Mapping IT Governance to Software Development Process: From COBIT 5 to GI-Tropos

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Abstract: Mapping IT Governance principles from frameworks like COBIT 5 to Requirements-Driven Software Processes such as (GI-) Tropos or even RUP-based ones allows IT managers to propose governance and management rules for software development to cope with stakeholders' requirements. On the one hand, IT Governance in software engineering has to ensure that software organization business processes meet strategic requirements of the organization. On the other hand, requirements-driven software methods are development processes using high-level social-oriented models to drive the software life cycle both in terms of project management and deductive iterative engineering techniques. Typically, such methods are well-suited for the inclusion and adaptation of governance principles immediately into the software development life cycle. To consolidate both perspectives, this paper proposes a generic framework allowing mapping IT governance principles to the GI-Tropos software processes.

1 INTRODUCTION

Software engineering (Sommerville, 2010) is devoted to support human activities and cope with socio-intentional problems through business modeling and requirements engineering techniques at the strategic level (Wautelet and Kolp, 2016). Information technology (IT) governance is defined as a framework that ensures the effective and efficient use of IT support and enables the achievement of its corporate strategies and objectives. IT governance reflects the alignment of IT strategy with the organization strategy to offer value-added for business based on corporate governance objectives (Weill, 2004). The goal of IT governance is to ensure that "*the results of a software organizations business processes meet the strategic requirements of the organization*" (Chulani et al., 2008). In software engineering, the software development process (or life cycle) is a structure of the development of a software product. It is a set of distinct phases to produce the software. Most IT governance studies have focused on more wide-ranging fields than software engineering. Therefore, few specific research has been completed on software development life cycle governance, including mappings from IT governance rules to software processes.

IT governance deals with the decision rights and accountability framework for encouraging desirable behaviors in the use of IT (Weill, 2004). It reflects broader corporate governance principles while focusing on the management of information systems to achieve enterprise-level performance and KPIs. Since IT outcomes are often hard to quantify, organizations must assign responsibility for desired outcomes and assess how well they achieve them in terms of quality management. IT governance should not be considered isolated since it is linked to other key enterprise assets for instance financial, human, intellectual property, physical and relationships. Consequently, IT governance can share mechanisms such as executive committees and budget processes with other asset governance processes, thereby coordinating enterprise-wide decision-making processes. A few standardized supporting references may be useful guides to IT governance. Some of them are ISO/IEC 38500:2008 Corporate governance of information technology (Calder, 2008) and COBIT (Control Objectives for Information and related Technology) (ISACA, 2012).

The ISO/IEC 38500:2008 international standard provides a framework for effective governance of information technology to assist (IT) managers at the highest level of organizations to understand and fulfill their legal, regulatory, and ethical obligations in respect of their organizations effective, efficient, and acceptable use of IT (Chaudhuri, 2011). It is orga-

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nized into three prime sections, specifically, Scope, Framework and Guidance. ISO/IEC 38500 is applicable to organizations of all sizes, including public and private companies, government entities, and not-for-profit organizations. By comprising definitions, principles and a model, the framework sets out six principles for good corporate governance of IT: Responsibility, Strategy, Acquisition, Performance, Conformance and Human Behavior.

COBIT, a popular IT governance and control framework, is formalized by the IT Governance Institute (ITGI). As a whole, COBIT offers a reference model of 37 IT processes found in an organization. Each process consists of process inputs and outputs, key process activities, process objectives, performance measures and an elementary maturity model. Furthermore, COBIT provides a "*set of controls over information technology and organizes them around a logical framework of IT-related processes and enablers*" (Haes and Grembergen, 2015).

