Control Objectives for DP: Digital Preservation as an Integrated Part of IT Governance

Christoph Becker
Vienna University of Technology
Vienna, Austria
becker@ifs.tuwien.ac.at

Gonçalo Antunes, José Barateiro, Ricardo Vieira, José Borbinha
INESC-ID Information Systems Group
Lisbon, Portugal
{goncalo.antunes,jose.barateiro,rjcv,jlb}@ist.utl.pt

ABSTRACT
Digital Preservation, often seen as information management with a long-term mission, is recognized as an independent research area, but the field's maturity is still evolving. Reference models and compliance criteria for archival systems are being developed, but the more general perspective of Governance, Risk and Compliance has yet to be fully considered. In particular, Digital Preservation can take advantage of the powerful tools for structuring processes to exercise control, assign responsibilities, and quantify goal achievements, provided by IT Governance.

This paper presents an integrated vision for Digital Preservation that aligns key organizational preservation processes with a leading framework for IT Governance. Based on a high-level capability model, we define control objectives for core Digital Preservation processes, present a reference assignment of responsibilities and accountabilities to typical Digital Preservation stakeholders, and discuss a maturity model for Digital Preservation processes. The resulting processes are related to key IT Governance processes. This integrated process model enables organizations with a long-term vision on the value of digital information to sustain and govern their Digital Preservation activities.

Keywords
Digital Preservation, IT Governance, Maturity Model.

INTRODUCTION
The fundamental importance of Digital Preservation (DP) as enabler for continuously managing and delivering valuable information over time in rapidly changing technical and contextual environments has been increasingly recognized over the past years. While there is considerable progress in clarifying the boundaries, goals and reference frameworks of DP, the integration into the related key disciplines of Information Systems and Information Technology is still unclear.

DP is an operational activity with a long-term vision, which can lead to difficulties in structuring effective and efficient processes. In comparison, the discipline of IT Governance has a medium-term vision: It strives to ensure business continuity by detecting changes early, assessing their impact proactively, and ensuring strategic alignment of technology with business goals. In IT Governance, a *control objective* is a "statement of the desired result or purpose to be achieved by implementing control procedures in a particular process" (IT Governance Institute, 2007).

Reference models for DP and compliance criteria for archival systems are being developed, but the more general perspective of Governance, Risk and Compliance (GRC) has not yet been fully considered. Formal maturity models such as the Capability Maturity Model Integration (CMMI) have been shown to be powerful tools in enabling quantitative assessment and improvement (Gibson, Goldenson, & Kost, 2006). However, no formal maturity models for DP have been proposed, and DP frameworks have not been explicitly integrated into GRC frameworks.

This not only presents a substantial barrier to increasing the recognition of DP in mainstream IT; it also hinders advances in the DP field where research is not taking into account some of the powerful tools in fields such as Information Systems and Organizational Engineering.

On the other hand, key frameworks such as COBIT (Control Objectives for IT), a widely accepted standard model for IT Governance, do not explicitly acknowledge and consider the implications of long-term effects of the evolving nature of IT and its context on authenticity and understandability of information. They are concerned with continuity and change, but do not integrate long-term effects into their processes. Specifically, they do not consider the implications of technology change and misalignment of access technologies on the authenticity and understandability of digital materials.

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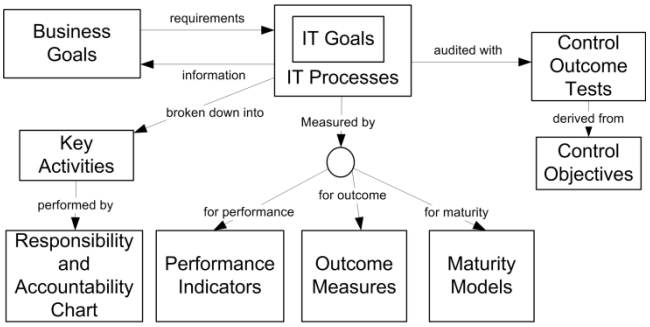

Figure 1: COBIT key components and relations (IT Governance Institute, 2007)

This paper addresses this gap and presents an integrated vision for DP that incorporates key organizational preservation processes into a leading framework for IT Governance. We extend COBIT to explicitly cover DP as integrated part of IT Governance by defining key preservation capabilities as IT Governance processes and linking them to core COBIT processes. Based on a high-level capability model, we define control objectives for core DP processes, present a reference assignment of responsibilities and accountabilities to typical stakeholders in DP, and discuss a maturity model for DP processes. The resulting processes are positioned in relation to key IT Governance processes. This integrated vision enables the flexible deployment of DP *capabilities* into the governance models of organizations.

The next section outlines related work in the disciplines of DP and IT Governance. We then present a high-level capability model for DP that is the basis for expressing key capabilities as IT Governance processes. We discuss control objectives, process metrics, and relationships with existing processes in COBIT. A maturity model aligned with the COBIT maturity concept concludes the paper.

RELATED WORK

Governance, Risk and Compliance

The increasing relevance of regulations like Basel II and the Sarbanes-Oxley Act, along with the recent series of global negative economic and financial events, raised the awareness to effectively address the GRC activities of today's organizations (Frigo & Anderson, 2009). The concepts of GRC are not new, but are traditionally addressed as separate concerns within an organization. However, these concepts share a set of knowledge, methodology and processes that allows a holistic view where GRC activities are addressed in an integrated way to improve decision making, strategy setting and performance. This avoids conflicts, overlaps and gaps between GRC activities.

