the impact of incidents that cannot be avoided, should be optimized, because they are an essential component of the PMP - It is important the degree of linkage between the incident management and service level management. This link allows to prioritize the resolution of incidents and obtain good recovery times. Therefore, it would be advisable there were a link at least acceptable between incident management and service level management
Changes (CHN)	- It is implemented the change management process to facilitate making changes that incorporate	- It would be necessary to implement the change management process that facilitate making changes that incorporate new features and improvements in IT services, with

	new features and improvements in IT services with minimum service disruptions	minimum service disruptions. This process ensures that changes are deployed safely, ie, they are assessed, they are assigned a priority, they are planned, tested, implemented and documented
Business Risk (RIN)	- There is a contingency plan (CP) to go back for each cloud-based service - The CP is reviewed periodically - Abilities and capacities of external providers are checked continuously over time	- Because IT services support core business in organizations, it is essential to control the risk of disruption of IT services provided by external providers. As part of business continuity plan, it would be necessary there was a contingency plan to go back for each cloud-based service that supports the core business in organizations. The CP should include technical, human and organizational measures in order to ensure business continuity and operations in the organization - The CP should be reviewed periodically. In general, the review would be as a result of a new risk analysis - The ability of the external provider refers to the external provider‘s capacity to provide a service properly. Thus, it would be necessary to check the abilities continuously over time, i.e. to check the strict compliance with signed agreements, e.g. service levels offered, quality of service, business continuity
Legislation (LEG)	- All European community and national standards, laws, decrees, directives and decisions on personal data protection, personal data processing, location where data processing takes place, clauses for the transfer of data and standard contractual clauses for the transfer of personal data to third countries, are moderately followed	- It would be necessary to follow moderately all European community and national standards, laws, decrees, directives and decisions on data protection, data processing, location where data processing takes place, clauses for the transfer of data and standard contractual clauses for the transfer of personal data to third countries. Thus, the potential risks that processing personal data, accomplished by third parties, represents for the privacy of individuals, would be avoided
Demand and capacity management (DCM)	- Demand management process (DMP) is implemented - Capacity management process (CMP) is implemented - DMP and CMP (justifiable in terms of cost) of every cloud-based IT service are well geared to each other	- Demand management is a process of the service strategy where service provision is tailored to demand, predicts it and try to regulate it. It would be necessary to have the demand management process implemented within the IT machinery in the organization - Capacity management is a process that must provide IT capacity, justifiable in terms of cost, in line with the current and future user needs. It would be necessary to have the capacity management process implemented within the IT machinery

		in the organization - The capacity to generate resources available for an IT service is adjusted according to the provisions and needs defined in the demand. There is a close link between IT demand and IT capacity in organizations, where consumption cycle generates demand and the production cycle addresses it and responds with the capacity. Therefore, there must be a good linkage between demand management and capacity management
Formal Agreement Management (FAM)	- There is a formal agreement management system independent of both knowledge management system (KMS) and configuration management system (CMS) - There is a contract manager, responsible for managing the agreements signed with external providers	- It would be necessary there was a management system of formal agreements with external providers, in order to obtain high-quality service at a competitive price. Also, it would be advisable to create a data base to manage external providers and agreements signed with them, in order to have the system implemented effectively. However, the system would not be integrated into the configuration management system yet - It would be necessary to create a new role called contract manager. This person would be responsible for managing the agreements signed with external providers using the management system of formal agreements with external providers
Guidelines on outsourcing an IT service (lifecyle) (PAS)	- Technical study (availability, continuity and capacity) - Measurement of service demand - Explore the cloud market - Renegotiate offers received	General guidelines or actions that should be carried out in the decision-making process on whether or not to outsource a given IT service to the cloud, would be: - Technical study focused mainly on the availability, continuity and capacity of the IT service provided internally - To conduct an assessment of the service demand could be requested by corporate government to the IT department in the organization. The assessment should take into account the percentage of availability, quality, continuity and capability of the service, including current and future available resources in the organization - Explore the cloud market and compare the IT service provided internally to the service offered by external providers - Renegotiate offers received from external cloud providers if the organization has made the decision to outsource an IT service, after