Following COBIT 5 (ISACA, 2012) principles depicted in Figure 1, a distinction can be introduced between governance and management with each enterprise projected to apply several processes of both types. The difference lies within the objectives of the business activities. Governance processes cope with the stakeholders' governance objectives – value delivery, risk optimization and resource optimization – and include practices and activities for evaluating strategic options, providing direction to IT and monitoring the outcome (Evaluate, Direct and Monitor (EDM) - corresponding to the ISO/IEC 38500 standard concepts). This domain contains five governance processes and EDM practices are defined within each process. Management processes – in agreement with their definitions of management, practices and activities – cover the responsibility of planning, building, running or monitoring enterprise IT to provide end-to-end coverage of corporate information systems. Even though the outcome of governance and management processes is different and proposed to a different audience, all processes require planning, building or implementation, execution and monitoring activities within the process and in the context of the process itself (ISACA, 2012).

COBIT 5 provides a process reference model which defines and describes a number of governance and management processes in detail. It represents all the processes usually found in an enterprise relating to IT activities, offering a common reference model consistent with operational IT and business managers. The proposed process model is not the only possibility but it forms a complete and comprehensive model. Every enterprise must define and/or customize its own

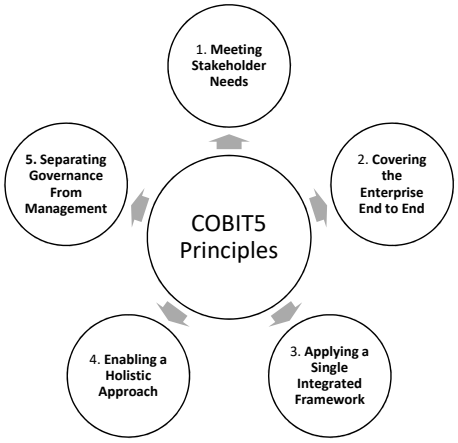

Figure 1: COBIT 5 Principles.

set of processes, taking into account the specific situation. One of the most important and critical steps towards efficient governance is the incorporation of an operational model and a common language for all parts of the enterprise involved in IT processes. It also provides a framework for measuring, monitoring and auditing IT performance, communicating with service providers, and integrating best business practices.

This paper proposes a generic framework allowing mapping IT governance rules and constraints to software processes. The framework uses strategic modeling techniques and techniques to represent the organizational setting but also governance and management structures. Then, we will discuss the adoption of this framework within particular processes in order to map IT governance principles to requirements-driven software specification, in which, COBIT 5 should be tackled.

This paper is organized as follows. Section 2 overviews our proposed development template called Governance I-Tropos (GI-Tropos) for requirements-driven software process and IT governance alignment. Section 3 proposes the generic mapping framework while Section 4 illustrate the mapping between IT governance best practices to requirements-driven software development process. Section 5 introduces a case study for validation. Finally, Section 6 concludes the paper and points out further work.

2 GI-Tropos

Iterative Tropos (I-Tropos) (Wautelet et al., 2011) is an extension of Tropos (Castro et al., 2002), a requirements-driven development methodology using the i* modeling framework (Yu et al., 2011) that supports iterative (Kruchten, 2003) and agent develop-

ment (Mylopoulos et al., 2002). It is a development process using coarse-grained (i.e., high-level) and social-oriented requirement models to drive the software development both in terms of project management (PMI, 2013) and deductive forward engineering (transformational) techniques. Traditional Tropos phases are considered as groups of iterations that are workflows with a minor milestone with the purpose of being compliant with the most generic terminology. Tropos consists of five phases: Early Requirements, Late Requirements, Architectural Design, Detailed Design and Implementation. These phases do not follow the traditional sequence of requirements analysis, design, coding, integration, and test. In I-Tropos, the Organizational Modeling and Requirements Engineering disciplines respectively correspond to Tropos' Early and Late Requirements phases. The Architectural and Detailed Design disciplines correspond to the same stages of the traditional Tropos process. I-Tropos not only includes core disciplines (i.e., Organizational Modeling, Requirements Engineering, Architectural Design, Detailed Design, Implementation, Test and Deployment) but also supports disciplines to handle Risk Management, Time Management, Quality Management and Software Process Management (Wautelet, 2008).