The key GRC Capability Model OCEG (Open Compliance & Ethics Group)[1] integrates governance, risk and compliance processes into the categories of *Culture and Content; Inform and Integrate; Organize and Oversee; Monitor and Measure; Respond and Resolve; Assess and Align; Prevent and Promote;* and *Detect and Discern.* Each of the categories has several elements with its own principles on what the element must accomplish, sources of failure, practices, requirements (which are external to OCEG, e.g. established by law), key deliverables, and technology components.

IT Governance

IT Governance encompasses "the leadership, organisational structures and processes that ensure that the enterprise's IT sustains and extends the organisation's strategies and objectives" (IT Governance Institute, 2007).

The key governance framework COBIT organizes activities into a well-defined process model and identifies which resources can be leveraged to achieve specified objectives. It aims to ensure alignment between technology and business requirements by making performance against measures transparent and defining control objectives to govern processes. COBIT provides a controlled process model organized in four domains: *Plan and Organise; Acquire and Implement; Deliver and Support; Monitor and Evaluate*. In COBIT, IT goals are driven by business goals. IT Processes, organized in domains and focus areas, leverage IT Resources to achieve these IT goals and assure information criteria. As shown in Figure 1, reproduced from (IT Governance Institute, 2007), each process achieves specific IT goals relevant to business goals and is broken down into key activities, each of which has assigned responsibilities. Processes are measured for internal performance, for external outcome and for maturity. All these controls are interlinked and auditable.

COBIT relates all processes to each other through input and output specifications and models the relevance of each process in supporting a number of *information criteria* (Effectiveness, Efficiency, Confidentiality, Integrity, Availability, Compliance, Reliability). These are clearly geared at a business management perspective, and none of these criteria directly express DP concerns such as information authenticity, understandability, or longevity. However, the COBIT view of *effectiveness* does partially cover DP concerns: "relevant and pertinent ... delivered in a timely, correct, consistent and usable manner" (IT Governance Institute, 2007).

Finally, COBIT includes a maturity model based on the CMMI (Software Engineering Institute, 2010), a capability model developed to integrate practices, methods and maturity models for different disciplines in a process improvement approach. The main goal is to help organizations to manage and control nowadays' complex development and maintenance processes, providing best practices that address development activities applied to products and services.

[1] http://www.oceg.org/

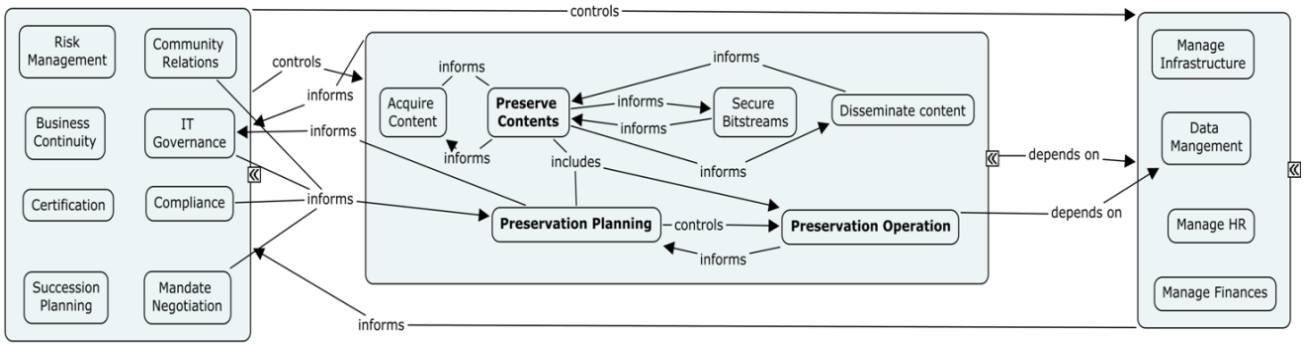

Figure 2: Relationships between Governance (left), Business (center) and Support Capabilities

The dimensions of the COBIT maturity model are similar to those in ISO 15504 (International Standards Organization, 2008). Each process can have different maturity levels in each of the six dimensions: *Awareness and Communication; Policies, Plans and Procedures; Tools and Automation; Skills and Expertise; Responsibility and Accountability*; and finally, *Goal Setting and Measurement*. This categorization supports systematic and targeted improvement of organizational processes and capabilities to desired maturity levels.

Digital Preservation

The Reference Model for an Open Archival Information System (OAIS) (International Standard Organisation, 2003) has provided the conceptual framework and vocabulary for the majority of efforts in the field of DP. Based on this conceptual model, the ISO 16363 standardization initiative for Repository Audit and Certification (International Standard Organisation, 2010) develops compliance criteria for repositories following the OAIS.

The process of specifying DP operations by exercising control, taking decisions and specifying action plans is called *Preservation Planning*. As such, it is a key concept of the functional specification of the OAIS Model. This complex issue has been discussed in detail in the last years (Becker, Kulovits, Guttenbrunner, Strodl, Rauber, & Hofman, 2009). In particular, the need to move towards quantification, control and systematic measurement has been increasingly recognized. A recent article presented an in-depth study of decision criteria and measures necessary to ensure control (Becker & Rauber, 2011).