		analyzing economic, technical and legislative issues

TABLE IV. CONTINUOUS IMPROVEMENT PLAN: LEVEL IV

Level IV - Managed and measurable		
Concept	***Improvement Objectives***	***Improvement Actions***
Formal Agreement: Contract, agreement or similar (FA)	- Good degree of enforcement of penalties for breach of formal agreements	- IT management should demand a good degree of enforcement of penalties for breach of formal agreements signed with external providers. The penalties should be stipulated in the agreements signed
Monitoring and adjustments (MON)	- KPIs and KGIs affect penalties, contracting and negotiation of cloud-based IT services to a great extent - Corrective actions are implemented, if need be, as a result of monitoring	- The results of KPIs and KGIs indicate the degree of compliance with the agreements signed. It would be necessary these results to affect penalties, contracting and negotiation of cloud-based IT services to a great extent - Corrective improvement actions should be implemented, if needed, as a result of monitoring
Alignment IT-Business (ALI)	- The requirements of the cloud-based IT services are very well defined, very well implemented and very well aligned with business objectives in organizations - End-users satisfaction surveys on the quality of service users receive are designed, distributed, collected and analyzed - End-users satisfaction survey responses on the quality of service users receive, affect the provision of cloud-based services	- The degree of alignment or integration of the cloud-based IT services with business depends on how the requirements of the cloud-based IT services have been met. Therefore, it would be necessary to have these requirements very well defined, very well implemented and very well aligned with business objectives in organizations - The degree of satisfaction of end-users of cloud-based IT services is another indicator of the degree of alignment of the cloud-based IT services with business in organizations or, to put it another way, the quality of service they receive. For that reason, it would be necessary to design, distribute, collect and analyze end-users satisfaction surveys on the quality of service end users receive. - End-users satisfaction surveys should be taken into account and they should affect the provision of service
Service Level Agreement (SLA)	- SLA includes the expected performance of the service	- Most service providers, and more specifically cloud service providers, offer SLA with the service availability they provide, but they do not ensure the service performance. If a service is available and meet the percentage agreed, but it has a poor response time, the service can be considered unavailable. Therefore, it would be very important to stipulate in the SLA the service performance to meet the

		demanded requirements
Incident and Problem Management (IPM)	- The degree of optimization of problem management process is very high - There is a close link between incident management and service level management	- It would be necessary to have a problem management process implemented with a high degree of optimization. IT manager should ultimately be the responsible for supervising the high degree of optimization of the process - As mentioned above, it is important the degree of linkage between incident management and service level management. This link allows prioritizing the resolution of incidents and obtaining good recovery times. Therefore, it would be advisable there were a close link between incident management and service level management
Changes (CHN)	- Every approved change has a backout plan to restore a service to its original or earlier state - A post-implementation review is performed in order to find out if the change has been carried out successfully	- It would be advisable to have a backout plan for every approved change in order to be able to restore a service to its original or earlier state. The backout plan would be part of the change management process and it would prevent business risks - In addition, it would be necessary to perform a post-implementation review for every change carried out in order to find out if the change has been carried out successfully and to proceed with the closing of the change, in addition to identifying opportunities to improve
Business risk (RIN)	- There is a contingency plan (CP) to go back for each cloud-based service - The CP is reviewed periodically - Abilities and capacities of external providers are checked continuously over time	- Because IT services support core business in organizations, it is essential to control the risk of disruption of IT services provided by external providers. As part of business continuity plan, it would be necessary there was a contingency plan to go back for each cloud-based service that supports the core business in organizations. The CP should include technical, human and organizational measures in order to ensure business continuity and operations in the organization - The CP should be reviewed periodically. In general, the review would be as a result of a new risk analysis - The ability of the external provider refers to the external provider‘s capacity to provide a service properly. Thus, it would be necessary to check the abilities continuously over time, i.e. to check the strict compliance with signed agreements, e.g. service levels offered, quality of service, business continuity
Demand and capacity	- Demand management process (DMP) and Capacity	- There is a close link between IT demand and IT capacity in

