UNIVERSIDADE FEDERAL DO ESTADO DO RIO DE JANEIRO
CENTRO DE CIÊNCIAS EXATAS E TECNOLOGIA
PROGRAMA DE PÓS-GRADUAÇÃO EM INFORMÁTICA

SINIS – METHOD TO SELECT INDICATORS FOR IT SERVICES

Bianca Trinkenreich

Advisor: Gleison dos Santos Souza

RIO DE JANEIRO, RJ - BRAZIL
February de 2016

SINIS – METHOD TO SELECT INDICATORS FOR IT SERVICES

Bianca Trinkenreich

DISSERTATION PRESENTED AS PARTIAL REQUIREMENT FOR OBTAINING COMPUTER SCIENCE MASTER DEGREE TITLE FROM UNIVERSIDADE FEDERAL DO ESTADO DO RIO DE JANEIRO (UNIRIO). APPROVED BY COMMISSION SIGNED BELLOW.

Approved by:

_____
Gleison dos Santos Souza, D.Sc. - UNIRIO

_____
Monalessa Perini Barcellos, D.Sc. - UFES

_____
Leonardo Azevedo, D.Sc. – UNIRIO

_____
Tayana Uchôa Conte, D.Sc. - UFAM

RIO DE JANEIRO, RJ - BRAZIL
February 2016

Trinkenreich, Bianca.
T833 SINIS – Method to Select Indicators for IT Services / Bianca Trinkenreich, 2016.
189 f. ; 30 cm

Orientador: Gleison dos Santos Souza.
Dissertação (Mestrado em Informática) - Universidade Federal do Estado do Rio de Janeiro, Rio de Janeiro, 2016.

1. Tecnologia – Serviços de informação. 2. Modelos de capacitação e maturidade (Software). 3. Medição. 4. SINIS. 5. GQM+Strategies. 6. COBIT Goals Cascade. I. Souza, Gleison dos Santos. II. Universidade Federal do Estado do Rio de Janeiro. Centro de Ciências Exatas e Tecnológicas. Curso de Mestrado em Informática. III. Título.

CDD – 004

ACKNOWLEDGEMENTS

I especially thank my mom Deborah, dad Jorge, and sister Ilana. My mom have sacrificed her life for my sister and myself, provided unconditional love and care and her requirement of never being satisfied with anything less than a perfect score. My hard-working dad have tried to give us everything he could. Ilana has been my best friend all my life and I love her dearly and thank her for all her advice and support. For sure I would not have made it this far without them. I know I always have my family to count on when times are rough. To my mother, the affection and the requirement to never be satisfied with anything less than a perfect score and always encourage me to be better in their studies. My father, by example in professional and academic and pride to know each approved article and presentation held in conference.

My husband Fabio Marcos de Abreu Santos, my best friend and soul-mate. I married the best person out there for me. Fabio has been a true and great supporter and has unconditionally loved me during my good and bad times. He has been non-judgmental of me and instrumental in instilling confidence. He has faith in me and my intellect even when I felt like digging hole and crawling into one because I didn't have faith in myself. I truly thank Fabio for sticking by my side, even when I was irritable and depressed thinking about my dissertation or about some paper I wanted to submit.

To my manager Ivo Pacheco and Brunno Aguiar, who have encouraged me on starting this master degree in conciliation to work activities, and provided me interviews and support with other managers for case studies I had carried out for this dissertation.

Special thanks to my advisors, Gleison and Monalessa, for supporting me during these past two years. Gleison is someone you never forget once you meet him. One of the smartest people I know, he is supportive and has given me the freedom to pursue various papers without objection. Thank you, Tayana Conte, even not being officially my advisor, for your interest, support and encouragement to my research.

I also thank PPGI teachers for transmitted knowledge and PPGI administrative staff for their collaboration in administrative procedures.

TRINKENREICH, Bianca. **SINIS – Método para Seleção de Indicadores de Serviços de TI**. UNIRIO, 2016. 189 páginas. Dissertação de Mestrado. Departamento de Informática, UNIRIO

RESUMO

Contexto: A medição é um processo essencial para apoiar as organizações na gestão e melhoria de processos, produtos e serviços. Indicadores são medidas usadas para monitorar o alcance das metas, tornando mais objetiva a avaliação e o julgamento do resultado, e ajudando as organizações a concentrarem atenção e esforço no que realmente importa. A literatura sobre serviços de TI, que inclui bibliotecas, padrões e modelos de maturidade, requer a identificação adequada dos processos críticos de negócio e a definição de medidas relevantes para a tomada de decisões. No entanto, não há uma direção clara sobre quais devem ser os processos e indicadores. Muitas vezes os departamentos de serviços de TI gastam tempo e esforço medindo sem terem certeza sobre o que os resultados da medição representam, e consideram a seleção indicadores como uma tarefa difícil. *Objetivos*: Este trabalho foi realizado para responder à questão de pesquisa: "Como apoiar a seleção de indicadores de serviços de TI em diferentes níveis organizacionais e alinhados aos objetivos de negócio?" *Método:* SINIS foi proposto para ajudar as organizações a selecionarem indicadores de serviços de TI em vários níveis e alinhados aos objetivos de negócio. Criado em duas versões: top-down e bottom-up, com base em conceitos de modelos de melhoria de processo e abordagens relacionadas ao gerenciamento de serviços de TI, o SINIS foi avaliado em departamentos de Infraestrutura e Segurança de TI de uma empresa global de grande porte. *Resultados*: Com o SINIS versão top-down, o departamento de Infraestrutura conseguiu definir indicadores e estratégias que a equipe pudesse trabalhar sem perder o foco nos objetivos de serviços de TI. Com o SINIS versão bottom-up, o departamento de Segurança conseguiu documentar e entender melhor os indicadores já existentes, associá-los aos objetivos e estratégias de negócios e descartar aqueles que não foram considerados úteis. O método SINIS foi evidenciado como aplicável a diferentes áreas de serviços de TI, apoiando a definição de estratégias e indicadores para as equipes trabalharem no que poderia ajudar a atender os objetivos do negócio, ao invés de medir por medir e trabalhar em diversas iniciativas sem foco.

Palavras-chave: Medição, Qualidade de Serviços de TI, Modelos de Maturidade, GQM+Strategies, MR-MPS-SV, CMMI-SVC, COBIT Goals Cascade.

TRINKENREICH, Bianca. **SINIS – Method to Select Indicators for IT Services**. UNIRIO, 2016. 189 pages. Master Degree Dissertation. Computer Science Department, UNIRIO

ABSTRACT

Background: Measurement is a key process to support organizations in management and improvement of processes, products and services. Indicators are measures used to monitor whether a goal is reached, increasing feedback and objectivity on judgment and helping organizations to focus attention and effort on what matters. IT services literature, such as libraries, frameworks, standards, and maturity models, requires proper identification of critical business process and definition of relevant measures to support decision-making. However, there is no clear direction about what should be those critical business processes and indicators. IT service departments often spend time and effort measuring without being sure about what the measurement results represent and organizations consider the indicators selection as a difficult task. *Aims*: We conducted this work aiming to answer the research question: "How to support selection of IT services indicators in different organizational levels and aligned to business goals?" *Method*: Considering this scenario, we proposed SINIS, a method to help organizations select indicators for IT services in several levels in alignment to business goals. SINIS was created based on concepts from process improvement models and approaches related to IT Services Management, in two versions: top-down and bottom-up. We evaluated SINIS in the IT Infrastructure and the IT Security areas of a global large company. *Results*: By using SINIS top-down version, IT Infrastructure was able to define indicators and an appropriate set of strategies aligned with IT Service goals in which teams could focus work. By using SINIS bottom-up version, IT Security was able to better understand and document indicators, associate them to business goals and strategies and discard those ones that were not considered useful. SINIS was evidenced as applicable to different IT Service areas, supporting definition of strategies and indicators for members to work on that could help attending IT service and business goals, instead of working in several and unfocused initiatives.

Key words: Measurement, IT Services Quality, Maturity Models, GQM+Strategies, MR-MPS-SV, CMMI-SVC, COBIT Goals Cascade.

SUMMARY

FIGURE INDEX

TABLE INDEX

ACRONIMS LIST

BSC - *Balanced Scorecard*

CMMI-DEV - *Capability Maturity Model for Development*

CMMI-SVC - *Capability Maturity Model for Services*

COBIT - *Control Objectives for Information and related Technology*

GQM - *Goal, Question, Metric*

GQ(I)M - *Goal, Question Indicator Metric*

ISO/IEC - *International Standard Organization and International Electrotechnical Commission*

ITIL - *Information Technology Infrastructure Library*

ITSM - *Information Technology Service Management*

MR-MPS-SV - *Reference Model for MPS Services Process Improvement*

MR-MPS-SW - *Reference Model for MPS Software Process Improvement*

PSM - *Practical Software Measurement*

RSMO - *Reference Software Measurement Ontology*

SME – *Small and Medium Enterprises*

SLA - *Service Level Agreements*

IT – *Information Technology*

UFO - *Unified Foundational Ontology*

CHAPTER 1 - Introduction

1.1. Motivation

The service sector (involving information, health, education, tourism, entertainment, and others) has been recognized as the largest economic sector in developed countries and as an expanding sector in emerging markets (TIEN and BERG, 2006). This scenario has turned organizations to adapt themselves from traditional production-based business models to new service-based ones (ENGELMANN, 2008). In this sense, many organizations started to use IT (Information Technology) for building services capabilities to their products, being able to provide a more accurate and fast service to customers (MAGIO *et al.*, 2009).

Service is about delivering value to customers by facilitating results they want to achieve without taking costs and risks ownerships. IT service management is a set of specialized organizational capabilities for providing value to customers through services. Its practice has been growing by adopting an IT management service-oriented approach to support applications, infrastructure and processes (OGCa, 2011).

There are some standards devoted to IT service, such as ISO/IEC 20000 (ISO/IEC, 2011), ITIL (Information Technology Infrastructure Library) (OGCa, 2011) and COBIT (ISACA, 2012a). There are also some models that address IT service by defining a set of processes that are organized in maturity levels. CMMI-SVC (Capability Maturity Model Integration for Services) (FORRESTER *et al.*, 2010) and MR-MPS-SV (Reference Model for Services Improvement) (SOFTEX, 2015a) are examples of IT service maturity models. Guidance on how to implement and improve IT service maturity practices is a key factor to improve service performance and customer satisfaction (FORRESTER *et al.*, 2010). Thus, IT service maturity models can help organizations to gradually implement IT services practices until they achieve high maturity.

Since the initial maturity levels, both CMMI-SVC and MR-MPS-SV require appropriate measures to be identified in order to monitor processes executed for service delivering and also to support process improvement initiatives. Thus, it is necessary to identify the processes to be measured and the measures to be used. The selection of processes to be measured must be aligned with organizational goals, so that measurement results are able to provide relevant information for decision-making and business support. However, there is no clear direction or strict suggestion about which processes and measures should be considered and selection of proper measures and indicators[1] is considered a hard task. The lack of a structured approach for selecting IT services indicators and practical examples are factors that cause such difficulty, besides the fact that usually IT support tools do not provide measurement capabilities (JÄNTTI *et al*., 2010) (LEPMETS *et al.*, 2014).

Teams may be more motivated and focused on achieving indicators targets and finding possible process improvements when having a clear understanding about how their work is aligned to business goals, and how it will be measured. Within this context, a method designed to support the selection of indicators can be a promising approach for measurement and process improvement initiatives.

1.2. Goal and Research Question

This dissertation' objective is *to define a method to select indicators for IT services supporting measurement initiatives by deriving business objectives in IT services goals, strategies and indicators.*

In order to achieve the dissertation's objective, requirements were defined, such as follows. These requirements are consistent with the used Design Research Methodology, explained in next section.

The method should (*Requirement 1*) reduce time and effort during indicators selection. Also, it should (*Requirement 2*) allow the definition of indicators and strategies in multiple levels in order to facilitate reporting the right information to each decision making management level, (*Requirement 3*) foster alignment between indicators and business goals in all those multiple levels, (*Requirement 4*) provide procedures and instruments (such as checklists, templates and examples) to proper

[1] When a measure is used to verify a goal achievement, it can be called as an indicator (BARCELLOS *et al.*, 2012).

support its execution, and (*Requirement 5*) follow consistent measurement concepts and terminologies.

The research question aimed to be answered is *"How to support selection of IT services indicators in different levels and aligned to business goals?"*

1.3. Methodology

Primary research approach used in this dissertation is Design Science Research, which is the design and investigation of artifacts in context, designed to interact and improve something in that context (WIERINGA, 2014). Figure 1 depicts the Design Science Research Map of this dissertation and is explained in the sequence. Diamonds indicate the chapter in which the subjects are detailed in this document.

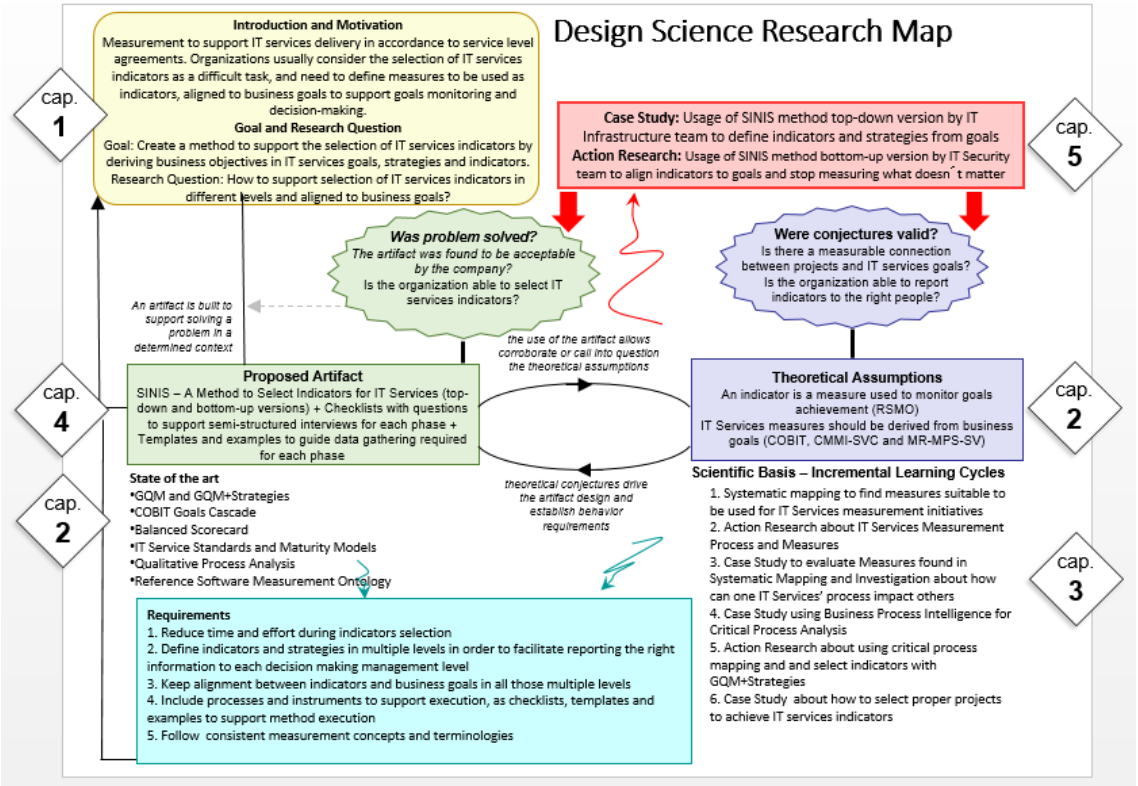

Figure 1 - Design Science Research Map and Dissertation Structure (based on (Santos, 2015))

The proposed artifact is a method called SINIS (Select Indicators for IT Services), which in addition to the method itself, provides procedures, checklists, templates and examples that help its application. Two versions of SINIS were developed: top-down and bottom-up.

.SINIS corroborates with some theoretical assumptions: an indicator is a measure used to monitor goals achievement (BARCELLOS *et al.*, 2012) and IT

Services measures should be derived from business goals (ISACA, 2012; FORRESTER *et al.*, 2010; SOFTEX, 2015a).

SINIS is based on several proposals recorded in the literature. GQM+Strategies (BASILI *et al.*, 2005) and Qualitative Process Analysis (DUMAS *et al.*, 2013) were used to support defining indicators and strategies aligned to business goals in multi-levels (Requirements 2 and 3, presented in the previous section). COBIT Goals Cascade (ISACA, 2012b), Balanced Scorecard (KAPLAN and NORTON, 1996), IT Service Standards such as ITIL (TSO, 2011), COBIT (ISACA, 2012a), ISO/IEC 20000 (ISO/IEC, 2011), and Maturity Models such as CMMI-SVC (FORRESTER *et al.*, 2010) and MR-MPS-SV (SOFTEX, 2015a) were used in checklists, templates and examples provided to support method execution (Requirements 1 and 4). The Reference Software Measurement Ontology (BARCELLOS *et al.*, 2012) was used to follow consistent measurement conceptualization and terminology (Requirement 5).

The steps followed to develop this work are presented bellow:

i. Literature investigation to acquire knowledge about the research topic in order to identify the problem and delimit the research scope;

ii. Execution of design and investigative activities in incremental learning cycles aiming to obtain useful knowledge to develop SINIS. Six studies were carried out:

   - Systematic Mapping to find measures suitable for IT Services measurement initiatives (TRINKENREICH *et al.*, 2015a);
   - Action Research about IT Services Measurement Process and Measures (TRINKENREICH and SANTOS, 2014);
   - Case Study to evaluate Measures found in by the Systematic Mapping and to investigate impact among IT Services processes (TRINKENREICH and SANTOS, 2015a);
   - Case Study about using Business Process Intelligence for critical process analysis (TRINKENREICH *et al.*, 2015b);
   - Action Research about using critical process mapping and expected results of MR-MPS-SV to evaluate an IT Services process and select indicators at different levels by using GQM+Strategies (TRINKENREICH and SANTOS, 2015b);

- Case Study involving Qualitative Analysis to find about how operational actions, projects or initiatives are defined to achieve IT Services indicators.

iii. Development of the first version of the proposed solution (SINIS Top-Down version);

iv. Evaluation of the proposed solution through a case study;

v. Evolution of the proposed solution by improving SINIS Top-Down version and developing SINIS bottom-up version through an action research.

Most of the results produced during the development of this work were published in conferences and all of them are recorded in this dissertation.

1.4. Final Considerations

This introductory chapter presented the context that motivated developing this work, and also the work objectives and used methodology. The remainder of this dissertation is structured as follows:

- **CHAPTER 2 – Theoretical Framework and Related Works**: presents a literature review of measurement approaches and GQM+Strategies, IT Services best practices, standards, frameworks and maturity models - ITIL, COBIT, ISO/IEC 20.000, CMMI-SVC e MR-MPS-SV. Also presents related works that deal with IT Services measures selection.
- **CHAPTER 3 –Incremental Learning Cycles**: presents the studies carried out in incremental learning cycles aiming to obtain useful knowledge for creating the SINIS method to select indicators for IT Services.
- **CHAPTER 4 – SINIS Method**: presents the method (top-down and bottom-up versions) and procedures, checklists and examples for method execution.
- **CHAPTER 5 – SINIS Method Evaluation**: presents a case study performed in an IT Infrastructure area to evaluate SINIS Method Top-Down version and an action research performed in IT Security area to evaluate SINIS Method Bottom-Up version.
- **CHAPTER 6 – Conclusions:** presents the final considerations, contributions, limitations and future works.

- **APPENDIX I – List of IT Services Measures for Reuse:** presents a consolidated list of IT Services measures gathered during incremental learning cycles.
- **ATTACHMENT I - List of COBIT GOALS CASCADE Measures for Reuse:** presents measures for IT-related goals and processes.

CHAPTER 2 – Theoretical Framework and Related Works

This chapter presents the literature review on measurement approaches and GQM+Strategies, IT Services best practices, standards, frameworks and maturity models. Also presents some related works (approaches, methods, techniques and frameworks) that address selection of measures for IT Services. Last, the measurement ontology used to provide the measurement conceptualization to SINIS method is briefly described.

2.1. IT Service Quality

There are several definitions of service. In general, they reflect, at certain level, the point of view of the academic disciplines and/or of the economic sectors wherein they were defined. According to OGCa, (2011), a service is "a logical representation of a repeatable activity that has a specified outcome. It is self-contained and is a 'black box' to its consumers." IT services (e.g., software application services and network services) are defined to support the realization of business services (CASES *et al.*, 2010). Thus, they are an important means towards establishing Business-IT alignment (ABDI and DOMINIC, 2010; HRGOVCIC *et al.*, 2011).

In general, the service lifecycle encompasses phases such as (OBERELE *et al.*, 2009; FERRARIO and GUARINO, 2012): service design (or innovation), service offer, service search, service negotiation (or matching), service delivery (or usage), service feedback (or after sale). However, although there are several phases, service negotiation and service delivery are the two mandatory phases in service lifecycles, since they respectively address service production and service consumption.

Service negotiation is characterized by the interaction between customer and provider in order to establish an agreement about their responsibilities (FERRARIO and GUARINO, 2012). If service negotiation is successfully achieved, a service agreement is established, determining what has been settled between service participants for

service delivery. Finally, service delivery concerns the execution of actions to fulfill the service agreement (DUMAS *et al.*, 2001).

Service quality is an abstract concept due to the nature of the service notion, which is intangible, non-homogeneous, and its consumption and production are inseparable. It can be understood as a measure about how much a service level meets or does not meet customers' requirements and expectations. The intangibility of services makes it difficult to understand how customers observe and evaluate their services quality (PARASURAMAN *et al.*, 1985).

IT services are crucial to organizations, since they contribute to business realization (CASES *et al.*, 2010). There are several approaches committed to IT services, such as COBIT (ISACA, 2012a), CMMI-SVC (FORRESTER *et al.*, 2010), MR-MPS-SV (SOFTEX, 2015a) and ITIL (OGCa, 2011), which address processes related to IT services (e.g., Incident Management, Change Management, Problem Management, etc.) and provide guidelines to their implementation.

In order to be able to offer quality, the supplier must continually assess the way service is being provided and what does the customer expect in the future. A customer can be unsatisfied with IT service providers who occasionally exceed expectations, but at other times disappoint them. Providing consistent quality is important, but is also one of the most difficult aspects of the service industry (ISO/IEC 20000, 2011).

Service Level Agreements (SLA) are contracts usually signed between service provider and contractor in order to clearly define quality service attributes and acceptance criteria for service being hired. Even service quality being agreed between IT service provider and his clients through SLA, there are commonly accepted quality service attributes, like: availability, capacity, performance, security, confidentiality, scalability, adaptability and portability (ISO/IEC, 2011). In order to assess and improve services quality, quality of processes performed to deliver services needs to be evaluated. Guidance on how to develop and improve IT service maturity practices is a key factor to improve service performance and customer satisfaction (FORRESTER *et al.*, 2010). CMMI-SVC (FORRESTER *et al.*, 2010) and MR-MPS-SV (SOFTEX, 2012) models had been created to attend this need and are based on more traditional models like ITIL (OGCa, 2011) and international standards such as ISO/IEC 20000 (ISO/IEC, 2011). It is worth notice that these models require appropriate measures to be identified in order to monitor various processes executed for service delivering to customers.

Quality assessments are not just service outputs. They also involve service delivery process evaluation (PARASURAMAN *et al.*, 1985). Measurements are the basis for detecting deviations from acceptable and desired performance and identifying opportunities for process improvement. Thus, they play a key role in process improvement initiatives (FLORAC and CARLETON, 1997).

2.2. Models and Standards about IT Services

Several initiatives (best practices, standards, maturity models, etc.) have been developed aiming to help organizations interested in IT services implementation. Among these initiatives we can highlight ITIL (TSO, 2011), COBIT (ICASA, 2012), ISO/IEC 20000 (ISO/IEC, 2011), CMMI-SVC (Forrester *et al.*, 2010), and MR-MPS-SV (SOFTEX, 2015a). These initiatives address important aspects related to IT services implementation and management.

CMMI-SVC and MR-MPS-SV are maturity models. Maturity models focus on improving organizational processes based on the assumption that the quality of a product or system is highly influenced by the quality of the processes used to develop and maintain it. Through essential elements of effective processes and an evolutionary path for improvement, maturity models provide guidelines on how to design processes, as an application of principles to meet the endless cycle of process improvement (FORRESTER *et al.*, 2010).

Following, each standard and maturity model cited is briefly described.

2.2.1. ITIL

Information Technology Infrastructure Library (ITIL) (OGCa, 2011) is an IT service management good practices library, created by the end of 1980's by the UK government in order to document how the best and most successful organizations approached service management. Originally, it used to have forty books. In 1990's, second version was created containing seven volumes. Then in 2007 third and current version was compiled in six books, addressing the service lifecycle: Introduction to ITIL Service Management Practice, Service Strategy, Service Design, Service Transition, Service Operation and Continual Service Improvement.

Service Strategy book is the core of service lifecycle and provides guidance about considering service management as a strategic asset, including topics as service markets development, internal and external provider types, service portfolio and others,

and includes five processes: Strategy management for IT Services, Service Portfolio management, Demand management, Financial Management and Business relationship management.

Service Design book provides guidance about appropriate IT services design in accordance to business objectives and includes eight processes: Design coordination, Service Catalogue management, Service level management, Availability management, Capacity Management, IT service continuity management, Information security management system and Supplier management.

Service Transition book guides about capabilities development and improvement for transitioning new and changed services into operation, and includes six processes: Transition planning and support, Change management, Service asset and configuration management, Release and deployment management, Service validation and testing and Knowledge management.

Service Operation book provides guidance about daily operation of services to business users and customers, and includes five processes: Event management, Incident management, Request fulfillment, Problem management and Identity management.

Continuous Service Improvement book guides about creating and maintaining value for customers through better design, transition and operation of services, following a seven-step process (OGCa, 2011):

i. Identify the strategy for improvement;
ii. Define what you will measure;
iii. Gather the data;
iv. Process the data;
v. Analyze information and data;
vi. Present and use information;
vii. Implement improvement.

2.2.2. COBIT

Control Objectives for Information and related Technology (COBIT) (ISACA, 2012a) is a good practices framework created to support enterprise IT governance and management. COBIT 5 (the current COBIT version) brings together the five principles (see Table 1 first column) that allow the enterprise to build an effective governance and management framework based on a holistic set of seven enablers (see Table 1 second

column) that optimizes information and technology investment and use for the benefit of stakeholders (ISACA, 2012a).

Table 1 - COBIT Five Principles and Seven Enablers (ISACA, 2012a)

COBIT Five Principles	**COBIT Seven Enablers**
1. Meeting Stakeholders Needs	1. Principles, Policies and Frameworks
2. Covering the Enterprise End-to-End	2. Processes
3. Applying a Single Integrated Framework	3. Organizational Structures
4. Enabling an Holistic Approach	4. Culture, Ethics and Behaviour
5. Separating Governance from Management	5. Information
	6. Services, Infrastructure and Applications
	7. People, Skills and Competences

COBIT considers practices and activities separated in two main areas or domains: Governance and Management. Governance includes Evaluate, Direct, and Monitor, while Management includes Align, Plan, and Organize; Build, Acquire, and Implement; Deliver, Service, and Support; and Monitor, Evaluate, and Assess (ISACA, 2012a).

COBIT Goals Cascade (ISACA, 2012b) is the mechanism to derive stakeholder needs into enterprise goals, IT-related goals and enabler goals, which should be specific, actionable and customized. This derivation allows setting specific goals at each organization level, being aligned to business goals and stakeholder requirements. COBIT Goals Cascade is composed by four steps, as follows in Figure 2 and explained bellow:

- *Stakeholder Drivers Influence Stakeholder Needs*: Different drivers can influence stakeholder needs, for example, business strategy changes, market trends, cost reductions, new technologies and others.
- *Stakeholder Needs Cascade to Enterprise Goals*: Identified stakeholder needs are related to generic enterprise goals, which be supported by Balanced Scorecard (KAPLAN and NORTON, 1996) dimensions.
- *Enterprise Goals Cascade to IT-related Goals*: In order to have IT supporting achievement of enterprise goals, COBIT Goals Cascade suggests to derive it in IT-related goals.
- *IT-related Goals Cascade to Enabler Goals*: In order to achieve IT-related goals, COBIT Goals Cascade suggests application and use of enablers, which are mainly processes, but can also include: principles, policies and frameworks,

organizational structures, culture, ethics and behavior, information services, infrastructure and applications, human resources, skills and competencies.

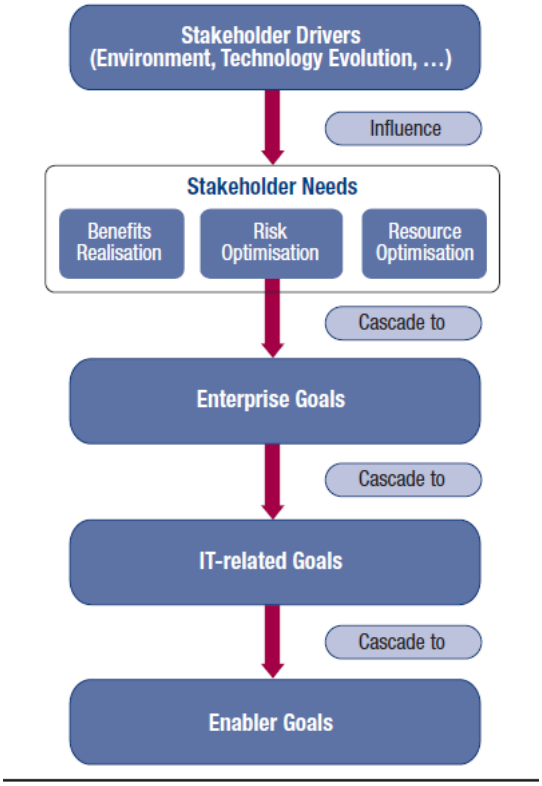

Figure 2 - COBIT Goals Cascade Overview (ISACA, 2012b)

COBIT Goals Cascade provides a catalog with 17 enterprise goals, 17 IT-related goals, 37 processes and more than 100 indicators that can be reused. However, as different market situations and environments require different measures, COBIT recommends that each organization should build its own goals cascade, compare it with COBIT's and then refine it (ISACA, 2012b).

For example, Organization can have "Business service continuity and availability" as one of Enterprise Goals from its Customer dimension of Balanced Scorecard. By using COBIT Goals Cascade, this organization should search for IT-Related goals that can be associated to achieve this Enterprise Goal. For example it can be "Adequate use of applications, information and technology solutions". Then, search for processes related to this IT-related goal. For example, "Manage Change Acceptance and Transitioning". List of relationships between Enterprise Goals and IT-Related Goals and between IT-Related Goals and processes is available at (ISACA, 2012b). COBIT Goals Cascade provides sample measures available for reuse for each Enterprise Goal,

IT-Related Goal and Process, so organization can also select those ones more applicable to its need.

2.2.3. ISO/IEC 20000

ISO/IEC 20000 (ISO/IEC, 2011) is an IT service management standard organized in five parts. ISO/IEC 20000–1 includes requirements for service management system planning, establishing, implementing, operating, monitoring, reviewing, maintaining, and improving. ISO/IEC 20000–2 (ISO/IEC, 2012) and ISO/IEC TR 20000–5 (ISO/IEC, 2010b) include management planning practices and an example to achieve requirements. ISO/IEC TR 20000–3 (ISO/IEC, 2009) guides scope definition, how to apply and get conformity of service management system. ISO/IEC TR 20000–4 (ISO/IEC, 2010a) shows a service management process reference model based on the ISO/IEC 20000–1 (ISO/IEC, 2011) requirements .

2.2.4. CMMI-SVC

Created in 2009, CMMI-SVC (FORRESTER *et al.*, 2010) is a maturity model based on CMMI-DEV concepts and practices, as well as on other standards and service models, such as ITIL, ISO/IEC 20000, COBIT, and Information Technology and Services Capability Maturity Model (ITSCMM) (NIESSINK *et al.*, 2005). CMMI-SVC has been developed for service providers and covers necessary steps to create, deliver and manage services.

Maturity levels are used to describe a recommended evolutionary path for organizations that aim to improve service delivery processes. In order to achieve each level, organizations need to attend all process areas objectives of that level. Like that, each maturity level matures a relevant subset of processes, making it ready to go to next level. Maturity levels are measured by generic and specific objectives associated to each predefined set of process areas. There are five maturity levels, starting on level 1 where processes are ad hoc or chaotic, going through levels that consider creation and description of process and work plans until level 4 and level 5 in which processes are quantitatively and continuously controlled and improved. Table 2 presents the maturity levels and associated process areas. Processes new to CMMI-SVC (FORRESTER *et al.*, 2010), which do not exist in CMMI-DEV (CMMI Product Team, 2010), are presented in italics.

Of the 24 process areas of CMMI-SVC (Table 3), only 7 are CMMI-SVC specific (see process areas in italic in Table 2). The other process areas are common to the development model (CMMI-DEV) (CMMI Product Team, 2010), just with a few nomenclature changes, as the term "work" instead of "project" due to continued operation service nature.

Table 2 - CMMI-SVC process areas by maturity level (FORRESTER *et al.*, 2010)

Maturity Levels	Process Areas
5 – Optimizing	Organizational Performance Management, Causal Analysis & Resolution
4 – Quantitatively Managed	Organization Process Performance, Quantitative Work Management
3 - Defined	Organizational Process Focus, Organizational Process Definition, Organizational Training, *Integrated Work Management*, Decision Analysis & Resolution, Risk Management, *Strategic Service Management*, *Capacity & Availability Management, Incident Resolution & Prevention, Service System Transition, Service Continuity, Service System Development*
2 – Managed	Requirements Management, *Work Planning*, *Work Monitoring & Control*, Supplier Agreement Management, Measurement & Analysis, Process & Product Quality Assurance, *Service Delivery*, Configuration Management

Table 3 - CMMI-SVC process areas/objectives (FORRESTER *et al.*, 2010)

Process Area	Objectives
Configuration Management (CM)	Create and maintain work products integrity through configuration identification, control, status accounting and audits
Measurement and Analysis (MA)	Create and maintain a measurement plan to support business information needs
Process & Product Quality Assurance (PPQA)	Provide all stakeholders with objective insight about processes and work products
Requirement Management (REQM)	Manage products and product components requirements to guarantee alignment between requirements, work plans and products
Supplier Agreement Management (SAM)	Manage and control products and services acquisition from suppliers
Service Delivery (SD)	Provide services in accordance to service contracts
Work Monitoring & Control (WMC)	Provide information and understanding of ongoing work for corrective actions be taken when needed if performance deviates from plan
Work Planning (WP)	Create and maintain plans that define work activities
Capacity & Availability Management (CAM)	Guarantee that resources are provided when needed and used to support service requirements
Decision Analysis & Resolution (DAR)	Analyze possible decisions using a formal evaluation process evaluating alternatives against defined criteria
Incident Resolution & Prevention (IRP)	Guarantee that service incidents have fast and effective solution and prevent them from occurring
Integrated Work Management (IWM)	Create and manage work and involvement of relevant stakeholders according to an integrated process that is derived from organization standard processes
Organizational Process Definition (OPD)	Create and maintain a usable set of organizational process assets, work environment standards, and rules and guidelines for teams
Organizational Process Focus (OPF)	Plan, implement, and deploy organizational process improvements to address current organization processes strengths and weaknesses
Organizational Training (OT)	Develop people skills and knowledge for them to perform their roles effectively and efficiently
Risk Management (RSKM)	Identify potential problems before they happen in order to plan and invoke risk activities as needed during work life cycle and mitigate

Process Area	Objectives
	adverse impacts on achieving objectives
Service Continuity (SCON)	Create and maintain plans to ensure services continuity during and after operations interruption
Service System Development (SSD)	Analyze, design, develop and validate service systems to meet service contracts agreements
Service System Transition (SST)	Deploy new or changed services components, controlling effect on the provision of on-going services
Strategic Service Management (STSM)	Create and maintain standard services jointly with strategic planning
Organizational Performance Management (OPM)	Proactively manage the organization's performance to meet its business objectives
Organizational Process Performance (OPP)	Create and maintain a quantitative understanding of selected processes performance about achieving process quality and performance targets, and providing data to quantitatively manage organization's work
Quantitative Work Management (QWM)	Quantitatively manage the work to achieve the established quality and process performance objectives for the work
Causal Analysis & Resolution (CAR)	Identify causes of selected outcomes and take action to improve process performance

2.2.5. MR-MPS-SV

The MPS.BR Program (ROCHA *et al.*, 2009) is an initiative funded by the Brazilian government that aims to make possible for micro, small and medium-sized Brazilian companies to invest in process improvement and software quality. Over 70% of the Brazilian software industry is constituted of micro, small and medium-sized enterprises (mSME). Until 2004 few Brazilian organizations had adopted reference models. It is a general belief that the use of reference models may improve the performance of organizations. However, some authors recognize the need in reducing process assessment costs and the amount of time necessary to make the software process improvement (SPI) benefits visible. Besides, Software and Service Process Improvements approaches should also focus on mSME (KALINOWSKI *et al.*, 2014).

Since 2004, more than 650 companies (www.softex.br) have already been assessed on the reference model for software process improvement, MR-MPS-SW (SOFTEX, 2012b) (www.softex.br). The Reference Model for Services Improvement (MR-MPS-SV) (SOFTEX, 2015a) was created to provide a maturity model more suitable for Brazilian mSME, but also compatible with the internationally accepted quality standards (including ISO/IEC 20000) and taking advantage of existing expertise in already available standards and maturity models.

Table 4 shows the MR-MPS-SV structure. Processes new to MR-MPS-SV (SOFTEX, 2015a), which do not exist in software model MR-MPS-SW (SOFTEX, 2012b), are presented in italics. Based on the requirements of ISO/IEC 15504 (ISO/IEC

15504), it is defined in two dimensions (SOFTEX, 2015a): process dimension and process capability dimension (process attributes). At all, there are seven maturity levels, ranging from level G (initial) to A (highest), enabling stepwise process improvement. The depicted process attributes are: 1.1 – the process is executed; 2.1 – the process is managed; 2.2 – the process work products are managed; 3.1 – the process is defined; 3.2 – the process is implemented; 4.1 – the process is measured; 4.2 – the process is controlled; 5.1 – the process is subject to incremental improvements and innovation; and 5.2 – the process is continuously optimized.

Table 4 - MR-MPS-SV maturity levels (ML) structure (SOFTEX, 2015a)

ML	Processes	Process Attributes
A	(no new processes are added)	1.1, 2.1, 2.2, 3.1, 3.2, 4.1*, 4.2*, 5.1*, 5.2*
B	Service Operation Management (evolution)	1.1, 2.1, 2.2, 3.1, 3.2, 4.1*, 4.2*
C	*Capacity Management*, *Continuity and Availability Management*, Decision Management, *Release Management*, Risk Management, *Information Security Management*, *Service Reporting*	1.1, 2.1, 2.2, 3.1, 3.2
D	*Service System Development*, *Service Billing and Accounting*	1.1, 2.1, 2.2, 3.1, 3.2
E	Assessment and Improvement of Organization Process, Definition of Organization Process, *Change Management*, Human Resource Management, *Service Operation Management (evolution)*	1.1, 2.1, 2.2, 3.1, 3.2
F	Measurement, Configuration Management, Acquisition, Quality Assurance Management, *Problem Management*, Portfolio and Operation Management	1.1, 2.1, 2.2
G	*Incident and Service Request Management*, *Service Level Management*, *Service Operation Management*	1.1, 2.1

** These Process Attributes (PAs) are applicable only on selected processes. The others PAs must be applied to all processes*

MR-MPS-SV has 22 processes, of which 12 are based on ISO/IEC 20000 quality of services standard and therefore have no equivalent in MR-MPS-SW (i.e., they are MR-MPS-SV specific). Those processes and their purposes are listed on Table 5.

Table 5 - MR-MPS-SV processes (SOFTEX, 2015a)

MR-MPS-SV Process	Purpose
Incident and Service Request Management	Restore agreed services when an incident occurs, and handle service requests, so both incident and service requests attend the established Service Level Agreement (SLA).
Service Level Management	Ensure to meet each customer SLA.

MR-MPS-SV Process	Purpose
Service Operation Management	Establish and maintain plans for operation' activities, assets and responsibilities of one or more services to be performed in order to meet agreed requirements for service operation. Also aims to provide information on service progress execution, allowing adjustments for performance significant deviations. The purpose evolves as the organization maturity grows. In level E, service operation management evolves to be based on defined process and integrated programs. In level B, service operation management takes on a quantitative approach, reflecting the expected high maturity for organization.
Acquisition	Manage services and products procurement to meet acquirer requirements
Configuration Management	Define and maintain the integrity of all work products of a service process or operation and make them available to all users
Quality Assurance Management	Ensure that work products and process execution comply with the plans, procedures and standards
Problem Management	Minimize service interruption by doing root cause investigation of incidents that impact service or SLA.
Portfolio and Operation Management	Initiate and maintain required, enough and sustainable service operations, in order to meet the organization's business goals. This process compromises investment and appropriate organizational resources and establishes the authority to execute selected services
Measurement	Define measurement objectives, identify, document and maintain an appropriate set of measures, establish procedures to collect, store and analyze measures, as well as collect, store, analyze and report data on service operations and implemented processes in order to support organization's business goals
Assessment and Improvement of Organization Process	Determine how organization´s standard processes contribute to achieving business objectives and support organization to plan, define and implement continuous process improvements based on the understanding of its' strengths and weaknesses
Definition of Organization Process	Establish and maintain a set of organizational process assets and patterns of useable working environment and applicable to the organization's business needs.
Change Management	Ensure that changes are implemented and evaluated in a controlled way.
Human Resource Management	Provide organization and service operations with required human resources and keep their appropriate skills to business needs.
Service System Development	Analyze, design, develop and validate services systems to meet Service Level Agreements.
Budget and Accounting Services	Control the budget and accounting of provided services.
Capacity Management	Ensure that supplier is capable to meet current and future agreed requirements.
Decision Management	Analyze critical decisions using a formal process, with an established criteria to evaluate identified alternatives.
Service Continuity and Availability	Ensure that SLAs are met under foreseeable circumstances.
Release Management	Release services in production environment in a controlled way.
Risk Management	Identify, analyze, address, monitor and continuously reduce risks at the organizational level and service operation.
Information Security Management	Manage information security in service management activities.
Service Reports	Produce timely and accurate reports to support communication and decision making.

2.3. IT Service Quality Measurement

Measure is the basic element for measurement. It represents, in a quantitative way, an object property and provides quantitative information in order to support technical and business decision making (MCGARRY *et al.*, 2002).

Through processes and products data collection and analysis, measurement can quantitatively demonstrate quality, predict processes behavior, and allow suppliers to increase the probability of achieving the expected IT service quality. The use of information provided by measurements as a basis to decision making can be seen as the real difference between organizations that really are pleasured with the benefits of their measurement programs and organizations that do only spend time storing useless data (MCGARRY *et al.*, 2002).

For performing measurement, initially, an organization must plan it. Based on its goals, the organization has to define which entities (processes, products and so on) are to be considered for software measurement and which of their properties (size, cost, time, etc.) are to be measured. The organization has also to define which measures are to be used to quantify those properties. For each measure, an operational definition should be specified, indicating, among others, how the measure must be collected and analyzed. Once planned, measurement can start. Measurement execution involves collecting data for the defined measures and analyzing them. The data analysis provides information to decision making, supporting the identification of appropriate actions. Finally, the measurement process and its products should be evaluated in order to identify potential improvements (BARCELLOS *et al.*, 2010).

Measurement plays an important role on maturity models, supporting both process and product management and improvement. It is one of the most important processes to manage work lifecycle and to evaluate work plans feasibility. Initial levels of both presented maturity models apply measurement in a traditional way, in accordance to Measurement and Analysis (MA) process area, at CMMI-SVC level 2, and Measurement (MED) process, at MR-MPS-SV level F. At these levels, measures are defined and data are collected and analyzed by comparing planned and executed values aiming to detect deviations and allow corrective actions to be taken in future executions of the analyzed process. At highest maturity models levels (CMMI-SVC levels 4/5 and MR-MPS-SV levels A/B), aiming to meet quantitative management,

measurement is associated to statistical process control techniques (FORRESTER *et al.*, 2010;SOFTEX, 2015a).