Software development is thus envisaged on the basis of the IT services it provides; it can thus be adapted adequately in the perspective of IT governance. The research method we have followed uses a bottom-up approach, I-Tropos was considered as a given and validated framework and has been enhanced with a (IT services) governance level. Following (Wautelet and Kolp, 2016), IT Services are coarse-grained structures aligned with the core values of the organization, i.e., what (added) value it provides to the external world.

GI-Tropos, an extension of I-Tropos, has been proposed in (Nguyen et al., 2017) for aligning requirements-driven software processes with IT governance. This extension aims to enable governing and managing requirements-driven software processes to cope with stakeholders' requirements and expectations in the context of business aspects. Figure 2 represents the GI-Tropos process in a classical iterative perspective based on a series of disciplines illustrated in the vertical dimension and a series of phases illustrated in the horizontal dimension. Disciplines of GI-Tropos are grouped in and transversal to each phase. They can be deployed in several iterations by phase depending on each software project characteristics. Consequently, the disciplines of GI-Tropos can be repeated iteratively and the effort/workload spent on each discipline varies from one iteration to another.

From a systems development perspective, GI-Tropos has the four following phases redefining (Setting, Blueprinting, Building, Setuping) and improving those of I-Tropos plus a new one, Operation, to operate the system in the perspective of IT enterprise governance and management. It also adds up core processes of governance (Evaluate, Direct, and Monitor) and management (Plan, Deploy, Deliver, and Assess).

In terms of disciplines, GI-Tropos includes all I-Tropos ones plus four new ones: Software Processes Governance, Change & Risk Management, Quality Management, Knowledge Management. These new disciplines ensure that software processes are evaluated, directed and monitored to meet stakeholders' requirements and achieve value added by aligning requirements-driven software processes with IT governance rules and constraints. They also enable identifying, analyzing and assessing changes and risks as well as developing strategies to manage them. Moreover, these disciplines ensure that quality expected and contracted with stakeholders is achieved throughout the system. Finally, they enable acquiring, storing and utilizing knowledge for such things as problem solving, dynamic and deep learning, strategic planning, decision making and business processes.

GI-Tropos also proposed a Strategic Rationale model for software processes governance as depicted in Figure 3. It has three main actors depending on each other (Operator, IT Service Management Board, IT Governance Board), resources (Organizational structures, IT infrastructure), goals (Implementing IT management structure, Continuous operating IT services), qualities (Organization strategies, IT services quality), and tasks (Business processes modeling, IT development & operations).

The IT Governance Board decides on the services and the environmental factors (risks, quality factors). The scope of the governance decisions relevant for GI-Tropos is thus only IT services. The IT Service Management Board allows aligning requirements-driven software processes with IT governance. The IT Service Management Board is thus a management board, not a governance one.

In the Strategic Rationale model, the **IT Governance Board** performs three tasks (Evaluate, Direct, and Monitor) corresponding to the three governance core processes (Evaluate, Direct, and Monitor) respectively. The **IT Service Management Board** performs four tasks (Plan, Deploy, Deliver and Assess) corresponding to the four management core processes (Plan, Deploy, Deliver and Assess) respectively. The **Plan** task depends on the **Direct** task based on the **Policies** resource and the **Monitor** task depends on the **Assess** task based on the **Performance** quality.