management (DCM)	management process (CMP) of every cloud-based IT service are perfectly geared to each other	organizations, where consumption cycle generates demand and the production cycle addresses it and responds with the capacity. At this stage, demand management and capacity management must be geared to each other perfectly
Knowledge management (KM)	- There is a knowledge management system (KMS) that contains documented cloud-based IT services. The KMS is available to all stakeholders, and must provide all kind of information related to cloud-based IT services requested	- The knowledge management eases decision-making. Also, it provides safe reliable information during the service lifecycle. In order to share knowledge in an effective way, it would be necessary to develop and maintain a knowledge management system of IT services. The KMS should be available to all stakeholders and should provide all kind of information related to cloud-based IT services requested
Legislation (LEG)	- All European community and national standards, laws, decrees, directives and decisions on personal data protection, personal data processing, location where data processing takes place, clauses for the transfer of data and standard contractual clauses for the transfer of personal data to third countries, are almost strictly followed	- It would be necessary to follow almost strictly all European community and national standards, laws, decrees, directives and decisions on data protection, data processing, location where data processing takes place, clauses for the transfer of data and standard contractual clauses for the transfer of personal data to third countries. Thus, the potential risks that processing personal data, accomplished by third parties, represents for the privacy of individuals, would be avoided
Guidelines on outsourcing an IT service (lifecyle) (PAS)	- Legislation study	General guidelines or actions that should be carried out in the decision-making process on whether or not to outsource a given IT service, would be: - Comprehensive study of the legislation in order to identify all the *regulatory requirements* and obligations that apply to the services provided by external providers. These suppliers should comply with all regulations applied to the cloud-based services they provide

TABLE V. CONTINUOUS IMPROVEMENT PLAN: LEVEL V

Level V - Optimized		
Concept	***Improvement Objectives***	***Improvement Actions***
Formal Agreement: Contract, agreement or similar (FA)	- Very high degree of enforcement of penalties for breach of formal agreements	- IT management should demand a very high degree of enforcement of penalties for breach of formal agreements signed with external providers. The penalties should be stipulated in the agreements signed with external providers, in addition to the termination of agreements for breach of them
Quality	- There is an EFQM- or CAF-	- Quality management is essential in order to

Management (QM)	type quality management system	ensure that IT is providing value to the organization, continuous improvement and excellence through IT services. Thus, it is needed to plan, implement and maintain a quality management system that provides clear requirements and procedures on quality. Quality requirements must be designed and documented with quantifiable and achievable indicators. Continuous improvement is achieved through constant monitoring, correcting deviations and communicating the results to stakeholders. Therefore, it would be necessary to develop and maintain an EFQM- or CAF-type quality management system that includes processes and proven standards
Alignment IT-Business (ALI)	- The requirements of the cloud-based IT services are perfectly defined, implemented and aligned with business objectives in organizations	- The degree of alignment or integration of the cloud-based IT services with business depends on how the requirements of the cloud-based IT services have been met. Therefore, it would be necessary to have these requirements perfectly defined, implemented and aligned with business objectives in organizations
Service Level Agreement (SLA)	- SLA includes: quality levels, and security requirements	- It would be advisable to include in SLAs, in addition to all components included in lower levels, the quality levels demanded and security requirements. Thus, a reliable provision of cloud-based IT services is ensured
IT Service Registration (RSS)	- The service catalogue includes for every service the following: conditions in providing the service, SLA, costs, and responsibilities of the parties	- IT Service Registration is like a portal or an acquisition channel for users. The service catalogue should include the costs, SLA, and the responsibilities of the parties, in addition to the terms and conditions in providing the services. Services should be broken down into its components and processes, in addition to defining points of entry and conditions of use and provisioning. This would result in a clearer and more direct information of cloud-based IT services that would allow their publicity and good use of them by the end users
Changes (CHN)	- Change management includes an internal study of priorities of requests for change (RFC)	- Change management should include an internal study of costs, if appropriate, depending on the kind of agreement signed with the external provider, and an internal study of priorities of requests for change
Control of External Providers (CEP)	- Independent audits of external providers are carried out to evaluate the efficiency, effectiveness and economy of the cloud-based IT services provided - Security reports are carried out on external providers in order to monitor and ensure the confidentiality, integrity and availability of information about the IT services provided	External providers should be subject to periodic independent reviews that will provide feedback to improve the delivery of services they provide. Therefore, it would be necessary to control external providers by carrying out independent audits and security reports - Independent audits would include review, evaluation, and reporting in order to assess the efficiency, effectiveness and economy of the suppliers in relation to their operational IT - Security reports would allow monitoring and ensuring the confidentiality, integrity and