Although maturity models guide about what organizations should do to implement IT services measurement, they do not define which measures organizations should use to monitor and improve the IT service processes. Some suggestions are presented in the maturity models documentation, but they are not enough.

Measurement plays a key role in process quality improvement initiatives regardless of being based on a specific maturity model. In general, effective service measurements are planned based on few vital and meaningful indicators (i.e., measures used to quantitatively verify goals achievement (ECKERSON, 2011)) that are quantitative, economical and adequate to support desired results.

Considering that an indicator is a measure used to monitor goals achievement (BARCELLOS *et al.*, 2012), even having a list of measures, it is still not easy to align them to goals and define indicators for IT services (PARMENTER, 2015). Besides, there is no clear direction or strict suggestion about which business processes and measures should be considered, and selecting proper set of measures and indicators is not an easy task. Selection of critical processes to be measured must be aligned with organizational goals in order to measurements results be able to deliver relevant information for decision making and business support. Alignment demands understanding stakeholders' information needs and the way IT services processes are designed and executed in the organization. Also alignment demands detecting IT services critical processes and choosing strategies that should be followed by IT services in order to achieve established goals.

Moreover, several authors argue that a method that includes a measure database for reuse can reduce effort and speedup selection (KANEKO *et al.*, 2011; JANTTI *et al.*, 2010; KILPI, 2001). However, just having goals, questions and measures without picturing an indicator is usually not enough to get a successful measurement initiative. Indicators and targets can quantitatively determine success or failure of a goal or strategy (GOETHERT e FISHER, 2003).

2.4. Methods and Approaches to Support Measurement Planning

2.4.1. Goal Question Metric (GQM)

There are some approaches devoted to help organizations do define their measurement programs. One of most known in the context of measurement applied to the Software Engineering domain is the GQM (Goal-Question-Metrics) (BASILI and ROMBACH, 1994), which guides measures identification from organizational goals. GQM is based on the understanding that for an organization to perform measurement efficiently, it must be guided by well-defined purposes. GQM is considered a top-down approach, and was primarily designed for software development measurement initiatives, aiming to set operational goals for software projects. Through a measurement model in three levels, GQM purpose is to use measurement to improve quality of software development process and delivered product quality. GQM three levels are:

(i) Measurement Goals, which are the top level, representing goals to be achieved by measuring;

(ii) Questions, which represent information need that will be answered by measurement results;

(iii) Measures, which are the bottom level to answer those questions.

Like that, in GQM, each measure is connected to a goal through one or more questions. That way a measure existence is justified by its associated measurement goal. Since it was created, GQM was broadly used by industry and evolved to the following template: "Analyze *object of study* in order to *purpose* with respect to *focus* from point of view of *subjects*" (PARK *et al.*,1996).

GQM brings a method to define goals and systematically refine those goals into measures, specifying which data needs to be collected and avoiding collecting data that will not be used. Although this approach was applied in many industrial sectors and public organizations, it does not provide explicit support for consolidating measurement goals with other organization levels and elements, such as higher-level business goals, projects, initiatives, strategies, or how to establish relationships between goals (BASILI *et al.*, 2005).

2.4.2. Goal Question Indicator Metric (GQ(I)M)

Similar to GQM, Goal Question Indicator Metric (PARK *et al.*,1996) is another goal-driven measurement approach, more comprehensive than GQM. GQ(I)M includes reference to business goals, actions to be performed to implement measures and indicators with charts and view definitions. While GQM focuses on operational project level and measurement goals, GQ(I)M aims to go beyond and derive business goals and indicators to monitor the progress in achieving those goals. GQ(I)M acronym for Goal Question Indicator Measure was created with the "I" in parenthesis to emphasize the difference to GQM. GQ(I)M steps are (BOYD *et al.*, 2005):

(i) Determine business goals;
(ii) Pinpoint information needs;
(iii) Find sub-goals;
(iv) Identify entities and attributes related to sub-goals;
(v) Declare measurement goals;
(vi) Establish quantifiable question and indicators to achieve measurement goals;
(vii) Select data to be collected for indicators;
(viii) Define measures;
(ix) Identify actions to execute measurement;
(x) Plan measurement execution.

2.4.3. Practical Software Measurement (PSM)

Practical Software Measurement (PSM) method (MCGARRY *et al.*, 2002) is aligned with the ISO/IEC 15939 (ISO/IEC, 2007) and consists on a process based on information-driven measurement to support software project managers in selection, collection, definition, analysis, and report for problems. For each information need an information product must be produced from measures collection and analysis in order to satisfy the information need. PSM is considered as best practice by measurement experts and is financed by US Department of Defense. PSM includes a classification of seven areas: schedule, cost, product quality, size, performance, effectiveness, and customer satisfaction. The method is supported by a tool and includes predefined goals and measures to be associated to specific needs. It provides best practices for running a measurement initiative on the project level. However, PSM does not address

measurement on business level and does not link measurement on different levels business goals and strategies (BASILI *et al.*, 2009).

Although approaches like GQM and PSM support measurement planning, it is still necessary to properly identify measures to be collected and analyzed for decision making. However, such approaches do not indicate what to measure and which measures should be used or how to select those measures. They only point out that measures should be aligned with organizational goals.

2.4.4. GQM+Strategies

The GQM+Strategies approach (BASILI *et al.*, 2005) is an extension of Goal Question Metric (BASILI *et al.*, 1994) for goal-oriented measurement. GQM+Strategies supports derivation, linkage and dissemination of goals and strategies across several levels of an organization. Like that, it helps controlling the success or failure of selected strategies and goals using a measurement system.

GQM+Strategies elements (Figure 3) allow to define related sequences of goals and associated projects or initiatives, which are called by GQM+Strategies as "strategies". Strategies represent a planned and goal-oriented line of actions to be executed in order to achieve the characterized goals at the respective organizational level. GQM+Strategies' conceptual model provides multiple levels for goals and related various strategies for each of these levels. A goal may be accomplished by one strategy or a group of strategies. Context factors represent organizational environment variables that we factually know, which can influence information and data that can be used. Assumptions are predicted, estimated or guessed unknowns, which can impact interpretation of measurement data, associated goals and strategies (BASILI *et al.*, 2005).

GQM+Strategies contributes with a mechanism for an organization, not exclusively to model goals and strategies, but also to consistently define measurement in alignment with high-level organizational goals and to interpret and compile the derived measurement data at each level (KOWALCZYK *et al.*, 2011). In order to do that, Goal Question Metric (BASILI *et al.*, 1994) is used, compounding the main element within GQM graphs that mean the measurement piece of the conceptual GQM+Strategies model (Figure 3). A Goal Question Metric graph consists of a Goal Question Metric goal (which measures a GQM+Strategies element), associated questions, measures, and supplementary interpretation models. For each level of goals,

such a Goal Question Metric graph is designed to measure the accomplishment of defined goal according to the selected strategy. In that sense, defining a complete measurement plan includes defining Goal Question Metric measurement goals, deriving questions and measures, and defining interpretation models to verify if the measurement goal has been attained (BASILI *et al.*, 2005).

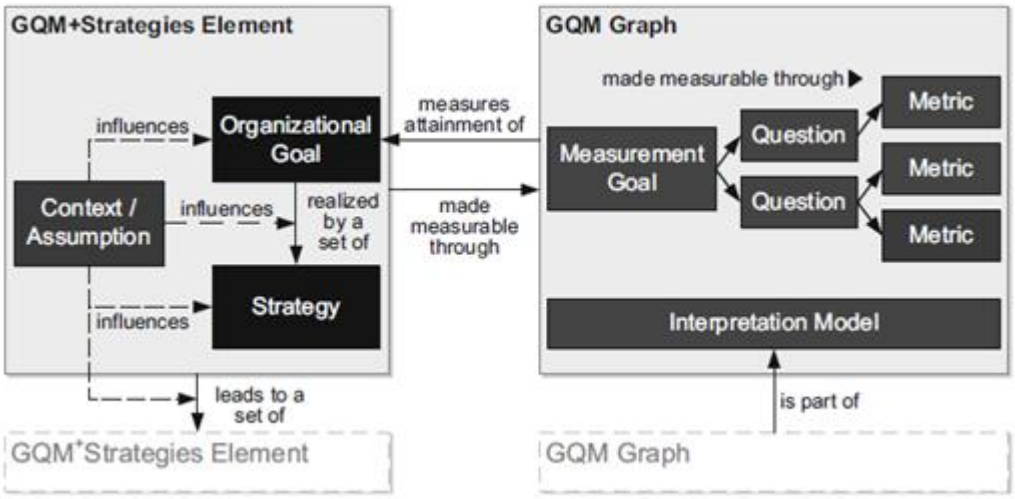

Figure 3 - GQM+Strategies conceptual model (BASILI *et al.*, 2005)

GQM+Strategies elements and related GQM graphs are the components used to model GQM+Strategies Grid, which indicates goals and strategies for all organization levels, including required Goal Question Metric models for monitoring and controlling. A benefit of modeling a grid is to support making goals and strategies explicit for an organization and to provide a clear correlation of all measurement initiatives. Like that, each organizational level has a clear understanding about how the strategies it is involved in can contribute to upper-level goals. The GQM+Strategies Grid provides transparency and is the core for measurement efficiency, as the organization can have a measurement system integrating all organizational measurement initiatives (KOWALCZYK *et al.*, 2011). However, GQM+Strategies does not detail how to identify critical processes to be considered in strategies or how to define proper strategies and measures.

2.4.5. Balanced Scorecard (BSC)

Balanced Scorecard (BSC) approach (KAPLAN and NORTON, 1996) is intended to measure if the actions performed by an organization are meeting its goals considering vision and strategy. Target public is decision-makers, to control

organization-wide goals, using different dimensions that should be selected based on organization' goals and aspects. A strategy map is created to derive goals and document relationships among them, associating different dimensions by using causal links (BSC stories). Usually, four dimensions are considered (learning & growth, internal process, customer, and financial), each dimension including one or more business goals. For each goal, related indicators, target values, and initiatives are defined. BSC aims to help defining causal chains for strategies to achieve business goals. However, it is not trivial to formulate goals, because there is no checklist for data gathering and no templates are provided. BSC does not provide an explicit way to define goals, strategies and indicators related to different organizational levels, being more applicable at higher levels (BASILI *et al.*, 2009).

2.4.6. Winning KPI Methodology

Winning KPI Methodology (PARMENTER, 2015) is composed by seven foundations and six stages, focusing on critical success factors as input to define performance indicators and providing a reporting framework to communicate and maintain indicators relevance.

The seven foundation stones that should be laid before implementing a project to define successful KPIs are:

i. Establish a partnership with all stakeholders for mutual acceptance and commitment for changes that will occur in organization and culture;
ii. Train and transfer power and responsibilities to employees in front line;
iii. Measure and report only what have a connection to a success factor and leads to an action, abandoning measures that do not matter;
iv. Source KPIs from critical success factors, or operational issues or aspects that must be well performed every day by staff;
v. Abandon processes that do not deliver, when recognizing initiatives that will never work as intended;
vi. Train and select an internal chief measurement officer, in order to have an expert in house with responsibility for managing the change;
vii. Organization-wide understanding of the winning KPIs definition.

The six stages, or important steps to be followed in order to implement the Winning KPIs are:

i. Get commitment from CEO and managements about changes that will happen with the KPI project;
ii. Provide training to organization´s resources for them to work and manage the KPI project;
iii. Lead and sell changes that will happen with the KPI project;
iv. Determine the operational critical success factors of the organization;
v. Define measures that will work in the organization;
vi. Get the measures to drive performance.

2.4.7. Other Approaches to Support Measurement Planning

In addition to the standards, methods and models presented before, there are other works that address selection of indicators for IT services measurement. Some of them are introduced in this section.

A framework for measuring IT services was presented by LEPMETS *et al. (*2011) and validated in industry (LEPMETS *et al.*, 2014), but only a catalog is provided, not a method to define and select measures, and align them to business goals. Authors state that alignment between business objectives and IT services industry needs to be studied and could provide additional support for their framework.

JÄNTTI *et al.* (2011) present a support system to IT Services Measurement. According to authors, in addition to a well-designed and easy to use measuring tool, there is a need for a systematic measurement process, and measures need to be based on business goals. To answer this need, authors suggest a summarized framework based on ITIL (OGCa, 2011), but emphasized that study focused on implementing the measurement system and that the framework has not been validated in real cases.

GENCEL *et al.* (2013) defined a decision support framework to select metrics in goal-based measurement programs called GQM-DSFMS, which is built upon Goal Question Metric (GQM) approach. The presented framework includes an iterative process to select goal-based metrics, including mechanisms for decision making, a pre-defined repository, and a traceability model. GQM-DSFMS was validated by case studies in a CMMI Level 3 software organization focusing on calculating costs for metrics. Authors incorporated "Indicators" concept to the framework in future, as it deals only with measures. Also, authors pointed out future work to extend the framework to include GQM+Strategies (BASILI *et al.*, 2005) concepts to monitor

deployment of strategy to achieve each goal and get feedback on the effectiveness of the chosen strategies.

ASGHARI (2012) used action research and proposed an elicitation approach called “The Goal Strategy Elicitation (GSE)” to support collecting information for goals and strategies to apply GQM+Strategies in an organization. Author considered that there is a need to conduct more empirical research on GQM+Strategies as the approach so far was evaluated in few cases.

2.5. Reference Software Measurement Ontology (RSMO)

The Reference Software Measurement Ontology (BARCELLOS *et al.*, 2012) is a reference domain ontology, i.e., a reference ontology constructed with the sole objective of making the best possible description of the domain in reality, with regard to a certain level of granularity and viewpoint. A reference ontology is to be a special kind of conceptual model, an engineering artifact with the additional requirement of representing a model of consensus within a community. It is a solution-independent specification with the aim of making a clear and precise description of domain entities for the purposes of communication, learning and problem-solving (GUIZZARDI, 2007).

RSMO was built based on the Unified Foundational Ontology (UFO) (GUIZZARDI, 2005), on the vocabulary used in standards as CMMI-DEV (CMMI Product Team, 2010), ISO/IEC 15939 (ISO/IEC, 2007), PSM (MCGARRY *et al.*, 2002), and IEEE Std. 1061 (IEEE, 1998) and on specific requirements of software measurement at maturity models high maturity levels found during a literature systematic review.

RSMO is composed by six sub-ontologies, as follows:

- *Measurable Entities & Measures sub-ontology*: is the RSMO core and addresses entities that can be submitted to measurement, their properties that can be measured, and measures used to measure them.
- *Measurement Goals sub-ontology*: addresses the alignment between measurement and organizational goals.
- *Operational Definition of Measures sub-ontology*: treats aspects related to operational definition of measures, which includes information regarding data collection and analysis.

- *Software Measurement sub-ontology*: is about data collection and storage.
- *Measurement Results sub-ontology*: refers to data analysis aiming to support decision making.
- *Software Process Behavior sub-ontology*: addresses using measurement results in software processes behavior analysis.

Although RSMO addresses the software measurement domain, there are several concepts that are common to both software and IT services measurement domain. Thus, a fragment of RSMO was used to provide the measurement conceptualization and terminology to SINIS method. Figure 4 shows a RSMO fragment containing relevant concepts to this work .

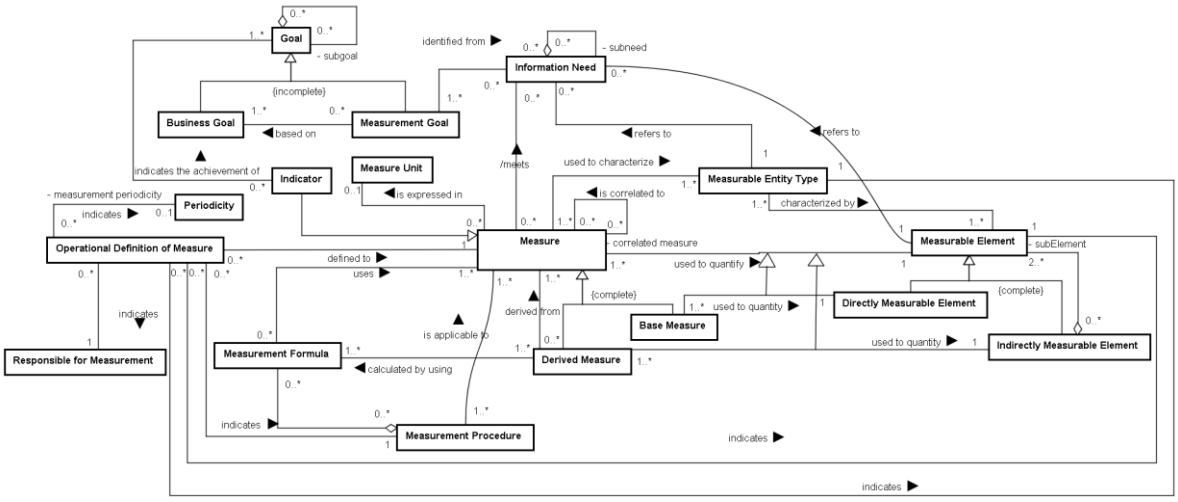

Figure 4 - RSMO Fragment (BARCELLOS, 2015)

A **Measurable Entity** is anything that can be measured, such as a process (e.g., the *Incident Management Process defined to the Organization Org*) and a service (e.g., the *Service S*). Measurable entities can be classified according to types (**Measurable Entity Type**). For instance, the *Incident Management Process defined to the Organization Org* is a measurable entity of the type *Incident Management Process.*

Measurable entities are characterized by **Measurable Elements**. A measurable element is a property of a measurable entity that can be distinguished, and thus measured. *Avaliability* and *cost* are examples of measurable elements of entities of the *Service* type. Measurable Elements can be directly (e.g., *size*) or indirectly (e.g., *productivity*) measured. **Indirectly Measurable Elements** are measured by means of other measurable elements, said their **sub-elements**.

Measures quantify measurable elements and can be classified into **Base Measures**, which are functionally independent of other measures (e.g., *number of recorded incidentes*) and used to quantify directly measurable elements, and **Derived Measures** (e.g., *resolution incidents rate*, given by the ratio of the *number of solved incidentes* to the *number of recorded incidents*), which are defined as a function of other measures and used to quantify indirectly measurable elements.

A Measure can be expressed in a **Measure Unit** (e.g., hours, reais). Derived measures are calculated by **Measure Calculation Formulas**, which, in turn, use other measures.

An **Operational Definition of Measure** details aspects related to the data collection and analysis of a measure. Regarding data collection, an operational definition of measure should indicate: he moment when measurement should occur (**measurement moment**); the **measurement periodicity**, that is, the frequency with which measurement should be performed (e.g. monthly, weekly); the **Responsible for Measurement** that can be the role played by the person responsible for collecting data for the measure (e.g., *Incident Manager*) or a tool (if the measure is automaticaly collected); and the **Measurement Procedure** to be followed in order to guide data collection.

A **Goal** expresses the intention for which actions are planned and performed. A goal can be, among others, a **Business Goal** (e.g., *increase customers satisfaction level*) or a **Measurement Goal** (e.g., *increase 10% the rate of incidents closed on time*). Measurement goals are defined based on business goals.

Information Needs are identified from measurement goals and refer to a measurable element and to a measurable entity type. For instance, the measurement goal *increase 10% the rate of incidents closed on time* could identify the information need *get to know the relation between incidents closed on time and the total of incidents*, which refers to the measurable element *efficiency* of the measurable entity type *Incident Management Process*. Information needs are satisfied by Measures. For example, the information need *get to the relation between incidents closed on time and the total of incidents* could be satisfied by the measure *rate of incidents closed according to service level agreement.*

Measures can be used to indicate the achievement of goals. In this case, the measure fulfills the role of **Indicator.** Considering the example cited above, if the measure *rate of incidents closed according to service level agreement* is used for

monitoring the achievement of the goal *increase 10% the rate of incidents closed on time*, then, in this context, it is an indicator.

2.6. Final Considerations

This chapter covered the theoretical basis for this dissertation. IT services logically represent a set of IT activities repeatedly performed to produce a specified outcome (OGCa, 2011) and are used to support business (CASES *et al.*, 2010). COBIT (ISACA, 2012a), CMMI-SVC (FORRESTER *et al.*, 2010), MR-MPS-SV (SOFTEX, 2015a) and ITIL (OGCa, 2011) are some of the several approaches devoted to IT services, providing best practices, processes and guidelines for implementation.

Measurement is used as a key role in process improvement initiatives (FLORAC and CARLETON, 1997) and can quantitatively demonstrate quality, predict processes behavior, and allow suppliers to increase the probability of achieving the expected IT service quality (MCGARRY *et al.*, 2002). Effective service measurements should cover meaningful indicators. Indicators should be able to verify goals achievement (ECKERSON, 2011), as an indicator is a measure that embodies a strategic objective and measures performance against a goal (BARCELLOS *et al.*, 2012).

Even having an available measures database, it is still not easy to select the proper ones and define indicators for IT services (PARMENTER, 2015). Goal Question Metric (GQM), Goal Question Indicators Metric (GQIM), Practical Software Measurement (PSM) and GQM+Strategies are approaches that cover alignment between selection of measures and business goals and information needs. GQM (BASILI and ROMBACH, 1994), GQ(I)M (PARK *et al.*,1996) and PSM (MCGARRY *et al.*, 2002) do not provide explicit support for consolidating measurement goals with multiple organization levels and elements. GQM+Strategies (BASILI *et al.*, 2005) provides this idea, and includes strategies as actions to be performed to support achieving goals. However, GQM+Strategies does not detail how to identify critical processes to be considered in strategies or how to define proper strategies and related measures. Also, none of those approaches is focused on IT services measurement.

COBIT Goals Cascade (ISACA, 2012b) provides a catalog with more than 100 indicators focused in IT services, and also enforces that indicators should be aligned to goals. However, COBIT recommends that each organization should build its own goals cascade, and there is no clear direction about how to execute this selection. Both service maturity models (CMMI-SVC (FORRESTER *et al.*, 2010) and MR-MPS-SV

(SOFTEX, 2015a)) include measurement processes and guide about what organizations should do to implement it. However, they do not define which measures should be selected and used, only present some suggestions of possible measures.

Chapter 3 details the followed steps to create the method to select indicators for IT Services proposed in this work. The applied methodology is based on Design Research and incremental learning cycles composed by systematic mapping in literature, case studies and action researches in industry.

CHAPTER 3 – Incremental Learning Cycles

As shown in Figure 1 (see Chapter 1), SINIS method to select indicators for IT Services is based on works recorded in the literature and on results obtained from design and investigative activities carried out in incremental learning cycles. This chapter presents the incremental learning cycles performed. The research methods used in each cycle are explained and the main results are presented.

Six studies were performed as incremental learning cycles to contribute to build SINIS:

- Systematic Mapping to find measures suitable to be used in IT Services measurement initiatives (TRINKENREICH *et al.*, 2015a);
- Case Study to evaluate measures found by systematic mapping and relationship between measures (TRINKENREICH and SANTOS, 2015a);
- Action Research about IT Services measurement process and measures evaluation under the light of MR-MPS-SV and selection of indicators in different levels using GQM+Strategies (TRINKENREICH and SANTOS, 2014);
- Case Study about using Business Process Intelligence for critical process analysis (TRINKENREICH *et al*., 2015b);
- Action Research about using critical process mapping and expected results of MR-MPS-SV to evaluate an IT Services process and select indicators in different levels using GQM+Strategies (TRINKENREICH and SANTOS, 2015b);
- Case Study using Qualitative Analysis to find about how operational actions, projects or initiatives are defined to achieve IT Services indicators.

Next, a brief background about the research methods used in the studies is provided. Following, the studies are described, including what was learned from each one of them in order to contribute with SINIS method creation.

3.1. Research Methods

3.1.1. Systematic Mapping

A systematic literature review is a way of seeking, finding, evaluating, and interpreting the applicable publications for determined research questions, research areas, or aspects of interest. Most common reasons to perform a systematic literature review is to compile the existing evidence about a subject, to find gaps in current research in order to suggest areas for more investigation or to deliver a background in order to properly position new researches. Three main phases of a systematic literature review include plan, execution and report. During planning phase, a review protocol is created including research questions, search terms, criteria for publications inclusion and exclusion, and strategy to extract and organize data. During execution phase, databases are searched, all steps are documented and publications are selected, read and synthetized following defined criteria. During reporting phase, reports are created to present the systematic review findings (KITCHENHAM and CHARTERS, 2007).

Mapping studies are a mode of systematic literature review that aims to find and classify the available research on a broad specific topic. Mapping studies can save time and effort for researchers and contribute with baselines to support new research efforts. Mapping studies are based on the same essential methodology as systematic literature review but aim to find and classify all research related to a specific topic rather than answering questions about corresponding benefits of competing technologies like conventional systematic literature review does (KITCHENHAM *et al.*, 2011).

3.1.2. Case Study

Case study is an exploratory research technique used to highlight and explore aspects, which may guide providing directions to answer a research question. This methodology is relevant for information system when researcher can study the information system in a natural environment, answering ‘‘how’’ and ‘‘why’’ questions and when there had been no much previously conducted formal research (RECKER, 2013).

3.1.3. Action Research

Action research (AR) is an approach intended to take action and also build knowledge about that action. It differs from positivist science, that aims to create

knowledge only, providing as outcomes both an action and a research. AR's main purpose is to use a scientific approach to study the resolution of a relevant social or organizational problem, together with those who directly experience this problem. Cyclical process of Action Research comprises iterative cycles of gathering data, feeding them back of those concerned, analyzing the data, planning action, taking action and evaluating, leading to further data gathering and so on. Different from traditional research where members are objects of the study, members of the phenomenon being studied actively participate in cyclical process. Also, as a problem solving approach, AR is an application of the scientific method of fact finding and experimentation to practical problems requiring action solutions and involving the collaboration and co-operation of the action researchers and members of the organizational system. The desired outcomes of the AR approach are not just solutions to the immediate problems but important learning from outcomes both intended and unintended, and a contribution to scientific knowledge and theory (COUGHIAN and COUGHIAN, 2002).

Action Research is considered appropriated for technology study in human context, placing the researcher in a collaborative and participative role to the activity being studied in the organization. Unlike positivist methods which only goal is to generate knowledge, Action Research can be described as a post-positivist method because is empirical, but interpretive; experimental but multivariate; observational, but interventionist (BASKERVILLE and WOOD-HARPER, 1996).

Action-Research is materialized by a sequence of actions revealed as the problem is confronted, and organization members and researcher attempt to solve it. This process can be generically abstracted by using an iterative and incremental approach. An Action Research cycle is composed by three kinds of phases, a preliminary phase to understand context and objectives; a main stage cyclic stages to collect, validate and analyze data, plan, implement and evaluate actions; and a central phase to monitor all the work, as Figure 5 (COUGHLAN and COUGHLAN, 2002).

Data collection can be performed in different ways according to the context. Reports and documentation analysis, interviews and discussions, or even observations during informal conversations. Behavior observation within organization is a relevant data collection source for Action Research, and can count on group dynamics during their work, such as gathering groups' communication patterns, leadership behaviors, use of power, ways to solve problems and make decisions. Data validation is done when the researcher organizes collected data in a way that you can validate and analyze collected

information, either in reports or other presentation forms. Data analysis is collaboratively performed by both the researcher and the organization, considering that organization have knowledge about its business, knows what might work, and in the end, will be responsible for implementing defined actions (COUGHLAN and COUGHLAN 2002).

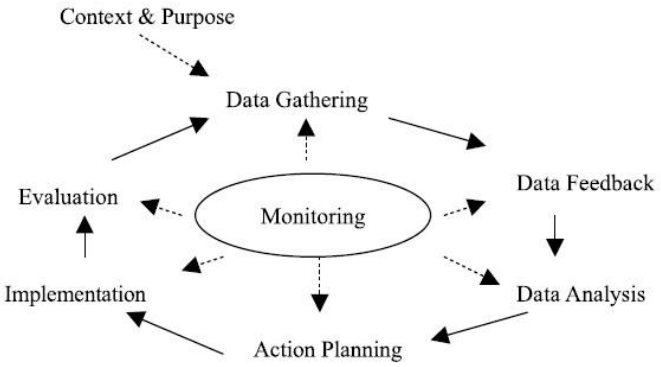

Figure 5 - Action-Research life cycle (COUGHIAN and COUGHIAN, 2002)

Action planning is carried out jointly between the researcher and the organization, in order to define what needs to be changed, in which organization areas, what kind of changes are needed, which is the required support to perform changes, how is the change commitment going to be established and how is the change resistance going to be managed (COUGHLAN and COUGHLAN, 2002).

Monitoring is a meta-phase that happens during the entire Action Research process cycle. Each Action Research cycle starts a new set of planning, executing and evaluating, being continuously conducted and also creating continuous learning (COUGHLAN and COUGHLAN, 2002).

3.1.4. Grounded Theory

Grounded Theory (GT) is a qualitative research method applicable in areas that were not previously studied or areas where it is necessary to get a deeper understanding of a particular phenomenon (STRAUSS and CORBIN, 1998). This method was created in 1967 by GLASER and STRAUSS researchers, as an answer for the idea about the social sciences' goal, which was understood as being only to derive explanations or formal theories about social behavior. Authors believed that social theories should not be absolute truths, because people interpret reality based on their personal values and therefore these values should not be ignored in qualitative studies (ADOLPH *et al.*, 2008).

Grounded Theory method was presented in (GLASER and STRAUSS, 1967), as a set of procedures to generate, develop and validate substantive theories about essentially social phenomena, in the context of a particular group of people or situation.

However, Grounded Theory creators differed on some points and the method was separated into two different lines. GLASER (1992) defended one line, emphasizing the emergency characteristic of the method and inductive processes developed by the Department of Sociology at Columbia University in the 50s and 60s. STRAUSS (1987) defended another line, later consolidated with CORBIN (1998), systematizing data collection and analysis of the method. In this dissertation, STRAUSS and CORBIN line is used, as it provides prescriptive features that could be directly used for the purpose.

The Emergency Principle of Grounded Theory defines that both the research product and the research process itself should be emergent. This means that they should be developed during the research process.

According to this principle, researchers must not initiate investigation with preconceived concepts or using any theoretical framework as a guide. Both concepts and theory should emerge from data, researchers must listen to data voice, or allow "data speak for themselves" (STRAUSS and CORBIN, 1998).

This principle aims to guarantee that theory derived from the study is reliably representing the vision of people involved in the study, and the investigation context (DUCHSCHER and MORGAN, 2004).

Grounded theory components include theoretical sampling, coding (open coding, axial coding and selective coding) and memoing, as detailed bellow (COLEMAN, O'CONNOR, 2007).:

- *Theoretical sampling*: Data is collected and analyzed, and also an emerging theory is created. Usually data collection is performed through interviews. As the researcher initially does not know much about the theory, only an few sampling can be planned. Based on the emerging theory, the researcher can change interview questions to have a more precise connection with emergent categories. Based on category creation, the researcher should choose certain individuals to be interviewed or get other sources of data. Analyzed data and emerging theory are constantly compared until saturation, which means, when new collected data is not providing new knowledge about existent categories, .
- *Open coding*: The researcher analyzes transcripts from interviews and defines codes to label parts of the text. Codes represent concepts that will be part of the

theory, providing meaning to the text, and can be defined by the researcher or also taken from the text itself (in vivo code). Benefits of in vivo codes include they (i) arise directly from interviewees, do not need researcher´s interpretation, and (ii) provide context-description. A list of codes is created from initial interviews and used to code next interviews.

- *Axial coding*: The researcher defines and associates categories in various levels. The term axial is used because coding occurs around a category axis, by associating categories to subcategories with properties and dimensions.
- *Selective coding*: The researcher integrates and refines the theory, by creating a central (or core) category to describe theory around it.
- *Memoing*: The researcher takes notes about ideas and questions while all data collection and analysis, which usually complement finding out the theory.

In this dissertation, after data collection, we used codification procedures based on Grounded Theory components..

3.2. Incremental Learning Cycles Performed to Build SINIS Method

Six studies were executed to obtain useful knowledge to develop SINIS. They were named as incremental learning cycles, because the researcher could acquire more knowledge through their results as they were being performed. A summary of how the obtained results contributed for SINIS development is shown in Table 6 . Details regarding each incremental learning cycle are provided in the sequence.

Table 6 – Incremental learning cycles and their contribution to SINIS creation

Incremental Learning Cycle	Contribution to SINIS
Systematic Mapping to find Measures Suitable for IT Services Measurement	Provide an initial list of measures to be reused in the SINIS context. The list is used as input in some SINIS activities.
Action Research about IT Services Measurement Process and Measures	Evaluate the measurement process to find what does an Organization needs to be improved and considered when selecting indicators and consider the usage of indicators related to more than one process.
Case Study to evaluate Measures found in Systematic Mapping and Investigation about how can one IT services process impact others	Evaluate and increase the list of measures to be reused during SINIS execution. Besides, the investigation about impact between different IT Services process contributed to include in SINIS activities to address critical process mapping in order to identify proper strategies to achieve IT Services Goals.
Case Study about using Business Process Intelligence for Critical Process Analysis	Usage of event log analysis (when appropriate) to discover processes bottleneck that can be addressed by strategies to achieve IT Services Goals.
Action Research about using Critical Process Mapping and Outcomes of MR-MPS-SV to evaluate an IT Services Process and Select Indicators using GQM+Strategies	Usage of GQM+Strategies approach as a base structure for SINIS, measures reuse during indicators selection and critical process mapping with a broader view of related processes to find strategies to achieve IT Services Goals.

Incremental Learning Cycle	Contribution to SINIS
Case Study using Qualitative Analysis to find about How Operational Actions, Projects or Initiatives are Defined to Achieve IT Services Indicators	Investigate how an organization select strategies to achieve IT Services Goals. The use of causal analysis techniques was identified as a good practice and it was included in SINIS as a way of identifying aspects on which the strategies to achieve IT Services Goals should focus.

3.2.1. Systematic Mapping to find Measures Suitable for IT Services Measurement

3.2.1.1. Systematic Mapping Motivation

This study aimed to acquire knowledge about IT Services Measurement, identify the problem to focus on and limit the scope of proposed solution, which was the selection phase of measurement process. Also, for SINIS contribution, this study aimed to provide an IT Services measures list to be searched for reuse.

Standards and models addressing IT services emphasize measurement to be used to manage and improve IT services quality, but none of them indicates which measures organizations should use.

The mapping study was done in three steps: planning, execution, results discussion and learning conclusions that contributed to build SINIS method.

3.2.1.2. Systematic Mapping Planning and Execution

The research questions the mapping aims to answer and their rationale are listed in Table 7.

Primary research questions are directly related to the study aims. Secondary questions, in turn, allow us to investigate other aspects related to the research topic, resulting in a broader panorama regarding the research topic than the one resulting from answering only the primary research questions.

Table 7 - Research Questions

ID	Research Question	Rationale
Primary Research Questions		
RQ1	Which measures suitable for IT service improvement initiatives have been proposed in the literature?	This research question investigates which measures had been found for IT services.
RQ2	To which IT service maturity models processes are the measures related?	This research question investigates how measures can be related to CMMI-SVC or MR-MPS-SV process areas.
Secondary Research Questions		
RQ3	When and where have the publications been published?	This research question aims at giving an understanding on whether there are specific publication sources for studies addressing measures for IT services as well as the distribution of the publications along the years.
RQ4	Have the measures been used in some	This research question investigates if authors had

	practical application?	reported any practical application of measures in industry.
RQ5	What tools have been used for supporting measurement in IT service context?	This research question investigates if there was used any tool or software to support measurement in selected papers.
RQ6	Which measurement activities (planning, collection, analysis) are supported by the tools?	This research question investigates which measurement activities are supported by tool proposed (if there is any).
RQ7	Which mechanisms (methods, techniques, etc.) have been suggested to support measures identification in the IT services context?	This research question investigates if there was any mechanism (method, techniques, algorithm...) to support measure identification.
RQ8	Were the measures categorized? Which were the considered categories?	This research question investigates what type of categories had been used to group measures (for example, internal/externals, ITIL processes etc.).
RQ9	Have been the measures related to IT services standards/models? Which ones?	This research question investigates if measures found were related to any standard/models (examples: ITIL, COBIT, ISO/IEC20000, CMMI...).

Publications selection was performed in three steps:

- S1: execution of the search string using the digital libraries search engine, and publications cataloguing;
- S2: publications (the ones selected in S1) titles and abstracts reading considering the selection criteria;
- S3: publications (the ones selected in S2) full text reading considering the selection criteria.

We considered papers from 2009 to 2014, published in scientific events and journals of the Computer Science area. Selected period for paper reading was six years, because the oldest control article year was published in 2010 and CMMI-SVC (FORRESTER *et al.*, 2010) maturity model was created in 2009.

At the end of cataloguing step, publications indexed by more than one digital library were identified and duplications were removed.

The search string considered four keywords' groups aligned to the systematic mapping goal: *identify measures* (*i.e.:* measurement OR metric OR measures OR measure OR measures OR measuring OR kpi OR "Key Performance Indicator") *related to quality/performance/maturity/quality-of-service* (*i.e.:* maturity OR quality OR performance OR qos) *suitable for models/standards* (*i.e.:* itil OR cobit OR "ISO/IEC 20000" OR itsm OR cmmi-svc OR "CMMI for Services" OR mps-sv OR mr-mps-sv) for IT services (*i.e.:* "IT service" OR "IT services").

The keyword groups were connected by using AND, resulting in the search string: *(measurement OR metric OR measures OR measure OR measures OR measuring OR kpi OR "Key Performance Indicator") AND (maturity OR quality OR performance*

OR qos) AND (itil OR cobit OR "ISO/IEC 20000" OR itsm OR cmmi-svc OR "CMMI for Services" OR mps-sv OR mr-mps-sv) AND ("IT service" OR "IT services").

For establishing the search string, we performed some tests using different terms, logical connectors, and combinations among them.

Some relevant publications identified during previous informal literature review were used as control publications, guiding the search string adjustment to be able to return them.

The following inclusion (IC) and exclusion (EC) criteria were considered to filter publications selected by the search string:

- IC1- the publication proposes or describes the use of measures to assess quality and/or performance and/or IT service maturity;
- EC1 - the publication does not have an abstract;
- EC2 - the publication is published as an abstract;
- EC3 – the publication is not written in English;
- EC4 - the publication is an older version of an already selected publication;
- EC5 – the publication full text is available.

The exclusion criteria EC3, EC4, and EC5 were considered only during S3 step execution.

Search procedures were applied in seven electronic databases, namely: Scopus (www.scopus.com), Compendex (www.engineeringvillage.com), IEEE Explore (ieeexplore.ieee.org), ACM Digital Library (dl.acm.org), Science Direct (sciencedirect.com), Springer (link.springer.com), and Web of Science (apps.webofknowledge.com).

The systematic mapping was carried out at the end of 2014 and considered publications until November 2014.

By following the publications selection procedure, in S1 295 publications were selected. After duplicates removal, 217 remained. 42 publications were selected in S2, from which 16 were selected in S3. Two publications were eliminated because their full text was unavailable.

Concerning the digital libraries used, 81% of the selected papers were indexed by Scopus. Springer and Scopus did not match any result. Table 8 presents the number of selected publications in digital libraries during each step.

Table 8 - Amount of selected publications during each step (TRINKENREICH et al., 2015a)

Number of papers by search engines	S1	S2	S3
ACM	48	1	1
ACM, Science Direct	2	0	0
ACM, Scopus	12	3	1
ACM, Springer	5	0	0
Compendex	1	0	0
Compendex, Scopus, Web of Science	1	1	0
IEEE	9	1	0
IEEE, Scopus, Compendex	5	4	1
Science Direct	1	0	0
Scopus	71	20	6
Scopus, Compendex	8	4	1
Scopus, Science Direct	1	1	1
Scopus, Web of Science	1	1	1
Scopus, Compendex, ACM	1	0	0
Scopus, Compendex, IEEE, ACM	4	2	1
Scopus, Compendex, IEEE, ACM, Web of Science	3	2	1
Springer	42	2	2
Web of Science	2	0	0
TOTAL	*217*	*42*	*16*

Table 9 presents the selected publications. Publications in bold are the ones used as control publications.

The mapping execution was conducted by one of the authors and, as a quality assurance procedure, publication selection and obtained results were validated by specialists in Systematic Mapping, Measurement and Maturity Models.

Table 9 - Selected publications (TRINKENREICH et al., 2015a)

#	Title, Authors, Publication Year	Source
1	DSS Based IT Service Support Process Reengineering Using ITIL: A Case Study - Valverde, R., Malleswara, T. - Journal Intelligent Decision Technologies (2014)	Scopus
2	**The Evaluation of the IT Service Quality Measurement Framework in Industry – Lepmets, M., Mesquida, A., Cater-Steel, A., Mas, A., Ras, E. - Global Institute of Flexible Systems Management (2014)**	**Scopus**
3	An architecture framework for enterprise IT service availability analysis – Franke, Johnson, P., Konig, J. - SoSyM - Journal Software and Systems Modeling (2014)	Springer
4	IT Service Incident Management Model Decision Based on ELECTRE III – Zhao, G., Yang, S. - International Conference on Information Management, Innovation Management and Industrial Engineering (2013)	Scopus
5	Toward a model of effective monitoring of IT application development and maintenance suppliers in multisourced environments - Herz, T., Hamel, F., Uebernickel, F., Brenner, W. - International Journal of Accounting Information Systems (2013)	Scopus e Science Direct
6	Proposal of a new model for ITIL framework based on comparison with ISO/IEC 20000 standard - Tanovic, A., Orucevic, F. - World Scientific and Engineering Academy and Society (2012)	Scopus
7	**Extending the IT Service Quality Measurement Framework through a Systematic Literature Review - Lepmets, M., Cater-Steel, A., Gacenga, F., Ras, E. - SRII Global Conference (2012)**	**Springer**
8	**A Quality Measurement Framework for IT Services - Lepmets, M., Ras, E., Renault, A. - SRII Global Conference (2011)**	**Scopus, Compendex, IEEE e ACM**

#	Title, Authors, Publication Year	Source
9	Implementing a request fulfillment process – Mendes, C., Silva, M. - IESS - International Conference Exploring Services Science (2011)	Scopus
10	**Case Study on IT Service Management Process Evaluation Framework Based on ITIL-Liu, M., Gao, A., Luo, W., Wan, J. – International Conference on Business Management and Electronic Information - BMEI (2011)**	**Scopus, Compendex e IEEE**
11	SLA Perspective in Security Management for Cloud Computing - Chaves, S., Westphall, C., Lamin, F. - International Conference on Networking and Services (2010)	Scopus
12	An international analysis of IT service management benefits and performance measurement – Gacenga, F., Cter-Steel, A., Toleman, M. - Journal of Global Information Technology Management (2010)	Scopus e Web of Science
13	Business-impact analysis and simulation of critical incidents in IT service management - Bartolini, C., Stefanelli, C., Tortonesi, M. - International Symposium on Integrated Network Management (2009)	Scopus, Compendex, IEEE, ACM e Web of Science
14	Measurement of Service Effectiveness and Establishment of Baselines - Donko, D., Traljic, I. - World Scientific and Engineering Academy and Society (2009)	Scopus e ACM
15	The most applicable KPIs of Problem Management Process in Organizations - Sharifi, M., Ayat, M., Ibrahim, S., Sahibuddin, S. - International Journal of Simulation Systems, Science & Technology (2009)	Scopus e Compendex
16	A Software Maintenance Maturity Model (S3M): Measurement Practices at Maturity Levels 3 and 4 – April, A., Abran, A. - Electronic Notes in Theoretical Computer Science - ENTCS (2009)	ACM

3.2.1.3. Systematic Mapping Results

During the data extraction we found more than 300 measures. Since we are interested in measures suitable for IT service improvement initiatives, we excluded the ones outside this scope, such as measures related to financial aspects (e.g., actual price paid for the service). As a result, 133 measures remained and had their relation with the processes maturity models analyzed. Measures were analyzed considering their name, description and formula. Most papers had not presented description and formula and for those cases, we analyzed only the measures name. By doing this analysis, we compared each measure against each maturity level process scope and we selected the one that better matched, and also defined a unique name to represent similar or identical measures, consolidating in only one measure. This process is explained and exemplified in Figure 6

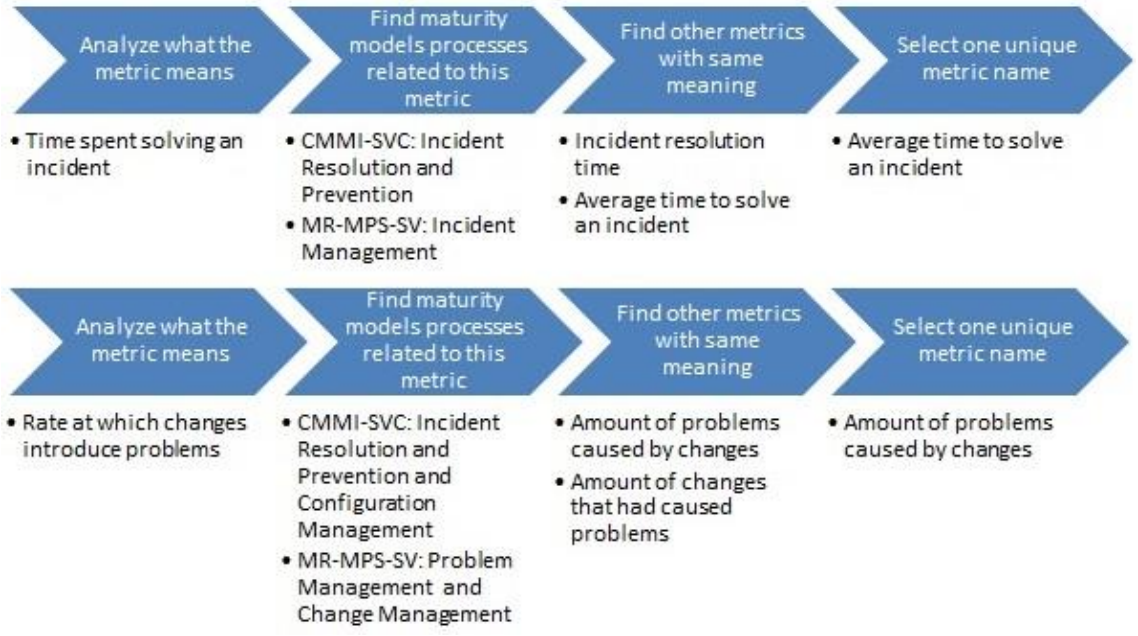

Figure 6 - Example of measures classification and aggregation

The measures and related CMMI-SVC and MR-MPS-SV processes are shown in Appendix I. These results address the primary research questions, which concern measures suitable for IT service improvement initiatives (RQ1) and their relation with the maturity models processes (RQ2).