In addition, the SHAMAN project[2] created a Reference Architecture for Digital Preservation that fed these and a number of related models developed in the DP field into a common and well-established Systems Architecture approach to create a capability-based view on DP. This Reference Architecture does not prescribe an Information Systems design, but instead describes fundamental DP goals, drivers and constraints, key stakeholders typically encountered in DP and their main concerns, and key *capabilities* that an organization needs to possess in order to meet its DP mandate. A capability in this context is *an* "*ability that an organization, person, or system possesses. Capabilities are typically expressed in general and high-level terms and typically require a combination of organization, people, processes, and technology to achieve*" (The Open Group, 2009).

Governance, Risk and Compliance in DP

Considering the broad field of GRC, where does DP stand today? Risk Management approaches such as DRAMBORA[3] customize standard risk assessment practices and tailor them to the needs of repository environments. Furthermore, the initiative to develop the ISO 16363 standard has been detailing compliance criteria for repositories based on the OAIS Reference Model. These models deliver some guidance on compliance criteria to be met, but they do not provide effective mechanisms for governance and control, nor do they provide guidelines on implementation and improvement.

IT Governance frameworks are geared at sustaining IT and achieving strategic alignment of technologies to goals in changing environments through efficient deployment of IT resources. Governance needs objective means to control operations. Preservation Planning exercises control based on objectives; but the relationships to organizational processes, responsibilities, goals and constraints are still unclear. To date, there is a lack of coherence and quantified objectives and no holistic governance framework that explicitly addresses DP concerns. This paper addresses that gap by integrating Digital Preservation processes into an established IT Governance framework.

DIGITAL PRESERVATION CAPABILITIES

The key DP capabilities identified in the SHAMAN Reference Architecture interrelate in a number of ways. Figure 2 shows a high-level conceptual view and includes a more detailed view on the directed relations relevant to the capability *Preserve Contents*. It shows that *Governance capabilities* exercise control over *Business* and *Support* capabilities and are informed by these. Business capabilities

[2] http://www.shaman-ip.eu/

[3] http://www.repositoryaudit.eu/

have a dependency relationship with Support capabilities. The Governance capabilities are:

1. **Compliance**: The ability to verify the compliance of operations and report deviations
2. **Community Relations**: The ability to engage with the designated community and ensure its needs are fulfilled
3. **Certification**: The ability to obtain and maintain certification status
4. **Mandate Negotiation**: The ability to negotiate mandates with governing institutions
5. **Business Continuity**: The ability to identify business capabilities and assure mission-critical operations
6. **Succession Planning**: The ability to negotiate formal succession plans
7. **IT Governance**: The ability to manage and develop the services, processes and technology solutions that realize and support the primary capabilities
8. **Manage Risks:** The ability to manage and control strategic and operational risks, and opportunities to ensure efficient business continuity and sustainability.

Figure 2 further provides details on the relations of *Preserve Content*: "the ability to maintain content authentic and understandable to the defined user community over time and assure its provenance" (Antunes, Barateiro, Becker, Borbinha, & Vieira, 2011). It includes two capabilities: Preservation Operation and Preservation Planning.

Preservation Operation is the ability to control the deployment and execution of preservation plans. This includes analyzing content, executing preservation actions and ensuring adequate levels of provenance, handling preservation metadata, conducting Quality Assurance, and providing reports and statistics, all according to preservation plans. *Preservation Actions* are concrete actions (usually implemented by a software tool) performed on content in order to achieve preservation goals. For example, a preservation action can consist of the migration of content to a different format using a certain tool in a certain configuration and environment to enable authentic rendering of this content through the preferred viewer environment of the designated target community.

Preservation Planning is the ability to monitor, steer and control the preservation operation of content so that the goals of accessibility, authenticity, usability and understandability are met with minimal operational costs and maximal (expected) content value. This includes managing obsolescence threats at the logical level as the core risk affecting content's authenticity, usability and understandability. Preservation actions are thus the main object of interest for planning, which has to find the best action among a number of choices.

Decomposing the relations between capabilities, and focusing on the *Preserve Contents* capability, it is possible to depict more detailed types of relations existing between capabilities of different groupings. For instance, Governance capabilities such as Community Relations, IT Governance, Compliance, and Mandate Negotiation inform the Preservation Planning Capability (PP). Table 1 describes all relationships involving PP. These capability relationships have to be considered when incorporating processes into an organization's architecture, since they need to be reflected in process inputs and outputs, responsibility and accountability specifications, and risk assessment. We will discuss below how these relationships translate into process relations in COBIT.

CONTROL OBJECTIVES FOR PP: A DP GOVERNANCE PROCESS

In this section, we specify the core process of PP that achieves the key goal of authenticity and understandability. This specification of PP is strongly founded on previous work (Becker, Kulovits, Guttenbrunner, Strodl, Rauber, & Hofman, 2009), but abstracts key activities, formalizes objectives and enables the clear assignment of responsibilities. The *IT process* of **Preservation Planning** satisfies the following business requirement for IT: *Authentically preserve understandable content in usable form for the specified time horizon, with an optimal efficiency.* To achieve it, its focus is to *detect and react to changes in the environment in order to define courses of actions and directives that manage obsolescence for the entirety of contents at the logical level, maximize user satisfaction with minimal costs, and monitor the correspondence of operations to objectives***.**