		availability of information about cloud-based IT services provided by external providers. Thus, risks would be minimized
Financial Management (FM)	- There is a financial management committee that provides vital information for IT management in order to ensure the provision of cloud-based IT services efficiently and cost-effectively	- Financial management implemented correctly provides vital information for IT management that ensures the provision of services efficiently and cost-effectively. Also, financial management ensures transparent service charges, via service catalogue, and allows services to fit into the business. In addition, **f**inancial management allows improving the following: decision-making capacity, compliance with the financial regulation, **f**inancial and operational control, and creating and capturing value. Therefore, it would be necessary to create a financial management committee. It would provide vital information for IT management in order to ensure the provision of cloud-based IT services efficiently and cost-effectively
Formal Agreement Management (FAM)	- There is a configuration management system (CMS) - The management system of formal agreements signed with external providers is integrated into the CMS	- It would be necessary there was a CMS. This system would allow to know and control easily: the infrastructure; relationships between configuration items that constitute the infrastructure and support services; and the lifecycle of configuration items - The database, which manages external providers and the agreements signed with them, is the core component of the management system of formal agreements signed with external providers. Also, this database should be integrated into the CMS
Knowledge Management (KM)	- The KMS that contains documented cloud-based IT services is integrated into the CMS	- The knowledge management system (KMS) available, which improves among other things the quality of decision-making and ensures that safe and reliable information is available during the service lifecycle, should be integrated into the CMS. This way, the CMS sends information to the KMS to facilitate the decision-making process, among other functions
Legislation (LEG)	- All European community and national standards, laws, decrees, directives and decisions on personal data protection, personal data processing, location where data processing takes place, clauses for the transfer of data and standard contractual clauses for the transfer of personal data to third countries, are strictly followed	- It would be necessary to follow strictly all European community and national standards, laws, decrees, directives and decisions on data protection, data processing, location where data processing takes place, clauses for the transfer of data and standard contractual clauses for the transfer of personal data to third countries. Thus, the potential risks that processing personal data, accomplished by third parties, represents for the privacy of individuals, would be avoided

In the aforementioned case studies we would apply the established scales, which rates the university surveyed and the object of study, at a level of maturity within the model. Depending on the level of maturity in which the university is rated, improvement actions, according to the continuous improvement plan, will be proposed to achieve a target level.

The continuous measurement process to be implemented in order to ascend in the model is as follows (see Fig. 1):

1. Perform an initial measurement after completing the questionnaire;
2. Set goals (benchmark);

3. Identify the gaps between the current measurement and the objectives set;
4. Recommend actions and policies to be implemented within the continuous improvement plan to ascend in the model; and
5. Implement actions. Once corrective actions have been implemented, perform a new measurement.

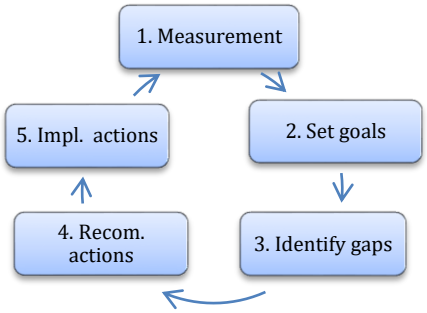

Fig. 1 *Continuous measurement process*

The continuous improvement plan to apply the established scales (see Table II) in order to achieve a target level is as follows (see Fig. 2):

1. Initial measurement of the current level of the institution studied after completing the questionnaire. Equivalent to step 1 of the continuous measurement process;
2. Identify improvement objectives using the values of the indicators. Equivalent to steps 2 and 3 of the continuous measurement process; and
3. Implement improvement actions or practices in order to achieve the improvement objectives identified in stage 2. Equivalent to steps 4 and 5 of the continuous measurement process. Back to the first stage.