Next, some results related to each secondary question are presented.

(RQ3) When and where have the studies been published?: Among the selected publications, 4 are from 2009, 2 from 2010, 3 from 2011, 2 from 2012, 2 from 2013 and 3 from 2014. Low variation values through years shows that studies has being continuously done in the area. Scopus was the search source that returned most of the selected studies (14 of 16). Regarding the publication vehicle type, 7 papers were published in conferences and 9 in journals. Typically, a high proportion of papers about a topic published in journals can be seen as a sign of maturity in the research about that topic. The percentage of papers published in journals and papers published in conferences are similar (56% and 44%, respectively).

(RQ4) Which research methods have been followed?: 11 of the selected publications are about Case Studies. One is about Survey, one about Systematic Review, one about Ethnography and one about Design Science. One paper had not specified the used method. The results show that even being a quantitative field of study, IT services measures have been more explored in literature through qualitative methods. The predominance of case studies can also indicate that new general theories

need to be further studied and created in literature, possibly by induction from case studies. An advantage of having more case studies than surveys is that the first ones provide richer description of situations. Even then, case study methods can present not enough evidence to support evidences and problems of replicability because of nature of inquiry that can be highly contextualized [RECKER, 2013].

(RQ5) Have the measures been used in some practical application?: Most of the measures were used in practical application (88%), which makes sense because most papers were about case studies, which are used for confirmatory purposes (theory testing) [RECKER, 2013]. In that sense, having most of the measures already confirmed in practical applications, contribute to consider the list of measures a reliable source to be consulted for reuse by organizations during planning phase of IT service measurement initiatives.

(RQ6) What tools have been used for supporting measurement in IT service context? And (RQ7) Which measurement activities (planning, collection, analysis) are supported by the tools?: Only two publications (#1 and #13 in Table 8) mentioned the use of a decision support system to support analysis activities. It shows there is lack of tools to support measurement activities in IT service context. One of the reasons that makes measures selection a difficult task is that usually the tools used to support service management activities does not include measurement, or is very limited [JÄNTTI *et al.*, 2010].

(RQ8)Which mechanisms (methods, techniques, etc.) have been suggested to support measures identification in the IT services context?: A framework as list of measures for IT service quality is proposed in publication #8. This list was validated by two subsequent researches (#2 and #7 also in Table 8). Publication #14 does not propose a method to identify measures, but a quantitative method to measure how the results of indicators contributes to losses for provider. It would support another phase of measurement, not the identification of measures, but the result analysis. This lack of mechanisms found for selection phase of IT service measures on results of this mapping study shows that measures are being suggested in literature without an associated method or mechanism to replicate this selection.

(RQ9) Were the measures categorized? Which categories were considered? In 62% of the papers the measures were grouped into categories, as we can see in Table 10 below.

Table 10 - Categories used by publications to group measures

#	*Title, Authors, Publication Year*	*Categories*
1	DSS Based IT Service Support Process Reengineering Using ITIL: A Case Study - Valverde, R., Malleswara, T. - Journal Intelligent Decision Technologies (2014)	Service Desk, Incidents, Changes, Configuration, Release, Problems, Service Level Management
2	**The Evaluation of the IT Service Quality Measurement Framework in Industry – Lepmets, M., Mesquida, A., Cater-Steel, A., Mas, A., Ras, E. - Global Institute of Flexible Systems Management (2014)**	**Process performance, Customer Satisfaction, Information system quality, IT service value and Service Behaviour**
3	An architecture framework for enterprise IT service availability analysis – Franke, Johnson, P., Konig, J. - SoSyM - Journal Software and Systems Modeling (2014)	No categories had been used to group measures
4	IT Service Incident Management Model Decision Based on ELECTRE III – Zhao, G., Yang, S. - International Conference on Information Management, Innovation Management and Industrial Engineering (2013)	No categories had been used to group measures
5	Toward a model of effective monitoring of IT application development and maintenance suppliers in multisourced environments - Herz, T., Hamel, F., Uebernickel, F., Brenner, W. - International Journal of Accounting Information Systems (2013)	ADM sub-functions Application development (AD) or Application maintenance (AM)
6	Proposal of a new model for ITIL framework based on comparison with ISO/IEC 20000 standard - Tanovic, A., Orucevic, F. - World Scientific and Engineering Academy and Society (2012)	Strategy, Demand, Financial, Service Portfolio, Business Relationship, Service Level, Capacity, Design Coordination, Availability, Security, Continuity, Supplier Management, Transitioning Planning and Support, Change, Release and Deploy, Service Validation and Testing, Service Asset and Configuration Management, Change Evaluation, Knowledge, Request Fulfilment, Incident, Event, Problem, Continual Service Improvement, Access, Capacity, Service Reporting, Continuity and Availability,
7	**Extending the IT Service Quality Measurement Framework through a Systematic Literature Review - Lepmets, M., Cater-Steel, A., Gacenga, F., Ras, E. - SRII Global Conference (2012)**	**Intrinsic (IS quality, IS service quality, process quality, value), Intrinsic and Extrinsic (customer satisfaction and service behaviour)**
8	**A Quality Measurement Framework for IT Services - Lepmets, M., Ras, E., Renault, A. - SRII Global Conference (2011)**	**External (Availability, Continuity, Capacity, Performance, Security, Reliability) and Internal (Fuctional Correctness, Portability, Usability, Availability, Reliability, Mainainability, Component capacity, Scalability, Adjustability), Process performance (Compliance, Efficiency, Effectiveness), Customer Satisfaction (Feedback, Support)**
9	Implementing a request fulfilment process – Mendes, C., Silva, M. - IESS - International Conference Exploring Services Science (2011)	No categories had been used to group measures
10	**Case Study on IT Service Management Process Evaluation Framework Based on ITIL-Liu, M., Gao, A., Luo, W., Wan, J. – International Conference on Business Management and Electronic Information - BMEI (2011)**	**Quality, Customer satisfaction, Cost budgeting, Service level, Configuration, Change, Problem, Incident, Service Desk Management**
11	SLA Perspective in Security Management for Cloud Computing - Chaves, S., Westphall, C., Lamin, F. - International Conference on Networking and Services (2010)	Security SLA and Conventional SLA
12	An international analysis of IT service management benefits and performance measurement – Gacenga, F., Cter-Steel, A., Toleman, M. - Journal of Global Information Technology Management (2010)	No categories had been used to group measures
13	Business-impact analysis and simulation of critical incidents in IT service management - Bartolini, C., Stefanelli, C., Tortonesi, M. - International Symposium on Integrated Network Management (2009)	External perspective (Customer satisfaction), Internal perspective (Cost of implementing new strategies, Aggregated cost for SLO penalties)

#	*Title, Authors, Publication Year*	*Categories*
14	Measurement of Service Effectiveness and Establishment of Baselines - Donko, D., Traljic, I. - World Scientific and Engineering Academy and Society (2009)	Financial, Customer, Learning and Growth, Internal perspectives
15	The most applicable KPIs of Problem Management Process in Organizations - Sharifi, M., Ayat, M., Ibrahim, S., Sahibuddin, S. - International Journal of Simulation Systems, Science & Technology (2009)	No categories had been used to group measures
16	A Software Maintenance Maturity Model (S3M): Measurement Practices at Maturity Levels 3 and 4 – April, A., Abran, A. - Electronic Notes in Theoretical Computer Science - ENTCS (2009)	No categories had been used to group measures

3.2.1.4. Systematic Mapping Learning Conclusions

The results obtained from the systematic mapping contributed to form a database of IT Services measures for reuse, in which measures are classified per IT Services maturity models areas (CMMI-SVC and MR-MPS-SV) to facilitate search. The measures database can be reused when one is applying the SINIS method. Besides, the mapping results revealed a lack of mechanisms for selection phase of IT service measures, which reinforced the motivation for creating the SINIS method.

3.2.2. Action Research about IT Services Measurement Process and Measures

3.2.2.1. Action Research Motivation and Preliminary Phase

This exploratory study investigate the measurement process and measures in use of an Organization to propose improvements for the process and for indicators in place. As contribution for SINIS, this study had observed usage of indicators related to more than one process.

This preliminary phase aimed at identifying the research context and purpose. This work took place within IT Services department of the same Organization A we worked in previous study. The IT Services Department provide IT services for all other departments of Organization A following ITIL library practices (OGCa, 2011), but it is not certified by any software or services maturity model.

This experience goal, following GQM template (SOLINGEN and BERGHOUT, 1999), can be summarized as:

Analyze the measurement process and measures, *in order to* evaluate process compliance, measures' results, stability, capacity to achieve target annual indicators and measures quality *with respect to* meeting business goals and *under the point of view* of outcomes of MR-MPS-SV maturity model measurement process (MED) (SOFTEX, 2015a), Statistical Process Control (ROCHA *et al.*, 2012) *in the context of* an IT

Services provider organization and considering measures related to GIN, GCD and OCS MR-MPS-SV processes.

Main subareas of IT Services Department are Infrastructure, Hosting, Applications, Security, Networking and End User Computing. All subareas spend lot of effort to perform its services measurement in order to attend performance indicators, which had been created from strategic organizational goals. Performance indicators are derived in measurable goals that employees of IT Services Department need to annually reach, and measurement results are monitored every three months during entire year. Performance indicators are created relating to different subareas, in order to motivate the work within and between teams and improve service quality as a whole. Thus, team members not only care about the processes that meet their areas, but also support the implementation of other areas. In addition to project goals and cost savings, there are also goals related to compliance incidents and availability of applications considered critical to business.

The researcher that conducted the Action Research study works in Hosting subarea of IT Services Department of Organization A. Her main responsibility is to manage the support of global Microsoft Sharepoint (*) web-based applications. She is focused on improving quality of services and for that conducts weekly reviews of capacity, availability, implemented changes and opened incidents with outsourcing support teams. IT Services Department does also include an ITIL Office subarea, with Service Delivery, Incidents, Problems, Changes and Service Continuity teams, cross serving all other subareas already cited here.

IT Services performance indicators are selected to attend goals, but there is no clear direction about how to create strategies for teams to work during the year in order to attend those performance indicators and goals. Many projects and initiatives are created but managers feel hard to control if projects and initiatives results are being effective in attending the respective goal.

The study used the phases proposed by Action-Research method: data gathering, feedback and analysis; action planning, implementation and evaluation.

3.2.2.2. Action Research Main phase

3.2.2.2.1. Data gathering, feedback and analysis

Data collection was based on informal interviews with selected people to get information on the measurement process and measures in use. In this study, measurement process is described and presented in terms of measurement process of MR-MPS-SV maturity model outcomes (SOFTEX, 2015a).

The researcher introduced to Organization A the concepts of process stability and capability to assess whether the processes associated to measures in use are stable and able to meet goals, under the light of Statistical Process Control.

In this study, collection, validation and data analysis phases were done through interviews with selected people to obtain information about measurement process and measures in use, as well as description of measurement process in terms of Measurement (MED) outcomes.

Interview selected people

An analyst from Quality team was interviewed to explain how measures are collected and analyzed. Analysts from Availability, Incidents and Budget teams were interviewed to explain why measures in place were selected and their association to business goals. The Quality analyst has high knowledge about measurement and some knowledge about IT services. Other involved analysts do not have the same knowledge in measuring than Quality analyst but have deep knowledge about IT services area in which they are in.

In order to understand measures related to Incident Management and Continuity and Availability Management is relevant to know what does "crisis" and "high impact critical applications" for Organization A. Crisis situations are handled by Continuity and Availability area. A candidate incident is escalated to a “crisis situation” if it is happening to an application classified as high impact to business. Applications classified in this way can impact business goals when service level is decreased. The list of high impact critical applications is previously communicated to Service Desk for analysts so they are properly classify an incident when it arrives from both a user call or a monitoring event. Also an incident happening for an entire location is escalated to "crisis". Thus, Incident Management and Continuity and Availability Management processes are related. Assertiveness in defining candidates incidents crisis allow the

incident escalation process being more precise, increasing productivity and supporting incident resolution time reduction.

In order to understand measures related to Budgeting and Accounting Management is relevant to know that each server connected in organization has fixed costs for hardware support, software licenses, data storage and backup. Aiming to achieve strategic objective to reduce costs, many actions for server decommissioning and consolidation projects were initiated, and the indicator related to the Budgeting and Accounting Management process is designed to quantify the cost reduction achieved by shutting servers down.

Describe the Measurement Process

Measurement process was described using MR-MPS-SV Maturity Model outcomes. Indicators were identified from business goals and documented in Table 11, following GQM (SOLINGEN and BERGHOUT 1999) definition stage. Thus, Table 11 evidences outcomes of "MED1 - Measurement goals are established and maintained from business goals and information needs" and "MED2 - An appropriate set of measures, guided by measuring goals, is identified and defined, prioritized, documented, reviewed and, where appropriate, updated".

Table 11 - Indicators in use by Organization A (TRINKENREICH and SANTOS, 2014)

Business Goals	Measurement Goals	MR-MPS-SV Process	Base Measures	Derived Measure	Indicator
Reduce Incident Resolution Time	Provide information about incidents solved on time	GIN	BM1: Number of incidents solved on time BM2: Total number of solved incidents	BM1/BM2	Incidents solved on time
Reduce Unavailability Time for Critical Applications	Provide information about effectiveness on solving crisis for critical applications	GCD	BM3: Time to escalate an incident to crisis BM4: Crisis duration time	BM3+BM4	Unavailability total time
Reduce Costs with Servers	Provide information about cost reduction rate due to decomissioned servers	OCS	BM5: Cost of decomissioned servers BM6: Servers total cost	(BM5/ BM6) x100	Cost reduction rate with servers decomissioning

Once a month, the Quality Analyst collects measurement data. Although data collection procedure is not documented. Therefore, current process does not meet "MED3 - Procedures for data collection and storage are specified."

Measurement and analysis plan for each indicator contains measures source, unit, target, calculation formula, purpose, description and scope. Thus, it was found that the present process meets expected result “MED4 - The procedures for measurement analysis are specified.”

In the beginning of the year, goals are reviewed and monthly collection begins. Managers have a quarterly meeting to analyze results. However, analysis is done by comparing current month to last month, or maximum comparing current month with same month of previous year. We identified improvement opportunities for data analysis (which is going to be showed in next steps) but even then, data is collected and evaluated according to the measuring plane of each measurement. Like that, current process meets expected result for “MED5 - Required data is collected and analyzed”.

Measurement and collected data is stored in a spreadsheet, but is on a shared network folder that can be accessed only by performance analyst who conducts the collection and analysis. Thus, the expected result for “MED6 - Data and analysis results are stored” was considered as partially met. There is a quarterly meeting of managers, but there is not a place where everyone can directly access and monitor measurement results. Thus, expected result for “MED 7 - Data and analysis results are communicated to stakeholders and used to support decision making” was also considered as partially met.

3.2.2.2.2. Plan Actions

In this study, planned changes included a new way to analyze measurement results, improvements to both measures in use and to the measurement process, as described below.

The first planned action was a new way to analyze measurement results. Measurement process does not require predictions through a quantitative and statistical analysis MR-MPS-SV highest maturity levels (A and B) do. However, in order to assess whether processes are able to achieve their targets, we proposed the usage of statistical analysis, instead of only comparing accumulated values at a point of the year to target. Organization A should investigate improvement opportunities to processes in order reduce variations and facilitate a better team planning and required effort to close incidents on time, to reduce applications downtime and to reduce servers’ cost. The second planned action was to improve quality of indicators in use. We observed that "Reduce total time in crisis" indicator is directly related to GCD process, but is also

associated to other MR-MPS-SV processes: (i) GIN, as an incident is escalated to crisis when impacts a critical application; (ii) GNS, because the purpose of this indicator is to minimize the total impact time to the user in order to meet availability established in service level agreement; (iii) GPL, because a problem record is always created after a crisis is closed, on order to investigate the failure root cause. Goal associated to this indicator would be more effectively measured if applications' unavailability could be directly measured.. This indicator goal is to encourage those involved to do the best possible for crisis to be closed as soon as possible, but measuring unavailability directly by a monitoring tool would count on automated data collection, less prone to human error or bias, being cheaper and more reliable. Other availability measures found in literature that could be considered are: Mean time to restore a service after failure and mean time between service outages (LEPMETS *et al*., 2014). Other measures related to GCD process can be found in (TRINKENREICH *et al*., 2015a). Organization A is planning to include new indicators for unavailability from monitoring systems, but will continue measuring crisis durations. We found "Incidents solved on time" indicator in literature, but also others for incident management that could complement it in (LEPMETS *et al*., 2014), (LIU *et al*., 2011), (TRINKENREICH *et al*., 2015a) and (VALVERDE and TALLA, 2014). Organization still needs to check data availability to help selection of new indicators to attend this goal. We did not find "Cost reduction with servers decommission" in literature, but measuring the reduction tax of production cost is suggested for financial control (BROOKS, 2014) and is directly aligned to cost reduction goal for Organization in this study. Organization plans to expand scope and include other reduction indicators for mailboxes and maintenance contracts.

The third planned action was to improve quality of measurement process. We suggested the following improvements for measurement process: create a collaboration shared site in Microsoft Sharepoint, which is the collaboration software solution used by Organization A, document data collection and analysis processes (according to MED3 outcomes), provide data storage and documentation in a centralized and organized way, and also not only for a single person access (MED6 outcomes), and provide access to up to date measurement results (MED7 outcomes).

Suggested improvements for measurement process can help improvement of IT service quality, as managers will have constant visibility of measurement results and data to support decision making and actions tracking.

3.2.2.2.3. Execute Actions

Actions execution is performed by Organization A according to plans created in previous step. Changes are still ongoing, being delivered under projects in place. No hiring or new contract with additional cost was necessary to implement planned actions. For process improvements, the shared virtual directory in Microsoft Sharepoint has been created to allow a single place to store data. Also, procedures for data collection and storage are being created to allow deeper analysis for measurement plans and start improving indicators in place. A shared area providing access to measurement results was not created yet.

3.2.2.2.4. Evaluate Actions

Evaluation includes considering results of Action Research whole process, in order to a possible future next cycle of research to take advantage of lessons learned in the current one. Lessons learned are shown in Table 12 bellow.

Table 12 - Lessons Learned during Action Research experiment in Organization A.

	Lessons Learned
1	The assessment IT services quality can be performed in organizations, even when core business is not IT, by measuring IT services and comparing to targets.
2	Using indicators related to more than one process area help different teams to work together and support each other to achieve targets
3	Organizations can foster work among team members when conditioning individual results to group results and this can be supported by measurement. For example, production support analyst, who is responsible for application X can have incidents being solved on time, but he needs that another analyst of the same department, responsible for another application, also have his application' incidents being solved on time, to achieve department goal that both are part.
4	Organization is able to foster work among different teams when using, even with different weights, indicator from one team to another team. For example, the project manager may have 20% of his total goal related to delivering project on time. For him to count on production commitment and support, production team goal does also include project delivery indicator, even though with 5% or less.
5	The practice of establishing measurable goals for IT can be considered by other organizations and the creation of total goals to consider indicators "intra teams" (between members of the same team) and between teams, and also the creation of measures that can permeate more than one team (example: incidents caused by changes).
6	Measurable goals to reduce IT costs encourage infrastructure consolidation activities, simplification of processes and applications, and decrease services high levels requirements for environments that are, in fact, not really critical to business.
7	While it is possible to find measures related to IT services processes in literature, evaluate them in a real context is not trivial due to lack of available data and, when available, wide variation in process, considering control limits for statistical tests.

3.2.2.3. Action Research Learning Conclusions

Through this action research study we found that indicators related to more than one process area can stimulate team work and support between different teams, having them supporting each other to achieve IT Services Goals. Like that, it was possible to perceive that indicators can be related to more than one process and, considering this fact, we decided to further investigate about measures related to different processes.

3.2.3. Case Study to evaluate Measures found in Systematic Mapping and to investigate how can one IT services process impact others

3.2.3.1. Case Study Motivation

This study aimed to provide a first investigation about usage of measures found in literature in a real scenario, increase the list of measures to be reused during SINIS execution with those in use by Organization that were not found in literature. Additionally, this study aimed to investigate impact about different IT services process can cause each other that could help selecting strategies to support achieving IT services goals.

Although some papers suggested the applicability to IT industry of some of the measures found in the systematic mapping, there is no detail about how they had been used. During the mapping study execution, measures related to more than one process area (i.e., measures that can be used do analyze more than one process) were identified, like: “Incident numbers can increase because an executed change that had failed” (number of executed changes is a measure that can be used to evaluate the Changes Management process as well as the Incidents Management process, since changes can be root cause of incidents); “Incident numbers can grow because of a Data Center unavailability”, “Unavailability can decrease because team had found root cause for a recurrent issue”. However, there is no analysis regarding the impact of a measure on others.

Therefore, this case study aimed to investigate the applicability of such measures in a real context and understand the relationship between the measures related to more than one IT service process by verifying in industry how the measures suggested in literature are being used. The case study was carried out in a global large company and was organized in two phases: planning and execution.

3.2.3.2. Case Study Planning and Execution

The research questions that the case study aimed to answer were: (i) What influence can an IT services processes have on others? (ii) Which of literature suggested metrics are being used by organization? The case study was performed by following these steps:

- Analyze measures found in literature to find relationships between them;
- Select organization for case study;
- Identify and select process areas and managers to be interviewed;
- Interview selected process areas managers and ask for available data for analysis in next steps;
- Identify measures in use by organization;
- Analyze measures in use by organization to find relationships between them;
- Identify organization measures that were found and were not found by mapping study in literature;
- Increase mapping study with measures used by organization that were not found by mapping study in literature;
- Provide information back to organization about measures suggested to be used for each process area and for correlated areas.

The case study was performed in IT services application and infrastructure department of a large global organization headquartered in Brazil, that here is called Organization A. In order to answer the research question (i), we analyzed all measures found in literature to find relationships between them by checking what happens to a second metric (if it increases or decreases) when a first metric value increases. Relationships were found by researcher by understanding each measure meaning and considering content of ITIL (OGCa, 2011) processes. By doing this, it was possible to find process areas with few metrics in literature, but related to many other process areas (for example Service Continuity and Change Management), with more measures. Table 13 shows the measures with more influence to others. The third column depicts what happens to the second metric when the first metric increases.

Table 13 - IT service measures with more relationships found to other measures .

First metric	Second metric	Impact
Service availability	Amount of incidents that caused business impact because of performance issues; MTBSI – mean time between system incidents; MTBF – mean time between system failures; Business impact caused by IT service outages; Number of service interruptions per month, per application, per configuration item; Duration of service interruptions per month, per application, per configuration item; Amount of services outages caused by capacity and availability issues	Decreases
Service availability	Number of avoided incidents per day	Increases
Percentage of change requests not tested because of due date	Percentage of successful change requests; Service availability; Number of avoided incidents per day; MTBSI – mean time between system incidents	Decreases
Percentage of successful change requests	Mean time between versions; Amount of IT services versions	Increases
Percentage of successful change requests	Amount of incidents caused by change requests; Amount of changes that had caused incidents and problems; Duration of service interruptions per month, per application, per configuration item; Service availability	Decreases
Percentage of change requests not tested because of due date	Amount of incidents caused by change requests; Amount of changes that had caused incidents and problems; Amount of change requests after a transition to production (considering a certain period)	Increases

One relation we identified from the list of measures occurs between Incident and Change Management processes (incidents can be caused by changes). We also interviewed managers from Organization A to understand how IT services processes are related. The results are shown in Figure 7 and the some of them are discussed in the sequence.

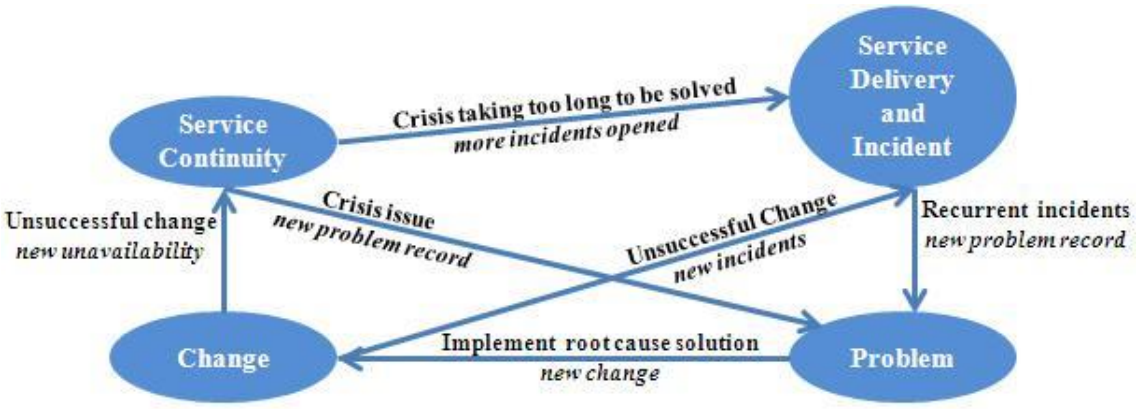

Figure 7 – Relationships between areas selected for case study in Organization A (TRINKENREICH and SANTOS, 2015a)

Incident and Service Delivery managers are the same manager, who is responsible of making sure that Service Desk (first support level for all IT Service Department subareas) receives users requests and process according defined flow,

provides solution using support scripts or, when is not possible to solve the issue or attend the request, opening Incident tickets for next levels support.

Problem manager is responsible for tracking all problems record lifecycle, including problem record opening, categorization, root cause identification and closing. It does not include root cause solution implementation, as it is scope of Change management, and this is how Problem and Changes relate with each other.

Change manager is responsible for keeping configuration database up to date and tracking all changes in steady state applications, network and infrastructure. An unsuccessful change can cause issue in the environment and then users can call Service Desk and Incidents can be opened. This way is another relation that can exist between Change and Incident areas.

Service Continuity manager is responsible for controlling by opening crisis rooms to return availability of high critical applications. This team controls not all applications because high cost involved. A crisis room is opened in this company when there is an unavailability of a high impact application. When a crisis room is opened, all technical teams connect to a conference room and get there working together until the issue is solved and application is back again. This process had been created to minimize impact to applications considered critical to business and as faster it can solve the issue, fewer incidents are opened by users. This is how Service Continuity and Incident areas relate with each other. Also, every time a crisis room is closed, it generated a new problem record to be opened and this is how Service Continuity and Problem areas relate with each other.

Managers of the five ITIL Office teams selected for case study have more than 10 years working at Organization A, are committed to provide and improve quality of services to users. They had highlighted that impacts caused by processes intersections are unknown and still need to be measured and controlled, in order to verify if, how and where can processes be improved.

Incident manager had informed that he can observe some applications that are running in production for quite a long time (years, for example), with a high amount of incidents continuously being opened by users reporting errors, and also with lots of changes in code being executed on it. He and the Change manager are interested in understanding if there is any cause-effect between Incidents and Changes for each of those applications, and how can they measure that. They aim to find if this is happening because Changes are being executed to release new versions.

.Looking at these processes in Organization A, we learnt that it does not document whether each incident is caused by a change. Both managers of Incident and Change Management processes said that is a big challenge to understand how changes impact incidents and how incidents impact changes. So, in addition to literature analysis that was already performed, we analyzed Incident and Change Management processes from Organization A by using statistical correlation tests to try to find some correlation between them.

The objective of that is to propose a way to help Organization A on finding root cause for having a large amount of incidents opened by users for applications that are hosted on this platform and so improve service quality. In order to do that, we compared values from changes in one period to incidents in next period, because we suppose that a change happens first, and after some time, the impact occurs and then incident happens.

We could not find correlation between changes and incidents when considering total applications, but managers informed that they still can notice errors and cases of unavailability after some changes that need to be further investigated. Although, we answered research question (i) and suggested a way to statistically find correlation between two processes.

In order to answer research question (ii), we interviewed managers of five IT service process areas (Incident, Problem, Service Delivery, Change and Service Continuity), asking what measures they use today and if they wish to get some other results by measurement that is not being done yet.

Also, we increased the mapping study metrics list with new metrics informed by the Organization A and marked those ones that were returned by literature and are really used.

Organization A uses 19 metrics for IT services areas selected for this case study, as follows: First Call Resolution, Incident Resolution on Time, Incidents - Backlog per Vendor and Support Group, Incidents - Backlog per Status, per Aging and per Priority, Total and % Incidents Closed on Target per Vendor and Support Group, Amount of problems with missed root cause due date, Amount of problems that had inconclusive root cause, Amount of open problems for high impact applications, MTBP - Mean Time Between Problems, Application Availability, Application Performance, Application User Experience, TTE - Time to Escalate an Incident to Crisis, Amount Time in Crisis, MTBC - Mean Time Between Crisis, Rate of denied x approved changes, Rate of successful x unsuccessful executed changes, MTBCC - Mean Time Between Corrective

Changes and Amount of Emergency changes. From those measures, 68% of them had been found in systematic mapping study. Only one metric used by Organization A correlates different process areas ("TTE - Time to Escalate an Incident to Crisis" which is about Incident and Service Continuity areas). All measures and respective sources are shown in Appendix 1, the ones that were found in Organization A but were not part of literature mapping study were marked with source being this present case study.

3.2.3.3. Case Study Learning Conclusions

Through this case study we were able to start evaluating and increasing the created database of IT Services measures for reuse when applying SINIS method. Also, we suggested relationships between measures and started investigation of cause-effect between different processes. Changes and new releases that cause incidents are examples of correlation and intrinsic cause-effect relationships between Change, Release and Incident processes. Increase and decrease analysis is a first step to study cause-effect between measures, and statistical correlation tests can be used for a deeper investigation to understand how long after an event one measure can affect another. Understanding that different IT services process can cause impact to each other was relevant to SINIS, as it was used during critical process mapping. Instead of investigating issues, difficulties or problems only at each isolated process, SINIS suggests a broader view of related processes in order to find proper strategies to achieve IT Services Goals.

3.2.4. Case Study about using Business Process Intelligence for Critical Process Analysis

3.2.4.1. Case Study Motivation

This study aimed to investigate how can Business Process Intelligence techniques support identification of suitable strategies to achieve IT Services goals.

We aimed to use Business Process Intelligence techniques for process qualitative analysis, discovering and obtaining knowledge about a certain process (related to a business goal) and like that being able to find critical sub-process to be focused by measurement to improve process quality. The selected IT Services process was Incident Management, recognizing that:

(i) Business goal of organization that participated in case study was reduce incident resolution time;

(ii) Incident Management produces a large amount of log data that can drive knowing users' needs and issues;

(iii) Incident Management is a process that is also used for corrective software maintenance support, a process that is mostly considered by service providers for measurement initiatives, and the process related to business goal of organization we worked with.

3.2.4.2. Case Study Planning

Research questions that we aim to answer through this case study were:

(i) Which Incident Management sub-process is causing more impact to resolution time?

(ii) Which measures can be used to measure this sub-process?

(iii) What actions can be taken to improve Incident Management process in order to reduce impact of this sub-process in resolution time?

In order to execute case study, we have followed a set of steps as follows:

- Select organization for case study and interview manager;
- Extract data, define filters and select the process mining tool to be used;
- Cleanup data, prepare and aggregate data, use selected process mining tool;
- Use statistics features from process mining tool to analyze data result and select process standard flow;
- Use GQM+Strategies to align organization goals with strategies, goals, questions and metrics for Incident Management;
- Provide information back to organization about metrics suggested to be used and process improvements.

3.2.4.3. Case Study Execution

In first stage, we identified IT services infrastructure department of Organization A, used in previous studies. Incident Manager was interviewed and informed that he spends more effort than he desires to perform, analyze, report and plan new metrics in order to attend organizational goal of reducing incidents resolution time. Also, he had mentioned that Organization A uses only three Incident Management metrics, that indirectly should support attending resolution time: "Incidents solved on time", "Service

desk resolutions" and "Incidents backlog". However, he pointed out that only these metrics are not effective and enough to provide results of reducing resolution time.

We had initiated the second stage by extracting and validating available data in Organization A's Incident Management tool (HP Service Manager 9 – SM9). We one month data (April 2014), due to the huge amount of information, and one application (Intranet), as it was reported as being the application with larger amount of incidents being opened by users. Because there was no preconceived process, we conducted a first execution to discover Incident Management process itself and answer some basic questions about it: how many incidents were opened in a determined month, what are the minimum, maximum and mean time closing an incident and which possible flows an incident resolution can have. We selected Disco[2] tool because it could discover control flow without removals or adjustments to original data, and because it abstracts the algorithm for process detection.

In third stage we had filtered incidents selected period and application, and started to prepare data. One incident has many activities and events, representing incident lifecycle. Original log file had 14.815 events. From those, there were 120 different activities. After extraction, we had to perform some cleanup of wrong entries that were not representing real activity names, for example concatenating an activity name with an incident number in same field. Possibly it was because some kind of bug in SM9 extraction tool, but as they represented only 1% of total, we removed and not considered entire incident registry for those. So, we had excluded 1% of incidents from data because of what we had considered bad data. After removing them by using Disco tool functionality to filter undesired activities, we could get a process with 27 activities. Through analysis of process variants, we found 507 different paths, from 993 total identified process instances. Although it answers one of basic questions (which process flows can an Incident Resolution have?), at this point this high number of activities and transitions did not allowed us to answer research question (i).

The control flow model identified by Disco tool at this point had many activities and transitions. At this stage, we used a Disco tool native functionality to aggregate some activities and transitions. For example, there are flow cases that go from activity A to activity B and then activity C. There are also cases where activity A flows directly to

[2] Process Mining and Automated Process Discovery Software for Professionals - Fluxicon Disco, http://fluxicon.com/disco/ (2014)

activity C. Disco tool easily abstracts these two types of cases making a control flow to consider only transition from A to C. Therefore, we can choose where to drill-down from a general and major flow to a detailed one. We considered the most regular flow (with 5 steps) and used Disco statistics and performance features to analyze elapsed time of each transition, in order to help us answering research question (i).

In fourth stage, we used global statistics feature to identify the amount of total events (11,203 events) and answer basic questions: How many incidents were opened and what are the minimum, maximum and mean time closing an incident. Total of 993 incidents had been opened, with 5.5 days of mean and 4.7 days of median to be solved. Minimum time to close an incident was 22 minutes and maximum had lasted 36 days. Even though, as we have shown that most cases had been solved with only 5 activities (Figure 8), this was considered a standard for analysis. Based on this, we had simplified incidents flow to a 5-steps process: Open, Assignment, Start Work in Progress, Resolved and Closed.

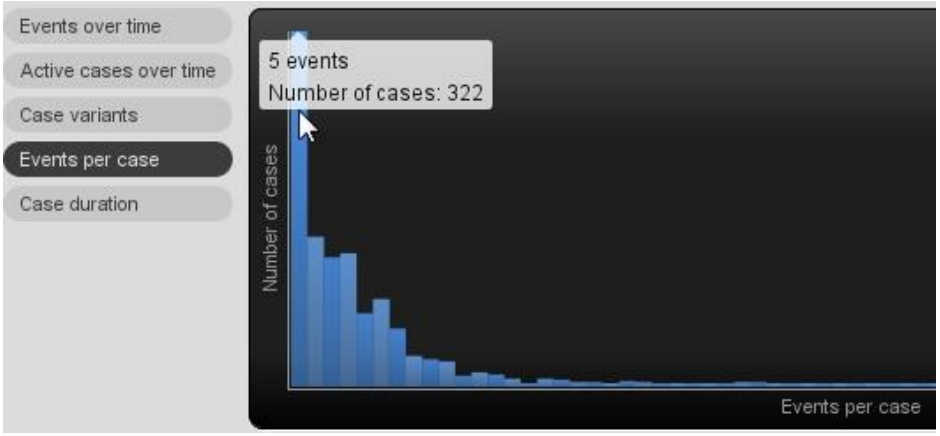

Figure 8 - Graph from Disco tool (TRINKENREICH *et al.*, 2015b)

Table 14 provides time performance analysis for each transition of the considered 5-steps process. We can notice that it is taking more for someone to take responsibility to solve the incident (Open to Assessment) than to properly solve it (Work in Progress to Resolved), answering research question (i) "Which Incident Management sub-process is causing more impact to resolution time?"

Table 14 - Duration analysis for each transition (TRINKENREICH *et al.*, 2015b)

Transition	Total Duration	Max Duration	Mean Duration	Median Duration
Open → Assignment	68,6 days	26,3 hours	109,3 minutes	51,5 minutes
Assignment → Work in Progress	11,6 days	5,9 days	24,6 minutes	68,5 minutes
Work in Progress → Resolved	13,5 days	22,4 hours	49,2 minutes	11,4 minutes
Resolved → Closed	111 months	4 days	3,8 days	4 days

In fifth stage we used GQM+Strategies (BASILI *et al.*, 2005) to align goals, strategies, questions and measures (Figure 9) in order to suggest a measurement improvement for Organization A, and answer research question (ii) “Which measures can be used to measure and control this sub-process?”. We used root cause analysis to investigate why Assignment is taking so long, and found that service desk commits many assignment errors, taking longer to define correct team to send incident. We also found that errors happen because lack of available, correct and updated information to be used by service desk during Assignment.

Considered context factor for GQM+Strategies was cost reduction scenario that Organization A is facing. Considered assumptions for GQM+Strategies were that there is already human resources available and with enough expertise to generate information and update knowledge articles. New metrics suggested were: “Time to Own” (number of minutes that an incident is taking to be assigned to correct team), “Incident Assignment Correctness" (percentage of incidents that were assigned to correct team) and “Articles not updated” (number of times that service desk cannot find required information to solve an incident or assign to correct team).

In sixth stage, in order to answer research question (iii), we proposed process improvements for “Open to Assignment” part of Incident Management process. Knowledge articles used by first level support represent the way that service desk team is able to solve incidents by itself and also assign to proper higher support teams when cannot be solved in first level. So, improve these artifacts is a way to make first level capable of solving more incidents and also reduce time and errors in Assignment phase, which is the bottleneck for incident resolution time (and reducing it is the Organization A goal). Service Desk support knowledge articles should contain direct, simple and proper questions for a first level support analyst to do when a user calls reporting an error or requesting a service. Search mechanisms should provide easy finding of articles by many key words.

3.2.4.4. Case Study Learning Conclusions

We found that BPM lifecycle is able to assist in Incident Management improvement, since the process identification and its variations (according to criticality, for example) to its monitoring & control and redesign. First result was discovery of actual Incident Management process by extracted data. From 5-steps process (Open,

Assignment, Work in Progress, Resolved and Closed) we had taken statistics to measure time performance for each transition, and answered research question (i). Transition "Open to Assignment" was the bottleneck, the one causing more impact to resolution time. After mining incident event logs, we found that Organization A is taking, in average, more than double time to assign proper support team than to actually solve an incident.

Also, this shows that stakeholder could discard transition "Resolved to Closed", that is, this transition not critical as the majority of this transition was handled automatically. Incident Manager for Organization A had explained us that first level support uses knowledge articles to understand what is being requested by user and for what team should be assigned to solve it. He had also informed that many times there is no information, or information in not updated about support teams for each service, and because of that, first level support can commit assignment errors.

Through this case study we could find that Business Process Intelligence can be used to evaluate critical process in cases when activity logs are available, finding process bottleneck and supporting process qualitative root cause analysis. Identify bottleneck in processes helps to understand points on which strategies should focus. We could also validate GQM+Strategies as a good approach to be used as a basis in SINIS method, selecting indicators for goals and strategies in more than one organization level.

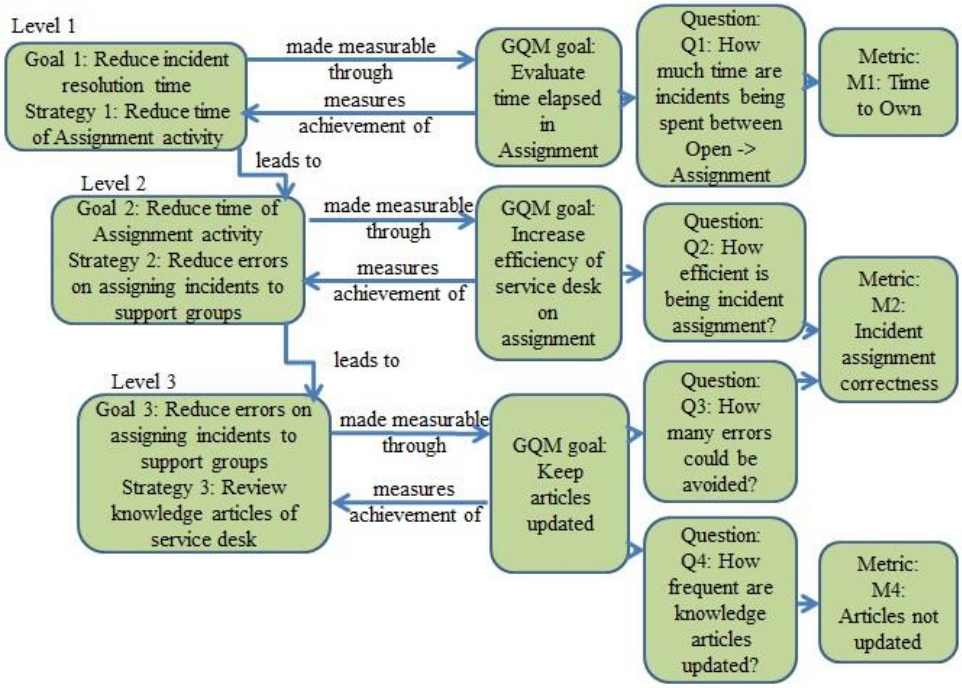

Figure 9 - GQM+Strategies diagram proposed for Organization A.