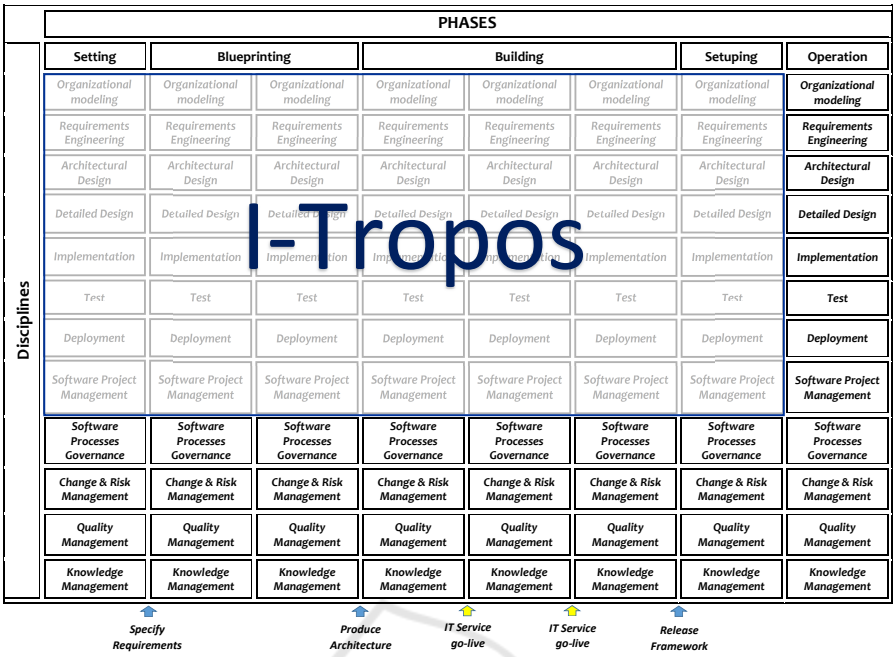

Figure 2: GI-Tropos iterative process framework.

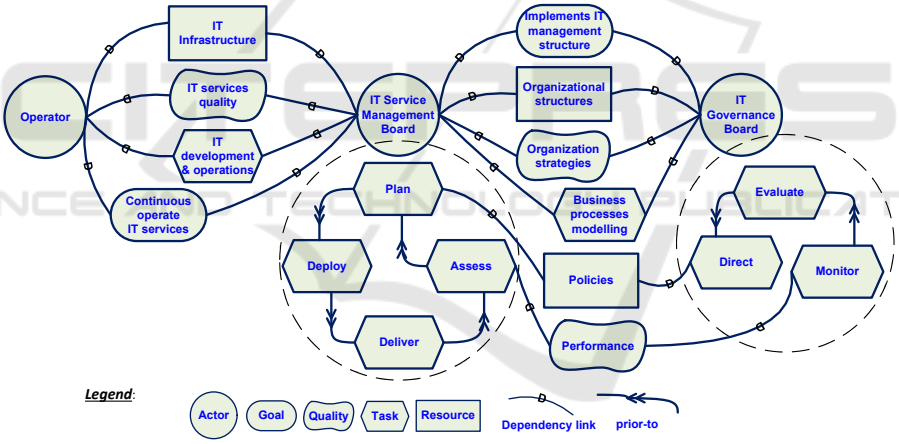

Figure 3: GI-Tropos Strategic Rationale model.

3 GENERIC MAPPING

We describe below the proposed generic framework allowing mapping IT governance rules and constraints to software processes. As pointed out, this framework includes governance processes (Evaluate, Direct, Monitor) and management processes (Plan, Deploy, Deliver, Assess). Figure 4 illustrates IT Governance to GI-Tropos transformation. These processes summarized as follows:

- The ***Evaluate*** process ensures that stakeholders needs, conditions and options are evaluated to determine balanced, agreed-on enterprise objectives to be achieved. It allows examining and judging current and future use of IT, including strategy proposals, supplying arrangements, considering internal and external pressures, evaluating continuously, considering current and future business needs and objectives: competitive advantage and specific strategies.

- The ***Direct*** process enables setting direction through prioritization and decision making. It assigns responsibility, directs preparation and implementation of IT plans and policies, sets directi-

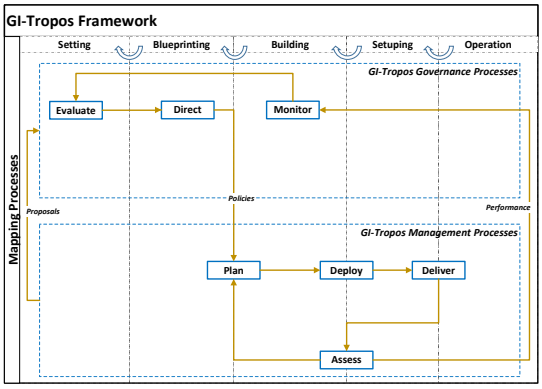

Figure 4: IT Governance to GI-Tropos transformation.

ons for IT investments, establishes sound behavior in IT use through policies, properly plans transition of project to operational status, encourages culture of good IT governance, directs submission of proposals identifying needs.