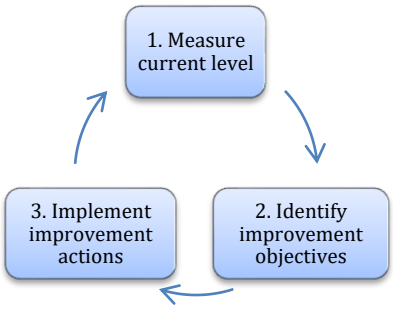

Fig. 2 *Continuous improvement plan*

The first stage of the continuous improvement plan involves measuring the current level of the institution under study. Once improvement objectives and improvement actions have been identified in the second stage, it is time to implement improvement actions. Once these actions have been implemented successfully, the third stage of the continuous improvement plan has been finished. That means institution under study has achieved the goals set in the stage 2 of the continuous improvement plan.

The continuous improvement plan is designed in such a way that allows moving up gradually in the model by repeating the three stages as many times as necessary.

Therefore, the next step would be to perform the first stage of the plan in order to measure the institution again. This first step is critical because the time between two measurements could be long, and some key practices done in the previous measurement, could not be done in the following measurement; and on the contrary, some key practices not done in the previous measurement, could be done in the next measurement, in addition to the practices to implement identified at the stage two and implemented at the stage three of the previous cycle of the continuous improvement plan.

V. CONCLUSIONS

In order to design the proposed innovative maturity model and the measurement tools, we studied in detail every reference on the provision of IT services that there is in the ISO 20000 and ISO 38500 standards and ITIL and COBIT methodologies. In addition, we investigated the relevant literature and failed to find any maturity model that brings together the previous methodologies with a specific focus on outsourcing and cloud-based services provided externally. As a result, a number of concepts and subconcepts were categorized to form the basis of the maturity model.

A questionnaire (survey form) forms the basis of the quantitative study of the maturity model. The questionnaire is based on the attributes or indicators that define the concepts and the different levels of the model. It contains standard and suitable questions, according to the nature of the research.

Questionnaire responses allow the obtaining or calculation of the level of maturity by applying the scale defined in the metrics tables (see Table II). In addition, questionnaire responses, after being properly analysed, shed light on the current situation of the different organizations under study in governance and management of cloud-based IT services provided externally.

The model allows organizations under study ascend from one level of maturity to the next without skipping any intermediate level. In practice, organizations can accomplish specific practices in upper levels. However, this does not mean they can skip levels, since optimum results are unlikely if practices in lower levels go unfulfilled.

MM-CBS advocates continuous learning and improvements in governance and management of cloud-based IT services through the continuous improvement plan by applying the established scales, even when institutions have consolidated the highest level of the model (level 5).

In addition, standards and guidelines showed in the continuous improvement plan tables (see Tables III, IV and V) are recommended in order to enable and facilitate adaptation to higher education institutions so

that they can move up the maturity model. Thus, the model, based on standards and best practices, is designed to achieve excellence in the management of cloud-based IT services. The applicability of the MM-CBS and the measurement tools (questionnaire, metrics tables and continuous improvement plan), allow higher education institutions to meet the goal of effective transition to a model of good governance and good management of cloud-based IT services. Aligned with the core business of this kind of institutions (education, research and innovation) this will impact on the effectiveness and efficiency of their management, optimize value and minimize risks.

This study recognizes that it is unlikely to achieve maximum effectiveness and efficiency in the government and management of cloud-based IT services, in a higher education institution in a relatively short period of time. The structure of the model proposed, organized in levels, provides a general understanding of the gradual and holistic development of IT governance and management of cloud-based services provided externally. MM-CBS expects to be an effective diagnostic tool to measure the efforts made around cloud computing in higher education institutions, in addition to a coherent roadmap to guide higher education institutions in their efforts to provide their teaching, research, and administrative staff, and ultimately their students, with a quality and effective IT services in line with the ever-evolving digital era of the XXI century.

On the basis of this research, by categorizing concepts and subconcepts with a specific focus on IT outsourcing firstly and cloud computing afterwards, and designing an assessment tool along with the maturity model that allows independent validation and practical application of the model, this study seeks to allow higher education institutions under study to meet successfully the requirements of EHEA (European Higher Education Area) and the complex digital era of the internet.

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