3.2.5. Action Research about using Critical Process Mapping and Outcomes of MR-MPS-SV to evaluate an IT Services Process and Select Indicators using GQM+Strategies

3.2.5.1. Action Research Motivation and Preliminary Phase

This study aimed to investigate how could process mapping be used to support strategies selection to achieve IT services goals, how could an existent measures database be reused during measures selection and if GQM+Strategies is applicable as a basis for the proposed method.

This preliminary phase aimed at identifying the research context and purpose. This work was a continuation of previous Action Research, taking place at the same IT Services department of Organization A used in previous studies, now focusing on deeper exploration of Incident Management process. As also found in previous case study that, more than measuring isolated processes, services providing should be considered as chain of interconnected processes to also control and measure these relationships.

This experience goal, following GQM template (SOLINGEN and BERGHOUT, 1999), can be summarized as:

Analyze the Incident Management process, *in order to* evaluate process compliance and relationships with other processes *with respect to* meeting business goals and *under the point of view* of MR-MPS-SV Incident Management process (GIN) outcomes (SOFTEX, 2015a), and GQM+Strategies approach (BASILI *et al.*, 2005) *in the context of* an IT Services provider organization and considering measures related to GIN, GCD and OCS MR-MPS-SV processes.

We used process mapping to document Incident Management process and included description of relationship with other IT services processes to support finding issues to be solved by strategies to achieve business goals. We used Incident Management process' outcomes in MR-MPS-SV maturity model to guide description and evaluation of organization process quality. Then, we applied GQM+Strategies to derive goals into strategies and selected indicators in different business levels.

3.2.5.2. Action Research Main Phase

3.2.5.2.1. Data gathering, feedback and analysis

Data collection was based on informal interviews with selected people to get information on Incident Management process and measures in use.

In this study, Incident Management process is described and presented in terms of MR-MPS-SV Incident Management process outcomes (SOFTEX, 2015a).

Interview Selected People

In this study, collection, validation and data analysis phases were done through interviews with selected people to obtain information about (i) Incident Management process and description; (ii) Incident Management goal and indicators in use and (iii) Process in place to select IT Services indicators and main difficulties.

In order to answer (i) and (ii), an analyst from Incident Management team was interviewed to explain how does the process work and what indicators are being collected today. He informed that his department goal (which is part of IT Service department) is to "Reduce Incident Resolution Time", which was not achieved last year.

As being one of IT services department main engineering areas (which solves infrastructure incidents), in order to answer (iii), Infrastructure Manager was interviewed to report issues he faces during IT services measurement overall process. He informed main difficulties faced in measuring IT services are: 1. Derive business goals in IT service goals; 2. Select projects or initiatives to meet IT service goals, 3. Keep control of changes that can impact goals and projects or initiatives being executed to achieve those goals.

In this study we created a new process based on GQM+Strategies (BASILI *et al.*, 2005) approach and process mapping focused on relationships between IT service processes to support Organization A.

Describe Incident Management process in terms of MR-MPS-SV outcomes

Incident Management process was described using MR-MPS-SV Maturity Model outcomes and summarized in Table 15 bellow, showing that Organization A attends all outcomes.

Table 15 - Incident Management process' outcomes in Organization A

Expected Result	How does Organization A attends outcomes
GIN 1 - An approach to manage incidents and service request is established and maintained.	Organization A has a structured and detailed documentation describing incident management process, which consists of seven main sub-processes for handling user requests.
GIN 2 – A system to manage incidents and service requests is established and maintained.	Organization A has an incident management system based "BMC Remedy" solution (http://www.bmc.com/it-solutions/remedy-itsm.html) to support the process, integrated with e-mail and instant messaging software to facilitate and accelerate communications and service. The system is

	also used by other service areas that have integration and interact with Incident Management, creating an integrated flow view.
GIN 3 - Incidents and service requests are recorded and classified	In sub-process “1-Incident record”, service desk receives incident request, checks for previous incidents, collects information and records the new incident. If service desk is able to resolve the request using knowledge base, the incident is closed. Otherwise, it is classified in relation to its impact (extension of the impact to users and how critical incident is to business) and Urgency (how urgent incident resolution is for user and effects on business processes).
GIN 4 – Incidents and service requests are prioritized and analyzed	According to predefined associations of Impact (which can be 1-Extensive 2-Large, 3-Moderate or 4-Small) and Urgency (which can be 1-Critical 2-High 3-Medium or 4-Low), the incident priority classification is done.
GIN 5 - Incidents and service requests are resolved and closed	When service desk receives the solution from specialist and is able to resolve an incident, the sub-process "6-Incident Closure" is followed. It updates and closes the incident with solution sent by specialist and offers the incident to the user to validate provided solution, going to sub-process "7- Incident Solution Validation".
GIN 6 - Incidents and service requests that have not progressed as service level agreements are escalated.	When an incident has impact 1-Extensive and urgency 1-Critical, it is escalated to crisis situations, following sub-process "5-Incident Escalation". Crisis management is part of the Availability and Continuity process, and happens through a war room with all necessary technical teams to restore service.
GIN 7 - Information about status or progress of a reported incident or service request is communicated to stakeholders	Upon receiving notification of incident solution, the user tries verifies the provided solution. If is acceptable, no need to take any action (in five days the incident is automatically closed). If the user does not consider an acceptable solution, he can login to the system and reopen the incident, requesting a better solution.

Map Incident Management process highlighting relationships with other processes

Incident Management process was mapped in Figure 10 using simple workflow notation to provide understanding about process flow.

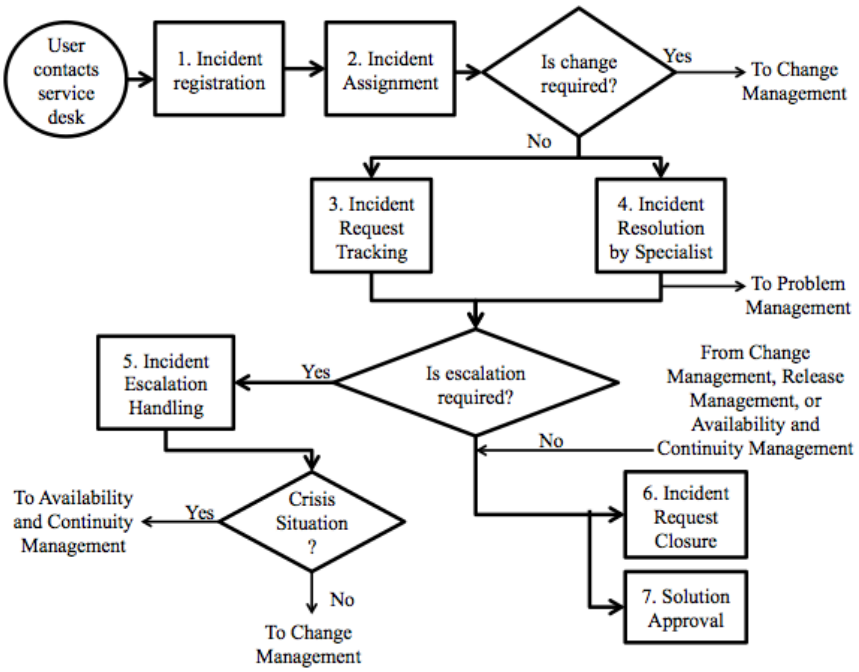

Figure 10 - Process mapping of Incident Management in Organization A.

Main goal was to highlight relationships with other processes (like Change Management, Problem Management impacting causing Incident Resolution Time). Sub-processes of Incident Management process for Organization A are described in Table 16.

Table 16 - Sub-processes of Incident Management process for Organization A.

Sub-processes	Objective
1-Incident Record	Used by service desk analysts when they receive requests from users and record incidents.
2-Incident Assignment	Used by a service desk analysts and coordinators to assign incidents to appropriate specialists or engineers for resolution
3-Incident Tracking	Used by engineers when they are dealing with reassignments or SLA escalations.
4-Incident Resolution	Used by solution engineers on incidents assigned to them.
5-Incident Escalation	Used by the owner of affected service in order to the incident to be more efficiently solved.
6-Incident Closure	Used by service desk analysts when they receive solution from engineer and can resolve incidents.
7-Incident Solution Validation	Used by requestor user after review and accept the provided solution to close his incident.

3.2.5.2.2. Plan Actions

In this study, planned changes included a new way to analyze measurement results, improvements to both measures in use and to the measurement process, as described below.

Indicators in use by Organization A for Incident Management are: "Percentage of Incidents Solved on Time", "Percentage of Incidents Solved by Service Desk" and "Percentage of non-Solved Incidents". Incident Management analyst reported that main goal of his department is to reduce incident resolution time.

Incident Management process is the one for which most of IT services measures can be found in literature, and the three indicators in use by Organization A were found in systematic mapping conducted in (TRINKENREICH *et al.*, 2015a).

Indicators based on operational measures are usually considered by IT organizations. However, when isolated, those indicators can be not able to answer questions about the overall efficiency of IT services providing. Other measures could help to do so, for example: "Percentage of Incident caused by Changes" (STEINBERG, 2001). This measure relates Incident Management and Change Management processes, and could be used by Organization A to help understanding root-cause for incidents being opening. Thus it would be possible to support the understanding of a possible cause-effect relationship between the two processes, as deeper investigation of change scenarios and impacts (as for example when there is a new hardware implementation, network, application or system update etc.), and the increase or decrease of open incidents.

Design a process to support selection of IT services indicators

In this research we designed a new process based on GQM+Strategies (BASILI *et al.*, 2005) approach and process mapping focused on relationships between IT service processes to support Organization A, as we show in Figure 11.

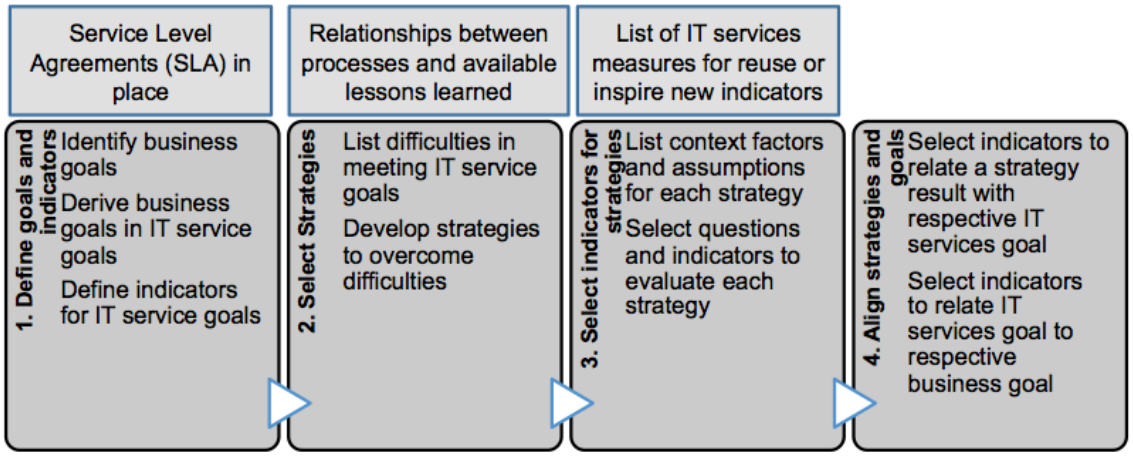

Figure 11 – Designed process to support indicators selection in multiple levels.

3.2.5.2.3. Execute Actions

We executed designed process in Organization A to validate effectiveness and find improvement opportunities for it. Considered business goal was "Improve User Experience with IT". Infrastructure manager informed that this goal is measured through results of service level agreements, which include incident resolution time, service availability, among others, and is measured by indicator "Percentage of Service Level Agreement Being Met". During 2014, service level agreements missed the incident resolution time. Thus, this was selected to be studies in this action research.

Process mapping focusing on relationships with other processes (in this case, between Incident Management process and Change Management, Problem Management and Availability and Continuity Management processes) was used in analysis of possible causes and difficulties to reduce incidents resolution time, even not being only source of cause for incidents not being solved on time.

Strategies were selected with indicators to overcome difficulties found in relationships between Incident Management process and Change Management, Problem Management and Availability and Continuity Management processes, and indicators to measure the contribution of each of these strategies for IT services goal.

In Figure 12 we present execution of designed process to select indicators and strategies in different levels in a grid based on GQM+Strategies approach (BASILI *et al.*, 2005).

3.2.5.2.4. Evaluate Actions

Evaluation includes considering results of Action Research whole process, in order to take advantage of lessons learned in the current cycle. The research objectives were achieved, and by mapping Incident Management process, we could find relationship with others service processes and new strategies related to difficulties under those integrations. As a contribution, a process to select indicators including more than one process and aligning business goal was created and applied.

The process is designed to select indicators for IT services and was evaluated by Infrastructure manager who reported that it meets the department needs and requested that it be applied to split other goals.

He informed that it would be interesting to have an automated tool for collection phase of measurement process to calculate indicators result. It will be addressed in future works.

3.2.5.3. Action Research Learning Conclusions

Using GQM+Strategies to breakdown business goals in IT services goals, before creating operational strategies, enables to reduce abstraction level of goals in more concrete and operational actions. We note that if reuse of an existent list of measures facilitated and inspired selection of indicators. We also noted that service level agreements are relevant artifacts to be used as inputs in IT services context, as they are able to translate a qualitative measure as "user satisfaction" in quantitative indicators agreed between both parts, that can be measured, controlled and managed, turning the selection of indicators IT services more direct and objective.

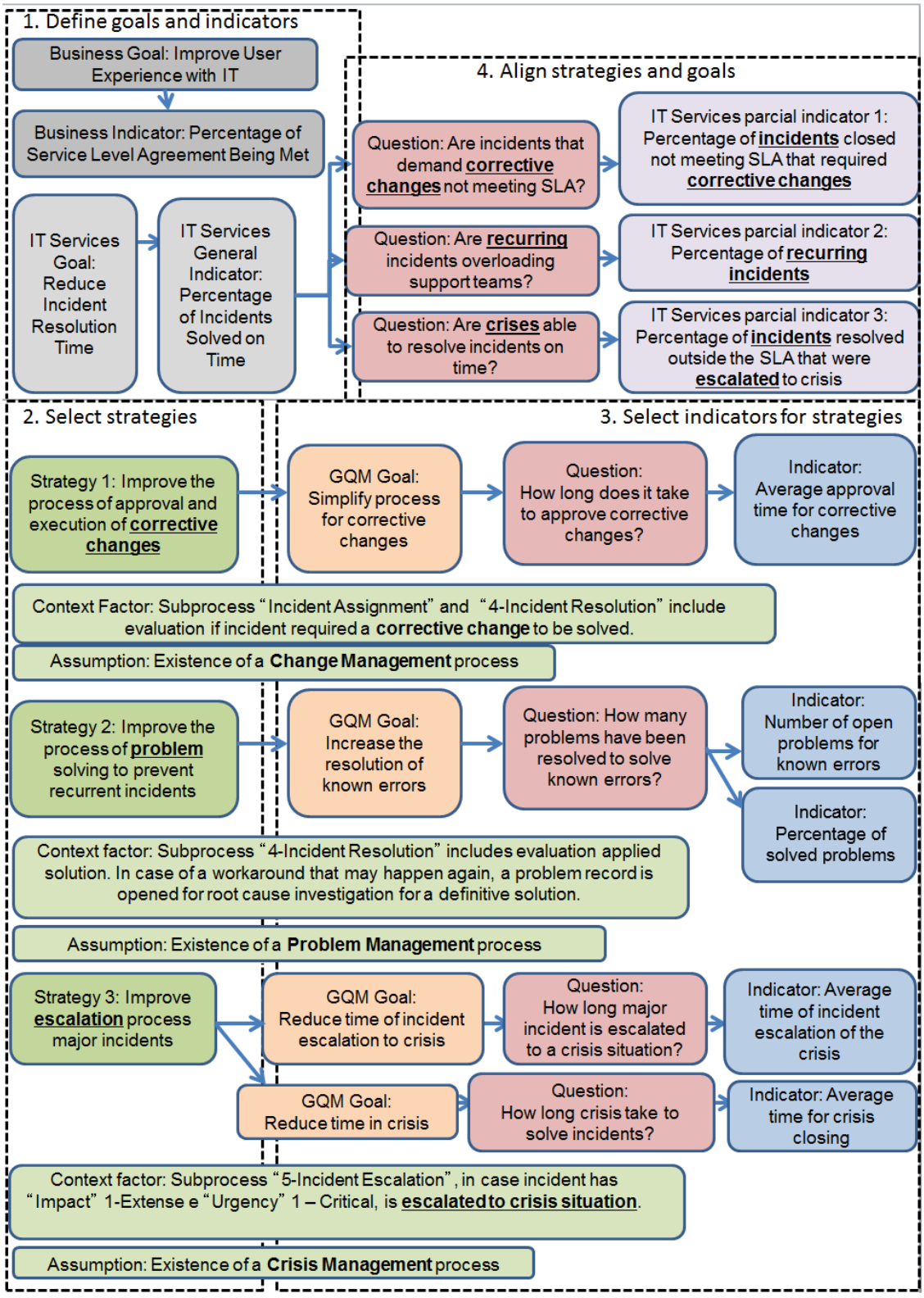

Figure 12 - GQM+Strategy grid created for Organization A

3.2.6. Case Study using Qualitative Analysis to find about How Operational Actions, Projects or Initiatives are Defined to Achieve IT Services Indicators

3.2.6.1. Case Study Motivation

This study aimed to support finding how can strategies be selected to achieve IT services goals. For that, we aimed to understand how IT Services departments define operational actions, projects or initiatives (called by GQM+Strategies as "strategies") to achieve its goals and indicators targets.

3.2.6.2. Case Study Planning and Execution

Research questions that we aim to answer through this case study were: (i) How are operational actions, projects or initiatives defined to achieve IT Services goals and indicators? (ii) What difficulties are faced during this process? In order to execute case study, we have followed a set of steps as follows:

- First stage: Select organization for case study and collect data through interviews with three different IT Services department managers
- Second stage: Perform qualitative analysis of data gathered in interviews
- Third stage: Provide results reporting back to organization

In first stage, we identified three different departments of IT Services directory same Organization A used in previous studies: Infrastructure, Service Desk and Applications. Data collection was done through one round of semi-structural interviews by phone using those two research questions and asking interviewees to be comfortable to talk as much they wanted and their time allows to. Interviews took from 30 to 60 minutes each and were done in Portuguese. Because of that in-vivo codes are in Portuguese.

In second stage, after getting all interviews done, we started to transcript interviews' recorded content and to code data from transcripts, comprising (a) identification of relevant codes within the context to answer research questions (i) and (ii); (b) analysis of relationships between codes; (c) identification of categories to group previously found codes.

After data collection, the qualitative analysis performed was based on coding procedures of Grounded Theory (GT) method. While analyzing data contained within interviews, we created in-vivo codes, using the marked text from interview transcript as code. For example, when reading the following passage to research question (ii) in

interview transcript: “We had difficulties on monitoring initiatives”, in-vivo code used was “difficulties on monitoring initiatives” and then code “Hard to monitor initiatives” .

For example, when reading the following passage to research question (ii) in interview transcript: “We had difficulties on monitoring initiatives, because we don´t have dedicated people for measurement activities, people have to share their time for other activities with it, and also there is a lack of discipline to measure and report”. We coded “Lack of discipline to measure and report” for transcript passage “lack of discipline to measure and report”, and associated category “Lack of Processes” for this code, as the interviewee explained that lack of discipline happens because people execute measurement by their own, not following any documented process and not being formally part of their day by day activities. We coded “Lack of dedicated people for measurement activities” for transcript passage “we do not have dedicated people for measuring activities, people need to share their activities with it” and associated category “Lack of Resources/People”, as interviewee explained that he is not able to allocate dedicated people for measurement activities due to cost reductions.

After that, we created two new codes to represent each research question and associated codes about respective answers to them, and created more codes to be used as categories to group similar data. Then, we started the axial coding phase, representing top-down (when strategies are mainly defined by leaders and cascaded to the team) and bottom-up (when the team actively participates on strategies definition) variation found in interview data. Quotations and associated codes are shown in Table 17. Codes relationships are shown in Figure 13 and Figure 14:

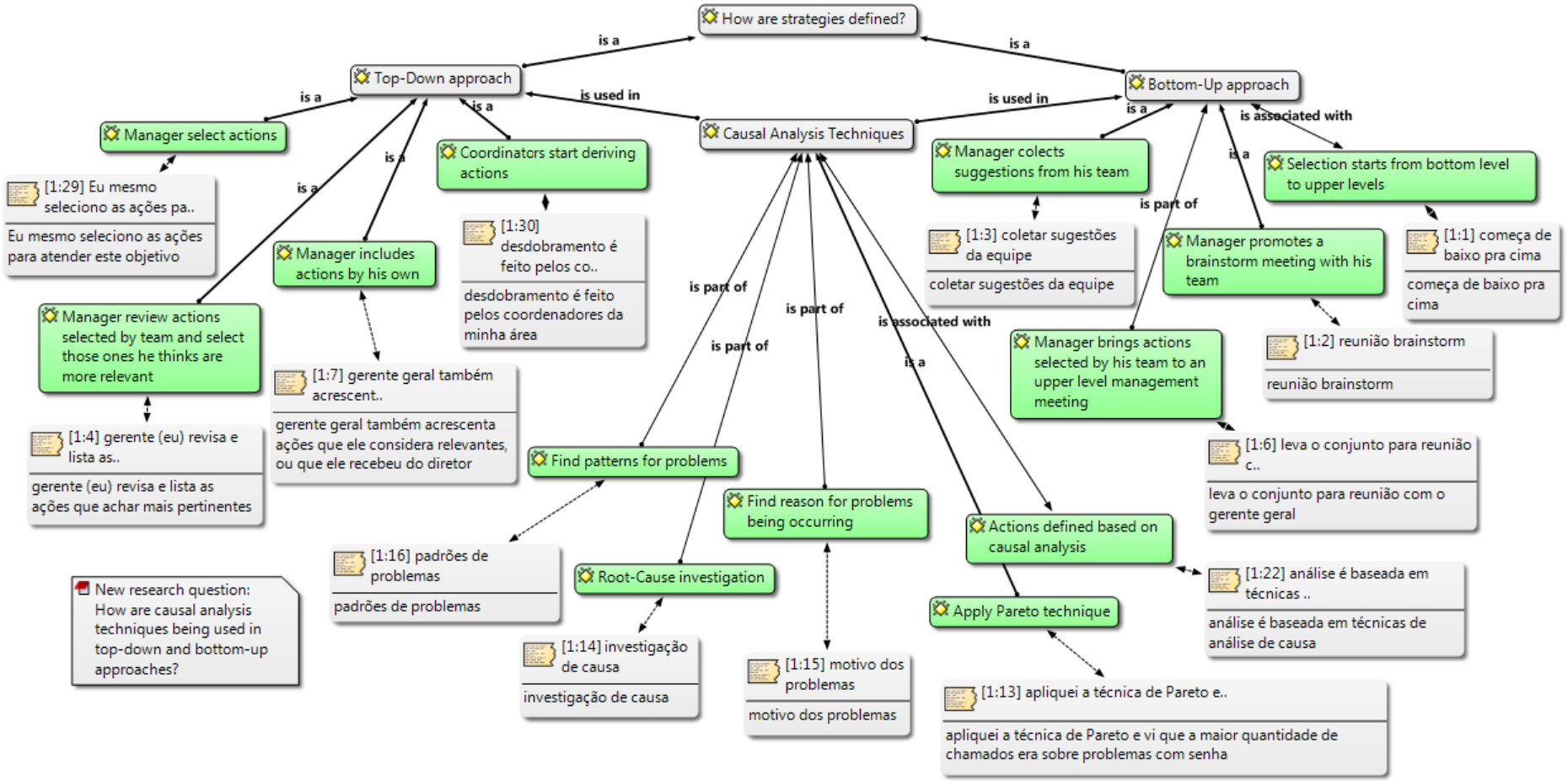

Figure 13 - Network view with related codes for Research Question (i): How are strategies defined?

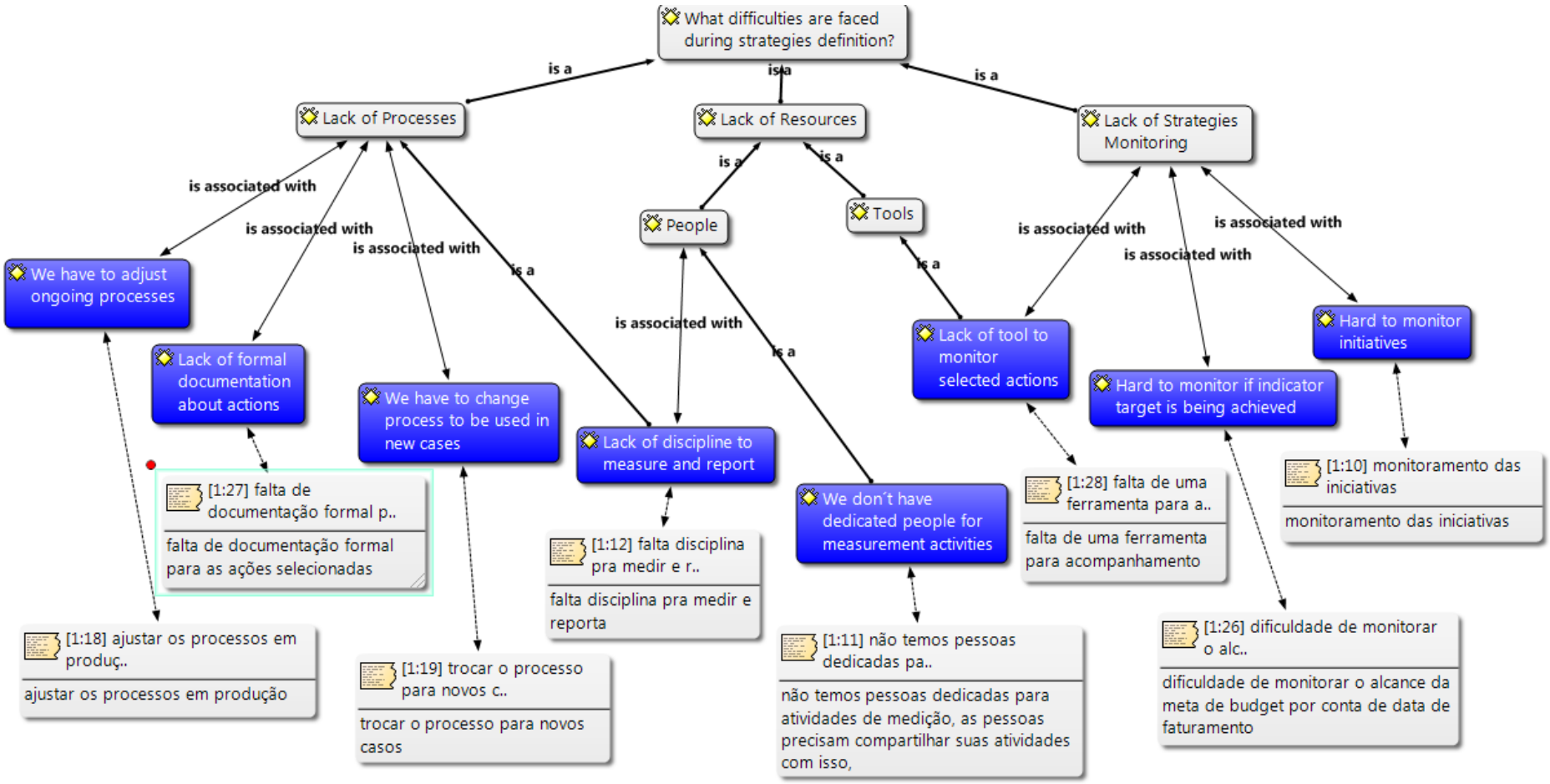

Figure 14 – Network view with related codes for Research Question (ii): What difficulties are faced during strategies definition?

Table 17 - Quotations and associated codes

Research Question	Categories	Code	Quotation	Participant Role
How are operational actions, projects or initiatives defined to achieve IT Services goals and indicators?	Top-Down approach	Selection starts from bottom level to upper levels	"starts from bottom to up"	Infrastructure manager
		Manager promotes a brainstorm meeting with his team	"brainstorm meeting"	Infrastructure manager
		Manager collects suggestions from his team	"collect suggestions from team"	Infrastructure manager
		Manager review actions selected by team and select those ones he thinks are more relevant	"manager reviews and lists actions that he considers more relevant"	Infrastructure manager
	Bottom-Up approach	Manager brings actions selected by his team to an upper level management meeting	"takes gathered list of actions to a meeting with upper manager"	Infrastructure manager
		Manager includes actions by his own	"upper manager does also include actions he considers relevant, or that he received from director"	Infrastructure manager
		Manager select actions	"Actions to achieve this goal are selected by me"	Service Desk
		Coordinators start deriving actions	"Actions derivation is done by coordinators of my department"	Applications manager
What difficulties are faced during this process?	Lack of Processes	Need to adjust ongoing processes	"adjust the processes already running in production"	Service Desk manager
		Lack of formal documentation about actions	"lack of formal documentation for selected actions"	Applications manager
		Need to change process to be used in new cases	"change process to be used in new cases"	Service Desk manager
	Lack of Processes	Lack of discipline to measure and report	"lack of discipline to measure and report"	Infrastructure manager
	Lack of Resources / People	Lack of dedicated people for measurement activities	"we do not have dedicated people for measuring activities, people need to share their activities with it"	Infrastructure manager
	Lack of Resources / Tools and Lack of Strategies Monitoring	Lack of tool to monitor selected actions	"lack of monitoring tool"	Applications manager
	Lack of Strategies Monitoring	Hard to monitor if indicator target is being achieved	"difficulty of monitoring the achievement of budget target by billing date account"	Applications manager
		Hard to monitor initiatives	"difficultly on initiatives' monitoring"	Infrastructure manager

In third stage, we analyzed results from qualitative research about how to define strategies to achieve IT Services goals. We encountered that strategies can be defined by leaders using a top-down approach, or by teams using a bottom-up approach. In both approaches, causal analysis techniques are performed to understand why goals are not being achieved and refine gathered reasons as investigating their root cause.

3.2.6.3. Case Study Learning Conclusions

This case study represented a preliminary study, on which the theoretical saturation was not achieved, and because of that, selective coding was not executed and there is not a formal theory formulated about research questions. Although, results of this case study were used in SINIS procedures to support strategies selection to achieve IT services goals,.

3.3. Final Considerations

Chapter 3 covered incremental learning cycles performed to obtain relevant knowledge to create a method to select indicators for IT Services. Six studies were performed: one systematic mapping in literature, three case studies and two action researches in industry.

The outcome of systematic mapping study was used to generate a list of IT Services measures for reuse when applying SINIS method (available at Appendix I) and also to reinforce motivation for proposing a method to select IT service measures.

The first case study was used to start validating and increasing the list of measures found in previously as result of systematic mapping study. We investigated which measures were used in an IT services real case. Also, as mapping study returned measures relating more than one process area, case study also analyzed how can one measure (and related process) influence others by cause-effect relations. Results contributed to SINIS procedure of finding proper strategies to achieve IT services goals.

The first action research was used to confirm that process mapping should focusing on relationship between different processes and that indicators related to more than one process have the benefit of stimulate team work and support between different teams.

The second case study was used to find a way to support finding critical processes for strategies definition in cases the event log can be used to discover the process itself and also ere an event log is available. By using Business Process

Intelligence mining techniques, the event log can be used to discover the process itself and find process bottleneck to be improved by one of strategies defined to achieve goals.

The second action research was used to validate usage of GQM+Strategies approach as basis for SINIS method, and the reuse of an existent list of measures during indicators selection.

The third case study was used to find in industry how strategies are defined to achieve IT service goals and that causal analysis techniques can be used to support this activity. Results from this case study contributed to SINIS procedure to define strategies to support achieving IT services goals..

Next chapter presents the SINIS method to support selection of indicators for IT Services proposed in this work.

CHAPTER 4 – SINIS Method to Select Indicators for IT Services

This chapter presents SINIS (Select Indicators for IT Services), a method to support selection of indicators for IT services aligned with organization goals. SINIS reuses knowledge provided by other proposals (mainly GQM+Strategies and COBIT) and addresses some of the gaps discussed in previous chapters.

SINS considers business process modeling of IT services, uses concepts from the Reference Software Measurement Ontology (BARCELLOS *et al.*, 2012) and defines a set of activities that guides about what should be done in order to select relevant indicators to goals monitoring. Besides, SINIS suggests templates and reuses goals and measures recorded in the literature.

According to BASILI *et al.* (2005), it is necessary to delimitate the scope to apply GQM+Strategies in an organization. GQM+Strategies gathering data does not have to start with entire organization, but with the part that was chosen to be in scope. Initially it is necessary to describe aspects of the organization to be kept as is and then ask questions to know about key elements of environment, in order to help understanding when a goal can conflict with organizational principles, like transparency, people satisfaction, risk management etc.

BASILI *et al.* (2005) suggest using simple questions for goals elicitation process, classifying goals in four categories (growth, success, maintain and specific goals), and prioritizing goals to be focused on.

According to PETERSEN *et al.* (2015), semi-structured interviews can be a better instrument to elicit GQM+Strategies elements than only using templates and notations, because templates require technical knowledge about measurement terms by participants to fill it, and information is written in tables sometimes inhibiting to get an overall overview.

According to KANEKO *et al.*. (2011), JANTTI *et al.* (2010) and KILPI (2001), reuse by searching a list of existent elements can save cost and time when available to be consulted during elicitation process, selecting an existent element suitable to organization, or being used to inspire creating of new one. SINIS method includes lists of questions to drive semi-structured interviews, templates and examples for each GQM+Strategies element in IT Services domain that is elicited during process of executing the method.

Considering that a domain ontology can be used to provide knowledge and promote common understanding, SINIS templates are based on concepts from the Reference Software Measurement Ontology (BARCELLOS *et al.*, 2012).

SINIS is a method to support indicators selection for IT Services measurement and has two versions:

- *Top Down version*: It should be used when there are IT Service Goals, but there are no IT services indicators derived from them to measure achievement of those goals, and neither strategies defined to support achieving IT Service Goals.
- *Bottom-Up version*: It should be used when there are indicators being used, but organization is not sure about alignment between those indicators and service goals or strategies. In this case, the organization is interested in review existent indicators to start measuring only what matters and abandon ineffective measurements.

Even not proven, it is suggested that SINIS should be executed or supported by a person familiar to IT Services general processes and measurement, not being required knowledge about approaches, frameworks and libraries used by author to design the method (like for example GQM+Strategies, COBIT and the Reference Software Measurement Ontology).

A comparison summary of top-down and bottom-up approach is present in Table 18 bellow. Activities that are quite the same in both versions are marked in italic.

SINIS is able to support both top-down and bottom-up alignment derivation of organization goals, IT services goals, strategies and indicators. This chapter covers both the versions and next chapter shows an application of SINIS in industry.

4.1. SINIS Top-Down Version

Figure 15 shows an overview of SINIS top-down version with four phases, represented by different colors. During first phase, information relevant to organization

IT Services measurement are acquired. During second phase, IT services goals and respective indicators to monitor their achievement are detailed. During third phase, strategies to achieve IT services goals, and also indicators to monitor their achievement are detailed. Finally, during fourth phase, a summary of produced information during previous phases is organized in a grid.

Activities' description for each phase is provided bellow. This version is provided to be used when there are defined organization goals, but no IT services indicators being used yet.

Table 18 - Comparison summary of top-down and bottom-up approach

	Comparison Summary of Top-Down and Bottom-Up versions	
	SINIS Top-Down Approach	**SINIS Bottom-Up approach**
When to be used?	IT Service Goals exist or it is possible to define them from Context Factors and Assumptions. In this case, organization is interested in create indicators and strategies deriving from IT Service Goals.	There are indicators being used, but organization is not sure about the alignment between those indicators and Service Goals or strategies. IT Service Goals and Strategies might exist or not. In this case, organization is interested in review existent indicators to start measuring only what matters and abandon ineffective measurements.
Requirements	IT Service Goals exist or it is possible to define them from Context Factors and Assumptions	IT Service Goals exist or it is possible to define them from Context Factors and Assumption Indicators are already being collected and analyzed, even not being sure about which goal they are related to
Activities	• *Elicit IT Services Context Factors and Assumptions* • *Define IT Service Goals* • *Define Indicators and Measurement Plans for IT Services Goals* • *Create Interpretation Models for IT services goals Indicators* • *Analyze Critical IT Services Processes* • *Establish Strategies to Achieve IT Service Goals* • *Define Indicators and Measurement Plans for Strategies' Goals* • *Create Interpretation Models for Strategies' Indicators* • *Build, Review and Adjust GQM+Strategies Grid*	• *Elicit IT Services Context Factors and Assumptions* • Gather Existing Indicators • Gather Existing IT Services Goals • *Include new IT Services' Goals* • Review and Aggregate similar IT Services Goals • Associate IT Services Goal to each indicator • *Create or Include new Indicators Measurement Plans for IT Services' Goals* • Review and Discard indicators not associated to any IT Services • Gather Existing Strategies • *Analyze Critical IT Services Processes* • *Establish Strategies to Achieve IT Services´ Goals* • Gather Existing Strategies' Indicators • *Create or Include new Indicators and Measurement Plans for Strategies* Review and Discard Strategies not associated to any IT Services' Goal • *Create or Review Interpretation Models for all Indicators*

	Comparison Summary of Top-Down and Bottom-Up versions	
	SINIS Top-Down Approach	**SINIS Bottom-Up approach**
		• *Build, review and adjust GQM+Strategies Grid*

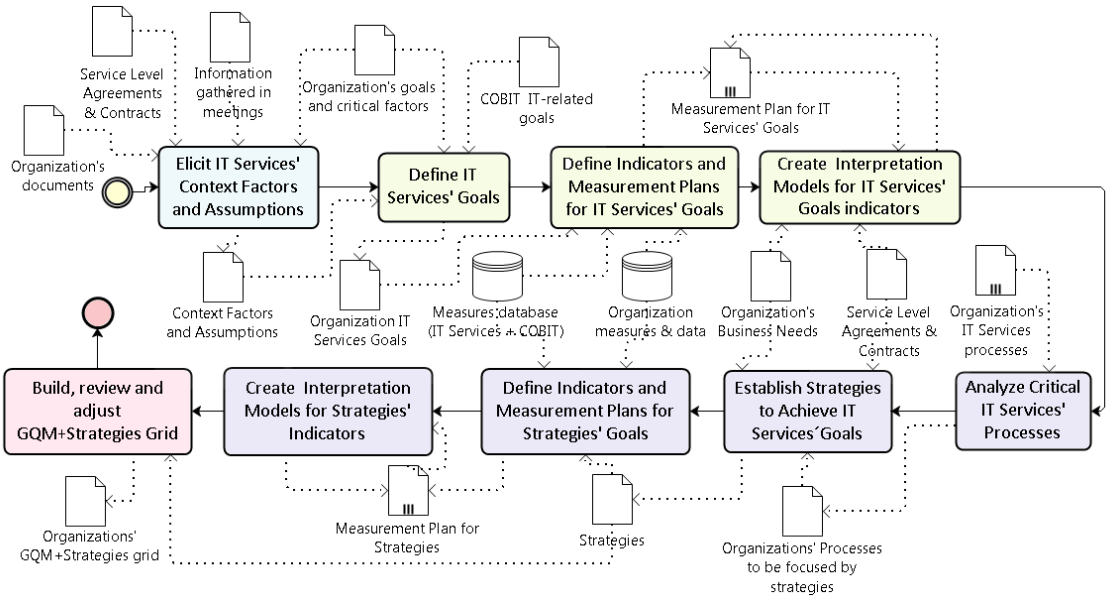

Figure 15 - Overview of SINIS method top-down version to select indicators for IT Services

Phase 1: Elicit IT Services Context Factors and Assumptions

Both IT service goals and strategies are defined in organization context, where options are limited by organization specific capabilities, issues or constraints. We start method by identifying context factors and assumptions for specified organization, in order to use them since the beginning for aligning IT service goals and strategies. During this phase, context factors and assumptions describing the organizational scenario are identified in order to help defining and limit scope (Basili *et al.*, 2005). Context factors are aspects factually known (e.g., organization X needs to improve service availability) and assumptions are aspects believed to be true but have little or no evidence about (e.g., in organization X IT Services costs cannot be increased).

Context factors and assumptions provide useful information to define the scope of IT Services goals and strategies to be considered. Besides, differentiate what we factually know and what we believe is true but have little or no evidence about will help later to properly interpret measurement data and find potential causes of strategies that did not succeed (BASILI *et al.*, 2005). Organization's business plans and current budget, goals and objectives set by business, targets and thresholds to maintain or achieve

service levels and service level agreements are some of the various sources of information that are relevant to IT Services measurement process (BROOKS, 2006).

Critical success factors for an effective measurement represent the ability to validate, direct, justify, and intervene when necessary to achieve IT service goals.

Documents can be used as a source to context factors and assumptions identification, being document analysis an important part of triangulation (PETERSEN *et al.*, 2015). Several sources can be used such as critical success factors, vision and mission statements, organizational goals, internal and external constraints, market trends, opportunities, staff competences, technological advances, contacts and infrastructure. If documents are not available, meetings with organization stakeholders can be used as a way to gather information. A list of questions to be used during interview to identify Context Factors and Assumptions is provided in Table 19, a template in Table 20 and examples in Table 21 bellow.

Table 19 - SINIS questions to support elicitation of IT Services Context Factors and Assumptions (based on (PETERSEN *et al.*, 2015; PARMENTER, 2015; BASILI *et al.*, 2005))

	SINIS questions to support elicitation of IT Services Context Factors and Assumptions
1	What is the scope of considered IT Services department about?
2	Which clients/customers does IT Services department support?
3	What can be gathered from existent service agreements with customers for service delivery?
4	What can be extracted from issues root cause on history reports about provided services?
5	What can be extracted from customers' satisfaction reports about provided services?
6	What can be linked to IT Services from organization Vision, Mission and Values statements?
7	Which are the organization's goals?
8	Which organizational aspects can be associated to IT Services? For example organization economic, social, political, market trends, environmental and technological aspects.
9	Which are the perceived IT Services critical success factors?
10	What can be used from existent measurement models, data, baselines and targets?

Table 20 - SINIS template for Context Factors and Assumptions

Context factors	
Context factor	<Description of context factor - what is factually known – related to IT Services >
Context factor source	<Description of source from where the context factor was obtained>
Date	<Date when context factor was taken as true>
Responsible	<Person responsible for describing this context factor>
Assumptions	
Assumption	<Description of assumption - what we believe is true but have little or no evidence about – related to IT Services >
Assumption source	<Description of source from where this assumption was obtained>
Date	<Date when assumption was considered>
Responsible	<Person responsible for describing this assumption >

Table 21 - SINIS examples of Context Factors and Assumptions for IT Services

Context factors	
Context factor	Incident management process includes an activity to evaluate if problem management process needs to be invoked to find a definitive solution for a workaround implemented
Context factor source	Incident Management process description version 1.1
Date	August/2015
Responsible	Bianca Trinkenreich
Assumptions	
Assumption	Technical resources are available to be contacted and join a crisis conference room until issue is solved.
Assumption source	There is an on-call schedule for technical resources available in Intranet page, but we don´t have sure if people will immediately pick the phone when contacted on off-hours.
Date	August/2015
Responsible	Bianca Trinkenreich

Phase 2: Define IT services goals, Indicators and Interpretation Models

IT service goals should be defined to be measurable and achievable (BASILI *et al.*, 2005), and also specific, relevant and time sensitive, following all five SMART principles: Specific, Measurable, Achievable, Relevant and Time-Bound (DRUCKER, 1954). Besides that, goals cannot be broad or vague, they need to be broken down into specific results, written using words that clearly describe results that are trying to be achievable, which are going to be evidenced by indicators results (BARR, 2014). During this phase, context factors and assumptions defined in the first phase are used to support definition of IT services goals, indicators are created to quantify if IT services goals were achieved and interpretation models are created to support analysis of those indicators' results.

Phase 2 – Activity 1: Define IT Service Goals

IT service goals should be defined to be measurable and achievable (BASILI *et al.*, 2005), and also specific, relevant and time sensitive, following all five SMART principles: Specific, Measurable, Achievable, Relevant and Time-Bound (DRUCKER, 1954). Besides that, goals cannot be broad or vague, they need to be broken down into specific results, written using words that clearly describe results that are trying to be achievable, which are going to be evidenced by indicators results (BARR, 2014).