- The ***Monitor*** process enables monitoring performance and compliance against agreed-on direction and objectives. It allows monitoring and measuring IT performance, assures that performance is in accordance with plans and business objectives, ensures that IT conforms with external obligations (regulatory, legislation, common law, and contractual), ensures that IT conforms with internal work practices.
- The ***Plan*** process plans activities in alignment with the direction set by the governance body to achieve the enterprise's objectives. It covers the use of information and technology and how best it can be used in an organization to help achieve the organization's goals and objectives. It also highlights the organizational and infrastructural form IT is to take in order to achieve the optimal results and to generate the most benefits from the use of IT.
- The ***Deploy*** process deploys activities in alignment with the direction set by the governance body to achieve the enterprise's objectives. It identifies IT requirements, acquires the technology, and implements it within the enterprise's current business processes.
- The ***Deliver*** process delivers activities in alignment with the direction set by the governance body to achieve the enterprise's objectives. It focuses on the delivery aspects of the information technology. It covers areas such as the execution of the software system within the IT system and its results, in addition to the support processes that enable the effective and efficient execution of these IT systems.
- The ***Assess*** process assesses activities in alignment with the direction set by the governance body to achieve the enterprise's objectives. It deals with the enterprise's strategy in assessing its needs and whether or not the current IT system still meets the objectives for which it was designed and the controls necessary to comply with regulatory requirements. It also covers the issue of an independent assessment of the effectiveness of IT system in its ability to meet business objectives and the enterprises control processes by internal and external auditors.

4 FROM COBIT 5 TO GI-Tropos

This section illustrates the global mapping of COBIT 5 governance processes to the GI-Tropos software life-cycle. It is based on the mapping of the inputs and outputs of COBIT 5 governance processes to the software processes artifacts that need to be governed.

COBIT 5 contains five governance processes in which Evaluate, Direct and Monitor (EDM) practices are defined within each process. They can be summarized as Table 1 below:

Table 1: COBIT 5 governance processes.

EDM01 Ensure Governance Framework Setting and Maintenance
○ EDM01.01 Evaluate the existing governance system
○ EDM01.02 Direct the governance system.
○ EDM01.03 Monitor the governance system
EDM02 Ensure Benefits Delivery
○ EDM02.01 Evaluate value optimization
○ EDM02.02 Direct value optimization
○ EDM02.03 Monitor value optimization
EDM03 Ensure Risk Optimisation
○ EDM03.01 Evaluate risk management
○ EDM03.02 Direct risk management
○ EDM03.03 Monitor risk management
EDM04 Ensure Resource Optimisation
○ EDM04.01 Evaluate resource management
○ EDM04.02 Direct resource management
○ EDM04.03 Monitor resource management
EDM05 Ensure Stakeholder Transparency
○ EDM05.01 Evaluate stakeholder reporting requirements
○ EDM05.02 Direct stakeholder communication and reporting
○ EDM05.03 Monitor stakeholder communication

Table 2: Mapping COBIT 5 governance processes to GI-Tropos.