Relation	Rationale
IT Governance Informs PP	IT Governance informs Preservation Planning about technical constraints and opportunities and provides the operational means to be deployed.
PP informs IT Governance	Preservation Planning informs IT Governance about the adequacy of available means to achieve ends.
Community Relations Informs PP	Information gathered about Producers and Users may include drivers and constraints that have to be considered by preservation.
Compliance Informs PP	Rules and regulations posed by external Regulators are documented as constraints in Compliance and have to be considered for preservation.
Mandate Negotiation Informs PP	The scope defined in the mandate determines the basic cornerstones of preservation (types of content, producers, users, time horizons etc).
PP controls Preservation Operation	Preservation Planning specifies actionable preservation plans that define concrete courses of actions and the directives governing their execution. This effectively controls Preservation Operation.
Preservation Operation Informs PP	Preservation Operation has to document activities in an adequate and understandable form so that Preservation Planning can monitor operations (including in particular the execution of plans).

Table 1: Preservation Planning Capability Relations

Activities	Producer/Depositor	Consumer	Executive Management	Repository Manager	Technology Manager	Operational Manager	Regulator	Auditor	Repository Operator	Technology Operator	System Architect	Solution Provider
Document context: Collect and describe all influence factors of interest and relevance; i.e., all drivers, constraints, goals and regulations applicable.			A	C	C	R	C	I				
Define scope of interest: Select a range of content for requiring a common treatment, to scope the decision making activities and ensure focussed planning.			A	R		I		I	C			
Define requirements: Make drivers and goals operational, i.e. define objectives and constraints represented by decision criteria			A	C	C	R		I	I	I		
Select options: Select a (minimal relevant) set of options potentially fulfilling requirements			I		C	A		I	R	C		C
Diagnose options: Gather information about available options, i.e. measures corresponding to a set of criteria.				C	C	A		I	R	C		C
Assess options: Assess options against requirements, i.e. specified criteria, to deliver efficient decisions and operational plans			A	C	C	R		I		C		
Specify preservation plan: Specify actions and directives in understandable form	I	I	A	C	C	R		I	I	I		
Deliver preservation plan: Deliver plan to operations (to prepare plan deployment)			I	I	C	A		I	R	C	I	
Internal Monitoring: Monitor operations specified by plans and operational attributes of the system, i.e. internal influencers.				C	C	A		I	R	R	I	
External Monitoring: Monitor external influencers (regulations, technological opportunities; user community shifts; etc.).	C	C	A	R	R	I	C	I		C	I	C

Table 2: Activities and Stakeholders (R)esponsible, (A)ccountable, (C)onsulted and (I)nformed for PP

The key control objectives are as follows:

Influencers and Decision Making: Make drivers and goals operational, i.e. define objectives and constraints represented by decision criteria and assess options against these criteria.

Options diagnosis: Gather information about available options, i.e. measures corresponding to a set of criteria.

Specification and Delivery: Specify actions and directives in an understandable form and deliver them to operations to prepare the deployment of plans.

Monitoring*:* Monitor operations and external influencers of interest for certain properties.

These control objectives are addressed by activities with assigned metrics and responsibilities. Table 2 describes these activities and maps them to stakeholders. Responsible for carrying out these activities are generally the stakeholders who are managing and operating the system in which content is stored. A full description of all stakeholders and their concerns can be found in (Antunes, Barateiro, Becker, Borbinha, & Vieira, 2011). Note that external users are not normally consulted in the context documentation and requirements definition activities, since these contacts are covered by the Governance capabilities.

To track the success of each of these activities, we specified process metrics that can provide a powerful tool for risk identification and process improvement. These are listed in Table 3. These *internal* process metrics relate strongly to completeness, correctness and timeliness, as well as to typical concerns of trustworthiness: repeatability, traceability and measurability of decisions are a core concern in preservation planning.

Preservation planning needs to take relevant and effective decisions in order to achieve key goals. Figure 3 integrates these internal metrics (on the bottom row) to goals and objectives (on the top row), combining the internal view on efficiency with the goal-oriented process-external view on effectiveness. For example, the IT goal of ensuring that content is authentic and understandable is translated into several process goals such as the timely detection of and reaction to changes in the environment. Such changes include shifts in the technology environments of user communities, which may threaten user access and require a realignment of access formats and features. These process goals are achieved by activities such as *Specify and deliver concrete courses of actions to be deployed*, which refers to the specification of preservation actions in a form understandable by operations. The activities can be measured internally along the criteria listed in the lower right box and specified in detail in Table 3. The processes can be measured by indicators such as the *percentage of content volume explicitly covered by a preservation plan* or the *average reaction time for responding to an obsolescence incident report*. In turn, the IT goal can be measured along metrics such as the *number of objects for which a breach of authenticity or understandability was reported during the time horizon.*