During this activity, context factors and assumptions defined in the first phase are used to support definition of IT Services goals.

In order to reduce effort, saving cost and time, reuse is supported by consulting COBIT IT-related goals available at Attachment I (ISACA, 2012b) to verify whether they are applicable or can inspire new ones. Template is based on GQM+Strategies (BASILI *et al.*, 2005) and also requires information regarding the BSC dimensions related to the recorded goal. BSC dimensions were included in the template mainly because next SINIS activities involve searching for COBIT management practices and indicators, and COBIT Cascade Goals (ISACA, 2012b) considers goal classification per BSC dimension. IT Service Process was included in template in order to support finding related critical process to be analyzed, and also facilitate finding required data source for measurements and indicators data collection (GUSMÁN *et al.*, 2010). A list of questions to be used during interview to identify IT services goals is provided in Table 22, a template in Table 23 and examples in Table 24.

Table 22 - SINIS questions to support elicitation of IT Service Goals (based on (PETERSEN *et al.*, 2015; BASILI *et al.*, 2005))

SINIS questions to support elicitation of IT Service Goals	
1	What is the scope of considered IT Services department about?
2	What are the clients/customers that considered IT Services department delivers for?
3	What can be gathered from existent service agreements with customers for service delivery?
4	What can be extracted from issues root cause on history reports about provided services?
5	What can be extracted from customers' satisfaction reports about provided services?
6	What can be linked to IT Services from organization Vision, Mission and Values statements?
7	What are organization's goals?
8	What can be associated to IT Services from organization economic, social, political, market trends, environmental and technological aspects?
9	What does IT Services department plan to execute in next period (year for example)?
10	What future can you figure for IT Services department in following years?
11	How does IT Services department wants to grow, having new clients or/and proving services based on new competencies?
12	What is definition of success for IT Services department?
13	Does IT Services department need or desire to improve any aspect of service delivery?

Table 23 - SINIS template for IT Services Goal

SINIS template for IT Services Goal	
IT Services Goal	<Name of the IT Services goal>
Activity	<Is the goal to Maintain, Increase or Reduce?>
Object	<What is the object the goal is related to?>
Magnitude	<What is the quantity of goal to be achieved?>
Time Frame	<When should the goal be achieved?>
Responsible	<Who is the primary responsible for goal attainment?>

Constraints	<What relevant constraints may prevent goal achievement?>
COBIT IT-Related Goal	<One of 17 available IT-Related Goals from COBIT: • Alignment of IT and business strategy • IT compliance and support for business compliance with external laws and regulations • Commitment of executive management for making IT-related decisions • Managed IT-related business risk • Realized benefits from IT-enabled investments and services portfolio • Transparency of IT costs, benefits and risk • Delivery of IT services in line with business requirements • Adequate use of applications, information and technology solutions • IT agility • Security of information, processing infrastructure and applications • Optimization of IT assets, resources and capabilities • Enablement and support of business processes by integrating applications and technology into business processes • Delivery of programs delivering benefits, on time, on budget, and meeting requirements and quality standards • Availability of reliable and useful information for decision making • IT compliance with internal policies • Competent and motivated business and IT personnel • Knowledge, expertise and initiatives for business innovation>
BSC Dimension	<Finance, Customer, Internal or Learn and Growth>
IT Service Process related	<Process that can impact goal achievement>

Table 24 - SINIS example of IT Service Goal

IT Services Goal	
IT Services Goal	Reduce Incident Resolution Time
Activity	Reduce
Object	Time to Solve Incidents
Magnitude	10%
Time Frame	Annual
Responsible	IT Services Infrastructure Department
Constraints	Do not increase cost
COBIT IT-Related Goal	Delivery of IT services in line with business requirements
BSC Dimension	Customer
IT Service Process related	Incident Management

Phase 2 – Activity 2: Define Indicators and Measurement Plans for IT Services Goals

In this activity, IT services goals are made measurable by specifying appropriate information needs and measurement plans that define goals indicators and how their data collection is going to be performed.

Aiming to avoid misunderstanding about measurement concepts due to lack of an agreed terminology and conceptualization, the template in Table 25 is based on the conceptualization provided by RSMO (BARCELLOS *et al.*, 2012).

An example is shown in Table 26. In order to reduce effort, saving time and cost, reuse is supported by consulting two sources: COBIT IT-related goals sample measures, available in Attachment I (ISACA, 2012b) and IT Services list of measures, available in Appendix I, to verify whether they are applicable or can inspire new ones.

Table 25 - SINIS template for Indicator´s Measurement Plan

SINIS template for Indicator´s Measurement Plan	
IT Services Goal related	<Name of the IT Services goal - Same to match IT Services Goal>
Measurement Goal	<What is going to be controlled: Maintain, Increase or Reduce?>
Information Need	<What is the information need attended by the measurement?>
Indicator	<Name of the indicator to monitor the recorded goal>
Measurable entity type	<What entity type is being measured by the indicator?>
Base measures	<Measures from which the indicator is obtained (if applicable)>
Measure calculation formula	<Formula used to calculate the indicator (if applicable)>
Measurement procedure	<Procedure to be followed to collect and store data for the indicator>
Measurement responsible	<Role performed by people in charge of collect and store data or tool that collect and record data without manual intervention>
Measure unit	<Measurement unit in which the indicator is expressed>
Measurement moment	<Activity on which measurement should be performed>
Measurement periodicity	<Frequency of measurement >

Table 26 - SINIS example for Indicator´s Measurement Plan

SINIS example for Indicator´s Measurement Plan of IT Services Goal	
IT Services Goal related	Reduce Time in Crisis
Measurement Goal	Reduce
Information Need	How many hours were spent in crisis?
Indicator	Number of hours in crisis (NHC)
Measurable entity type	Crisis
Base measures	Time spent in a crisis (TSC); Number of crisis (NC)
Measure calculation formula	$NHC = TSC_1 + TSC_2 + \ldots + TSC_{NC}$
Measurement procedure	TSC: Extract data from incident report and conference call report NC: Extract data from incident report
Measurement responsible	Service continuity analyst
Measure unit	Hours

A checklist to support derivation of IT Service Goals in indicators is provided in Table 27. An indicator should be reviewed if at least one answer is “No”. Indicators should be based on standard definitions and terms so that all the people within organization can communicate in one language (ECKERSON, 2011). In order to reduce effort, saving time and cost, before creating new indicators, reuse is supported by consulting two sources: COBIT IT-related goals sample measures and IT Services list

of measures (available at Appendix I) to verify whether they are applicable or can inspire new ones.

Table 27 - SINIS checklist to support derivation of IT Services Goals in indicators (based on (DRUCKER, 1954; BROOKS, 2006; ECKERSON, 2011))

SINIS checklist to support derivation of IT Services Goals in indicators		
1	**Specific**	Does the indicator measure a specific process or part of a process? If indicator measures more than one process, are both process owners aware of their responsibility about achieving this indicator result?
2	**Measurable**	Is the indicator measurable? For example, if you need to measure how long users spend on the phone with service desk opening an incident, there might be some kind of PABX to report calling times or something like this.
3	**Achievable**	Is the indicator target achievable? For example, if target is to have service desk calls ending in 3 minutes, but attendant has a long form to fill with user information or a service management application to use that is slow and consumes most or more than 3 minutes, this target is not achievable.
4	**Realistic**	Is the indicator realistic? For example, if there are many reasons for an incident to be in "Waiting" status (Waiting for user call back, for next level support, for new version installation), it does not make sense to have an indicator simply about how long an incident is in waiting status.
5	**Timetable**	Is the indicator timely? For example, if service desk measurement of customer satisfaction is collected quarterly, but analysis need to be done once a month, there will not be a timely measurement, because during two months there will be no data for analysis.
6	**Aligned**	Is indicator aligned with any IT service goal? For example, an indicator "Amount of incidents solved with expired SLA" can be related to IT Services' Goal "Increase Incidents Solved On Time"
7	**Owned**	Is the indicator designed and owned by an individual or a group to evaluate its outcome? For example, an indicator "Percentage of machines with antivirus up to date" is owned by antivirus specialist from security team.
8	**Predictive**	Is it possible (even in future) to use a statistical technique for this indicator to predict future outcomes based on current levels of activity so indicator owner can see whether it are going to meet targets by the end of measurement defined period?
9	**Actionable**	Are there known and possible actions to improve performance if indicator outcome performs under or over expected limits? It doesn't make sense having an indicator to measure a goal if users cannot change the outcome.
10	**Easy to understand**	Is indicator name and measurement plan straightforward and easy to understand to all involved stakeholders?

Phase 2 – Activity 3: Create Interpretation Models for IT services goals Indicators

During this activity, interpretation models are defined to determine how data collected for the defined indicators should be interpreted in order to support informed decisions about the IT Services goals achievement. Targets can be defined based on previous service level agreement contracts and reports or business's needs.

A checklist to be used during elicitation of Interpretation Model of IT Service Goals indicators is provided in Table 28, a template in Table 29 and an example in Table 30 bellow.

Table 28 - SINIS checklist to support for Indicators Interpretation Models

SINIS checklist to support for Indicators Interpretation Models	
1	What is the expected result for this indicator in order to achieve related goal?
2	Between which range is the result considered as achieved?
3	If the result is below the range considered as achieved, should it be interpreted as good or bad?
4	If the result is up the range considered as achieved, should it be interpreted as good or bad?
5	What was the result for this indicator in last measurement period?
6	Who is the responsible for interpreting this indicator result?
7	How should the indicator be interpreted?
8	When should the indicator be analyzed and interpreted?

Table 29 - SINIS template for Indicators Interpretation Model

SINIS template for Indicators Interpretation Model	
Indicator related	<Name of indicator – Same to match Measurement Plan>
Target	<Value expected for the indicator in order to achieve the associated goal>
Range	<Value limits of defined scale according to historical data or organization goal>
Baseline	<Result from the same period last year>
Interpretation model	<Procedure to be followed to analyze data collected for the indicator >
Interpretation Responsible	< Role performed by people in charge of analyze data>
Interpretation Moment	<Activity in which data analysis should be performed>
Interpretation Periodicity	<Frequency in which data analysis should be performed>

Table 30 - SINIS example for Indicators Interpretation Model

SINIS example for Indicators Interpretation Model	
Indicator related	Percentage of security incidents that caused financial loss
Target	688 hours and 30 minutes (annual value)
Range	Reduction
Baseline	750 hours last year
Interpretation model	If value is 5% over target, only follow task plan to reduce. If value is between from 6 to 10% over target, apply financial penalty 1 to service provider and follow task plan to reduce. If value is between 11 to 15% over target, apply financial penalty 2 to service provider and follow task plan to reduce If value is more than 15% over target, apply penalty 3 and cancel contract.
Interpretation Responsible	IT Services Continuity team
Interpretation Moment	During managers performance meeting
Interpretation Periodicity	Every month, accumulated data is analyzed and compared to goal taking same month in previous year as a reference. In the end of the year, total value is compared to total value in the previous year.

Phase 3: Elicit Strategies to Achieve IT services goals

In this phase, strategies to achieve established IT service goals are defined and indicators are created in order to quantitatively evaluate if strategies are able to achieve outcomes.

Phase 3 – Activity 1: Analyze Critical IT Services Processes

Process analysis is considered both art and science, with no and unique way of performing it well, but various techniques and practices that drive us to good results. Process qualitative analysis include principles for removing waste, or unnecessary parts of the process and making it leaner, and techniques to identify parts of the process that not performing well, which means, weak parts that are negatively impacting process performance (DUMAS *et al.*, 2013).

A typical process improvement initiative includes the following steps: (i) process mapping; (ii) wastes identification and removal; (iii) problems identification and prioritizing; (iv) problems' root-cause investigation and remediation; (v) alternatives analysis, and (vi) process redesign (CONGER, 2015). The main goal of process mapping in SINIS is discussion with domain experts to find proper strategies, and not to perform a complete process redesign. Wastes are identified for removal only if they can impact IT Service Goal. Problems identification, prioritizing and root-cause investigation are done to support understanding what can be executed as SINIS strategies to achieve IT Service Goals.

A critical process is a process that can impact business goals, a failed process, or a process that might fail (HUXLEY, 2003). In this activity, processes identified in last phase as being related to IT service goals are mapped and analyzed to find the critical processes to be focused by strategies. Besides the processes themselves, also relationships between it and other processes are analyzed to help finding cause and effect for difficulties that the organization is having to achieve IT service goals. By doing this, it is possible to identify critical processes where the strategies must be focused on. This analysis is done to identify opportunities for improvement and answer the question 'How do we get there?' (OGCb, 2011), selecting strategies to achieve IT service goals. This activity is performed after defining IT service goals (and not before), in order to analyze only processes that are related to those goals, and avoid losing cost and time by analyzing all processes.

Root cause analysis, sensitivity analysis, or process performance model can help to identify sub-processes that contribute the most to achieving goals (FORRESTER *et al.*, 2010). Analysis of Business Process Models can be used to investigate ways of improving processes (VAN DER AALST *et al.*, 2003). Understanding the process is one of the most elemental mechanisms in root-cause analysis (ROBITAILLE, 2004). SINIS advocates that the processes related to IT services goals should be modeled to provide a detailed view about how processes related to IT service goals are being executed and provide insights about finding critical sub-processes for establishing strategies. Besides each process related to IT service goals, also the relationship between them and the other processes should be investigated to provide critical cause-effect relations that need to be considered when finding critical sub-processes for establishing strategies (TRINKENREICH and SANTOS, 2015b).

Process mining techniques can be used to extract knowledge from event logs and discover, monitor, and improve processes in several different application domains (VAN DER AALST *et al.*, 2011). For processes that generate activities log database (such as Incident Management), process mining can be used to find which part of the process is causing delay and possibly is a root cause that needs to be addressed by a strategy (TRINKENREICH *et al.*, 2015b).

This activity includes two sub-activities that are not showed in Figure 15 for simplification purposes. First sub-activity is about critical process mapping and second is about finding root cause analysis for issues related to critical processes mapped, or reasons that can be preventing the organization on attending IT services goals.

Phase 3 – Activity 1.1: Map and Identify Critical Sub-processes in Processes Related to IT Services Goals

A process map or a diagram basically represents a set of graphic symbols to provide information about the process nature. Process maps are useful mechanisms for understanding the processes as basis for analysis and improvement, diagnosing problem areas and opportunities for improvements, training stakeholders in how to perform the work and disseminate process requirements (AKPOLAT, 2004). Process mapping configures a way to understand a process by building up a map and graphically highlighting, in a model, relationships between activities, people, data and involved objects.

Process mapping methods can offer useful and not much expensive descriptions which can help towards improving business processes (BIAZZO, 2000). Process maps describe activities and interactions of all process participants, including people, roles, software applications, departments, other processes and external organizations (CONGER, 2015).

In activity "Define IT Service Goals", SINIS advocates the classification of IT services goals per IT services process in order to map those processes and help finding which part (sub-process) or which relationships with other processes is impacting goal and need to be focused by strategies.

Data gathering for process mapping should be done by triangulation, obtaining three sources of information in order to have more confidence that it is correct. Documentation analysis about the process; one or several interviews with process owner and stakeholders to describe the process works steps; and observation of process being executed can compose those three sources for triangulation (CONGER, 2011).

SINIS does not specify if process mapping should be done more or less detailed, if it should be represented by input/output flows or other representations, neither requires a specific software application for it. Relevant is that process mapping might be enough understandable to find critical sub-processes or possible struggles, issues, difficulties or problems that impact and are going to be candidates for strategies to achieve related IT service goals. Sub-processes selected during this phase are going to be candidates for strategies definitions in next phase.

An example of a mapped IT Service overall process (Incident Management) is shown in Figure 16, including relationships with other processes.

This process mapping was used in the Action Research about using critical process mapping and MR-MPS-SV maturity model outcomes to evaluate an IT Services process and select indicators in different levels using GQM+Strategies presented in Chapter 3.

Process mapping is used in SINIS as a basis for further meetings and deeper investigation of existent issues to be candidates for strategies in relationships between Incident Management, Change Management, Problem Management and Availability and Continuity Management (TRINKENREICH and SANTOS, 2015b).

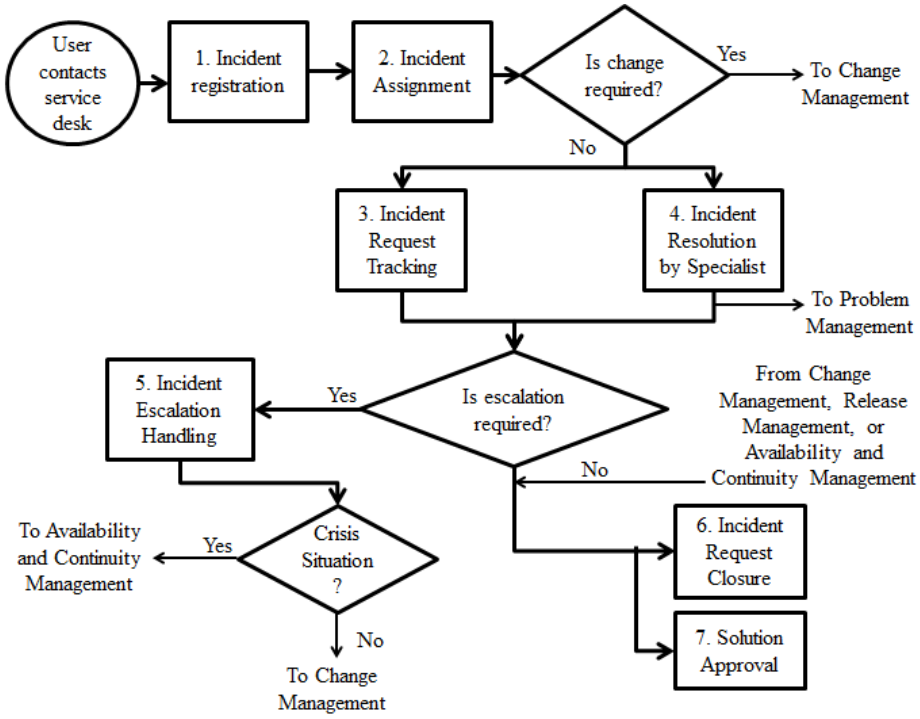

Figure 16 - Mapping of Incident Management overall process (TRINKENREICH *et al*., 2015c)

After having a clear knowledge about the target process, an investigation should be carried out on what part of the process (sub-process) is impacting IT service goals and can be addressed by strategies.

According to CONGER (2015), a process improvement project includes processes to recognize and analyze a problem and root-cause techniques can be used, such as cause-effect diagrams.

In SINIS, remediation does not represent a complete process redesign, but a root-cause investigation to better understand what part of the process is impacting the achievement of related IT Service Goal and can be listed as critical to be candidate for strategies in next phase.

A checklist to be used during identification of critical sub-processes is provided in Table 31, a template in Table 32 and an example in Table 33.

Table 31 - SINIS checklist to support identification of IT services critical sub-processes (based on (FORRESTER *et al.*, 2010; PETERSEN *et al.*, 2015))

SINIS checklist to support identification of IT services critical sub-processes	
1	Which sub-processes of IT Services processes related to selected IT Services Goal have the highest improvement potential? Do you have a plan to improve them?
2	Which sub-processes of IT Services processes related to selected IT Services Goal are not working out good today?
3	Which sub-processes of IT Services processes related to selected IT Services Goal have strong correlation with goal results?

4	Which sub-processes of IT Services processes related to selected IT Services Goal are important to stabilize performance?
5	Which sub-processes of IT Services processes related to selected IT Services Goal can provide major risks to goal or stop it of being accomplished?
6	Which sub-processes of IT Services processes related to selected IT Services Goal serve as key inputs to goal?
7	Which sub-processes of IT Services processes related to selected IT Services Goal will be executed frequently enough to provide sufficient data for analysis?
8	Which sub-processes of IT Services processes related to selected IT Services Goal represent more consumed effort to be performed?

Table 32 - SINIS template to document IT services critical sub-processes

SINIS template to document IT services critical sub-processes	
Related IT Services Goal	<Name of related IT Services goal – same inserted in SINIS template for IT Services Goal>
Related IT Services Process	<Process that can impact goal achievement– same inserted in template SINIS template for IT Services Goal>
Name of Critical Sub-process to be addressed	<Name of sub-process (part of related IT Services goal) identified as critical to related IT Services Goal (that can impact success of failure)>
Description of Critical Sub-process to be addressed	<Textual description of sub-process (part of related IT Services goal) identified as critical to related IT Services Goal (that can impact success of failure)>
When critical sub-process was identified	<Date when critical sub-process was identified>
Description of how critical sub-process was identified	<Textual description about how sub-process was identified as critical>

Table 33 - SINIS example to document IT services critical sub-processes

SINIS example to document IT services critical sub-processes	
Related IT Services Goal	Reduce Incident Resolution Time
Related IT Services Process	Incident Management, Change Management, Problem Management and Availability and Continuity Management
Name of Critical Sub-process to be addressed	Solve recurrent incidents (Problem management)
Description of Critical Sub-process to be addressed	If applied solution is a workaround, and incident can happen again, a problem record should be opened for root-cause analysis. Recurrent issues cause overload support teams and contribute to increase incident resolution time.
When critical sub-process was identified	May 2015
Description of how critical sub-process was identified	Incidents reports were analyzed and grouped by issue description to find recurrent ones. Problem management reports were also analyzed and found that most of recurrent issues are not having a proactive record being opened as process was designed to happen.

Phase 3 – Activity 1.2: Identify Root-Cause for Issues in Critical Sub-processes

Root-cause represents the most basic reason for an unwanted condition, issue, or problem which, if eliminated or solved, can prevent it from happening (WILSON *et al.*, 1993). Root-cause analysis is the process of identifying causal factors. It includes various techniques to support finding root causes of problems, defects, difficulties, issues or undesired events that are preventing a better or a desired performance to be

achieved. In general, root-cause methods encompass guidelines for meetings and interviews with domain experts and relevant stakeholders, and also for organizing data gathered during those meetings and interviews (DUMAS *et al.*, 2013).

Symptoms, apparent causes and root-cause are different. While symptoms represent actual evidence indicating an episode of something wrong and apparent cause is usually the immediate reason for that issue being happening, root-cause is the real basic reason for problem and needs to be solved in order for it not happen again (WILSON *et al.*, 1993). After removing root-cause, symptoms can be monitored to help ensuring that problem is not happening anymore (ANDERSEN and FAGERHAUG, 2006).

Many tools and techniques can be used to support the process of identifying root-cause for a problem, and there is not a specific order to be followed. Documents and records analysis, Interviews, Brainstorms, Flowcharts, Five Whys, Cause-Effect (which is also called as Ishikawa for its developer Kaoru Ishikawa or fishbone for its appearance) and Pareto Analysis are the most used ones and the ones that work better for the situation can be selected to be used (ROBITAILLE, 2004). Those techniques will be discussed as follows.

Documents are used to understand the requirement of a process, while records are used to verify outputs of those defined requirements. Interviews are used to have process owners explaining about documented and not documented practices. While Brainstorming is a common team builder technique used as a creative way to get ideas flooding, Five Whys is an informal way to track back the sequence of events that led the issue. Both can uncover causes that could be missed. Flowcharting, Cause-and-Effect and Pareto Analysis provide an easy view picture about a process. Flowcharting is used to understand how the process flows and help focus on linkage between other processes and both Cause-and-Effect and Pareto Analysis graphically represent contributors to the issue (ROBITAILLE, 2004).

Pareto Analysis principle affirms that highest effects, usually 80 percent, are the consequence of a few number of causes, often only 20 percent. It considers, then, that an efficient approach for root-cause analysis is to focus on those 20 percent (ANDERSEN and FAGERHAUG, 2006). Pareto diagrams are tools that graphically provide a quantitative way to represent problems and respective causes, by degree of gravity. Assuming the problem being handled has multiple known causes, it would be appropriate to address the ones that are most contributing to the problem

(ROBITAILLE, 2004). For example, if we need to reduce incident resolution time, besides doing process quality investigation, it would be useful to check incidents reports. Like that it would be possible to get which applications are causing the largest amount of incidents, or incidents that had taken longer to be solved, in order to be addressed first. Since the use of Pareto diagrams is related to a known list of causes, problem and causes must be defined first. A checklist to be used during Pareto diagram creation is provided in Table 34, and an example in Figure 17, showing applications that had more incidents escalated to crisis.

Cause-and-Effect diagrams are also called as fishbone diagrams because of their appearance, or Ishikawa diagrams, because of their developer (Kaoru Ishikawa). They support identification of processes and factors that are contributing to goal not being achieved and characterize the relation between not achieving and its causes, which can be split into causal and contribution factors (ROBITAILLE, 2004). Causal factors are issues that if solved, can prevent negative event from happening again in future. Contributing factors are issues that increase chances of negative events from happening. In process analysis context, a negative event can be a recurrent issue or an unsatisfactory performance level (DUMAS *et al.*, 2013). Cause-and-Effect diagrams use the concept of "Five M´s and one E", which mean material, manpower, machinery, method, measurement and environment (ROBITAILLE, 2004).

For SINIS, negative events can be anything that is impacting organization on achieving IT service goals, and causes (either causal or contribution factors) are candidates to be selected during strategies establishment in next phase. An example is provided in Figure 18.

Table 34 - SINIS checklist to support Pareto diagram creation (ANDERSEN and FAGERHAUG, 2006)

SINIS checklist to support Pareto diagram creation	
1	Define the problem to be investigated and the list of potential causes that were determined
2	Establish a criterion to be used when comparing possible causes for ranking
3	Define a time period for data collection about causes
4	Collect data and build Pareto diagram
5	Place causes along horizontal axis, from left to right, in descending order of relevance, according to established criterion
6	Point data value on left vertical axis and percentage on the right, draw a curve of cumulative importance along top edges of rectangles

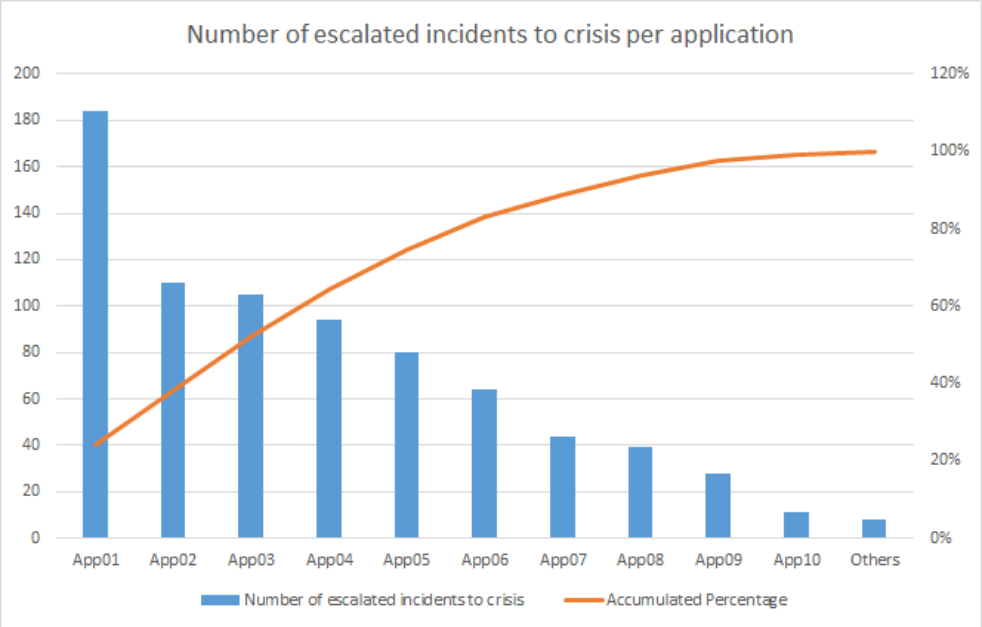

Figure 17 – Example of Pareto analysis showing applications that had more incidents escalated to crisis (Source: The author)

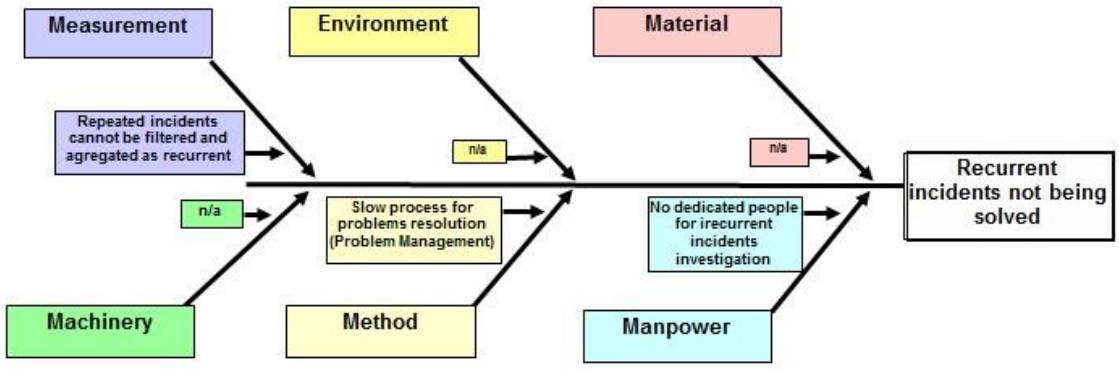

Figure 18 – Example of using Cause-and-Effect diagram to identify factors that are contributing to issue identified in critical sub-process "Solve recurrent incidents" (Source: the author)

Five Whys technique follows a sequential logic, starting in a final point following a path back, returning to process results and investigating actions that antecede them (ROBITAILLE, 2004). When trying to solve a problem, it helps beginning at the end result, and then start reflecting about what caused that, and proceed with the question five times (SERRAT, 2009). So, this technique objective is to ask a "why" question five times to find root-cause. Questions examples are: "What caused this to happen?", "What happened before it?", "Why did it happen?". Five Ways is usually performed during brainstorm meetings, where contributors use natural curiosity always asking at least five times in a progressive investigation to drive discussion to root-cause (ROBITAILLE, 2004). Three key principles for an effective use of Five

Whys technique are: (i) have an exact statement of the problem, (ii) provide correct answers to questions, (iii) have the persistence for basic root-cause (SERRAT, 2009). An example is provided in Figure 19.

Phase 3 – Activity 2: Establish Strategies to Achieve IT Service Goals

Strategies represent ways to achieve goals (BASILI *et al.*, 2005), which can be understood as works, initiatives or projects. One or various strategies can be implemented to achieve the same goal. Prioritization for strategies can be done considering which are more effective and feasible, considering the context of each organization, which means its constraints and capabilities (BASILI *et al.*, 2005). In this phase, we need to know what is needed to do in order to achieve IT service goals (PETERSEN *et al.*, 2015), or in other words, how do we get there. GQM+Strategies (BASILI *et al.*, 2005) does not provide specific directions about how to support organization on selecting strategies. SINIS considers that strategies to achieve IT service goals must focus on processes that impact goals achievement, i.e., the critical processes, and also on removing barriers or solving difficulties that organization is having on achieving IT services goals.

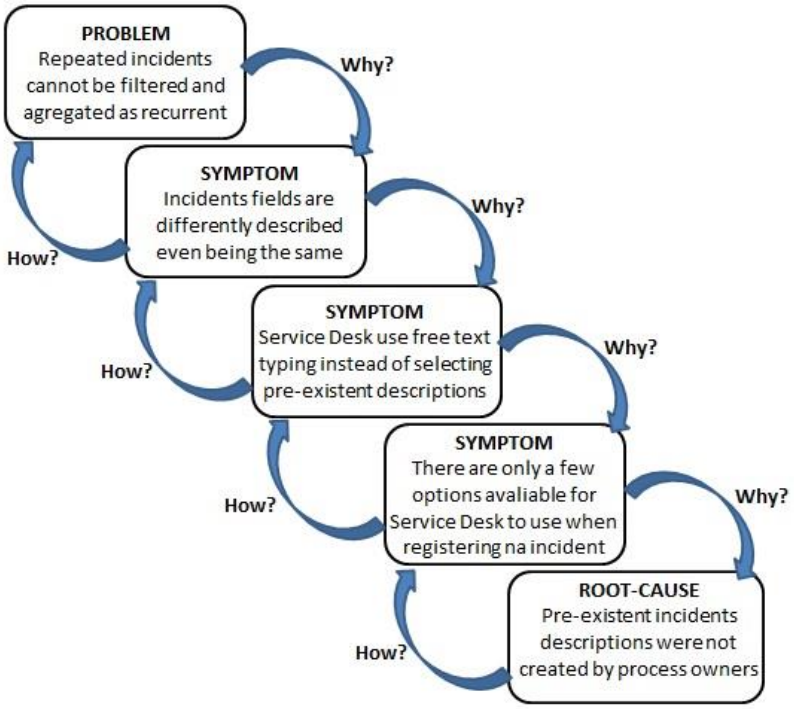

Figure 19 – Example of a Five Why´s diagram to identify root-cause for contributing factor "Repeated incidents cannot be filtered and aggregated as recurrent" found by Cause-and-Effect diagram as contributor to critical sub-process "Solve recurrent incidents" (Source: The author)

In this activity, considering the results of root-cause done for qualitative processes analysis made in the previous activity, strategies are established aiming to achieve the IT Service goals. Established strategies will be implemented in projects, initiatives or even simple activities. General context factors and assumptions for IT Services were defined in SINIS' first activity. Now we elicit specific context factors and assumptions for strategies, and compare them with general context factors and assumptions in order to check if there is any incoherence that needs to be adjusted. The suggested template for recording the established strategies is shown in Table 35 and an example is provided in Table 36.

Table 35 - SINIS template for Strategies (TRINKENREICH *et al.*, 2015c)

SINIS template for Strategies	
IT Services Goal	<Name of associated IT Services Goal - same as inserted in SINIS template for IT Services Goal>
Strategy Name	<Project or initiative or strategy name>
Strategy Scope	<Description of scope for strategy>
Start date	<Date for strategy to start>
Finish date	<Foreseen date for strategy to be completed>
Strategy owner	<Person responsible for delivering this project or initiative or strategy>
Strategy sponsor	<Sponsor responsible for funding and supporting the implementation of this project or initiative or strategy>
Strategy complexity	<Complexity for strategy implementation – Low, Medium, High>
Strategy risk	<Risk of implementation for this project or initiative or strategy - Low, Medium, High>
Strategy cost	<Cost to deliver strategy>
Strategy context factors	<Context factors - what we factually know – considered for this project or initiative or strategy>

Table 36 - SINIS example for Strategies (TRINKENREICH *et al.*, 2015c)

SINIS example for Strategies	
IT Services Goal	Reduce Incident Resolution Time
Strategy Name	Improve service-desk scripts
Strategy Scope	Provide training for service owners about how to review service-desk scripts, Create templates covering all different known issues, including set of questions to be done and data to be collected from user during first call, Provide training to service-desk on using new templates and reviewed scripts.
Start date	01/Nov/2015
Finish date	30/Mar/2016
Strategy owner	Service Desk Manager
Strategy sponsor	IT Services Director
Strategy complexity	Medium
Strategy risk	Low
Strategy cost	No Cost – Usage of internal resources only
Strategy context factors	There is an internal team called ITIL Office, with no additional cost, available to provide trainings for service owners about how to review

SINIS example for Strategies	
	service-desk scripts. Service owners have access to review and create new service-desk scripts, and also templates to be used by service-desk team during users' first call. Service-desk team charges per each attended call, do not charge for having their personnel trained.
	Service owners will be available to work on this strategy.
	Incident Management and Problem Management
	Root-Cause "Pre-existent incidents descriptions were not created by process owners " that was identified for problem "Repeated incidents cannot be filtered and aggregated as recurrent" for critical sub-process "Solve recurrent incidents"

Phase 3 – Activity 3: Define Indicators and Measurement Plans for Strategies' Goals

In this activity, similar to the activity "Define Indicators and Measurement Plans for IT Services Goals", strategies are made measurable by specifying appropriate questions and measurement plans to define indicators and how their data collection must be performed. Analogous to the cited activity, COBIT sample measures available at Attachment I (ISACA, 2012b) and IT Services list of measures (Appendix I) can be used as sources to measurement plans definition. The template used to record the measurement plan items is the same "SINIS template for Indicator´s Measurement Plan."

Phase 3 – Activity 4: Create Interpretation Models for Strategies' Indicators

This activity is similar to "Create Interpretation Models for IT services goals Indicators". However, indicators related to strategies' goals are considered, instead of indicators related to IT services goals. Same checklist, template and example can be used.

Phase 4: Build, Review and Adjust GQM+Strategies Grid

During this phase, context factors, assumptions, goals, strategies and indicators are organized in a GQM+Strategies grid aiming to provide an overview of IT services measurement and help validation and identification of review needs. Being flexible to allow GQM+Strategies Grid iterative changes is important to make sure all plan is aligned and reflect organization needs (MUNCH *et al.*, 2013). Ideally, the grid has to present the cleanest possible view. SINIS template for grid is shown in Figure 20 and an example in Figure 21. The template was designed in a way to facilitate viewing different levels goals, strategies and indicators in a single page. Also, general context

factors and assumptions were disposed in this same single page, allowing to verify if they are current or changed. If it is necessary to change context factors and assumptions, the grid provide an easy view of goals, strategies and indicators that are impacted by the changes and also might change. Although using the template we can show the grid in a single page, if there are many context factors, assumptions, goals, strategies and indicators and it is not viable to represent them in a single page, they can be organized in more than one by following the same proposed structure.

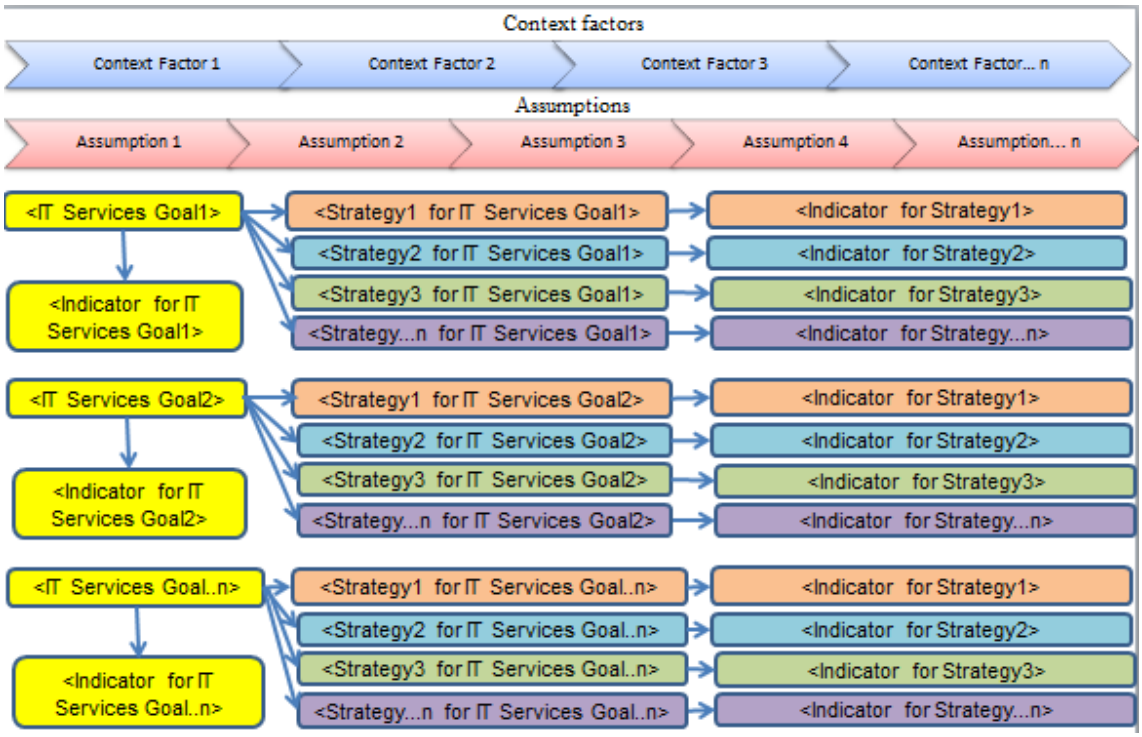

Figure 20 - SINIS template for GQM+Strategies grid (TRINKENREICH *et al*., 2015c)

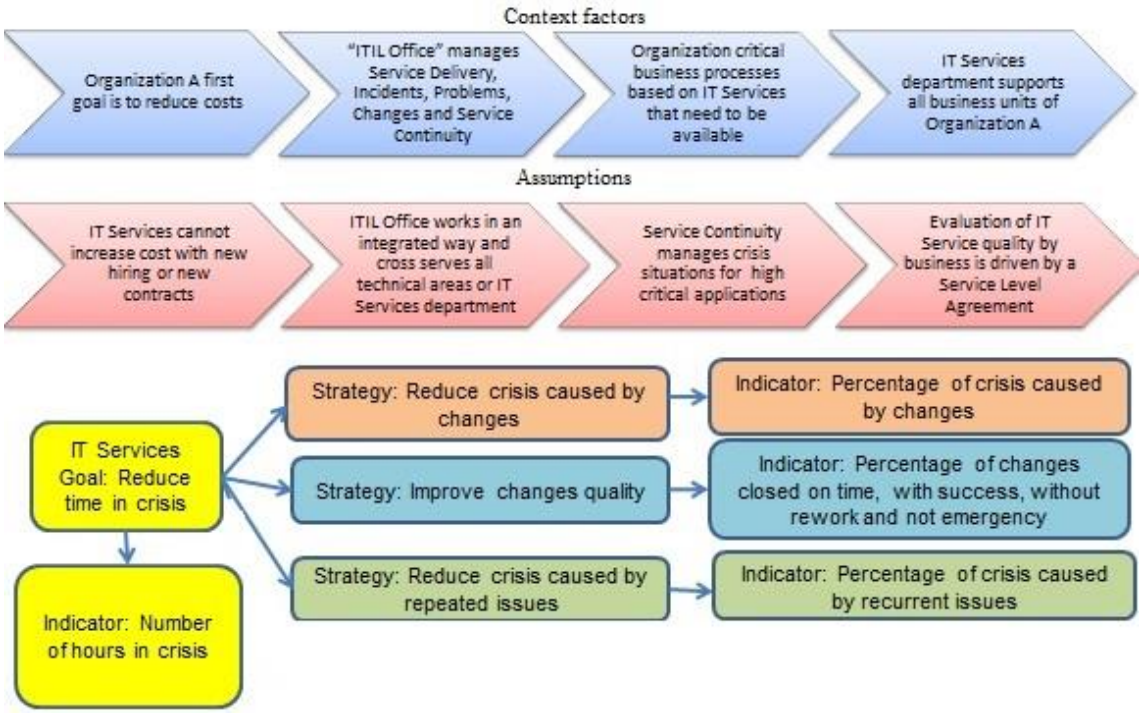

Figure 21 - SINIS template for GQM+Strategies grid (TRINKENREICH *et al*., 2015c)

GQM+Strategies Grid and Interpretation Models must be presented to all stakeholders through meetings in which information sources, context factors and assumptions must be validated, and applicability, completeness, accuracy and consistency of goals, strategies and indicators must be evaluated. Also, discussions can point out potential findings and improvement opportunities. It is recommended to include people who were not involved in SINIS application, but will be eventually involved in established strategies, executing or being impacted by execution or results. During this phase, if any definition needs to be adjusted, it is possible to get back to where is necessary to make changes and then continue following method from that point until the end again. For example, if an IT service goal needs to be changed, the related measurement plan needs to be adjusted to reflect changes, and also respective interpretation model, and also strategies created to attend that goal need to be revisited (and of course respective measurement plan and interpretation models). Which mean that traceability is done in order to keep everything consistent after a change.

4.2. SINIS Bottom-Up Version

Figure 22 shows an overview of SINIS bottom-up version with four phases, represented by different colors. Activities' description for each phase is provided

bellow. This version is provided to be used when there are indicators being used but organization does not know how to align them with IT service goals.