	COBIT 5 governance processes				
GI-Tropos phase	***EDM01***	***EDM02***	***EDM03***	***EDM04***	***EDM05***
Setting	EDM01.01	EDM02.01	EDM03.01	EDM04.01	EDM05.01
Blueprinting	EDM01.02	EDM02.02	EDM03.02	EDM04.02	EDM05.02
Building	EDM01.03	EDM02.03	EDM03.03	EDM04.03	EDM05.03
Setuping	n/a	n/a	n/a	n/a	n/a
Operation	n/a	n/a	n/a	n/a	n/a

The mapping is summarized in Table 2. The following tables target each phase one by one: Table 3 illustrates the specific mapping from COBIT 5 to the

GI-Tropos Setting phase respectively in terms of inputs and outputs, Table 4 illustrates the mapping to the GI-Tropos Blueprinting phase, and Table 5 illustrates the mapping COBIT 5 to the GI-Tropos Building phase.

Table 3: Mapping COBIT 5 governance processes to GI-Tropos Setting phase.

	COBIT 5 governance processes	GI-Tropos Setting phase
Input	**EDM01.01** • Communications of changed compliance requirements • Business environment trends • Regulations • Governance/decision making model • Constitution/bylaws/statutes of organisation	• The source of problem statement (real business case vs. developer's wish) • Use case and requirements
	EDM02.01 • Strategic road map • Investment return expectations • Selected programmes with return on investment (ROI) milestones • Benefit results and related communication • Stage-gate review results	• Project roadmap, timeline and resource constraints
	EDM03.01 • Emerging risk issues and factors • Enterprise risk management principles	• Effort level and risks
	EDM04.01 • Gaps and changes required to realise target capability • Skill development plans • Decision results of supplier evaluations	
	EDM05.01 • Actions to improve value delivery • Risk management issues for the board • Feedback on allocation and effectiveness of resources and capabilities • Refined scope	
Output	**EDM01.01** • Enterprise governance guiding principles • Decision-making model • Authority levels	• Process exists to ensure right stakeholders are engaged, agreed upon project roadmap is defined, and resource pool, delivery timeline and risks are identified • Requirement document reviewed and signed off from all major stakeholders (business, development and testing teams)
	EDM02.01 • Evaluation of strategic alignment • Evaluation of investment and services portfolios	
	EDM03.01 • Risk appetite guidance • Approved risk tolerance levels • Evaluation of risk management activities	
	EDM04.01 • Guiding principles for allocation of resources and capabilities • Guiding principles for enterprise architecture • Approved resources plan	
	EDM05.01 • Evaluation of enterprise reporting requirements • Reporting and communication principles	

Table 4: Mapping COBIT 5 governance processes to GI-Tropos Blueprinting phase.

	COBIT 5 governance processes	GI-Tropos Blueprinting phase
Input	**EDM03.02** • Aggregated risk profile, including status of risk management actions • Enterprise risk management (ERM) profiles and mitigation plans	• Alignment with corporate IT • Non functional requirements like performance, security • Design guidelines
	EDM05.02 • Risk analysis and risk profile reports for stakeholders	
Output	**EDM01.02** • Enterprise governance communications • Reward system approach	• Architecture Review • Design review
	EDM02.02 • Investment types and criteria • Requirements for stage-gate reviews	
	EDM03.02 • Risk management policies • Key objectives to be monitored for risk management • Approved process for measuring risk management	
	EDM04.02 • Communication of resourcing strategies • Assigned responsibilities for resource management • Principles for safeguarding resources	
	EDM05.02 • Rules for validating and approving mandatory reports • Escalation guidelines	

Table 5: Mapping COBIT 5 governance processes to GI-Tropos Building phase.

	COBIT 5 governance processes	GI-Tropos Building phase
Input	**EDM01.03** • Performance reports • Status and results of actions • Results of benchmarking and other evaluations • Results of internal control monitoring and reviews • Results of reviews of self-assessments • Assurance plans • Compliance confirmations • Reports of non-compliance issues and root causes • Compliance assurance reports • Obligations • Audit reports	• Code quality • Feature implementation • Test plan and strategy • Test results and coverage • Score card on non-functional requirements
	EDM02.03 • Investment portfolio performance reports	
	EDM03.03 • Risk analysis results • Opportunities for acceptance of greater risk • Results of third-party risk assessments • Risk analysis and risk profile reports for stakeholders	
	EDM05.03 • Assurance review report • Assurance review results	
Output	**EDM01.03** • Feedback on governance effectiveness and performance	• Code review • Code coverage • Feature demo • Review of test plan, strategy, coverage, and results • Review of non-functional requirements score card or compliance report
	EDM02.03 • Feedback on portfolio and programme performance • Actions to improve value delivery	
	EDM03.03 • Remedial actions to address risk management deviations • Risk management issues for the board	
	EDM04.03 • Feedback on allocation and effectiveness of resources and capabilities • Remedial actions to address resource management deviations	
	EDM05.03 • Assessment of reporting effectiveness	