Metric	Description
Criteria Completeness	% of influencers of which this capability is informed that are either related to an objective/constraint or discarded with a reason
Criteria Relevance	% of criteria that can be shown to relate to a concrete influencer
Criteria Measurability	% of criteria that are independently measurable in finite time
Decision Traceability	% of decisions that can be traced to the influencers through their explicit assessment
Decision Repeatability	% of decisions that can be repeated, i.e. independent decision making activities will arrive at the same results
Decision Timeliness	% of decisions that are taken within a certain time frame
Decision Efficiency	Average effort to take decisions
Decision Completeness	% of decisions that did not specify all relevant aspects necessary for operational deployment
Diagnosis Completeness	% of measures that are delivered for all options and each criterion
Diagnosis Correctness	% of measures that are correct
Diagnosis Efficiency	Average costs of diagnosing an option
Diagnosis Timeliness	% of measures that are delivered in a certain time frame
Plan Understandability	% of delivered plans that are successfully understood by Preservation Operation
Plan Completeness	% of specified plans that completely reflect the decisions taken.
Plan Correctness	% of specified plans that accurately reflect the decisions taken.
Plan Timeliness	% of specified plans delivered within a certain time frame.
Monitoring Completeness	% of relevant measures delivered
Monitoring Correctness	% of measures that are correct
Monitoring Timeliness	% of measures that are younger than a certain time frame

Table 3: Preservation Planning Process Metrics

Correspondingly, Figure 4 shows the goals and metrics for *Preservation Operation*. The IT goal of enabling PP to monitor operations sets a process goal to "ensure timely delivery of adequate and understandable documentation of operations". This requires a reporting activity which can be measured for completeness, correctness, timeliness, currentness, relevance and understandability.

These metrics drive measures such as the average delay between plan execution and report delivery or the number of issues reported that led to a plan revision.

While space limits an in-depth discussion of all goals and metrics, the relationships between goals and metrics suggested by COBIT are a powerful tool to verify the coherence of processes, quantify expected results, and track process performance and achievement of objectives against desired levels of key performance indicators.

PROCESS RELATIONS

The process specification maps activities to stakeholders and clarifies objectives and metrics. However, these processes cannot exist in a vacuum and need to be clearly positioned with respect to the particular process model of an organization. While this process model will vary, we will map the PP and Preservation Operation process to the key processes specified in the COBIT reference. This can be used as a guide for operational deployment. The important distinction here has to be made along the lines of COBIT domains: Preservation Planning clearly has strong connections to the domain *Plan and Organise*, while *Preservation Operations* is closer connected to the domains *Monitor and Evaluate* and *Deliver and Support.* We will focus our discussion on the *PP* process and its relation to selected key processes in the COBIT domain *Plan and Organise* (PO), and provide a short summary of the remaining relationships below.

The process **PO1: Define a Strategic IT Plan** determines the value of preservation investments and aligns time horizons. By creating and maintaining a strategic plan, it sets goals and constraints and defines the means available to preservation. The IT service portfolio sets out services provided for preservation operations. The Strategic IT Plan is an important input for PP in that it provides the means necessary to achieve preservation goals and may also constrain the means available to PP. PO1 also includes Tactical plans which can be projects addressing preservation needs that are managed in project portfolios to balance short-term costs and (expected) long term costs.

The Information Architecture described in the process **PO2: Define the Information Architecture** encompasses the definition of a data dictionary and data syntax which should contain information about the representations of content, as well as a data classification scheme that will determine certain properties of the content to preserve. This process supports decision-making activities for preservation and checks data for integrity and consistency. An awareness of preservation concerns will be required for successful process integration.

The process **PO3: Determine Technological Direction** can provide technology directions to preservation planning and set boundaries, constrains and goals for each preservation plan. The process identifies the need to establish a technology forum and an IT architecture board to provide technology and architecture guidelines. The output of these groups may include structural business directives that govern the preservation processes.