During first phase, information relevant to organization IT Services measurement are acquired. During second phase, existent indicators and IT services goals in use by organization are gathered, reviewed and new ones are included if needed. Also during this phase, alignment between indicators and IT services goals is provided, and indicators not aligned to any goal are eliminated. During third phase, existent strategies to achieve IT services goals are gathered, reviewed and new ones are included if needed. Also during this phase, alignment between strategies and IT services goals is provided, and strategies not related to any goal are eliminated. In the end of this phase, interpretation models for all indicators in place (after eliminations) are created to support analysis of measurement results. Finally, during fourth phase, a summary of produced information during previous phases is organized in a grid.

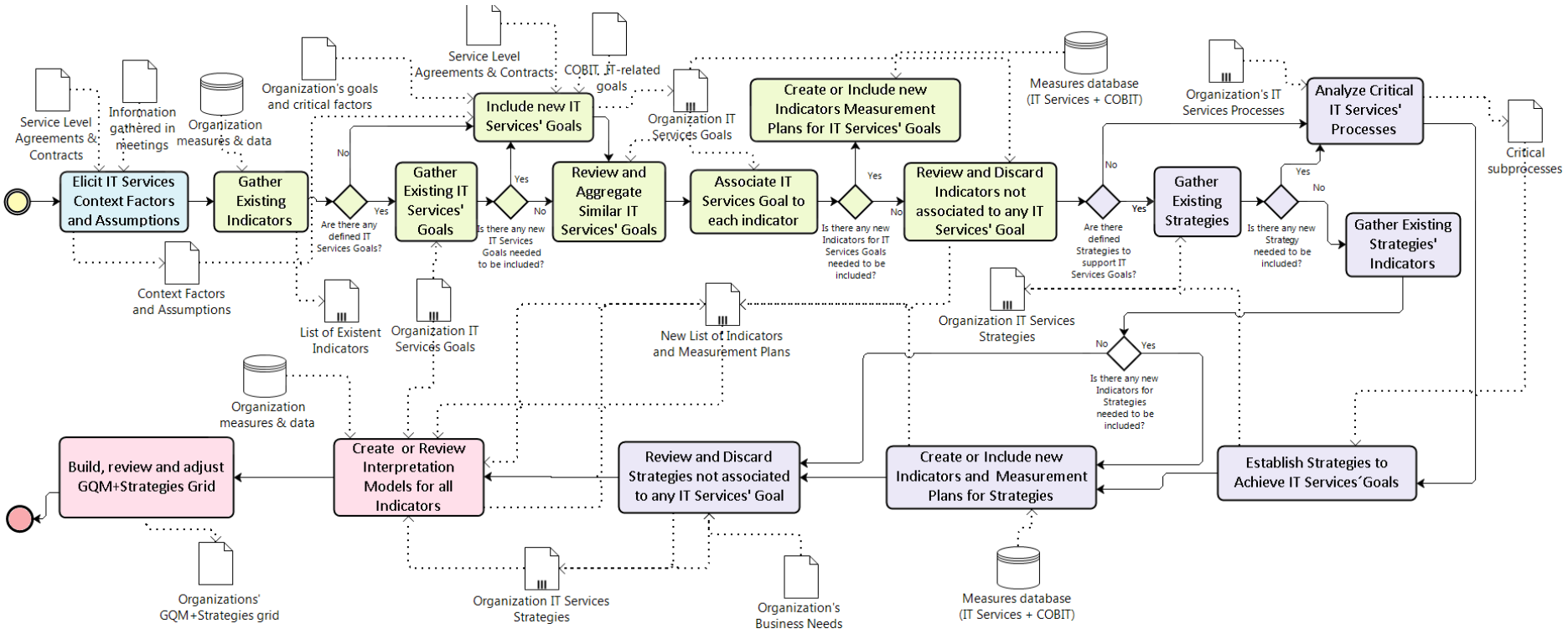

Figure 22 - Overview of SINIS method bottom-up version to select indicators for IT Services

Phase 1: Elicit IT Services Context Factors and Assumptions

This activity is just the same of top-down version, described in subsection 4.1.1. The same checklist, template and example can be used.

Phase 2: Review and Define IT services goals, Indicators and Interpretation Models

Phase 2 – Activity 1: Gather Existing Indicators

During this activity, all indicators in use by organization are listed and described, in order to have an initial understanding about their meaning. No selection, analysis or judgment is done during this activity. Considering that indicators are already being collected and analyzed, data should be gathered from existent measurement documentation and meetings. This activity can be executed by documentation analysis and open interview meetings with stakeholders responsible for measurement.

The checklist "SINIS checklist for Indicator´s Measurement Plan of IT Services Goal" is not used in this activity because new indicators are not being defined, they can be defined in activity "Create or Include new Indicators Measurement Plans for IT Services' Goals". Template to be used to document gathered indicators is "SINIS template for Indicator´s Measurement Plan" and example is "SINIS example for Indicator´s Measurement Plan", shown in subsection 4.1.3. The only difference is that now the fields "Information Need" and "IT Services Goal related" are going to be filled only in activity "Associate IT Services Goal to each indicator", as this information is not known yet. Checklist and example are also the same.

An example of a gathered indicator (at this moment without Information Need and without IT Service Goal) is provided Table 37.

Table 37 - SINIS example of gathered Indicator´s Measurement Plan

SINIS example of gathered Indicator´s Measurement Plan	
IT Services Goal related	*** Unknown ***
Measurement Goal	Reduce
Information Need	*** Unknown ***
Indicator	Number of closed incident tickets
Measurable entity type	Incident Management Process
Base measures	Total number of IT Security closed tickets per month (TN)
Measure calculation formula	$TN = N_1 + N_2 + \ldots + N_{NC}$
Measurement procedure	N: Extract data from incident report
Measurement responsible	IT Security Manager
Measure unit	-

Phase 2 – Activity 2: Gather Existing IT Services Goals

During this activity, IT service goals are gathered and reviewed, if available. This is different than SINIS Top-Down version, because here we assume that IT services goals can exist, as indicators that measurement is already happening. Even then, if IT services goals are not known or incomplete, they can be defined and refined in next activity. Data should be gathered from existent documentation and meeting registers. The checklist "SINIS questions to support elicitation of IT Service Goals" is not used in this activity because new goals are not being elicited nor reviewed, they can be elicited in activity "Include new IT Services' Goals" and reviewed in activity "Review and Aggregate similar IT Services Goals". This activity can be executed by documentation analysis or open interview meetings with managers responsible for IT Services department. Template to be used is the same of SINIS template for IT services goal, shown in subsection 4.1.2.

Phase 2 – Activity 3: Include new IT Services' Goals

During this activity, if the organization does not have a list of existent IT service goals, they must be defined. This activity is the same of top-down version, using the same checklist, template and example described in subsection 4.1.2.

Phase 2 – Activity 4: Review and Aggregate similar IT services goals

During this activity, gathered IT service goals are reviewed using checklist to review existent IT service goals, as shown in Table 38. Questions should be made for each existent goal to support evaluation if the goal is measurable and achievable (BASILI *et al.*, 2005), specific, relevant and time sensitive (DRUCKER, 1954) and not broad or vague (BARR, 2014). An example of a reviewed goal in shown in Table 39. In this example, the goal was not clear about how much should be the cost reduction and question "In which quantity is the goal achieved?" helped to find what should be reviewed on it.

Similarities in IT services goals are reviewed in order to remove duplicated goals and aggregate those ones with similar meaning. There is no specific template to be used for that. Template to be used is the same of SINIS template for IT services goal, provided in subsection 4.1.2.

Table 38 - SINIS questions to support review of an existent IT Service Goals (based on (BASILI *et al.*, 2005))

SINIS questions to support review of an existent IT Service Goals	
1	Is the goal scope related to something that IT Services department is able to deliver?
2	How is the service goal related to organization's goals?
3	Which IT service process is related to the goal?
4	Is the goal to Maintain, Increase or Reduce something?
5	What is the object the goal is related to?
6	In which quantity is the goal achieved?
7	What is the timeframe to achieve this goal?
8	Who is the primary responsible for goal attainment?
9	What relevant constraints may prevent goal achievement?

Table 39 - SINIS example of a reviewed IT Service Goal

SINIS example of a reviewed IT Service Goal		
IT Service Goal before review:		***Cost Reduction with Security Incidents***
1	Is the goal scope related to something that IT Services department is able to deliver?	*Yes*
2	How is the service goal related to organization's goals?	*Aligned with Cost Reduction organization goal*
3	Which IT service process is related to the goal?	*Incident Management*
4	Is the goal to Maintain, Increase or Reduce something?	*Reduce*
5	What is the object the goal is related to?	*Cost with incident solution solving*
6	In which quantity is the goal achieved?	*It is not clear*
7	What is the timeframe to achieve this goal?	*One year*
8	Who is the primary responsible for goal attainment?	*IT Security Manager*
9	What relevant constraints may prevent goal achievement?	*Increase the number of users, Unexpected Security Issues*
IT Service Goal after review:		*Reduce 10% the cost with IT Security incidents solution*

Phase 2 – Activity 5: Associate IT Services' Goal to each indicator

Considering that information needs describe needed information to monitor measurement goals (BARCELLOS *et al.*, 2012; MCGARRY *et al.*, 2002), during this activity, information needs to be met by indicators are evaluated to associate each existent indicator to an IT services goal. IT service goal is then inserted in table presented in subsection "Gather Existing Indicators". An example of a gathered indicator to have now IT Service Goal is provided in Table 40 bellow.

Table 40 - SINIS example for Associating IT Services Goal to an existent gathered indicator

SINIS example for Associating IT Services Goal to an existent gathered indicator		
	Indicator´s Measurement Plan of IT Services Goal Before Association	**Associating Information Need and IT Goal**
IT Services Goal related	*** Unknown ***	*Reduce 10% the cost with IT Security incidents solution*
Measurement Goal	Reduce	Reduce
Information Need	*** Unknown ***	Cost related to closed incidents
Indicator	Number of closed incident tickets	Number of closed incident tickets
Measurable entity type	Incident Management Process	Incident Management Process
Base measures	Total number of IT Security closed tickets per month (TN)	Total number of IT Security closed tickets per month (TN)
Measure calculation formula	$TN = N_1 + N_2 + \ldots + N_{NC}$	$TN = N_1 + N_2 + \ldots + N_{NC}$
Measurement procedure	N: Extract data from incident report	N: Extract data from incident report
Measurement responsible	IT Security Manager	IT Security Manager
Measure unit	-	-

Phase 2 – Activity 6: Create or Include new Indicators Measurement Plans for IT Services' Goals

During this activity, if the organization finds that any new indicator is needed to measure a service goal achievement, they must be defined. This activity is the same of top-down version, using the same checklist, template and example described in activity "Define Indicators and Measurement Plans for IT Services Goals". Analogous to the cited activity, in order to reduce effort, saving time and cost, reuse is supported by consulting two sources: COBIT Process sample measures, available in Attachment I (COBIT, 2012) and IT Services list of measures, available in Appendix I, to verify whether they are applicable or can inspire new ones.

Phase 2 – Activity 7: Review and Discard Indicators not Associated to any IT Services' Goal

During this activity, indicators and goals are reviewed in new round of brainstorm meetings with stakeholders responsible for measurement and a moderator in order to review indicators names and discard those ones not associated to any goal. The checklist provided in Table 41 can be used to support this review.

Table 41 - SINIS checklist to support review of existent Indicators

SINIS checklist to support review of existent Indicators	
1	Verify if there is any indicator not associated to any IT Services' Goal.
2	If yes, review again this indicator to make sure if there is missing IT services goals to be defined (in this case, go back to phase "Include new IT Services' Goals" and continue following phases).
3	Verify if the indicator is necessary but needs rewriting to be associated to an existent IT Services' Goal (in this case, review its name and/or measurement plan and continue following phases).
4	Finally, if indicator is really not needed, discard it.
5	Review and adjust indicators' names to improve understanding about what indicator is about

Phase 3: Review and Elicit Strategies to Achieve IT services goals

Phase 3 – Activity 1: Gather Existing Strategies

During this activity, if the organization already has a list of existent IT service strategies, projects, initiatives or operational actions planned or in course to achieve IT services goals, they are gathered and reviewed. If not, they are going to be defined in the activity "Analyze Critical IT Services Processes" and then "Establish Strategies to Achieve IT Services´ Goals". Data should be gathered from existent documentation and meetings records. This activity can be executed by documentation analysis and open interview meetings with IT Services department manager and team. There is no checklist for this activity. Template to be used is the same of SINIS template for IT services strategy, shown in subsection 4.6.

Phase 3 – Activity 2: Analyze Critical IT Services Processes

During this activity, if the organization does not have a list of existent strategies, projects, initiatives or operational actions planned or in course to achieve IT Services goals, they are going to be defined. SINIS used analysis of critical IT services process as a way to support definition of strategies to achieve IT service goals. This activity is just the same of top-down version, using the same checklists, templates and examples.

Phase 3 – Activity 3: Establish Strategies to Achieve IT Services´ Goals

During this activity, pre-existent and newly defined ones strategies are reviewed in new round of brainstorm meetings with stakeholders responsible for measurement and a moderator in order to associate them to IT services goals, and discard or adjust those ones not associated to any goal. This activity is just the same of top-down version, using the same checklists, templates and examples.

Phase 3 – Activity 4: Gather Existing Strategies' Indicators

During this activity, indicators in use by organization to measure existent strategies are listed and described, in order to have an initial understanding about their meaning. No selection, analysis or judgment is done during this phase. Considering that indicators are already being collected and analyzed, data should be gathered from existent measurement documentation and meetings.

This activity can be executed by documentation analysis and open interview meetings with stakeholders responsible for measurement. The checklist "SINIS checklist for Indicator´s Measurement Plan of IT Services Goal" is not used in this activity because new indicators are not being defined, they can be defined in activity "Create or Include new Indicators and Measurement Plans for Strategies". Template to be used to document gathered indicators is "SINIS template for Indicator´s Measurement Plan" and example is "SINIS example for Indicator´s Measurement Plan of IT Services Goal", shown in subsection 4.1.3. The only difference is that now the fields "Information Need" and "IT Services Goal related" are going to be filled only in activity "Associate IT Services Goal to each indicator", as now this information is still not knows. Checklist and example are also the same.

Phase 3 – Activity 5: Create or Include new Indicators and Measurement Plans for Strategies

In this activity, similar to the activity "Define Indicators and Measurement Plans for IT Services Goals", strategies are made measurable by specifying appropriate questions and measurement plans to define indicators and how their data collection must be performed. Analogous to the cited activity, in order to reduce effort, saving time and cost, reuse is supported by consulting two sources: COBIT Process sample measures, available in Attachment I (COBIT, 2012) and IT Services list of measures, available in Appendix I, to verify whether they are applicable or can inspire new ones.

Analogous to the cited activity, COBIT Goals Cascade sample measures, available at Attachment I (ISACA, 2012b) and IT Services list of measures, available at Appendix I can be used as sources to measurement plans definition. The template used to record the measurement plan items is the same "SINIS template for Indicator´s Measurement Plan".

Phase 3 – Activity 6: Review and Discard Strategies not associated to any IT Services' Goal

During this activity, existent strategies are reviewed in new round of brainstorm meetings with stakeholders responsible for IT Services department and a moderator in order to discard those ones not associated to any goal. The checklist provided in Table 42 can be used to support this review.

Table 42 - SINIS checklist to support review of existent Strategies

SINIS checklist to support review of existent Strategies	
1	Verify if there is any strategy not associated to any IT Services' Goal.
2	If yes, review again this strategy to make sure if there is missing IT services goals to be defined (in this case, go back to phase "Include new IT Services' Goals" and continue following phases).
3	Verify also if the strategy in place is necessary but needs rewriting to be associated to an existent IT Services' Goal (in this case, review its name and/or description and continue following phases).
4	Finally, if strategy is really not needed, discard it.

Phase 3 – Activity 7: Create or Review Interpretation Models for all Indicators

In this activity, interpretation models for all indicators (related to IT services goals and Strategies) are created. In SINIS top-down version this activity takes place just after indicator and measurement plan definition. However, in SINIS bottom-up, the activity was moved to the end, in order to avoid rework and time waste in case of discarding or adjusting any indicator.

Interpretation models are defined to determine how data collected for the defined indicators should be interpreted in order to support informed decisions about strategies and IT services goals achievement. Targets can be defined based on previous service level agreement contracts and reports or business's needs.

Checklist, template and example to be used are the same as the ones defined in activity "Create Interpretation Models for IT services goals Indicators" of SINIS top-down version.

Phase 4: Build, review and adjust GQM+Strategies Grid

This activity is the same of "Build, review and adjust GQM+Strategies Grid" of SINIS top-down version.

4.3. Final Considerations

Chapter 4 covered the activities included in SINIS top-down and bottom-up versions to support selection of indicators for IT Services.

COBIT Goals Cascade provides a large catalog of goals and indicators to be reused for IT Services organizations. However, COBIT recommends that each organization should build its own goals cascade, compare it with COBIT's and then refine it (ISACA, 2012b), and does not provide a mechanism to drive this building. SINIS is covering this gap by providing procedures, checklists, templates and examples to be followed for an IT Services organization to define its own goals and indicators, while accessing COBIT catalog for reuse.

GQM+Strategies indicates that goals, measures and strategies should be aligned and modeled in a grid is to support making goals and strategies explicit for an organization and to provide a clear correlation of all measurement initiatives (BASILI *et al.*, 2005). However, GQM+Strategies does not detail how to identify critical processes to be considered in strategies or how to define proper strategies and measures. SINIS is covering this gap by providing analysis of critical processes, which includes mapping and identifying critical sub-processes in processes related to IT services goals and finding root-cause for issues in those critical sub-processes.

Next chapter presents a case study and an action research applying and evaluating SINIS top-down and bottom-up versions in industry. SINIS method was not fully validated because only two experiences were performed (one for top-down version and another for bottom-up version) and some new instruments (as checklists and examples) were created as a method evolution after executing the experiences presented in next chapter.

CHAPTER 5 – Application of SINIS in Industry

In this chapter we present one case study and one action research executed in industry applying SINIS method to select indicators for IT services top-down and bottom-up versions. The case study presented here was published in (TRINKENREICH et al., 2015c).

5.1. Case Study applying SINIS Top-Down version

Top-Down was the first version created for SINIS. At the moment of the case study, there was not a bottom-up version. The case study exploratory research technique was used to observe the applicability of SINIS in industry, in order to verify if SINIS is useful to support selection of IT services indicators from business level to operational levels and aligned to organizational goals, and how could SINIS be further improved. We aimed to answer the research question "How to support selection of IT services indicators for different levels and aligned with organizational goals?"

The following steps were performed for the case study:

- Select Organization for Case Study;
- Execute SINIS method and present main results;
- Collect Lessons Learned to improve SINIS.

5.1.1. Select Organization for Case Study

We identified the Infrastructure department of IT Services of the same Organization A used in previous studies presented in incremental learning cycles in Chapter 3. All IT Services directory follows ITIL library practices [OGC, 2011] and intends to improve measurement process because much effort has been spent to select proper indicators and perform services measurement.

Infrastructure members do not know how their projects and operational work results influence the department, area or organizational goals. Infrastructure manager

does not participate in defining Organization A or IT Services strategic plan and goals. In the beginning of the year he receives a list of goals to be achieved by the Infrastructure and is free to define the department plans to achieve those goals.

He derives lower level indicators to support goals monitoring, but he does not follow any specific method. Each department member defines by himself/herself a list of initiatives and keeps working on it during all year, expecting to contribute to indicators targets achievement. It is worth noticing that there is no clear connection between initiatives' and indicators' results.

5.1.2. Execute SINIS method and present main results

5.1.2.1. Elicit IT Services Context Factors and Assumptions

In this activity, the researcher met with infrastructure manager and coordinators to identify relevant context factors and assumptions from organizational goals and other information about the organization. The obtained results are shown in Table 43.

Table 43 - Context Factors and Assumptions of Infrastructure Department of Organization

Context Factors	Assumptions
CF1: Organization A first goal is to reduce costs.	A1: IT Services cannot increase costs.
CF2: IT Services Area has a subarea "ITIL Office" to manage Service Delivery and Continuity, Incidents, Problems and Changes.	A2: Even having several subareas, ITIL Office works in an integrated way and cross serves all technical subareas of IT Services Area.
CF3: Organization A has critical business processes based on IT Services that need high availability.	A3: There is a Service Continuity team responsible for managing crisis situations that are opened for applications that support critical business processes.
CF4: IT Services Area supports all business units of Organization A.	A4: Evaluation of IT Service quality is driven by a Service Level Agreement.

5.1.2.2. Define IT Services Goals

In this activity, together with Infrastructure manager, we analyzed elicited context factors and assumptions and COBIT IT-Related Goals. We fully explored only one of the defined IT services goals. Context factor CF3 reveals that Organization A business requirements include service availability improvement.

Considering the COBIT IT-Related Goal "Delivery of IT services in line with business requirements" and the context factor CF3 ("…service availability need to be increased"), we defined the IT services goal "Reduce time in Crisis". It is directly related to the Crisis process (a sub-process of Incidents Management) that is started in Organization A when a crisis situation (mentioned in the assumption A3) occurs, i.e.,

when an application classified as high critical for business is unavailable. In this case, a crisis room is opened by the Service Continuity team.

When a crisis room is opened, all technical teams connect to a conference room and work together until the issue is solved and the application is back again. This process had been created to minimize service unavailability and to reduce impact to applications considered critical to business. Table 44 shows the IT service goal defined by using the SINIS template. We considered Assumption A1 to establish a constraint during IT service goal definition.

Table 44. IT Services Goal

IT Services Goal	Reduce Time in Crisis
Guidance	Reduce
Object	Time in Crisis
Magnitude	10%
Time Frame	Annual
Responsible	IT Services Infrastructure Department
Constraints	Do not increase cost
COBIT IT-Related goal	Delivery of IT services in line with business requirements
BSC Dimension	Customer
IT Service Process	Incident Management

5.1.2.3. Create Measurement Plans for IT Services Goals

This activity was carried out with the infrastructure manager, department members and an expert in quality and measurement who knew about data available and possible to be collected.

Analyzing the measures associated to the COBIT IT-Related goal "Delivery of IT services in line with business requirements", which was used as a basis to define the IT service goal considered, the measures suggested in the IT Services list of measures (Appendix I) and data available in Organization A, we selected "number of crisis" and "number of hours in crisis" as the measures to be used. The first measure was based on "number of business disruptions due to IT service incidents" from COBIT (ISACA, 2012b) and the second one on "service interruptions duration" (from IT Services list of measures). "Number of hours in crisis" indicator was selected to monitor the IT service goal "Reduce Time in Crisis". Table 45 presents the defined measurement plan.

Table 45. Measurement Plan for IT Services Goal "Reduce Time in Crisis"

IT Services Goal	Reduce Time in Crisis
Measurement objective	Reduce
Information Need	How many hours were spent in crisis?
Indicator	Number of hours in crisis (NHC)

Measurable entity type	Crisis
Base measures	Time spent in each crisis (TSC) (being NHC the number of hours in crisis)
Measure calculation formula	NHC = TSC1 + TSC2 +… + TSCNC
Measurement procedure	TSC: Extract data from incident report and conference call report NC: Extract data from incident report
Measurement responsible	Service continuity analyst
Measure unit	Hours
Measurement moment	Base measures must be collected after every crisis situation. Indicator must be collected before performance monitoring meetings.
Measurement periodicity	Monthly (indicator)

5.1.2.4. Create Interpretation Models for IT Services' Indicators

This activity was performed with the infrastructure manager. He defined targets for the indicator and how its data should be interpreted. IT Service goal is to reduce 10% of time in crisis, compared to previous year. Reports for 2014 year informed that total time in crisis was 765 hours. Thus, decreasing 10% means to get a target of 688.5 hours. Table 46 presents the interpretation model defined by using the SINIS template.

Table 46 - Interpretation Model for IT Services Goal Indicator "Number of hours in Crisis"

Indicator	Number of hours in crisis
Target	Maximum 688.5 hours (annual value)
Interpretation model	If total time in crisis is the target or less, IT Services goal is achieved
Interpretation Responsible	IT Services Continuity team
Interpretation Moment	During managers performance meeting
Interpretation Periodicity	Every month, accumulated data is analyzed and compared to goal taking same month in previous year as a reference. In the end of the year, total value is compared to total value in the previous year.

5.1.2.5. Analyze Critical IT Service Processes

In order to identify possible blockers that can prevent IT Services goals to be achieved and identify processes in which the strategies should be focused on, we accessed available documents for Incident Management process (including crisis), the IT Service process related the "Reduce Time in Crisis" goal (see Table 43), modeled it (Figure 23) and looked for relations with other processes. As a result, Change and Problem Management processes were identified.

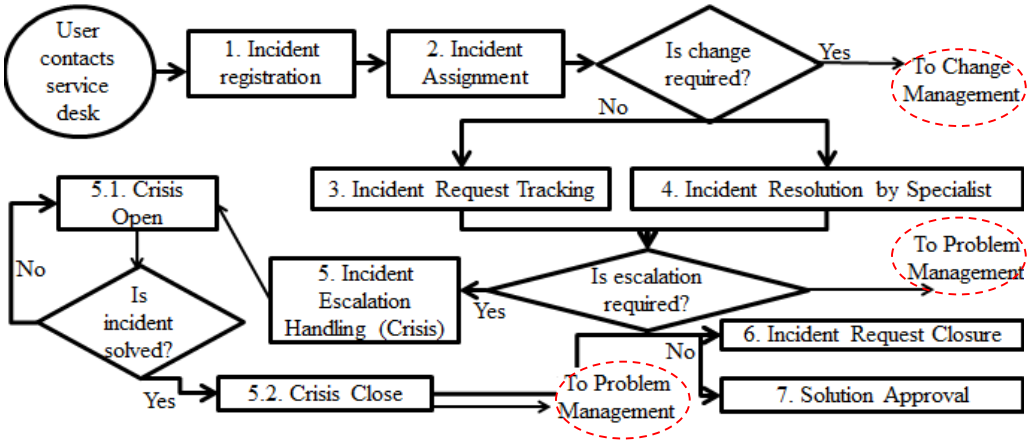

Figure 23 - Incident Management process of Organization A

5.1.2.6. Establish Strategies to achieve IT Service Goals

We started this activity by investigating problems related to the processes identified in the previous activity that could impact goal achievement. We searched for root-cause crisis reports of service level agreement for last year and noticed that several root-causes were recurrent, i.e., several crises were caused by repeated problems. Problem Management is a process related to Incident Management and responsible for investigating root-causes. In this sense, when a crisis is closed, the root-cause that derived it must be found and definitive solution must be implemented aiming to avoid recurrences. Since we noticed that a same issue was causing several crises, we concluded that root-cause investigation was not working properly. By analyzing root-cause crisis reports we also found that many crises were caused by implemented changes. Infrastructure manager informed that Change Management should guarantee proper planning to prevent services being impacted, which means Change Management should not impact Incident Management. However, reports showed evidences that this was not happening, resulting in crisis caused by changes. After understanding possible reasons that are blockers to IT Services goals achievement, strategies were defined to mitigate them. Table 47 presents three strategies defined using SINIS template.

Table 47. Strategies for IT Services Goal "Reduce Time in Crisis"

SINIS Strategies for IT Services Goal			
IT Services Goal	Reduce Time in Crisis		
Strategies	Reduce crisis caused by changes	Improve changes quality	Reduce crisis caused by repeated issues
Description	Reduce number of hours of crisis caused by changes	Improve quality of changes planning and execution	Reduce number of hours in crisis caused by issues that could have been avoided

5.1.2.7. Create Measurement Plans for Strategies' Goals

This activity was done with infrastructure, services continuity, problem and change managers, and an expert in quality and measurement who knew about available and possible data to be collected.

Since we identified that the processes to be focused by the strategies were Problem Management, Change Management and Incident Management, we analyzed measures related to these processes in COBIT, the measures associated to these processes in the IT Services list of measures (Appendix I) and data available in Organization A.

Table 48 shows some of the measures identified in each source and the measures selected to be used, defined considering the identified measures and the available data.

Table 48 - Measures Investigated and Measurement Plan for Strategies' Goals

Source	Measures found	Measures Defined for Organization A
COBIT Indicators	Number of recurring incidents caused by unresolved problems	Percentage of crisis caused by recurrent issues
IT Services list of measures	Successful/failed change requests	Number of changes executed with success
	Emergency/normal requests	Number of emergency changes
	Amount of time to find/solve root cause	Total number of hours to find problems root cause

After selecting measures, the measurement plans were defined. Table 49 presents the plans by using the SINIS template. Several measurement plans are being presented in the same table.

Table 49 - Measurement Plans for Strategies' Goals

SINIS Measurement Plan for Strategies Goals Indicators			
IT Services Goal	Reduce Time in Crisis	Reduce Time in Crisis	Reduce Time in Crisis
Strategy	Reduce Crisis Caused by Changes	Improve Changes Quality	Reduce Crisis Caused by Repeated Issues
Measurement objective	Control and Decrease	Control and Increase	Control and Decrease
Information Need	How many hours in crisis were due to failed changes?	How many changes were closed on time, with success and not emergency?	How many hours in crisis were due to repeated issues?
Indicator	Percentage of hours in crisis caused by changes	Percentage of changes closed on time, with success, without rework and not emergency	Percentage of hours in crisis caused by recurrent issues
Measurable entity	Crisis	Changes	Crisis

SINIS Measurement Plan for Strategies Goals Indicators			
Base measures	Hours in crisis caused by changes (HCCG); Total hours in crisis (THC)	Number of changes closed on time, with success, without rework and not emergency (NCTSRE); Total number of executed changes (TC)	Hours in crisis caused by recurrent issues (HCCRI); Total hours in crisis (THC)
Calculation formula	(HCCG/THC)*100	((NCTSRE)/ TC)*100	(HCCRI/THC)*100
Measurement procedure	HCCG: Extract data from problem report; THC: Extract data from crisis report	NCTSRE: Extract data from problem report; TC: Extract data from change report	HCCRI: Extract data from problem report; THC: Extract data from crisis report
Measurement responsible	Problem management performance responsible	Change management performance responsible	Problem management performance responsible
Measurement moment	Before performance monitoring meetings	Before performance monitoring meetings	Before performance monitoring meetings
Measurement periodicity	Once a month	Once a month	Once a month

5.1.2.8. Create Interpretation Models for Strategies' Indicators:

This activity was performed with the infrastructure manager, who defined targets for indicators and how results should be interpreted. IT Service goal is to reduce 10% of time in crisis, compared to previous year. Table 50 presents the defined interpretation model.

Table 50 - Interpretation Model for IT Services Goal Indicator "Number of Hours in Crisis"

SINIS Interpretation Model for IT Services Goal Indicator			
Indicator	Percentage of crisis caused by changes	Percentage of changes closed on time, with success, without rework and not emergency	Percentage of crisis caused by recurrent issues
Target	Maximum 6%	Minimum 90%	Maximum 8%
Interpretation model	If maximum 6% hours in crisis had root-cause identified as related to changes, they are considered exceptions and target is reached.	If minimum 90% of changes were closed on time, with success, without rework and not emergency, target is reached.	If maximum 8% hours in crisis are related to recurrent issues, target is reached.
Interpretation Responsible	Problem Manager	Change Manager	Problem Manager
Interpretation Moment	Before managers performance meeting		
Interpretation Periodicity	Every month and once a year		

5.1.2.9. Build, review and adjust GQM+Strategies grid

During this phase, we organized context factors, assumptions, goals, strategies and indicators in a GQM+Strategies grid and presented it to all infrastructure team to

gather members' opinion and concerns. Figure 24 presents the resulting grid. As a feedback, infrastructure team commented that many useless measures will be now abandoned. Like that, team's activities will be more focused on achieving strategies' indicators. Infrastructure manager stated that now he will spend less time managing team activities to achieve IT Services indicators, since now the team knows how to support it.

As examples of indicators usage, Figure 25 shows data collected to "Number of hours in crisis" , which has been monthly evaluated and compared to last years.

Figure 26 presents data collected to the indicator "Percentage of crisis caused by changes", related to the strategy "Reduce crisis caused by changes", which has been monthly evaluated. Average of percentage is now 8.32%, still not reaching the indicator target (6%). Figure 26 also shows data collected to the indicator "Percentage of changes closed on time, with success, without rework and not emergency" related to the strategy "Improve changes quality".

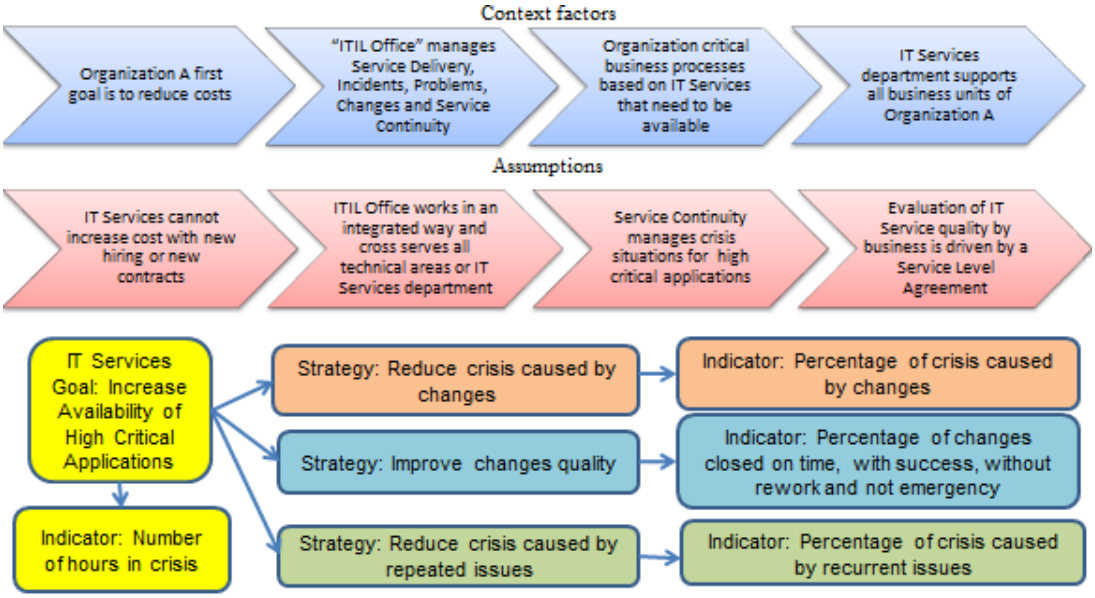

Figure 24 - GQM+Strategies grid (TRINKENREICH et al.,2015c)

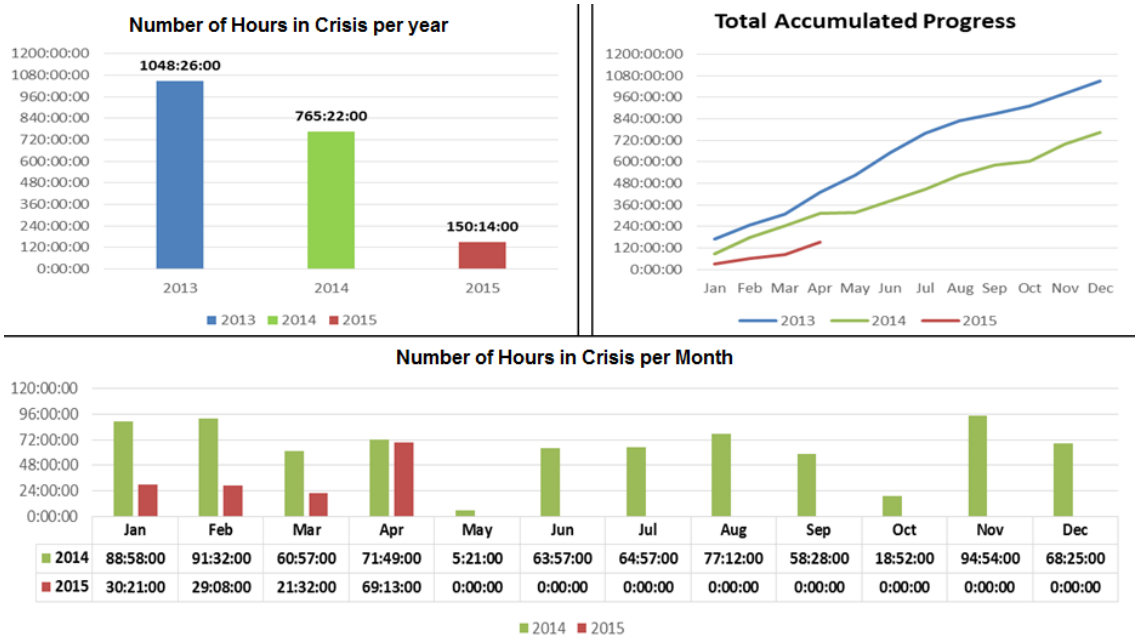

Figure 25 - Number of hours in crisis: indicator of achievement of the "Reduce time in crisis" goal (TRINKENREICH *et al.*, 2015c)

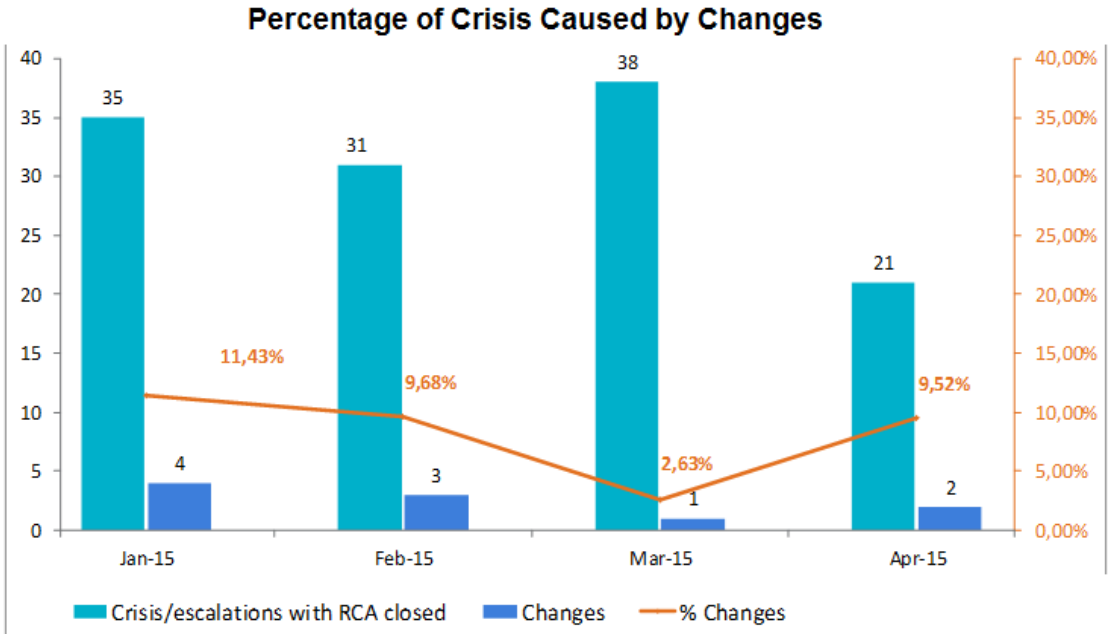

Figure 26 - Indicator for "Reduce crisis caused by changes" strategy (TRINKENREICH *et al.*, 2015c)

5.1.3. Case Study Threats to Validity

This case study has treats to validity, classified per Conclusion Threats, Internal Threats, Construction Threats and External Threats (WOHLIN *et al.*, 2012). Threats to

validity and respective actions taken to minimize with each of them are presented in Table 51 bellow.

Table 51 - Threats to Validity SINIS Top-Down Case Study

Threat to Validity Type	Threat to Validity Description	Action to Minimize Threat to Validity
External	SINIS Top-Down was applied in one single case scenario. This can affect generalizing results as method was not applied in more than one scenario.	SINIS instruments (checklists, templates and examples) facilitate execution for new and other cases.
Internal	Researcher who executed case study is part of Infrastructure team and so, familiarized to goals, existent data to be collected and possible projects and initiatives to be part of strategies.	SINIS instruments (checklists, templates and examples) were created to provide knowledge to another person to execute SINIS even without being part of the selected IT Services team.
Conclusion	Being part of Infrastructure team and at the same time, the SINIS' creator, the researcher herself could have less difficulties to be listed as lessons learned than if case study was performed by someone who is new to the context or to the method.	As a result of this case study, SINIS instruments were enriched with checklists to facilitate information gathering and procedures execution by other people.
Construction	Being the SINIS' creator, the researcher who worked in case study could have better expectations about industry needs being covered by method than if it was executed by another person, different from SINIS creator.	IT Infrastructure manager was presented to case study results and provided his insights documented in lessons learned.

5.1.4. Collect Lessons Learned to improve SINIS

In the last step of the case study, we collected lessons learned (Table 52) to improve SINIS. Some lessons were considered positives and represent SINIS characteristics that could support successful results. Other lessons were considered negatives and represent SINIS characteristics that need to be improved.

Table 52. Lessons Learned

	Impact	Lesson Learned	Future Work
1	Positive	Having available sources to read, support and reuse was good for having ideas and remembering goals, indicators and strategies.	Create a unique catalog of IT services goals, strategies and indicators, using RMSO conceptualization and categorized by maturity models processes, COBIT and ITIL processes, aiming to make easier to directly search and reuse.
2	Negative	Searching different sources for reuse was difficult because sources do not follow a common conceptualization and categorization.	
3	Positive	Having numeric targets for strategies' indicators was good for having a way to measure if strategies are performing as expected.	Start data collection and, after having enough data, submit processes to Statistical Process Control to evaluate if they are stable and able to attend expected targets.
4	Negative	Targets for indicators were created based on past experiences and manager expectations; there is no information if processes are able to attend them.	

5.2. Action Research applying SINIS Bottom-Up version

5.2.1. Action Research Motivation and Preliminary Phase

This preliminary phase aimed at identifying the research context and purpose. This work took place within IT Security department of the same Organization A we worked in previous study. The IT Security Department provide IT services for all other departments of Organization A following ITIL library practices (OGCa, 2011), but it is not certified by any software or services maturity model.

We conducted the action research aiming to answer the research question: "How to support alignment of IT services indicators with organization goals to measure only what really matters?"

SINIS Top-Down was fully executed by the researcher in the case study presented in the previous section. After that, researcher used Top-Down templates and examples to create SINIS Bottom-Up version, as a variation of top-down version, while executing it together with IT Security. The IT Security department scenario motivated the creation of the bottom-up version, since the version available at that moment was not completely suitable for an organization that had already started measurement .

Bottom-up version of SINIS was created to allow IT Services departments review existent indicators, goals and strategies and discard indicators and strategies not aligned to goals, reducing waste of time and cost. Bottom-up name was selected to be used because in this case we start gathering existent indicators and then verify if they can be aligned to goals, instead of deriving indicators from goals.

Organization A's IT Security manager informed that his team spend too much effort to perform measurements not created aligned to strategic organizational goals. Thus, team members didn't know why they are spending so much time on measurement activities and were losing motivation and trust on measurement results. Although the team had a large list of measures collected, its members didn't know how these measures were related to the IT Security Goals, and neither whom they should report to nor how to interpret measurement results.

The researcher that conducted the action research study works in the IT Services directory but in Hosting department, a subarea different than the IT Security department, being external to the context.

The following phases proposed by Action-Research method were performed: data gathering, feedback and analysis; action planning, implementation and evaluation.

5.2.2. Action Research Main Phase

This study attended a request from the IT Security manager to review existent indicators. At that time, researcher had created SINIS Top-Down method and was starting to study what should be different for possible Bottom-Up version. Data gathering, actions planning and execution will be distributed through SINIS Bottom-Up procedures as follows. Feedback and lessons learned will be presented in Action Research Feedback and Lessons Learned section.

5.2.2.1. Elicit IT Services Context Factors and Assumptions

In this activity, the researcher met with IT Security coordinator to identify relevant context factors and assumptions from organizational goals and other information about the organization. The obtained results are shown in Table 53.

Table 53 - Context Factors and Assumptions of IT Security Department of Organization A

Context Factors	Assumptions
CF1: Organization A first goal is to reduce costs.	A1: IT Security cannot increase costs.
CF2: IT Security Area does not have people dedicated to measurement activities.	A2: Members of IT Security area will responsible for collecting and storing data for indicators and present results in weekly meeting to manager.