During ***Setting***, governance decisions on services are evaluated. This phase determines 'WHAT' IT services need to be taken into account and also 'WHY' they need to be considered in order to determine environmental factors faced by IT services, i.e. threats and quality factors. The mapping ensures controlling the operational environment, specifying the stakeholders requirements and expectations, gathering and formalizing system requirements, defining the project scope, assessing critical risks, and establishing an initial baseline for the software system architecture. It also measures, estimates and minimizes development risks and plans for compliance.

In the ***Blueprinting*** phase, governance decisions on IT services are directed. The blueprinting phase prototypes and further evaluates the decisions taken on IT service through a practical mock-up. The goal of this is to get field feedback to better understand elements that could not be fully understood previously. Governance decisions on IT services could here still be changed or adapted at coarse-grained level. The mapping includes describing an information architecture, forming framework for technology planning, defining organization and processes, describing development investment, managing human resources, developing quality management system, developing project management framework.

During ***Building***, governance decisions on servi-

ces are monitored. The building phase fully implements decisions taken on IT services. Governance decisions on IT services could here be changed or adapted on a fine-grained level only. Contrarily to I-Tropos, the deployment of IT Services is continuous within the Building phase. The mapping ensures implementing software system counterparts totally the stakeholders requirements and expectations. It consists of managing business goals and requirements continuously, designing and developing resource, validating and measuring quality, measuring development and ongoing costs, estimating value, measuring and reviewing risk with different stakeholders based on initial prototyping result. It also manages projects based on alignment between goals and software engineering concerns.

In the ***Setuping*** phase, governance decisions on services are deployed and delivered. The mapping ensures delivering software system counterparts totally implementing the stakeholders requirements and expectations.

During the ***Operation*** phase, governance decisions on services are assessed. The mapping ensures monitoring and managing effort and other metrics to enable control and future planning, managing applications and information to maximize usage and flexibility, prioritizing risks, tracking actual values of effort, encountering compliance needs. It also manages projects based on alignment between goals and software engineering concerns.

5 CASE STUDY

The validation of this framework should to be undertaken deeply based on case studies to support the application of this method. Currently, ARUM (Adaptive Production Management) (ARUM, 2013) is being studied in the framework of an European Union funded project. The aim is to improve planning and control systems for complex, small-lot products manufacturing, such as aircraft, and ships.

Figure 5 describes the work plan of ARUM project. First, the ARUM work plan starts with capturing and analyzing of the end-users' requirements (WP1) and the definition of use cases (WP2) for the ARUM project. Then, the specification and adaptation/development of technical bricks (WP3, WP4, WP5, WP6) required for the ARUM solution and the overall architecture will be developed. Finally the end-users will be heavily involved again in technical trails, assessment and benchmarking activities for validation the ARUM solution against today's automation control and optimization solutions (WP7, WP8). Finishing stage is the demonstration, dissemination and exploitation of ARUM results (WP9, WP10).