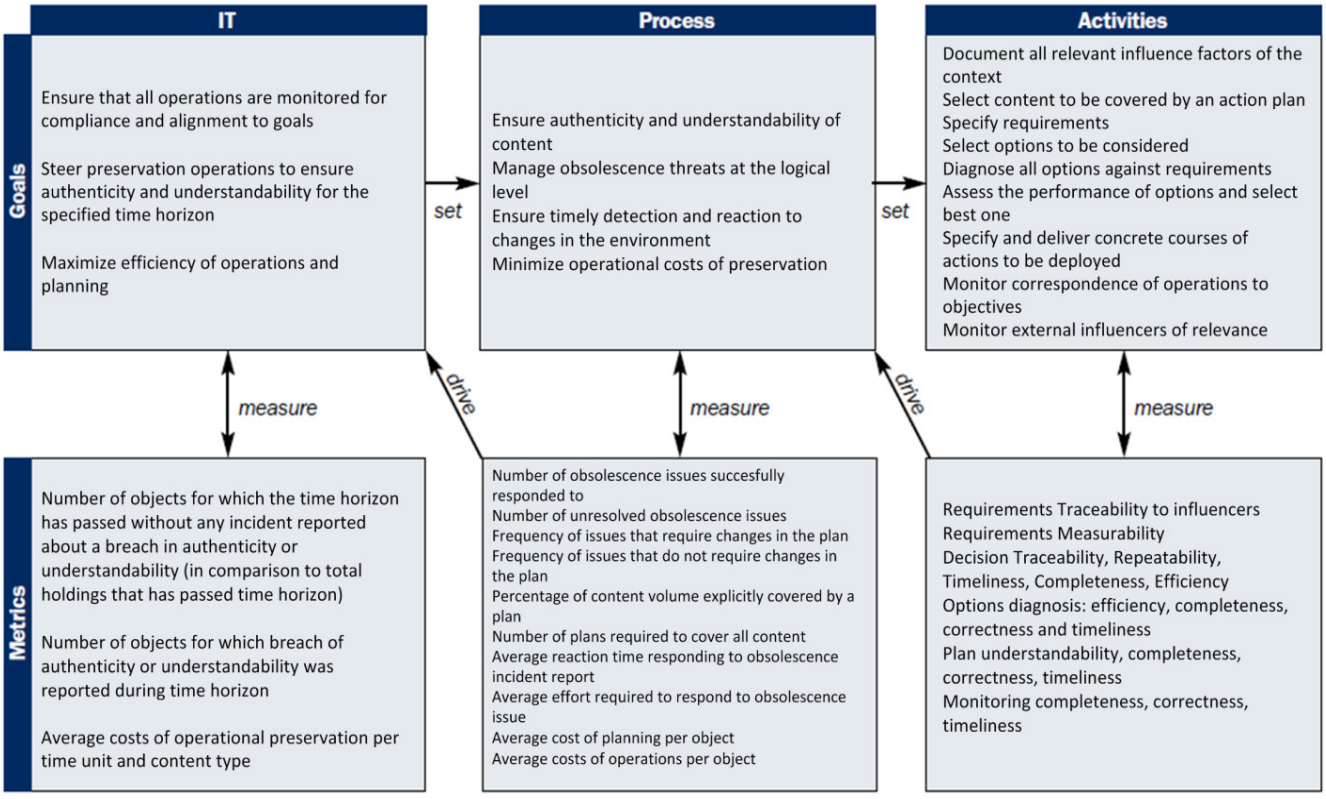

Figure 3: Goals and Metrics for Preservation Planning

The control objectives further include a proactive process to monitor future trends and regulations, which needs to be integrated with the external monitoring activity in PP.

PO4: Define the IT Processes, Organisation and Relationships constitutes the definition of a process framework necessary to deploy preservation capabilities. In a given context, this framework will set out the exact structure of the activities defined in PP. It will define how they are controlled by IT Governance, specify responsibilities and control objectives, and detail inputs and outputs between all processes.

PO5: Manage the IT Investment and **PO7: Manage IT Human Resources** manage and provide monetary and staff resources. PP has to leverage these efficiently and effectively and report back on their sufficiency. The level of these resources may constrain operational preservation and goal achievement.

PO6: Communicate Management Aims and Direction, on the other hand, is responsible for defining and communicating strategic goals and policies. In an organization striving to address DP as a new concern, this process will play a key role in successfully articulating the arising goals and necessary actions. Moreover, it can be seen as the process that supports the "control" relationship between capabilities, in particular between governance capabilities and Preservation Planning. In this sense, it serves as a vehicle for capability control.

The process **PO8: Manage Quality** includes the definition of a Quality Management System that commits to "ongoing monitoring, analysis and acting upon deviations". This constitutes essential input for PP, which needs to monitor quality levels of ongoing operations.

The process **PO9: Assess and Manage IT Risks** creates and maintains a Risk Management Framework that documents IT risks and mitigation strategies. The residual risks acceptable to an organization are a key concern for trustworthy preservation. On the other hand, DP deals with key long-term risks threatening information and provides an important part of the risks to be considered in the framework. Thus, close integration with preservation processes is crucial[4].

Finally, the process **PO10: Manage Projects** aims to ensure timely delivery of projects within budget and quality. Preservation may need specific projects when the solutions required are outside the scope of delivery (DS) or acquisition (AI). These projects will be managed in PO10.

[4] Note that COBIT requires risk assessment results to be expressed in financial terms. While there is continuous progress towards clarifying the financial value of preserved information (Blue Ribbon Task Force on Sustainable Digital Preservation and Access, 2010), this will currently still be infeasible in many cases.