5.2.2.2. Gather Existing Indicators

This activity started with IT Security coordinator sending the researcher a Microsoft Excel spreadsheet by email containing a list of existent measures currently being collected in the department. This list had only the name of the measure and responsible for data collection, there was no further description, neither measurement plan or interpretation model. Although IT Security coordinator called this list as Indicators List, it should be a Measures List, as there was not any alignment between measures and goals[3]. Total amount of measures was 39, showed in Table 54.

At that time, SINIS template for Indicator´s Measurement Plan could not be used to document each measure because there was not available information about each measure. In order to gather more information, the researcher performed three meetings with the team. Meetings duration varied from 1 to 2 hours across two weeks due to analysts time restrictions (according to CF2: IT Security Area does not have people dedicated to measurement activities).

[3] According to BARCELLOS *et al.* (2012) indicators are measures used to monitor whether a goal is reached.

Most measures names were not clear enough to understand what was being measured. During the meetings the first question asked by the researcher for each measure was “What is this measure about?” The researcher asked the team to suggest new names to be used as “Indicator” in “SINIS template for Indicator´s Measurement Plan.”

Table 54 – Original measures in use by IT Security and responsible analysts for data collection

Measure	Responsible for Data Collection
Number of applications Supported	Analyst 1
Profiles	Analyst 1
Number of application owners that participate on IAM processes	Analyst 1
Closed Tickets	Analyst 1
Total Tickets by Application	Analyst 1
Number of Digital Certificates	Analyst 2
#NFE Usage	Analyst 2
Number of investigations	Analyst 3
Manual resolution rate	Analyst 4
Number of Internet Users by High Tiers	Analyst 4
Number of Virus Events	Analyst 4
Percentage of machines with antivirus up to date	Analyst 4
Percentage of machines without antivirus	Analyst 4
Antivirus (SLA) Server	Analyst 4
Antivirus (SLA) Workstations	Analyst 4
Antivirus Malware Detection / Protection	Analyst 4
Unique Vulnerabilities	Analyst 2
Unresolved Virus (cleansing)	Analyst 4
Vulnerability Management Resolution Rate	Analyst 2
Number of critical applications with critical vulnerabilities	Analyst 2
Number of NFE expiring	Analyst 2
Number of reported phishing cases	Analyst 4
Incoming Mail Summary	Analyst 3
Number of Opened Audit Findings	Analyst 5
Number of Opened Audit Findings expiring next month	Analyst 5
SOX Controls – GAPS	Analyst 6
Percentage of users with critical Access	Analyst 6
SAP Job Functions	Analyst 6
SAP Users	Analyst 6
SAP Manual Actions	Analyst 7
Number of BCJs	Analyst 8
Number of Technical Notes Impacting Security	Analyst 5
Number of Technical Notes expiring next month	Analyst 5
Number of projects with issues identified	Analyst 5
Approved SAP Privileged Accounts	Analyst 6
SOX Controls – Area	Analyst 6
Number of projects monitored by IT Security (high impact/SOX)	Analyst 5
IT Users	Analyst 8
Number of Scanned Hosts	Analyst 2

During explanation about each measure, the researcher asked questions following “SINIS template for Indicator´s Measurement Plan”. The only field not asked

about was “IT Services Goal” (as described in SINIS Bottom-Up activity, that will be associated in another activity).

An example of gathered measure is shown in Table 55.

Table 55 - SINIS Measurement Plan for gathered measure “Manual resolution rate”

SINIS Measurement Plan	
IT Services Goal related	****Unknown****
Measurement Goal	Reduce Manual Resolution for IT Security Incidents
Information Need	Number of incidents where a manual intervention was needed to solve the issue
Measurable entity type	Incident Management Process
Indicator	Manual resolution rate
Base measures	NM = Number of incidents where a manual intervention was needed to solve the issue TN = Total number of IT Security incidents
Measure calculation formula	NM/TN
Measurement procedure	Extract and export incidents list to Microsoft Excel from Remedy application where Designed group is IT Security, Status is solved, Summary is antivirus events In exported spreadsheet, filter and count number of lines where Resolution Type was manual (NM) and total number of lines (TN) Store spreadsheet in IT Security measurement directory in current month folder
Measurement responsible	Analyst 4
Measure unit	-
Measurement moment	Every 5th day of the month
Measurement periodicity	Monthly

5.2.2.3. Gather Existing IT services goals

IT Security coordinator did not have a list documented IT services goals. He informed that IT Security manager wanted the team to define their own IT security goals and review existent indicators, and present him to validate. The team was not used to think about goals, they were used to collect and report operational measures. Therefore, there was no information to be gathered, so goals were created in next activity.

5.2.2.4. Include new IT Services' Goals

This activity started with brainstorm meetings with the team asking them “What goal you think each measure can support?” This was the longest activity because team was not used to think about goals. Meetings duration varied from 1 to 2 hours distributed over four months also due to analysts time constraints (according to CF2: IT Security Area does not have people dedicated to measurement activities).

SINIS questions to support elicitation of IT Service Goals was used to guide brainstorms and ten IT services goals were created:

- Reduce the cost with IT Security incidents solution;
- Reduce the resolution time for IT Security incidents;
- Increase efficiency in controls execution;
- Reduce number of users with elevated access to Internet;
- Increase efficiency of blocking malware messages;
- Reduce the number of users with SAP SOD conflict;
- Increase IT Security team productivity;
- Maintain applications adherence to IT Security policies;
- Increase vulnerability detection and remediation;
- Increase efficiency of workstations and servers protection.

An example of one of the IT services goals created is provided in Table 56.

Table 56 - SINIS IT Services' Goal

SINIS template for IT Services' Goal	
IT Services Goal	Reduce the Cost with IT Security Incidents Solution
Activity	Reduce
Object	Cost to Solve Incidents
Magnitude	10%
Time Frame	Annual
Responsible	IT Security Department
Constraints	Do not increase cost
COBIT IT-Related Goal	Delivery of IT services in line with business requirements
BSC Dimension	Customer
IT Service Process related	Incident Management

5.2.2.5. Review and Aggregate similar IT Services Goals

This activity was not performed as IT Security team did not have any existent goals reported.

5.2.2.6. Associate IT Services' Goal to each indicator

This activity happened during brainstorm meetings with the team to include new IT services goals. Instead of first creating all IT services goals and after that associating indicators for all of them, the team preferred to work for each goal, defining the goal and then associating an indicator before defining the next goal.

Table 57 presents an example of associating two IT services goals to an indicator. IT Security needed to reduce cost and time with incident resolution. Organization A is charged per incident that had to be manually solved, which means, when an incident cannot be automatically solved by antivirus tool and need a support technical person to manually investigate and remove the malware from server or workstation. In that sense, the indicator "Manual resolution rate" was associated to IT security goal "Reduce the cost with IT Security incidents solution". Also, when manually solving an incident, time to solve is higher than when automatically solving. In that sense, the indicator "Manual resolution rate" was also associated to IT security goal "Reduce the Resolution Time for IT Security Incidents."

Table 57 - SINIS Measurement Plan for gathered measure "Manual resolution rate" updated with associated IT services goals

SINIS Measurement Plan	
IT Services' Goal related	Reduce the cost with IT Security incidents solution and Reduce the Resolution Time for IT Security Incidents
Measurement Goal	Reduce Manual Resolution for IT Security Incidents
Information Need	Number of incidents where a manual intervention was needed to solve the issue
Measurable entity type	Incidents Management Process
Indicator	Manual resolution rate
Base measures	NM = Number of incidents where a manual intervention was needed to solve the issue TN = Total number of IT Security incidents
Measure calculation formula	NM/TN
Measurement procedure	Extract and export incidents list to Microsoft Excel from Remedy application where Designed group is IT Security, Status is solved, Summary is antivirus events In exported spreadsheet, filter and count number of lines where Resolution Type was manual (NM) and total number of lines (TN) Store spreadsheet in IT Security measurement directory in current month folder
Measurement responsible	Analyst 4
Measure unit	-
Measurement moment	Every 5th day of the month
Measurement periodicity	Monthly

Table 58 shows a summary of association between indicators and IT services goals.

Table 58 - Association between Existent Indicators and IT Services Goals for IT Security

Indicator	**IT Services´ Goal**
Number of applications Supported	Increase IT Security team productivity
Profiles	Increase IT Security team productivity

Indicator	IT Services´ Goal
Number of application owners that participate on IAM processes	Increase IT Security team productivity
Closed Tickets	Reduce the cost with IT Security incidents solution Reduce the Resolution Time for IT Security Incidents
Total Tickets by Application	Reduce the cost with IT Security incidents solution
Number of Digital Certificates	*** Unknown ***
#NFE Usage	*** Unknown ***
Number of investigations	Increase IT Security team productivity
Manual resolution rate	Reduce the cost with IT Security incidents solution Reduce the Resolution Time for IT Security Incidents
Number of Internet Users by High Tiers	Reduce number of users with elevated access to Internet
Number of Virus Events	Increase efficiency of workstations and servers protection
Percentage of machines with antivirus up to date	Increase efficiency of workstations and servers protection
Percentage of machines without antivirus	Increase efficiency of workstations and servers protection
Antivirus (SLA) Server	Increase efficiency of workstations and servers protection
Antivirus (SLA) Workstations	Increase efficiency of workstations and servers protection
Antivirus Malware Detection / Protection	Increase efficiency of workstations and servers protection
Unique Vulnerabilities	Increase vulnerability detection and remediation
Unresolved Virus (cleansing)	Increase efficiency of workstations and servers protection
Vulnerability Management Resolution Rate	Increase vulnerability detection and remediation
Number of critical applications with critical vulnerabilities	Increase vulnerability detection and remediation
Number of NFE expiring	*** Unknown ***
Number of reported phishing cases	Increase efficiency of blocking malware messages
Incoming Mail Summary	Increase efficiency of blocking malware messages
Number of Opened Audit Findings	Increase efficiency in controls execution
Number of Opened Audit Findings expiring next month	Increase efficiency in controls execution
SOX Controls – GAPS	*** Unknown ***
Percentage of users with critical Access	*** Unknown ***
SAP Job Functions	Reduce the number of users with SAP SOD conflict
SAP Users	Reduce the number of users with SAP SOD conflict
SAP Manual Actions	Reduce the number of users with SAP SOD conflict
Number of BCJs	Maintain applications adherence to IT Security policies
Number of Technical Notes Impacting Security	Maintain applications adherence to IT Security policies
Number of Technical Notes expiring next month	Maintain applications adherence to IT Security policies
Number of projects with issues identified	Maintain applications adherence to IT Security policies
Approved SAP Privileged Accounts	*** Unknown ***
SOX Controls – Area	*** Unknown ***
Number of projects monitored by IT Security (high impact/SOX)	Maintain applications adherence to IT Security policies
IT Users	Increase IT Security team productivity
Number of Scanned Hosts	Increase vulnerability detection and remediation

5.2.2.7. Create or Include new Indicators Measurement Plans for IT Services' Goals

This activity was not performed. IT Security team considered they did not have to create any new indicator as existent ones were enough.

5.2.2.8. Review and Discard Indicators not Associated to any IT Services' Goal

During this activity, indicators and goals were reviewed in a new round of brainstorm meetings with all IT Security team in order to discard those ones not associated to any goal. SINIS activity includes a review for indicator names in this activity. Seven indicators listed in Table 56 as IT services goal "***unknown***" were discarded, no longer measured. Existing indicators were renamed (see Table 59).

Table 59 – Indicators name review

Old Indicator Name	New Indicator Name
Number of applications Supported	Number of applications that use Identity Access Management system for authentication
Profiles	Number of profiles maintained by Identity Access Management system
Number of application owners that participate on IAM processes	*(continued the same)*
Closed Tickets	Incidents opened and closed in current month
Total Tickets by Application	Incidents closed and resolved by application
Number of investigations	Number of legal or internal audit investigations supported by IT Security team
Manual resolution rate	Percentage of incidents where field intervention was necessary to solve the issue (manual/total)
Number of Internet Users by High Tiers	*(continued the same)*
Number of Virus Events	*(continued the same)*
Percentage of machines with antivirus up to date	*(continued the same)*
Percentage of machines without antivirus	*(continued the same)*
Antivirus (SLA) Server	*(continued the same)*
Antivirus (SLA) Workstations	*(continued the same)*
Antivirus Malware Detection / Protection	Percent of total number of threats that were solved/deleted/eliminated within one month
Unique Vulnerabilities	Number of found vulnerabilities unique on Organization A environment
Unresolved Virus (cleansing)	Number of threats against servers or workstations that presented issues and could not be deleted or quarantined
Vulnerability Management Resolution Rate	*(continued the same)*
Number of critical applications with critical vulnerabilities	*(continued the same)*
Number of reported phishing cases	*(continued the same)*
Incoming Mail Summary	Number of messages blocked by the gateway
Number of Opened Audit Findings	*(continued the same)*
Number of Opened Audit Findings expiring next month	*(continued the same)*

Old Indicator Name	New Indicator Name
SAP Job Functions	Percentage of SAP Job Functions
SAP Users	Percentage of SAP approved risky profile users
SAP Manual Actions	Number of SAP manual actions
Number of BCJs	Number of IT Security exceptions accepted
Number of Technical Notes Impacting Security	*(continued the same)*
Number of Technical Notes expiring next month	*(continued the same)*
Number of projects with issues identified	*(continued the same)*
Number of projects monitored by IT Security (high impact/SOX)	*(continued the same)*
IT Users	Number of IT Users
Number of Scanned Hosts	Number of servers and workstations scanned

5.2.2.9. Gather Existing Strategies

The IT Security coordinator informed he did not have a list of documented strategies being executed to achieve IT services goals. The researcher considered this as expected, because the team did not have a defined list of goals to be achieved. They were used just to collect many operational measures and work on solving critical issues as they appear. There was no information to be gathered, therefore strategies were created in next activity.

5.2.2.10. Analyze Critical IT Services Processes

This activity was performed in order to find critical processes related to IT services goals to support finding proper strategies to be executed to achieve those IT services goals.

The process mapping for processes related to IT services goals was the first step carried out in this activity. The IT services goal indicator “Percentage of incidents where field intervention was necessary to solve the issue (manual/total)” was selected to have strategies defined during this research. The process related to this indicator is “Manual Resolution for IT Security Incidents”, mapped as follows in Figure 26.

When an antivirus detects a threat in a server or user workstation, which can happen during scheduled or real-time scan, the antivirus solution tries to automatically perform the configured action for each type of threat. This first action is usually to clean the threat, which can be successful or not. Because of that, there is a secondary configured action that can be quarantine or delete the threat. Both actions can be automatically executed without any support analyst intervention.

If the second attempt of automatic action fails, the server or the workstation are included in a list of failed threat solution. This list is monitored by a team that opens incident records in Organization A's Incident Management solution to solve those failure cases. At this time, the incident is considered not billable by the IT Security support provider. By contract only manually attended incident are charged. Although, when a remote solution is not possible to be done, the incident is assigned to a local support team that needs to physically go to the workstation or server and manually solve the threat. This manual resolution procedure impacts two IT services goals: "Reduce the Cost with IT Security incidents solution" (because manual support is paid to the supplier) and "Reduce Resolution time for IT Security Incidents" (because incident takes more time to be solved). In that sense, when IT Security is not able to automatically remove a threat or, at least, remotely solve it, manual resolution can happen and therefore impact goals.

This process mapping helped IT Security to clarify and understand how to start investigation of possible causes for manual resolution being needed, and then plan strategies to reduce their occurrence in next activities.

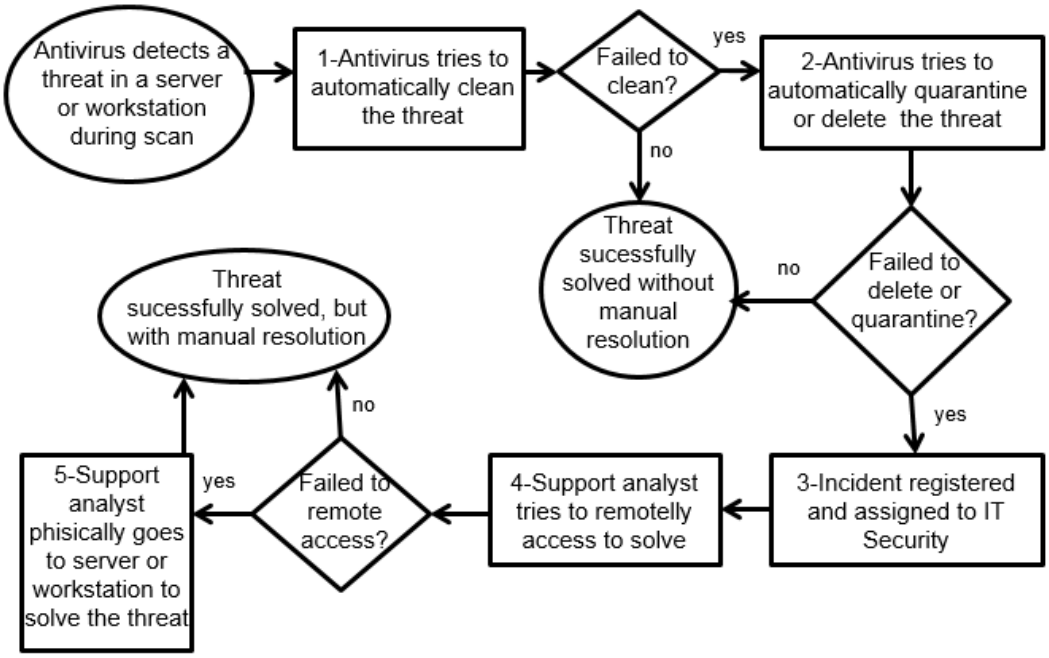

Figure 27 – Process map for IT Security Incidents resolution

5.2.2.11. Identify Root-Cause for Issues in Critical Sub-processes

This activity was performed in order to find why manual resolution is happening in order to be part of strategies. As IT Security team has a subarea for antivirus, in this

activity, the meeting was done directly with the researcher and the responsible for antivirus subarea, which is the domain expert.

By using process mapping, we could already find that incident manual resolution happens when IT Security is *not able to automatically remove a threat* and neither *remotely solve* it. Those two are the unwanted conditions or issues to be focused during root-cause analysis. The Pareto diagram should be created to rank potential causes and prioritize those ones that happen the most. As there were only those two potential causes, we skipped Pareto. The meeting continued by building Cause-and–Effect diagram as shown in Figure 28.

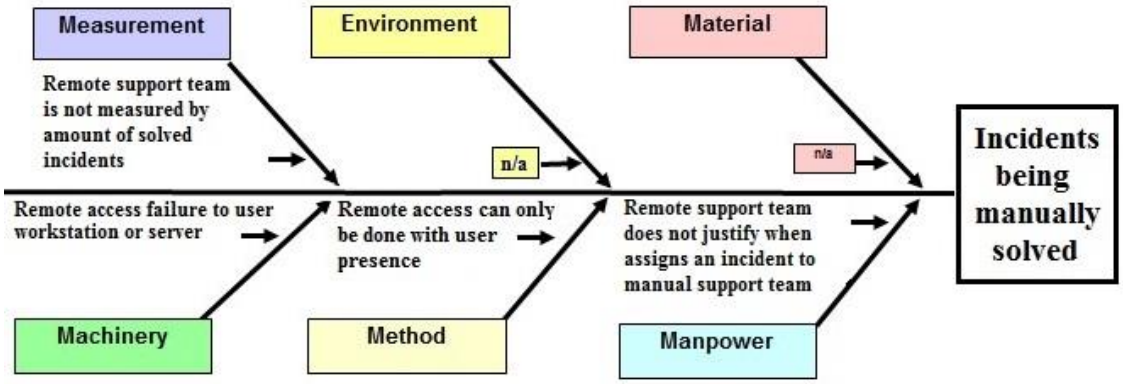

Figure 28 - Cause-and-Effect diagram to identify factors that are contributing to "Manual Resolution of IT Security Incidents"

After that, we followed Five Whys technique to reflect about what caused each identified factor showed in Figure 27. The scope of this study included analysis for Machinery factor, as this was identified by the domain expert as being the more critical to be solved.

Continuing the meeting, the researcher asked a "why" question five times for each identified factor showed in Figure 27 to find root-cause. An example is provided in Figure 29.

According to investigation, Machinery cause of not being able to perform remote access is related to an error default installation of users workstations, which is missing to enable Remote Procedure Call.

This service is required to be enabled and running for a remote access session to be established. Root-cause was focused by strategies in next activity. Measurement, Method and Manpower causes were not investigated during this research because IT

Security expert had no available time, he informed that had learned about how to execute the procedure and would continue later.

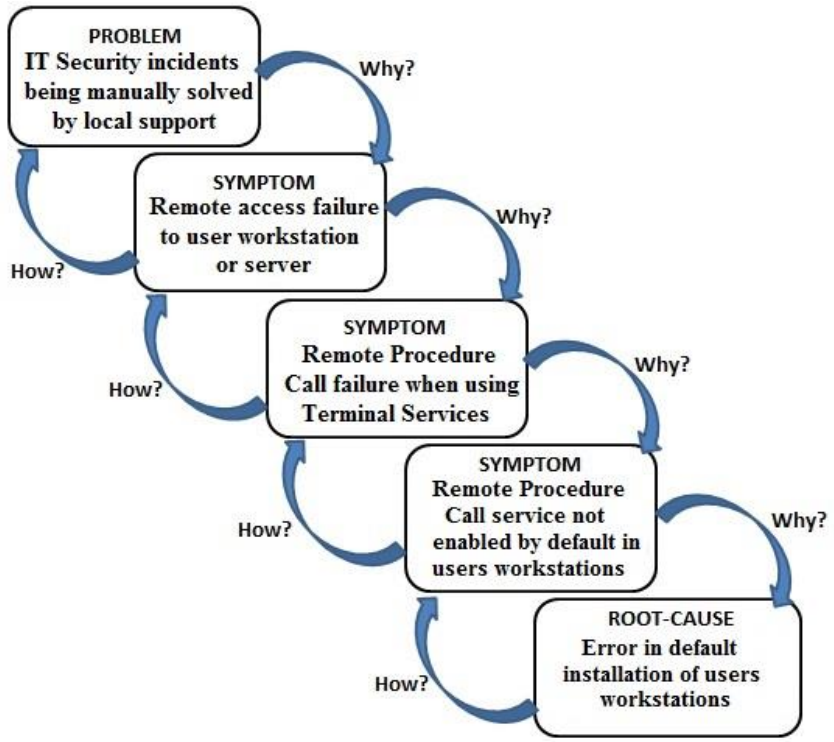

Figure 29 - Five Why´s diagram to identify root-cause for Machinery contributing factor "Remote access failure user workstation" found by Cause-and-Effect diagram as contributor to "Manual Resolution of IT Security Incidents"

5.2.2.12. Establish Strategies to Achieve IT Services´ Goals

In a new meeting with IT Security antivirus domain expert, the researcher asked how can Organization A solve the identified root-cause. He informed that he contacted the area responsible for installing users' workstations about the issue and the strategy will consist of providing (i) a new installation image to workstations to be tested and deployed to new workstations, and (i) a script to enable and start Remote Procedure Call in every restart for existent workstations. The strategy was documented following SINIS Template for Strategies, as shown in Table 60.

Table 60 - SINIS Strategy "Enable Remote Procedure Call in workstations"

SINIS Strategy "Enable Remote Procedure Call in workstations"	
IT Services Goal	Reduce the Cost with IT Security incidents solution and Reduce Resolution time for IT Security Incidents
Strategy Name	Enable Remote Procedure Call in workstations
Strategy Scope	Create a new installation image to workstations to be tested and deployed to new workstations. Create a script to enable and start

SINIS Strategy "Enable Remote Procedure Call in workstations"	
	Remote Procedure Call in every restart for existent workstations.
Start date	01/Feb/2015
Finish date	30/Apr/2016 (estimated)
Strategy owner	End User Manager
Strategy sponsor	IT Services Director
Strategy complexity	High
Strategy risk	Low
Strategy cost	No Cost – Usage of internal resources only
Strategy context factors	End User department will not hire new service provider to deliver the strategy because there is no available budget
	There are users with personal workstations which do not have standard installation image and do not login in network to run the script
Strategy assumptions	End User department will execute the strategy with existent resources and cannot guarantee when strategy will be completed
	Users with personal workstations will not be included in scope

5.2.2.13. Gather Existing Strategies' Indicators

This activity was not executed. As strategy was just established, so there was no indicator for it yet.

5.2.2.14. Create or Include new Indicators and Measurement Plans for Strategies

Continuing the same meeting with IT Security antivirus domain expert, the researcher asked how can he verify in strategy goal was successful. He informed that he will need information about number of times that remote support was not possible to be done in default workstations (because personal machines could not be guaranteed by End User department) caused by Remote Procedure Call not being enabled. COBIT Process sample measures and also IT Services list of measures were consulted, but strategy was too specific, there was no available measure to be reused. This was not considered as an issue because indicator was easily defined, as shown in Table 61.

Table 61 - SINIS Indicator´s Measurement Plan for Strategy "Enable Remote Procedure Call in workstations"

SINIS Indicator´s Measurement Plan for Strategy	
IT Services Goal related	Reduce the Cost with IT Security incidents solution and Reduce Resolution time for IT Security Incidents
Measurement Goal	Reduce
Information Need	How many times remote support could not be done in default workstations because Remote Procedure Call was not enabled?
Indicator	Percentage of manual incidents where remote support failed due to Remote Procedure Call was not enabled (P)
Measurable entity type	Incidents
Base measures	Number of manual incidents where remote support failed due to Remote

	Procedure Call was not enabled (N1); Total number of manual incidents (N2)
Measure calculation formula	P = N1/N2
Measurement procedure	N1: Extract data from incidents report considering incident type and incident solution field N2: Extract data from incidents report considering incident type
Measurement responsible	IT Security antivirus responsible
Measure unit	Percentage

5.2.2.15. Review and Discard Strategies not associated to any IT Services' Goal

There was no strategy to be discarded and reviewed as only one was created during this study.

5.2.2.16. Create or Review Interpretation Models for all Indicators

Continuing the same meeting with IT Security antivirus responsible, interpretation models for related indicators were created, as shown in Table 62 and Table 63, to determine how collected data should be interpreted and drive decision making.

Table 62 - Percentage of incidents where field intervention was necessary to solve the issue

SINIS Interpretation Model for IT Services' Goal Indicator	
Indicator related	Percentage of incidents where field intervention was necessary to solve the issue (manual/total)
Target	20%
Range	Reduction
Baseline	60% last year
Interpretation model	If value is 5% over target, only verify isolated cases. If value is more than 6% over target, review root-cause and strategies in place.
Interpretation Responsible	IT Security antivirus responsible
Interpretation Moment	Every month, starting one month after End User team completes strategy
Interpretation Periodicity	Every month, current value is compared to target and to previous month as a reference. In the end of the year, total value is compared to total value in the previous year.

Table 63 - SINIS Interpretation Model for Strategy Indicator "Percentage of manual incidents where remote support failed due to Remote Procedure Call was not enabled"

SINIS Interpretation Model for Strategy Indicator	
Indicator related	Percentage of manual incidents where remote support failed due to Remote Procedure Call was not enabled
Target	10%
Range	Reduction
Baseline	40% last year
Interpretation model	If value is 5% over target, only verify isolated cases.

	If value is more than 6% over target, review implemented strategy.
Interpretation Responsible	IT Security antivirus responsible
Interpretation Moment	Every month, starting one month after End User team completes strategy
Interpretation Periodicity	Every month, current value is compared to target and to previous month as a reference to verify if strategy was successful.

5.2.2.17. Build, review and adjust GQM+Strategies Grid

During this phase, researched organized context factors, assumptions, goals, strategies and indicators in a GQM+Strategies grid of indicator covered during the study and presented it to all IT Security team to gather members' opinion and concerns and extend the work to all other indicators with respective responsible. Figure 30 presents the resulting grid.

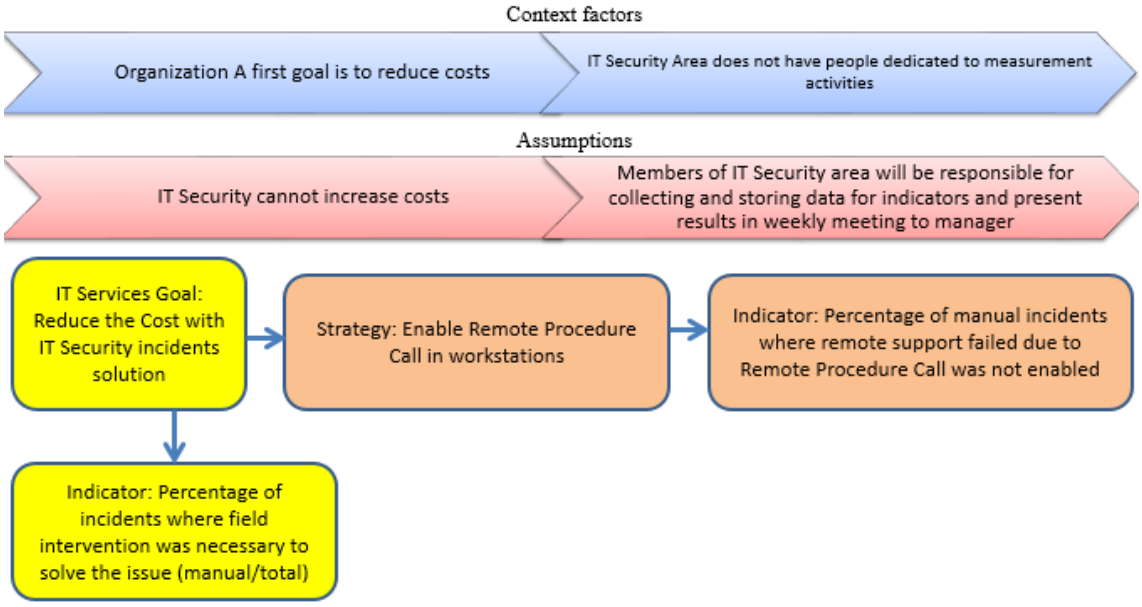

Figure 30 - GQM+Strategies grid

5.2.3. Action Research Threats to Validity

This action research has treats to validity, classified per Conclusion Threats, Internal Threats, Construction Threats and External Threats (WOHLIN *et al.*, 2012). Threats to validity and respective actions taken to minimize with each of them are e procedure represented in Table 64.

Table 64 - Threats to Validity SINIS Bottom-Up Action Research

Threat to Validity Type	Threat to Validity Description	Action to Minimize Threat to Validity

Threat to Validity Type	Threat to Validity Description	Action to Minimize Threat to Validity
External	SINIS Bottom-Up was applied in one single case scenario. This can affect generalizing results as method was not applied in more than one scenario.	SINIS instruments (checklists, templates and examples) may help execution for new and other cases, as checklists and templates support knowing what to ask and collect during semi-structured interviews, and examples illustrate data to be considered.
Internal	IT Security manager had a short due date given by director to present only the reviewed list of indicators aligned to goals. IT Security team did not have enough available time to completely execute SINIS.	One strategy was to fully create an interpretation model for this strategy indicator and related IT Service goal. IT Security expert learned about SINIS concepts and procedures to replicate and define for all others indicators.
Conclusion	Only one strategy and respective indicator and interpretation model were created during the presented action research. This can affect evaluating SINIS instruments and can provide less collected lesson learned.	Following SINIS procedures and instruments, and using the created strategy, respective indicator and interpretation model, IT Security team is able to further execute the complete SINIS, replicating the work and create strategies to achieve all others IT services goals.
Construction	Usage of indicators' targets is a new concept for IT Security members and can increase their daily workload. Because of that they were not comfortable to decide about it, and IT Security Manager was not available.	IT Security Manager will be able to use SINIS instruments to define targets with the team, during creation of interpretation models.

5.2.4. Action Research Feedback and Lessons Learned

IT Security coordinator stated that IT Security team is now more dedicated to measurement activities, as they understand the relationship with IT services goals.

Also, he informed that interpretation models and strategies were new concepts for him and for the team, and that team is motivated to complete the creation of respective indicators (following what was done by the antivirus responsible), but is afraid of the amount of required time to dedicate on that.

As the last step of this action research, we collected lessons learned (Table 65) to improve SINIS Bottom-Up.

Some lessons were considered positives and represent SINIS characteristics that could support successful results. Other lessons were considered negatives and represent SINIS characteristics that need to be improved.

Table 65. Lessons Learned

	Impact	Lesson Learned	Future Work
1	Negative	Reuse by searching a catalog is not effective for an organization that does already have a large list of measures in place and needs to reduce time and cost during indicators selection.	Evaluate if there can be restrictions to search each catalog type (goals or measures) for reuse during SINIS execution.
2	Positive	On the other hand, reuse by searching IT services goals provides inspiration for an organization is not used to think about goals to be achieved.	
3	Positive	Having root cause investigation to derive goals in strategies is effective to select actions that can directly solve issues, instead of working in many possible (and not targeted) initiatives.	Keep having process qualitative analysis through root-cause investigation to find proper strategies, but define instructions more precise about when using each technique.
4	Negative	Some root-cause techniques can be useful or not in each case. It was not clear when to use each technique.	
5	Positive	Templates and examples help and save time while executing SINIS procedures, but more information is needed for a person not very familiar to IT services process when applying SINIS data collection	Keep having templates and examples, but create checklists and a case tool with forms based on templates and tips based on those checklists and examples to facilitate following SINIS procedures.
6	Negative	Filling lots of tables in Microsoft Word or Excel while consulting templates and examples is not very effective because takes time to scroll data up and down	

5.3. Final Considerations

Chapter 5 covered application of SINIS top-down and bottom-up versions in industry.

SINIS top-down version was applied in a case study, where researcher observed Infrastructure process to select indicators under the light of SINIS procedures and activities in order to validate if the method was coherent with a real case in industry. SINIS bottom-up version was applied in an action research study, where researcher was invited by IT Security department to actively drive procedures to review existent indicators.

Even having only one experience for each version and not being able to statistically and effectively prove SINIS applicability, there is evidence that the method is able to provide support during indicators definition for IT Services departments. The researcher was able to collect lessons learned to validate some decisions about SINIS procedures and instruments and others to improve SINIS in future.

Next chapter present the dissertation Threats to Validity, Conclusions and Future Works.

CHAPTER 6 – Final Considerations, Contributions, Limitations and Future Works

In this chapter we present Final Considerations, Contributions, Limitations and Future Works around SINIS method to select indicators for IT services Top-down and Bottom-up versions.

6.1. Final Considerations

Being part of the largest economic sector in the world (Tien and Berg, 2006), IT services have been growing by adopting an IT management service-oriented approach to support applications, infrastructure and processes (OGCa, 2011). Measurement supports monitoring whether business goals are reached, increases feedback and decision making objectivity, and plays a key role to support management and improvement of delivered services to customers.

Although IT services literature requires proper identification of critical business process and definition of relevant measures to support decision-making, and also provide examples, there is no clear direction about how to decide about which indicators should be used. IT service departments often spend time and effort measuring without being sure about what the measurement results represent. Moreover, organizations consider the indicators selection as a difficult task.

This dissertation presented SINIS, a method to help organizations select indicators for IT services in multiple levels in alignment to business goals. SINIS was presented and evaluated in two versions: Top-down and Bottom-up. Top-down version was created to be used when there are IT service goals, but no IT services indicators derived from them to measure achievement of those goals, and neither strategies defined to support achieving IT service goals. Bottom-Up version was created to be used when there are indicators being used, but organization is not sure about the alignment between those indicators and service goals or strategies.

SINIS was created following Design Science Research method, and following six defined requirements as showed in Table 665 bellow. Several studies were performed in incremental learning cycles aiming to obtain relevant results for building SINIS.

Table 66 – Requirements defined for Design Science Research and attended by SINIS

Design Science requirements		How does SINIS attends requirement
Requirement 1	Require reduced time and effort during indicators selection	Usage of COBIT Goals Cascade (ISACA, 2012b), Balanced Scorecard (KAPLAN and NORTON, 1996), ITIL (TSO, 2011), ISO/IEC 20000 (ISO/IEC, 2011), CMMI-SVC (FORRESTER *et al.*, 2010) and MR-MPS-SV (SOFTEX, 2015a) in checklists, templates and examples to support method execution
Requirement 4	Provide procedures and instruments (such as checklists, templates and examples to proper support its execution)	
Requirement 2	Allow the definition of indicators and strategies in multiple levels in order to facilitate reporting the right information to each decision making management level	Usage of GQM+Strategies (Basilli *et al.*, 2005) and Qualitative Process Analysis to support defining indicators and strategies aligned to business goals in multi-levels
Requirement 3	Foster alignment between indicators and business goals in all those multiple levels	
Requirement 5	Follow consistent measurement concepts and terminologies	Usage of Reference Software Measurement Ontology (BARCELLOS et al., 2012)

6.2. Contributions

The main contribution of this work is creation of SINIS method in two versions, Top-Down and Bottom-Up, with respective set of procedures, checklists, templates and examples to be used during selection phase of IT Services measurement initiatives. Besides that, SINIS instruments contributes to lack of practical examples and guidance provided by GQM+Strategies (BASILLI *et al.*, 2005) during strategies derivation.

Contribution is also given to service maturity models CMMI-SVC (FORRESTER *et al.*, 2010) and MR-MPS-SV (SOFTEX, 2015a) on selection measures for the Measurement process. SINIS does also contributes to lack of formal procedures provided by COBIT Goals Cascade (ISACA, 2012b) for organizations to build its own goals' cascade as it recommends to be done.

An industrial contribution is a practical step by step procedure to be followed by real Organizations when selecting or reviewing IT Services Goals, Indicators and Strategies. On departments where SINIS was executed, members became more devoted to measurement activities and operational activities (that we call strategies), now they understand what goals are indicators and strategies related to.

Another type of contribution provided during incremental learning cycles of this dissertation is related to published researches in conferences and journals, available to be used by other researchers all over the word:

- TRINKENREICH, B., SANTOS, G., 2014, "Evaluation of measurement process for incidents, continuity and availability management under the light of MR-MPS-SV maturity model", *10th Annual workshop for software and services Quality improvement (WAMPS)*, Campinas, Brazil (Best Paper Award)
- TRINKENREICH, B., SANTOS, G., BARCELLOS, M., 2015a, "Measures to Support IT Service Maturity Models – A Systematic Mapping Study", *17th International Conference on Enterprise Information Systems (ICEIS)*, Barcelona, Spain
- TRINKENREICH, B., SANTOS, G., 2015a "Measures to Support IT Service Maturity Models – A Case Study", *17th International Conference on Enterprise Information Systems (ICEIS)*, Barcelona, Spain
- TRINKENREICH, B., SANTOS, G., CONFORT, V., SANTORO, F., 2015b, "Toward using Business Process Intelligence to Support Incident Management Measures Selection and Service Improvement". *27th International Conference Software Engineering Knowledge Engineering*, Pittsburg, USA
- TRINKENREICH, B., SANTOS, G., 2015b, "Evaluation of incident management process under the light of MR-MPS-SV maturity model and measurement to support IT Service quality improvement", *14th Software Quality Brazilian Conference (SBQS)*, Manaus, Brazil
- TRINKENREICH, B., SANTOS, G., 2015c, "Evaluation of measurement process on a Global Organization under the light of MR-MPS-SV maturity model ", *iSys Brazilian Journal of Information Systems*, vol 8 issue 2: pp. 58-77.
- TRINKENREICH, B., SANTOS, G., BARCELLOS, M., 2015c, "SINIS - A Method to Select Indicators for IT Services", *16th International Conference on Product-Focused Software Process Improvement* (PROFES), Bolzano, Italy, pp. 68-86. (Indicated for Best Paper Award)
- TRINKENREICH, B., SANTOS, G., BARCELLOS, M., 2015d, "Poster about SINIS Research in Progress". *AASSQ – Amazon Advanced School on Software Quality – 14th Software Quality Brazilian Conference (SBQS)*, Manaus, Brazil (Best Master Degree Poster Award)

- TRINKENREICH, B., SANTOS, G., BARCELLOS, M., 2015d, "Paper about SINIS Research in Progress". *WTDQS - Workshop of Thesis and Dissertations about Software Quality – 14th Software Quality Brazilian Conference (SBQS)*, Manaus, Brazil

Also this dissertation contributes to Design Research method, showing the usage of incremental learning cycles being applied based on industry. Like that, the artifact produced during Design Research is being validated in real cases before finally presenting it. This approach can reduce time waste because parts of the method were validated before being included into the method.

6.3. Limitations

Although all contributions, some limitations can be observed. Only one case study and one action research were executed for SINIS Top-Down and Bottom-Up versions, in different IT Services departments, but both in the same organization. New case studies can be necessary to evaluate SINIS.

In order to investigate SINIS easy use and acceptance, it should be executed more times by people different than SINIS researcher and then evaluated through a consistent acceptance model, like Technology Acceptance Model (DAVIS, 1989). SINIS Top-Down was fully executed by the researcher during IT Infrastructure case study. After that, researcher used Top-Down templates and examples to create SINIS Bottom-Up version, while executing it together with IT Security during Action Research.

Other limitation is related to the fact that the only way to really validate if indicators and strategies were properly selected by using SINIS is to collect data for expected time period and evaluate goals' results, which does also requires more time.

6.4. Future Works

Some possible future works for SINIS include:

- Implementation of a supporting tool to be used to input data during SINIS execution. This tool can be used to automate questions based on checklists, showing examples and providing forms to be filled according to templates;
- A method to evaluate if indicators and strategies were properly selected to support business goals;

- Implementation of an online and detailed catalog of IT Services Measures, classified by possible goals, ITIL processes, Balanced Scorecard dimensions, maturity models processes, and any other categories related to IT Services management libraries that could help searching for reuse;
- Execution of new case studies applying SINIS Top-Down and Bottom-Up versions and evaluating perceived usefulness and ease of use based on Technology Acceptance Model (DAVIS, 1989), for method improvement and new versions.

Another kind of future works is related to publications. Systematic Mapping that was presented in a conference will be increased to be sent to a journal. SINIS Bottom-Up action research and case study using Qualitative Analysis to find about how operational actions, projects or initiatives are defined to achieve IT Services indicators are being prepared to be published. Also, a case study about researcher experience when using Design Science is going to be written to help other researchers on similar works.

REFERENCES

ABDI, M.; DOMINIC, P. D., 2010, “Strategic IT Alignment with Business Strategy: Service Oriented Architecture Approach”. *International Symposium on Information Technology*. Kuala Lampur – Malaysia

ADOLPH, S., HALL, W., KRUCHTEN, P., 2008, "A methodological leg to stand on: Lessons learned using grounded theory to study software development", pp. IBM Toronto Software Lab.; IBM Centers for Advanced Studies, Richmond Hill, ON, Canada.

ASGHARI, N., 2012, “Evaluating GQM Strategies Framework for Planning Measurement System”, Master Degree Thesis, School of Computing, Blekinge Institute of Technology (BTH), Karlskrona, Sweden, 54 pp. http://btu.se/fou/cuppsats.nsf/all/54b15b6d93105546c1257abc005d0cd3/$file/BTH2012Asghari.pdf (Accessed on Oct, 2015)

AKPOLAT, H., 2004, “Six Sigma in Transactional and Service Environments” Gower Publishing. 163pp

ANDERSEN, B., FAGERHAUG, T., 2006, “Root Cause Analysis, Second Edition: Simplified Tools and Techniques”. 2nd Edition. American Society for Quality, Quality Press

BASILI, V.R., ROMBACH, H.D. AND CALDIERA, G., 1994. “Goal Question Metric Paradigm”. Encyclopedia of Software Engineering, 2 Volume Set, John Wiley & Sons, Inc.

BASILI, V., TRENDOWICZ, A., KOWALCZYK, M., HEIDRICH, J., SEAMAN, C., MÜNCH, J., ROMBACH D., 2005, “Aligning Organizations Through Measurement - The GQM+Strategies Approach” Springer

BASILI, V., HEIDRICH, J., LINDVALL, M., MÜNCH, J., SEANIAN, C., REGARDIE, M., TRENDOWICZ, A., 2009, “Determining the Impact of Business Strategies Using Principles from Goal-oriented Measurement”. 9th International Conference on Business Informatics. Vienna, Austria. vol.1 pp. 545-554.