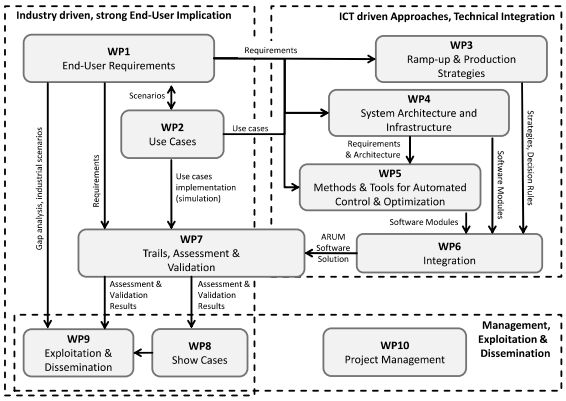

Figure 5: ARUM work plan (ARUM, 2013).

The ARUM project is evaluated, directed and monitored by the mapping COBIT 5 governance processes to the system development life cycle. It enabled achieving the project's objectives. Table 6 presents the mapping COBIT 5 governance processes and GI-Tropos phases to ARUM work plan. Mapping COBIT 5 governance processes to ARUM work plan (system development processes) aims to ensure that the project will be governed efficiently. First, the mapping starts with processes considering stakeholder needs, conditions and options. Then, it performs processes to set IT plans and policies, and direct IT investments to establish IT behavior. Finally, it ends with processes measure IT performance and ensure compliance.

Table 6: Mapping COBIT 5 governance proceses and GI-Tropos phases to ARUM work plan.

COBIT 5 governance processes	GI-Tropos phase	ARUM work plan	Objectives
EDM01.01 EDM02.01 EDM03.01 EDM04.01 EDM05.01	***Setting***	WP1 WP2 WP3	• Examining and judging current and future use of IT include strategy proposals, supply arrangements; • Considering internal and external pressures (technological changes, economic • trends, social trends, and political influences); • Evaluating continuously; considering current and • future business needs and objectives: competitive • advantage and specific strategies.
EDM01.02 EDM02.02 EDM03.02 EDM04.02 EDM05.02	***Blueprinting***	WP4 WP5	• Assigning responsibility and directing preparation and implementation of IT plans and policies; • Setting directions for IT investments. • Establishing sound behaviour in IT use through policies; • Planning transition of project to operational status properly; • Encouraging culture of good IT governance; • Directing submission of proposals identifying needs.
EDM01.03 EDM02.03 EDM04.03 EDM03.03 EDM05.03	***Building***	WP6 WP7	• Monitoring and measuring IT performance; • Assuring that performance is in accordance with plans and business objectives; • Ensuring that IT conforms with external obligations (regulatory, legislation, common law, and contractual); • Ensuring that IT conforms with internal work practices.
n/a	***Setuping***	WP8	n/a
n/a	***Operation***	WP9	n/a

6 CONCLUSION

In software development and IT project methods, governance can be viewed as evaluating, directing and monitoring software processes all along the life cycle. Mapping IT Governance best practices like COBIT 5 to a requirements-driven software processes such as GI-Tropos enables coping with stakeholders' requirements and expectations. Contributions of this paper consist of the specifications to emphasize integration and mapping IT governance rules and constraints to requirements-driven software processes based on the software processes artifacts that need governance. The paper proposes a new identification of critical moments in the software development life cycle for IT governance since the main objective of this mapping was to deliver an efficient governance for software development that meets stakeholders' needs and expectations. On the one hand, the strengths of GI-Tropos are to systematically offer structure and direction through the whole software processes governance and enable tailoring the process to the project needs. On the other hand, GI-Tropos also points out how to establish governance rules to the software processes with the principles of IT governance to apply in the software processes.

COBIT 5 can be implemented in software development processes by a proper mapping. This mapping is performed based on the software processes artifacts that need to be governed and COBIT 5 governance processes' inputs and outputs. Our proposed mapping indicates how to carry out governance processes for a collaborative software development life cycle.

Further work points to other additional practices that need to be integrated in this mapping to propose a completed mapping framework taking into consideration, for instance, IT management, project management and agile practices (Ambler and Lines, 2012; Kruchten, 2013; Luna et al., 2015) for managing the day-to-day activities and reacting to changing requirements and feedback. In addition, a CASE tool should be developed to help designing and implementing all the processes defined in this paper.

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