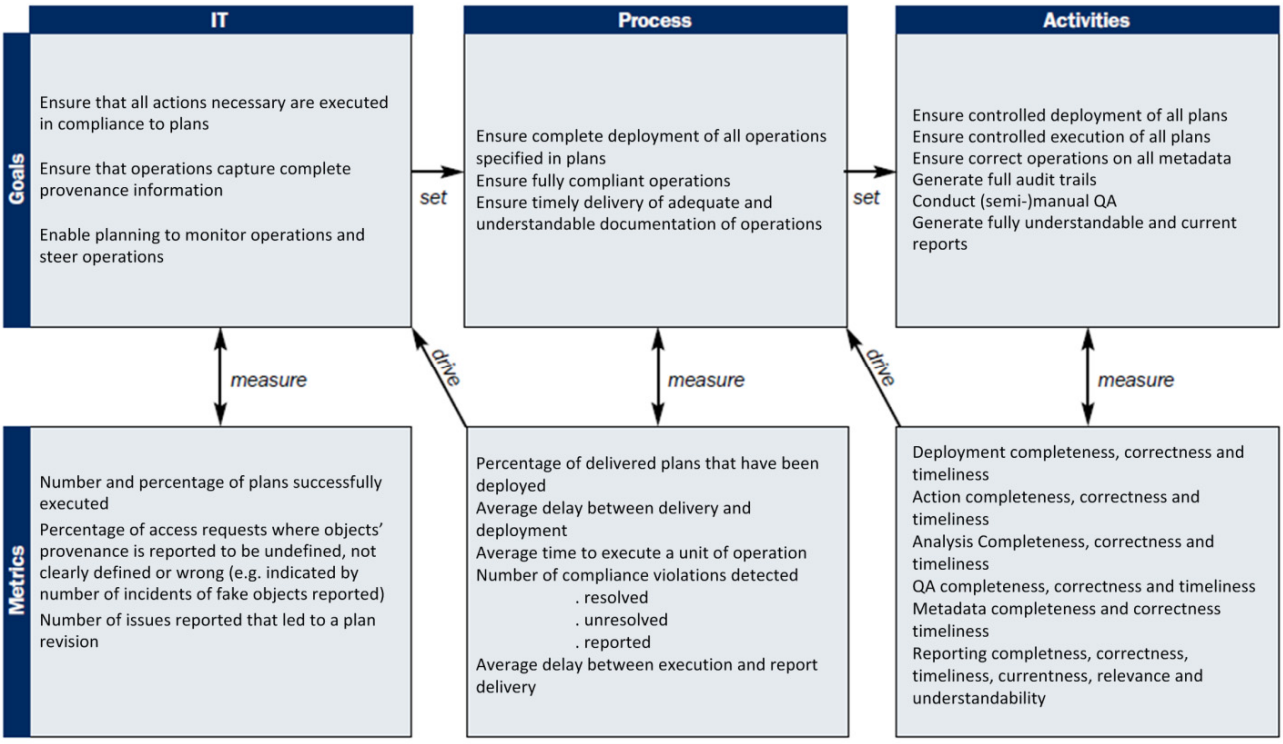

Figure 4: Goals and Metrics for Preservation Operation

Space constraints prohibit a detailed analysis of the domains Acquire and Implement (AI), Deliver and Support (DS) and Monitor and Evaluate (ME). DS has far fewer critical relations to PP and PO since it addresses issues such as training and education, helpdesk services etc. that are quite orthogonal to preservation concerns and can easily be integrated. However, the process **DS1: Define and manage service levels** can partially cover relations between PP and Community Relations (for defining Service Level Agreements) and between PP and Preservation Operations (for defining Operating Level Agreements).

Preservation Planning may request to acquire, implement and/or upgrade technology infrastructure if the available automated solutions do not adequately meet preservation goals. The processes of the **Acquire and Implement** (AI) domain will then be leveraged to manage these change requests.

Finally, the processes of the domain **Monitor and Evaluate** (ME) focus on performance measurement, control and compliance. They provide powerful means to support Preservation Watch with IT-focused monitoring and evaluation tools, and to monitor Preservation Planning and Operations along the metrics described above. Ultimately, all these COBIT processes are located in the *Governance* and the *Support* capabilities of the Capability Model described above and should have specified responsibilities and clear communication paths.

PROCESS MATURITY

As COBIT states, "... maturity modeling enables gaps in capabilities to be identified and demonstrated to management. Action plans can then be developed to bring these processes up to the desired capability target level." (IT Governance Institute, 2007) As mentioned, COBIT provides maturity level specifications for each process along a number of dimensions. Table 4 correspondingly specifies maturity assessment criteria for the PP process along these dimensions. For each dimension and maturity level, it describes specific criteria that a process needs to fulfill to be assumed on this level. A PP process that achieves maturity level 4: *Managed and Measurable* on the skills and expertise dimension, for example, needs to show that required skills are clearly defined for all roles and that formal training is in place to ensure that these skills are present. These detailed criteria enable us to assess specific process instances and to create a process maturity profile.

Figure 5 visualizes a comparative assessment of the three generations of a key Preservation Planning approach. The *Plato* approach is partially based on the DELOS Testbed (Strodl, Rauber, Rauch, Hofman, Debole, & Amato, 2006). It substantially increased the maturity of PP in all dimensions compared to the previous approach and achieved increased automation and formalization, but did not specify responsibilities or formalize required skills and expertise. The approach is taken forward in the project SCAPE, with its vision to advance PP to at least maturity level 4 in all dimensions. The specific focus is on improving scalability, focusing on *tools and automation*. A similar in-depth assessment can be conducted for different approaches such as (McKinney, 2010) to enable systematic improvement on clearly defined dimensions.

Level	Awareness and Communication	Policies, Plans and Procedures	Tools and Automation	Skills and Expertise	Responsibility and Accountability	Goal Setting and Measurement
1: Initial/Ad-Hoc	There is some recognition of the need for controlling and steering prese-rvation operations, but only inconsistent and sporadic communication.	Some decisions affecting operations are taken on an ad-hoc basis, at a high level and in reaction to significant incidents. Assessment addresses only the actual incident. Decisions are disorganised, without communication or monitoring.	Some tools may exist; there is no planned approach to tool usage.	Skills and expertise are undefined.	Employees are not aware of their responsibilities.	Goals are not clear and no measurements take place.
2: Repeatable but Intuitive	Management recognizes the need for controlling and steering preservation operations by preservation planning and communicates overall issues.	A planning process emerges and similar, though non-documented, informal and intuitive, procedures are followed by different indivi-duals within the organisation, de-pendent on knowledge and motiva-tion. Tactical requirements drive the control of preservation. There is no complete understand-ding of DP risks and threats; decisions address technology rather than contextual influencers and are driven by incidents.	Some tools are used sporadically, without systematic usage or integration.	Staff may not be aware of their responsibilities. They obtain their PP skills in through hands-on experience and repeated application of techniques.	People take ownership of issues based on their own initiative on a reactive basis.	The assessment of influencers is not documented, decisions may be based on influencers, but their assessment is not made explicit and not traceable. Effectiveness is not adequately evaluated.
3: De-fined	The importance of a planning approach is understood, accepted and widely communicated.	A formally defined planning function is in place, setting organization-wide standards and beginning to report on decisions and operations. Related proce-dures, tools and techniques have been defined and documented. Basic preservation policies have been developed, including some strategic requirements. Occasional analysis of the root causes for obsolescence takes place.	Automated tools are beginning to be employed, but the processes and rules used are defined by available components, services and skills.	Skills required are assigned, documented and communicated. A formal training plan exists, but formal training is still based on individual initiatives.	Responsibilities required are assigned, documented and clearly communicated.	Some measures are linked to business goals, but compliance with policies and standards is not consistently enforced. Assessment of influencers is documented, but not quantitatively specified and standardized.
4: Managed and Measurable	Systematic planning has become part of the organization's culture. The development and enforcement of control processes that monitor and steer preservation operations is fully understood and communicated.	Planning is fully supported by well-specified methods and techniques based on standardized models. Internal best practices are used to ensure consistent delivery of status information from operations and integrate planning with other processes. The information provided to planning is used and acted upon. The planning process is proactive and addressing future business needs.	An automated planning system supporting operational monitoring and control is implemented. Supporting automated tools are widespread, but are not yet fully integrated.	Required skills and expertise are defined for all roles, and formal training is in place.	Responsibility and accountability for the performance of PP is enforced, and decision makers are enabled to fully discharge their responsibility.	The success of operational control is being measured. Quantified metrics have been identified and are linked to goals, and a measurement system is in place. Influencer assessment is quantitative and traceable.
5: Optimised	The value of PP to the business is continually stressed. PP is continuously improving, forward-looking and taking into account non-traditional approaches to ensure authenticity and understandability of content.	Extensive use is being made of industry good practices in monitoring operations, reacting to changes in the environment and achieving understandability and authenticity of content, including a continuous improvement process.	Preservation constraints, drivers, and objectives are consistently enforced by fully integrated monitoring and control. A high degree of automation is continuously improved as new tools emerge.	Planners have the expertise, skills and means to monitor and control operations. Continuous skills and expertise assessment ensures systematic improvement.	A formal responsibility and accountability plan is fully traceable to all decisions taken.	Operations fully respond to business needs, and balance them successfully with available means to ensure minimal costs and maximal value of content delivery.

Table 4: Maturity dimensions and levels for the *Preservation Planning* process

CONCLUSION AND OUTLOOK

In this paper, we extended COBIT to cover DP as and integrated part of IT Governance. To do so, we defined key preservation capabilities as IT Governance processes and linked them to core COBIT processes. Based on a well-established method for defining and controlling preservation operations, we defined a process model that abstracts key activities, formalizes objectives and enables the clear assignment of responsibilities. Furthermore, we contribute a maturity model for Preservation Planning that enable us to assess and improve processes in a systematic way and quantify benefits.

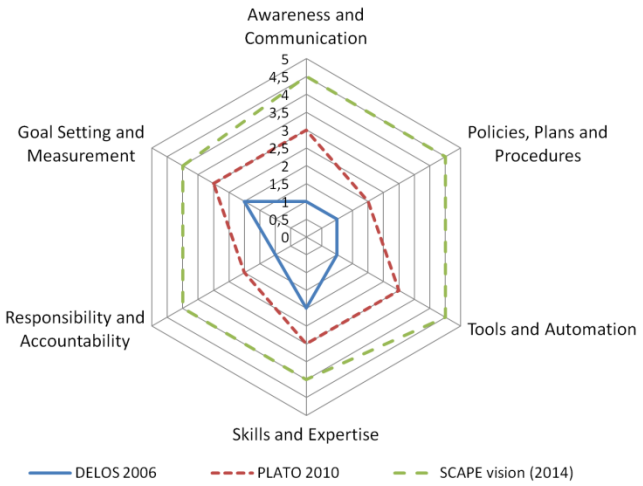

Figure 5: Maturity Progress in Preservation Planning

Unlike prescriptive models that specify in detail how certain domain concerns should be addressed, this goal-oriented process model is entirely independent of any organizational and technical architecture. It can be deployed into any domain and organizational environment that needs IT to support business goals. This makes it directly applicable for all organizations that need to provide authentic information, internally or externally. It enables organizations with a long-term vision on the value of digital information to manage expectations, set goals, assign responsibilities, measure performance, and exercise control. Clearly, any concrete deployment of these processes will need a specific mapping of processes in the same way that it is required for the deployment of the COBIT framework.

In the engineering and science disciplines, the maturity of emerging fields is often judged based on the quantification of results and the degree of control. While DP has made impressive advances in the last decade, we still need benchmarking that allows us to quantitatively assess systems, organizations, and approaches. A flexible process model with clearly understood control objectives can be an important step towards such a maturity assessment. For example, Quality Assurance is one of the largest cost factors in successful DP operations and currently often an inhibitor to the deployment of *any* actions: Trustworthiness requires an archive to validate and verify any actions taken, but this is technically often infeasible with current methods and tools. By quantifying the coverage of automated measures that can be delivered, it becomes possible to derive specific roadmaps for process improvement, quantify Return on Investment for automation initiatives, and specify required levels of Quality of Service. Our current work focuses on an impact assessment of measures, integration of DP processes into IT Governance models and processes, and an integration of DP concerns into a general GRC model that incorporates standard Governance, Risk and Compliance approaches.

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