BARCELLOS, M. P., FALBO, R.D., ROCHA, A.R., 2012, “Using a Reference Domain Ontology for Developing a Software Measurement Strategy for High Maturity Organizations” *16th IEEE International Enterprise Distributed Object Computing Conference p.114*

BARCELLOS, M.P., 2015, “Reference Software Measurement Ontology – Short Documentation” In: Notes of the Software Engineering discipline – PPGI/UFES

BARR, S., 2014, “Practical Performance Measurement Using the PuMP Blueprint for Fast, Easy and Engaging Performance Measures

BASKERVILLE, R. L., WOOD-HARPER, A. T., 1996, “A critical perspective on action research as a method for information systems research” *Journal of Information Technology*, vol. 11, pp 235-246

BIAZZO, S, 2000 "Approaches to business process analysis: a review", *Business Process Management Journal*, vol.6 Iss 2 pp.99–112

BOYD, A., 2005, “The evolution of goal-based information modeling: literature review” In Aslib proceedings. Emerald Group Publishing Limited vol. 57, n.6, pp. 523-538

BROOKS, P., 2006, “Measures for IT Service Management”. Van Haren Publishing, UK

DUCHSCHER, B., MORGAN, D., 2004, “Grounded theory: reflections on the emergence vs. forcing debate. Journal of advanced nursing”, vol.48 n.6, pp.605-612

CASES, M.; BODNER, D. A.; MUTNURY, B., 2010, “Architecture of Service Organizations” In: Salvendy, G.; Karwowski, W. (Eds.). Introduction to Service Engineering. Hoboken: John Wiley & Sons, Inc., p. 109–134.

CMMI Product Team, 2010, “CMMI for Development Version 1.3” Pittsburgh, USA

COLEMAN, G., O’CONNOR, R., 2007, “Using grounded theory to understand software process improvement: A study of Irish software product companies” Journal of Information and Software Technology. vol. 49, pp. 654–667

CONGER, S., 2011, “Process Mapping and Management”. Business Expert Press, LLC 1st Edition 486pp

CONGER, S., 2015, “Six Sigma and Business Process Management”. Handbook on Business Process Management 1. pp 127-146

COUGHLAN, P., COUGHLAN, D., 2002 "Action research for operations management". *International journal of operations & production management*, vol. 22, n. 2, pp. 220-240

DAVIS, F., 1989, "Perceived usefulness, perceived ease of use, and user acceptance of information technology", MIS Quarterly, v. 13, n. 3, pp. 319-339.

DRUCKER, P. F., 1954, "The Practice of Management". Harper Collins, New York

DUMAS, M., LA ROSA, M., MENDLING, J., & REIJERS, H. A., 2013, "Qualitative Process Analysis in Fundamentals of Business Process Management" pp. 185-211. Springer Berlin Heidelberg

ECKERSON, W., 2011, "Performance Dashboards: Measuring, Monitoring and Managing Your Business", 2nd Edition Wiley

ENGELMANN, K., 2008. "Service Science - Where Practice Meets Theory". Service Science: Fundamentals, Challenges and Future Developments. Berlim: Springer, part4 pp. 119–136.

FERRARIO, R.; GUARINO, N., 2012. Commitment-based Modeling of Service Systems. Third International Conference, IESS. Geneva, Switzerland: Springer Berlin Heidelberg vol. 103 pp. 170-185

FORRESTER, E., BUTEAU, B., SHRUM, S., 2010, "CMMI For Services, Guidelines for Superior Service. CMMI-SVC Version 1.3", - 2nd Edition. SEI. Addison-Wesley Professional

GENCEL, C., PETERSEN, K., MUGHAL, A., IQBAL, M., 2013, "A decision support framework for metrics selection in goal-based measurement programs: GQM-DSFMS". Journal of Systems and Software, vol. 86(12), pp. 3091-3108

GLASER, B.G., STRAUSS, A., 1967, "The Discovery of Grounded Theory: Strategies for Qualitative Research" Chicago / Illinois, Aldine.

GOETHERT, W., FISHER, M., 2003, "Deriving Enterprise-Based Measures Using the Balanced Scorecard and Goal-Driven Measurement Techniques" Software Engeneering Instutute - Carnegie Mellon University

GUIZZARDI, G., 2005, "Ontological Foundations for Structural Conceptual Models", Universal Press, The Netherlands

GUIZZARDI, G., 2007, "On Ontology, ontologies, Conceptualizations, Modeling Languages and (Meta)Models", In O. Vasilecas, J. Edler, A. Caplinskas (Org.). Frontiers in Artificial Intelligence and Applications, Databases and Information Systems IV. IOS Press, Amsterdam,.

GUZMÁN, J. G., MITRE, H. A., AMESCUA, A., VELASCO, M., 2010, "Integration of strategic management, process improvement and quantitative measurement for managing the competitiveness of software engineering organizations" *Software Quality Journal* v18 pp341–359

HRGOVCIC, V., UTZ, W., KARAGIANNIS, D., 2011. "Service Modeling: A Model Based Approach for Business and IT Alignment" 35th IEEE Annual Computer Software and Applications Conference Workshops. Munich, Germany.

HUXLEY, C.M., 2003, "An Improved Method to Identify Critical Processes". Faculty of Information Technology. Queensland University of Technology, Brisbane

ISACA, 2012a, "COBIT 5 – Control Objectives Management Guidelines Maturity Models: A Business Framework for the Governance and Management of Enterprise IT". Information Systems Audit and Control. Association, USA

ISACA, 2012a, "COBIT 5 – Control Objectives Management Guidelines Maturity Models: Enabling Processes". Information Systems Audit and Control. Association, USA

IEEE, 1998, Std 1061, "IEEE Standard for a Software Quality Metrics Methodology"

ISO/IEC, 2003, "ISO/IEC 15504-2 - Information Technology – Software Process Assessment", International Organization for Standardization and the International Electrotechnical Commission, Geneva, Switzerland.

ISO/IEC, 2009, "ISO/IEC TR 20.000-3: Information Technology – Service Management – Part 3: Guidance on scope definition and applicability of ISO/IEC 20.000-1" International Standard Organization/International Electrotechnical Commission, Switzerland

ISO/IEC, 2010a, "ISO/IEC TR 20.000-4: Information Technology – Service Management – Part 4: Process reference model" International Standard Organization/International Electrotechnical Commission, Switzerland

ISO/IEC, 2010b, "ISO/IEC TR 20.000-5: Information Technology – Service Management – Part 5: Exemplar implementation plan for ISO/IEC 20.000-1" International Standard Organization/International Electrotechnical Commission, Switzerland

ISO/IEC, 2011, "ISO/IEC 20.000-1: Information Technology – Service Management – Part 1: Service management system requirements. International Standard Organization/International Electrotechnical Commission, Switzerland

ISO/IEC, 2012, “ISO/IEC 20.000-2: Information Technology – Service Management – Part 2: Code of practice”. International Standard Organization/International Electrotechnical Commission, Switzerland

ISO/IEC, 2007, “ISO/IEC 15939 Software Engineering - Software Measurement Process”. Geneva, Switzerland: International Organization for Standardization and the International Electrotechnical Commission.

JÄNTTI , M., LAHTELA, A., KAUKOLA, J., 2010, “Establishing a Measurement System for IT Service Management Processes: A Case Study”. *International Journal on Advances in Systems and Measurements*, vol 3 no 3 & 4

KALINOWSKI, M.,WEBER, K. C., FRANCO, N., BARROSO, E., DUARTE, V., ZANETTI, D., SANTOS, G., 2014 “Results of 10 Years of Software Process Improvement in Brazil Based on the MPS-SW Model”, International Conference on the Quality of Information and Communications Technology (QUATIC) pp.28-37

KANEKO, T., KATAHIRA, M., MIYAMOTO, Y., KOWALCZYK, M., 2011, “Application of GQM+Strategies in the Japanese Space Industry” *International Workshop on Software Measurement*

KAPLAN, R., NORTON, D.P., 1996, “The Balanced Scorecard Translating Strategy Into Action”. Havard Business School Press, Boston

KILPI, T., 2001, “Implementing a software measures program at Nokia”, *IEEE Software*. Volume18, issue 6, pp. 72–77. ISSN: 0740-7459

KITCHENHAM, B., CHARTERS, S. Guidelines for performing systematic literature reviews in software engineering. Technical Report. EBSE-2007-01, KeeleUniversity, 2007

KITCHENHAM, B., BUDGEN, D., Brereton, P., 2011, “Using mapping studies as the basis for further research – A participant-observer case study” *Journal of Information and Software Technology* vol. 53 pp. 638–651

KOWALCZYK, M., BARTHEL, H., MÜNCH, J., HEIDRICH, J., TRENDOWICZ, A., 2011, “A Deployment Process for Strategic Measurement Systems” *8th Software Measurement European Forum (SMEF)*, pages 45-60, Rome, Italy

LEPMETS, M., RAS, E., & RENAULT, A., 2011, “A Quality Measurement Framework for IT Services”. In Annual SRII Global Conference, San Jose, CA. pp. 767-774

LEPMETS, M., MESQUIDA, A. L., CATER-STEEL, A., MAS, A., RAS, E., 2014, "The Evaluation of the IT Service Quality Measurement Framework in Industry", Global Journal of Flexible Systems Management, vol. 15(1), pp. 39-57

LIU, M., GAO, Z., LUO, W., & WAN, J., 2011, "Case Study on IT Service Management Process Evaluation Framework Based on ITIL" Business Management Electronic Information Conference, vol. 2, pp. 199-202, Guangzhou, China, IEEE.

MAGLIO, P.P., VARGO, S.L., CASWELL, N., SPOHRER, J., 2009. "The service system is the basic abstraction of service science" Information Systems and e-business Management vol 7, 4, pp. 395–406.

MCGARRY, J., CARD, D., JONES, C., LAYMAN, B., CLARK, E., DEAN, J., HALL, F., 2002. "Practical Software Measurement: Objective Information for Decision Makers". Addison Wesley, Boston, USA.

MUNCH, J., FAGERHOLM, F., KETTUNEN, P., PAGELS, M., PARTANEN, J., 2013, "Experiences and Insights from Applying GQM+Strategies in a Systems Product Development Organisation". 39th Euromicro Conference Series on Software Engineering and Advanced Applications. pp. 70-77

NIESSINK, F., CLERC, V., TIJDINK, T., VLIET, H., 2005. "The IT Service Capability Maturity Model - IT Service CMM", version 1.0RC1 224pp.

OBERLE, D., BHATTI, D. I. N., BROCKMANS, S., NIEMANN, D. W. I. M., JANIESCH, C., 2009. "Countering service information challenges in the internet of services". Business & Information Systems Engineering, vol 1(5), pp. 370-390

OGCa, 2011, "ITIL Service Operations" The Stationary Office – TSO. London, UK

OGCb, 2011, "ITIL Continual Service Improvement" The Stationary Office – TSO. London, UK

PETERSEN, K., GENCEL, C., ASGHARI, N., BETZ, S., 2015, An elicitation instrument for operationalizing GQM+Strategies (GQM+S-EI)". *Empirical Software Engineering*, vol. 20 no. 4

PARASURAMAN, A. ZEITHAML, L. A., BERRY, L. L., 1985. "A conceptual model of service quality and its implications for future research" Journal of Marketing, vol. 49, pp. 41-50.

PARK, R., GOETHERT, W., FLORAC, W., 1996. "Goal-Driven Software Measurement —A Guidebook". Software Engineering Institute (SEI). Carnegie Mellon University Pittsburgh, PA 15213

PARMENTER, D., 2015, “Key Performance Indicators – Developing, Implementing and Using Winning KPIs” 3rd Edition Wiley

RECKER, J., 2013, “Scientific Research in Information Systems” ISBN 978-3-642-30048-6 (eBook) DOI 10.1007/978-3-642-30048-6. Springer Heidelberg New York Dordrecht London.

ROBITAILLE, D., 2004, “Root Cause Analysis: Basic Tools and Techniques” Paton Press 104pp

ROCHA, A, SANTOS, G., WEBER, K. C., 2009. “Software Process Improvement in Brazil: Evolving the MPS Model and Consolidating the MPS.BR Program” In: XXXV Conference Latino Americana de Informática.

SANTOS, THIAGO MARCONDES, 2015, “Computação Ubíqua para apoiar a educação musical: explorações com o Makey Makey”. Master Degree Dissertation, UNIRIO. 195pp.

SERRAT, OLIVIER., 2009, “The Five Whys Technique”. *Asian Development Bank* http://hdl.handle.net/11540/2732 License CC BY 3.0 IGO

SMITH, D., 2008, “Implementing Measures For IT Service Management” Van Haren, 202pp

SOFTEX, 2015a. “MPS.BR – Guia Geral MPS de Serviços”. Available at www.softex.br (in Portuguese and Spanish)

SOFTEX, 2012b, “MPS.BR – Guia Geral MPS de Software”. Available at www.softex.br (in Portuguese and Spanish).

SOLINGEN, R., BERGHOUT, E., 1999, The Goal Question Indicator Method: A Practical Guide for Quality Improvement of Software Development McGraw-Hill.

STEINBERG, R., 2013, “Measuring ITSM – Measuring, Reporting, and Modeling the IT Service Management Measures that Matter Most to IT Senior Executives”. Trafford Publishing

STRAUSS, A., CORBIN, J.M., 1998, Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory, 2nd ed., Sage Publications

TIEN, J.M., BERG, D., 2006, “On Services Research and Education” Journal of Systems Science and Systems Engineering vol. 15, 3, 257–283.

TRINKENREICH, B., SANTOS, G., 2014, “Evaluation of measurement process for incidents, continuity and availability management under the light of MR-MPS-SV maturity model”, *10th Annual workshop for software and services Quality improvement (WAMPS)*, Campinas, Brazil

TRINKENREICH, B., SANTOS, G., BARCELLOS, M., 2015a, "Measures to Support IT Service Maturity Models – A Systematic Mapping Study", *17th International Conference on Enterprise Information Systems (ICEIS)*, Barcelona, Spain

TRINKENREICH, B., SANTOS, G., 2015a "Measures to Support IT Service Maturity Models – A Case Study", *17th International Conference on Enterprise Information Systems (ICEIS)*, Barcelona, Spain

TRINKENREICH, B., SANTOS, G., CONFORT, V., SANTORO, F., 2015b, "Toward using Business Process Intelligence to Support Incident Management Measures Selection and Service Improvement". *27th International Conference Software Engineering Knowledge Engineering*, Pittsburg, USA

TRINKENREICH, B., SANTOS, G., 2015b, "Evaluation of incident management process under the light of MR-MPS-SV maturity model and measurement to support IT Service quality improvement", *14th Software Quality Brazilian Conference (SBQS)*, Manaus, Brazil

TRINKENREICH, B., SANTOS, G., BARCELLOS, M., 2015c, "SINIS - A Method to Select Indicators for IT Services", *16th International Conference on Product-Focused Software Process Improvement* (PROFES), Bolzano, Italy.

VALVERDE, R., TALLA, M., 2014, "DSS Based IT Service Support Process Reengineering Using ITIL: A Case Study" Journal Intelligent Decision Technologies vol. 55 pp. 35-65 Springer Berlin Heidelberg.

VAN DER AALST, W., ADRIANSYAH, A., DE MEDEIROS, A. K. A., ARCIERI, F., BAIER, T., BLICKLE, T., ... & PONTIERI, L., 2012, "Process mining manifesto" *BPM 2011 International Workshops*, Clermont-Ferrand, France, pp. 169-194 Springer Berlin Heidelberg.

VAN DER AALST, W., HOFSTEDE, A., WESKE, M., 2003, "Business Process Management: A Survey" *BPM 2003 International Workshops* Eindhoven, The Netherlands vol 2678 pp 1-12

WIERINGA, R., 2014, "*Design Science Methodology for Information Systems and Software Engineering*", Springer Heidelberg, ISBN 978-3-662-43839-8, 332pp.

WIERINGA, R., MAIDEN, N., MEAD, N., ROLLAND, C., 2006, "Requirements engineering paper classification and evaluation criteria: a proposal and a discussion" *Requirements Engineering*, vol. 11, pp. 102-107.

WILSON, P. F., DELL, L. D., ANDERSON, G. F., 1993, "Root Cause Analysis: A Tool for Total Quality Management" 1st Edition ASQ Quality Press 216pp.

WOHLIN, C., RUNESON, P., HÖST, M., REGNELL, B., WESSLÉN, 2012. Experimentation in Software Engineering, Springer, ISBN: 978-3642290435.

APPENDIX I – List of IT Services Measures for Reuse

This appendix presents a consolidated of IT Services measures for reuse during the selection of indicators in SINIS method. Measures were gathered during the first two phases of incremental learning cycles presented Chapter 3 in Table 67.

Sources:

- [1] Systematic mapping to find measures suitable to be used in IT Services measurement initiatives (based on TRINKENREICH et al., 2015a);
- [2] Case Study to evaluate measures found by systematic mapping and relationship between measures (based on TRINKENREICH and SANTOS, 2015a).

Table 67 - List of IT Services measures gathered during the first two phases of incremental learning cycles presented in Chapter 3

Measures	CMMI-SVC	MR-MPS-SV	Source
Amount of incidents that had caused business impact due to performance issues Amount of incidents caused by growth rate issues	Capacity & Availability Management Incident Resolution & Prevention	Capacity Management Incident and Service Request Management	[1]
Percentage of exactness of capacity forecast Amount of capacity adjustments cases Amount of resolution hours due to capacity shortage cases Amount of money for capacity reserves	Capacity & Availability Management	Capacity Management	[1]
Service Availability	Capacity & Availability Management	Service Continuity and Availability	[1]
Response time for a change request Successful/failed change requests	Change Management	Change Management	[1]

Measures	CMMI-SVC	MR-MPS-SV	Source
Change requests not tested changes because of due date Change requests emergency/normal. Change requests rejected/accepted Change requests major x minor Change requests released/pending Average interactions with Change Management process			
MTBCC - Mean Time Between Corrective Changes			[2]
Frequency of configuration updates Percentage of configuration correctness Mean time between versions	Configuration Management	Configuration Management	[1]
Amount of IT service versions	Configuration Management	Release Management	[1]
Amount of changes that had caused incidents and problems	Change Management Incident Resolution & Prevention	Change Management Incident and Service Request Management Problem Management	[1]
Amount of change requests after a transition to production (considering a certain period)	Change Management Service System Transition	Change Management Release Management	[1]
Amount of incidents caused by change requests	Change Management Incident Resolution & Prevention	Change Management Incident and Service Request Management	[1]
Amount of avoided incidents per day Mean time between incidents Mean time to restore system Amount of recurrent incidents Amount of escalated incidents Amount of redirected incidents Average time to register an incident by phone Average time to register an incident by system Average time to categorize an incident Average time to prioritize an incident Average time to start solving in an incident Average time to solve an incident Amount of incidents per SLA meet Amount of incidents per application Amount of incidents per period of day	Incident Resolution & Prevention	Incident and Service Request Management	[1]

Measures	CMMI-SVC	MR-MPS-SV	Source
Amount of incidents per month, Amount of incidents per support person and support level Amount of incidents per resolution way (local/remote) Amount of incidents per status Amount of incidents per priority Average response time per support level; Percentage of correctness incident description; Percentage of existence of service desk support script			
Amount of time to find root cause and solve problems; Rate of closed/on-going problems; Rate of recurrent/new problems number; Amount of time between issue start and problem open; Amount of problems solved by known errors; Average cost to solve a problem; Amount of problems per status, month, application, configuration item, with/without root cause, repeated/new, overdue/on time	Incident Resolution & Prevention	Problem Management	[1]
MTBP - Mean Time Between Problems			[2]
Rate of problem number increase comparing to incidents; Recurrent incidents with/without an associated problem record to investigate it	Incident Resolution & Prevention	Incident and Service Request Management Problem Management	[1]
Rate of onshore x offshore allocated resources for projects; Amount of previous projects executed successfully for the same client; Rate of delivered projects with/without cost optimization	Integrated Work Management	Portfolio and Operation Management	[1]
Frequency of organization policies update; Amount of CMMI maturity or capacity level matches; Amount of process evaluations; Amount of identified weaknesses; Rate of improvement initiatives completed/pending; Number of cases where process is being circumvented	Organizational Process Focus	Assessment and Improvement of Organization Process	[1]
Frequency and amount of time hours for people training; Rate of employees who finished the training; Number of trainings per year	Organizational Training	Human Resource Management	[1]
Amount of systems maintenance correctness after training	Organizational Training Service System Development	Human Resource Management Service System Development	[1]

Measures	CMMI-SVC	MR-MPS-SV	Source
Amount of time, frequency and duration used for verification activities	Process & Product Quality Assurance	Quality Assurance Management	[1]
Amount of identified risks per severity Amount of identified risks per area Amount of identified risks per application Amount of identified risks per status Average impact of risks Rate of deviations from the expected real goals Amount of reduced deviations Frequency of backup execution Amount of hours to execute backup routines	Risk Management	Risk Management	[1]
Amount of identified issues during security tests amount	Risk Management	Risk Management Information Security Management	[1]
Frequency of SLA monitoring Grades of SLA satisfaction level; Amount of services covered by SLA and OLA Amount of delivered services in accordance with SLA Average of time for SLA change request approval Amount of fines paid because of SLA failures Amount of SLAs under review Number of identified contract breaches	Supplier Agreement Management	Service Level Management	[1]
Mean time between system failure Business impact caused by IT service outages Service interruptions number and duration per month Service interruptions number and duration per application Service interruptions number and duration per configuration item Business processes with/without continuity agreements Number of disaster practices, shortcomings and gaps per month Number of disaster practices, shortcomings and gaps per application Number of disaster practices, shortcomings and gaps per configuration item Number of implemented preventive measures	Service Continuity	Service Continuity and Availability	[1]
Application Performance Application User Experience Amount Time in Crisis			[2]

Measures	CMMI-SVC	MR-MPS-SV	Source
MTBC - Mean Time Between Crisis			
Service outages caused by capacity and availability issues	Service Continuity Capacity & Availability Management	Capacity Management Service Continuity and Availability	[1]
Deployments duration Release backouts Automatic/manual release distribution Failed/successed release component acceptance tests New services released to production per application New services released to production per month	Service System Transition	Release Management	[1]
Grades received on user satisfaction about received IT service Support calls received/abandoned per day Support calls average time per day Support calls average time per month Support calls average time per person Business impact caused by late service deliveries Service request time per user, month, application; User complaint response time; Service requests on time/late, with correct/wrong description, completed/pending	Service Delivery	Service Operation Management	[1]
Retention rate of specific key employees	Work Monitoring & Control	Human Resource Management	[1]
Projects delivered in/not accordance of scope; Projects delivered in/not accordance of time; Projects delivered in/not accordance of resources; Projects delivered in/not accordance of budget; Learned lessons by project; Projects per defined risk status	Work Monitoring & Control	Service Operation Management	[1]
Amount of incidents caused by new releases transitioned to production	Service System Transition Incident Resolution & Prevention	Risk Management Incident and Service Request Management	[1]
Application defect density and complexity; Requirement defects found per project phase;	Service System Development	Service System Development	[1]

Measures	CMMI-SVC	MR-MPS-SV	Source
Service documentation update frequency; Hours spent on rework, review, inspection and tests; Cost and Defects per application function point; Correction time effort; Correction per project phase and severity Function points delivered by developer per day; Application components per business results; Time per each application development phase; Failed/accepted acceptance tests; Reduced/increased time for maintenance; Planned/unplanned new services			

ATTACHMENT I – List of COBIT Goals Cascade Measures for Reuse

This appendix presents measures for IT-related goals in Table 68 and measures about IT-related processes in Table 69, both gathered from COBIT Goals Cascade (ISACA, 2012b) for reuse during the selection of indicators in SINIS method. COBIT measures were not classified by service maturity models processes, they are classified by IT-related process and by Balanced Scorecard dimensions.

Table 68 - List of measures for IT-Related goals provided by COBIT Goals Cascade classified per Balanced Scorecard dimension (ISACA, 2012b)

Measure	IT-Related Goal	BSC Dimension
Percent of enterprise strategic goals and requirements supported by IT strategic goals	Alignment of IT and business strategy	Financial
Level of stakeholder satisfaction with scope of the planned portfolio of programs and services		
Percent of IT value drivers mapped to business value drivers		
Cost of IT non-compliance, including settlements and fines, and the impact of reputational loss	IT compliance and support for business compliance with external laws and regulations	
Number of IT-related non-compliance issues reported to the board or causing public comment or embarrassment		
Number of non-compliance issues relating to contractual agreements with IT service providers		
Coverage of compliance assessments	Commitment of executive management for making IT-related decisions	
Percent of executive management roles with clearly defined accountabilities for IT decisions		
Number of times IT is on the board agenda in a proactive manner		
Frequency of IT strategy (executive) committee meetings		

Measure	IT-Related Goal	BSC Dimension
Rate of execution of executive IT-related decisions		
Percent of critical business processes, IT services and IT-enabled business programs covered by risk assessments	Managed IT-related business risk	
Number of significant IT-related incidents that were not identified in risk assessments		
Percent of enterprise risk assessments including IT-related risk		
Frequency of update of risk profile		
Percent of IT-enabled investments where benefit realization is monitored through the full economic life cycle	Realized benefits from IT-enabled investments and services portfolio	
Percent of IT services where expected benefits are realized		
Percent of IT-enabled investments where claimed benefits are met or exceeded		
Percent of investment business cases with clearly defined and approved expected IT-related costs and benefits	Transparency of IT costs, benefits and risk	
Percent of IT services with clearly defined and approved operational costs and expected benefits		
Satisfaction survey of key stakeholders regarding the level of transparency, understanding and accuracy of IT financial information		
Number of business disruptions due to IT service incidents	Delivery of IT services in line with business requirements	Customer
Percent of business stakeholders satisfied that IT service delivery meets agreed-on service levels		
Percent of users satisfied with the quality of IT service delivery		
Percent of business process owners satisfied with supporting IT products and services	Adequate use of applications, information and technology solutions	
Level of business user understanding of how technology solutions support their processes		
Satisfaction level of business users with training and user manuals		
Net present value (NPV) showing business satisfaction level of the quality and usefulness of the technology solutions		
Level of satisfaction of business executives with IT's responsiveness to new requirements	IT agility	Internal
Number of critical business processes supported by up-to-date infrastructure and applications		
Average time to turn strategic IT objectives into an agreed-on and approved initiative		
Number of security incidents causing financial loss, business disruption or public embarrassment	Security of information, processing infrastructure and applications	
Number of IT services with outstanding security requirements		
Time to grant, change and remove access privileges, compared to agreed-on service levels		
Frequency of security assessment against latest standards and guidelines		
Frequency of capability maturity and cost optimization assessments	Optimization of IT assets, resources and capabilities	
Trend of assessment results		
Satisfaction levels of business and IT executives with IT-related costs and capabilities		
Number of business processing incidents caused by technology integration errors	Enablement and support of business processes by integrating applications and technology into business	
Number of business process changes that need to be delayed or reworked because of technology integration issues		

Measure	IT-Related Goal	BSC Dimension
Number of IT-enabled business programs delayed or incurring additional cost due to technology	processes	
Number of applications or critical infrastructures operating in silos and not integrated		
Number of programs/projects on time and within budget	Delivery of programs delivering benefits, on time, on budget, and meeting requirements and quality standards	
Percent of stakeholders satisfied with program/project quality		
Number of programs needing significant rework due to quality defects		
Cost of application maintenance vs. overall IT cost		
Level of business user satisfaction with quality and timeliness (or availability) of management information	Availability of reliable and useful information for decision making	
Number of business process incidents caused by non-availability of information		
Ratio and extent of erroneous business decisions where erroneous or unavailable information was a key factor		
Number of incidents related to non-compliance to policy	IT compliance with internal policies	
Percent of stakeholders who understand policies		
Percent of policies supported by effective standards and working practices		
Frequency of policies review and update		
Percent of staff whose IT-related skills are sufficient for the competency required for their role	Competent and motivated business and IT personnel	Learning and Growth
Percent of staff satisfied with their IT-related roles		
Number of learning/training hours per staff member		
Level of business executive awareness and understanding of IT innovation possibilities	Knowledge, expertise and initiatives for business innovation	
Level of stakeholder satisfaction with levels of IT innovation expertise and ideas		
Number of approved initiatives resulting from innovative IT ideas		

Table 69 - List of measures for processes provided by COBIT Goals Cascade classified per IT-Related processes (ISACA, 2012b)

Measure	COBIT Process	Associated IT-related Goals
Actual vs. target cycle time for key decisions Level of stakeholder satisfaction (measured through surveys) Number of roles, responsibilities and authorities that are defined, assigned and accepted by appropriate business and IT management Degree by which agreed-on governance principles for IT are evidenced in processes and practices (percentage of processes and practices with clear traceability to principles) Number of instances of non-compliance with ethical and professional behavior guidelines Frequency of independent reviews of governance of IT Frequency of governance of IT reporting to the executive committee and board Number of governance of IT issues reported	Evaluate, Direct and Monitor - EDM01 Ensure Governance Framework Setting and Maintenance	Alignment of IT and business strategy Commitment of executive management for making IT-related decisions Delivery of IT services in line with business requirements

Measure	COBIT Process	Associated IT-related Goals
Level of executive management satisfaction with IT's value delivery and cost Deviation between target and actual investment mix Level of stakeholder satisfaction with the enterprise's ability to obtain value from IT-enabled initiatives Number of incidents that occur due to actual or attempted circumvention of established value management principles and practices Percent of IT initiatives in the overall portfolio where value is being managed through the full life cycle Level of stakeholder satisfaction with progress towards identified goals, with value delivery based on surveys Percent of expected value realized	Evaluate, Direct and Monitor - EDM02 Ensure Benefits Delivery	Alignment of IT and business strategy Realized benefits from IT-enabled investments and services portfolio Transparency of IT costs, benefits and risk Delivery of IT services in line with business requirements Knowledge, expertise and initiatives for business innovation
Level of alignment between IT risk and enterprise risk Number of potential IT risks identified and managed Refreshment rate of risk factor evaluation Percent of enterprise projects that consider IT risk Percent of IT risk action plans executed on time Percent of critical risk that has been effectively mitigated Level of unexpected enterprise impact Percent of IT risk that exceeds enterprise risk tolerance	Evaluate, Direct and Monitor - EDM03 Ensure Risk Optimization	Managed IT-related business risk Transparency of IT costs, benefits and risk Security of information, processing infrastructure and applications IT compliance with internal policies
Level of stakeholder feedback on resource optimization Number of benefits (e.g., cost savings) achieved through optimal utilization of resources Number of deviations from the resource plan and enterprise architecture strategies Number of deviations from, and exceptions to, resource management principles Percent of projects with appropriate resource allocations • Percent of re-use of architecture components Percent of projects and programs with a medium- or high-risk status due to resource management issues Number of resource management performance targets realized	Evaluate, Direct and Monitor - EDM04 Ensure Resource Optimization	IT agility Optimization of IT assets, resources and capabilities Competent and motivated business and IT personnel
Date of last revision to reporting requirements Percent of stakeholders covered in reporting requirements Percent of reports that are not delivered on time Percent of reports containing inaccuracies Level of stakeholder satisfaction with reporting Number of breaches of mandatory reporting requirement	Evaluate, Direct and Monitor - EDM05 Ensure Stakeholder transparency	Commitment of executive management for making IT-related decisions Transparency of IT costs, benefits and risk Delivery of IT services in line with business requirements

Measure	COBIT Process	Associated IT-related Goals
Percent of active policies, standards and other enablers documented and up to date Date of last updates to the framework and enablers Number of risk exposures due to inadequacies in the design of the control environment Number of staff who attended training or awareness sessions Percent of third-party suppliers who have contracts defining control requirements	Align, Plan and Organize - APO01 Manage the IT Management Framework	Alignment of IT and business strategy IT compliance and support for business compliance with external laws and regulations IT agility Optimization of IT assets, resources and capabilities IT compliance with internal policies Competent and motivated business and IT personnel Knowledge, expertise and initiatives for business innovation
Percent of objectives in the IT strategy that support the enterprise strategy Percent of enterprise objectives addressed in the IT strategy Percent of initiatives in the IT strategy that are self-funding (financial benefits in excess of costs) Trends in ROI of initiatives included in the IT strategy Level of enterprise stakeholder satisfaction survey feedback on the IT strategy Percent of projects in the IT project portfolio that can be directly traced back to the IT strategy Percent of strategic enterprise objectives obtained as a result of strategic IT initiatives Number of new enterprise opportunities realized as a direct result of IT developments Percent of IT initiatives/projects championed by business owners Achievement of measurable IT strategy outcomes part of staff performance goals Frequency of updates to the IT strategy communication plan Percent of strategic initiatives with accountability assigned	Align, Plan and Organize - APO02 Manage Strategy	Alignment of IT and business strategy Delivery of IT services in line with business requirements Knowledge, expertise and initiatives for business innovation
Number of exceptions to architecture standards and baselines applied for and granted Level of architecture customer feedback Project benefits realized that can be traced back to architecture involvement (e.g., cost reduction through re-use) Percent of projects using enterprise architecture services Level of architecture customer feedback Date of last update to domain and/or federated architectures Number of identified gaps in models across enterprise, information, data, application and technology architecture domains	Align, Plan and Organize - APO03 Manage Enterprise Architecture	Alignment of IT and business strategy IT agility Optimization of IT assets, resources and capabilities

Measure	COBIT Process	Associated IT-related Goals
Level of architecture customer feedback regarding quality of information provided Percent of projects that utilize the framework and methodology to re-use defined components Number of people trained in the methodology and tool set Number of exceptions to architecture standards and baselines applied for and granted		
Increase in market share or competitiveness due to innovations Enterprise stakeholder perceptions and feedback on IT innovation Percent of implemented initiatives that realise the envisioned benefits Percent of implemented initiatives with a clear linkage to an enterprise objective Inclusion of innovation or emerging technology-related objectives in performance goals for relevant staff Stakeholder feedback and surveys	Align, Plan and Organize - APO04 Manage Innovation	Realized benefits from IT-enabled investments and services portfolio Adequate use of applications, information and technology solutions IT agility Optimization of IT assets, resources and capabilities Knowledge, expertise and initiatives for business innovation
Percent of IT investments that have traceability to the enterprise strategy Degree to which enterprise management is satisfied with IT's contribution to the enterprise strategy Ratio between funds allocated and funds used Ratio between funds available and funds allocated Percent of business units involved in the evaluation and prioritization process Level of satisfaction with the portfolio monitoring reports Percent of changes from the investment program reflected in the relevant IT portfolios Percent of investments where realized benefits have been measured and compared to the business case	Align, Plan and Organize - APO05 Manage Portfolio	Alignment of IT and business strategy Realized benefits from IT-enabled investments and services portfolio Delivery of programs delivering benefits, on time, on budget, and meeting requirements and quality standards
Number of budget changes due to omissions and errors Numbers of deviations between expected and actual budget categories Percent of alignment of IT resources with high-priority initiatives Number of resource allocation issues escalated Percent of overall IT costs that are allocated according to the agreed-on cost models Percent of variance amongst budgets, forecasts and actual costs	Align, Plan and Organize - APO06 Manage Budget and Costs	Realized benefits from IT-enabled investments and services portfolio Transparency of IT costs, benefits and risk

Measure	COBIT Process	Associated IT-related Goals
Number of service definitions and service catalogues Level of executive satisfaction with management decision making Number of decisions that could not be resolved within management structures and were escalated to governance structures Percent of staff turnover Average duration of vacancies Percent of IT posts vacant	Align, Plan and Organize - APO07 Manage Human Resources	Alignment of IT and business strategy Optimization of IT assets, resources and capabilities Delivery of programs delivering benefits, on time, on budget, and meeting requirements and quality standards Competent and motivated business and IT personnel Knowledge, expertise and initiatives for business innovation
Percent of alignment of IT services with enterprise business requirements Ratings of user and IT personnel satisfaction surveys Survey of business stakeholder technology level of awareness Inclusion rate of technology opportunities in investment proposals	Align, Plan and Organize - APO08 Manage Relationships	Alignment of IT and business strategy Delivery of IT services in line with business requirements Enablement and support of business processes by integrating applications and technology into business processes Knowledge, expertise and initiatives for business innovation
Number of business processes with undefined service agreements Percent of live IT services covered by service agreements Percent of customers satisfied that service delivery meets agreed-on levels Number and severity of service breaches Percent of services being monitored to service levels Percent of service targets being met	Align, Plan and Organize - APO09 Related Guidance	Delivery of IT services in line with business requirements Availability of reliable and useful information for decision making

Measure	COBIT Process	Associated IT-related Goals
Percent of suppliers meeting agreed-on requirements Number of service breaches to IT-related services caused by suppliers Number of risk-related events leading to service incidents Frequency of risk management sessions with supplier Percent of risk-related incidents resolved acceptably (time and cost) Number of supplier review meetings Number of formal disputes with suppliers Percent of disputes resolved amicably in a reasonable time frame	Align, Plan and Organize - APO10 Manage Suppliers	Managed IT-related business risk Delivery of IT services in line with business requirements IT agility
Average stakeholder satisfaction rating with solutions and services Percent of stakeholders satisfied with IT quality Number of services with a formal quality management plan Percent of projects reviewed that meet target quality goals and objectives Percent of solutions and services delivered with formal certification Number of defects uncovered prior to Production Number of processes with a defined quality requirement Number of processes with a formal quality assessment report Number of SLAs that include quality acceptance criteria	Align, Plan and Organize - APO11 Manage Quality	Realized benefits from IT-enabled investments and services portfolio Delivery of IT services in line with business requirements Delivery of programs delivering benefits, on time, on budget, and meeting requirements and quality standards
Degree of visibility and recognition in the current environment Number of loss events with key characteristics captured in repositories Percent of audits, events and trends captured in repositories Percent of key business processes included in the risk profile Completeness of attributes and values in the risk profile Percent of risk management proposals rejected due to lack of consideration of other related risk Number of significant incidents not identified and included in the risk management portfolio Percent of IT risk action plans executed as designed Number of measures not reducing residual risk	Align, Plan and Organize - APO12 Manage Risk	IT compliance and support for business compliance with external laws and regulations Managed IT-related business risk Transparency of IT costs, benefits and risk Security of information, processing infrastructure and applications Delivery of programs delivering benefits, on time, on budget, and meeting requirements and quality standards

Measure	COBIT Process	Associated IT-related Goals
Number of key security roles clearly defined Number of security related incidents Level of stakeholder satisfaction with the security plan throughout the enterprise Number of security solutions deviating from the plan Number of security solutions deviating from the enterprise architecture Number of services with confirmed alignment to the security plan Number of security incidents caused by non-adherence to the security plan Number of solutions developed with confirmed alignment to the security plan	Align, Plan and Organize - APO13 Manage Security	IT compliance and support for business compliance with external laws and regulations Managed IT-related business risk Transparency of IT costs, benefits and risk Security of information, processing infrastructure and applications Availability of reliable and useful information for decision making
• Percent of stakeholders effectively engaged • Level of stakeholder satisfaction with involvement Percent of stakeholders approving enterprise need, scope, planned outcome and level of project risk Percent of projects undertaken without approved business cases Percent of activities aligned to scope and expected outcomes Percent of active programs undertaken without valid and updated program value maps Frequency of status reviews Percent of deviations from plan addressed Percent of stakeholder sign-offs for stage-gate reviews of active programs Number of resource issues (e.g., skills, capacity) Percent of expected benefits achieved Percent of outcomes with first-time acceptance Level of stakeholder satisfaction expressed at project closure review	Build, Acquire and Implement - BAI01 Manage Programs and Projects	Alignment of IT and business strategy Managed IT-related business risk Realized benefits from IT-enabled investments and services portfolio Delivery of programs delivering benefits, on time, on budget, and meeting requirements and quality standards
Percent of requirements reworked due to misalignment with enterprise needs and expectations Level of stakeholder satisfaction with requirements Percent of requirements satisfied by proposed solution Number of incidents not identified as risk Percent of risk unsuccessfully mitigated Percent of business case objectives met by proposed solution Percent of stakeholders not approving solution in relation to business case	Build, Acquire and Implement - BAI02 Manage Requirements Definition	Alignment of IT and business strategy Delivery of IT services in line with business requirements Enablement and support of business processes by integrating applications and technology into business processes
Number of reworked solution designs due to misalignment with requirements Time taken to approve that design deliverable has met requirements Number of solution exceptions to design noted during stage reviews	Build, Acquire and Implement - BAI03 Manage Solutions Identification and Build	Delivery of IT services in line with business requirements

Measure	COBIT Process	Associated IT-related Goals
Number of errors found during testing Time and effort to complete tests Number of tracked approved changes that generate new errors Number of demands for maintenance that go unsatisfied		
Number of unplanned capacity, performance or availability upgrades Number of transaction peaks where target performance is exceeded Number of availability incidents Number of events where capacity has exceeded planned limits Number and percentage of unresolved availability, performance and capacity issues	Build, Acquire and Implement - BAI04 Manage Availability and Capacity	Delivery of IT services in line with business requirements Optimization of IT assets, resources and capabilities Availability of reliable and useful information for decision making
Level of stakeholder desire for the change Level of senior management involvement Satisfaction ratings of implementation team by affected stakeholders Number of identified skills or capacity issues Stakeholder feedback on level of understanding Number of queries received Percent of role players with appropriately assigned authority Role player feedback on level of empowerment Percent of role players trained Role player self-assessment of relevant capabilities Level of satisfaction of role players operating, using and maintaining the change Percent of users appropriately trained for the change Level of satisfaction of users with adoption of the change	Build, Acquire and Implement - BAI05 Manage Organizational Change Enablement	Adequate use of applications, information and technology solutions Delivery of programs delivering benefits, on time, on budget, and meeting requirements and quality standards Knowledge, expertise and initiatives for business innovation
Amount of rework caused by failed changes Reduced time and effort required to make changes Number and age of backlogged change requests Percent of unsuccessful changes due to inadequate impact assessments Percent of total changes that are emergency fixes Number of emergency changes not authorized after the change Stakeholder feedback ratings on satisfaction with communications	Build, Acquire and Implement - BAI06 Manage Changes	Managed IT-related business risk Delivery of IT services in line with business requirements Security of information, processing infrastructure and applications
Percent of stakeholders satisfied with the completeness of testing process Number and percent of releases not ready for release on schedule Number or percent of releases that fail to stabilize within an acceptable period Percent of releases causing downtime Number and percent of root cause analyses completed	Build, Acquire and Implement - BAI07 Manage Change Acceptance and Transitioning	Adequate use of applications, information and technology solutions Enablement and support of business processes by integrating applications and technology into

Measure	COBIT Process	Associated IT-related Goals
		business processes
Percent of information categories covered Volume of information classified Percent of categorised information validated Percent of available knowledge actually used Number of users trained in using and sharing knowledge Level of satisfaction of users Percent of knowledge repository used Frequency of update	Build, Acquire and Implement - BAI08 Manage Knowledge	IT agility Knowledge, expertise and initiatives for business innovation
Percent of used licenses against paid-for licenses Number of assets not utilized Benchmark costs Number of obsolete assets	Build, Acquire and Implement - BAI09 Manage Assets	Transparency of IT costs, benefits and risk Optimization of IT assets, resources and capabilities
Number of deviations between the configuration repository and live configuration Number of discrepancies relating to incomplete or missing configuration information	Build, Acquire and Implement - BAI10 Manage Configuration	IT compliance and support for business compliance with external laws and regulations Optimization of IT assets, resources and capabilities Availability of reliable and useful information for decision making
Number of non-standard operational procedures executed Number of incidents caused by operational problems Ratio of events compared to the number of incidents Percent of critical operational event types covered by automatic detection systems	Deliver, Service and Support (DSS) - DSS01 Manage Operations	Managed IT-related business risk Delivery of IT services in line with business requirements Optimization of IT assets, resources and capabilities
Number and percent of incidents causing disruption to business-critical processes Mean time between incidents according to IT-enabled service Percent of incidents resolved within an agreed-on/acceptable period of time Level of user satisfaction with service request fulfilment Mean elapsed time for handling each type of service request	Deliver, Service and Support (DSS) - DSS02 Manage Service Requests and Incidents	Managed IT-related business risk Delivery of IT services in line with business requirements
Decrease in number of recurring incidents caused by unresolved problems Percent of major incidents for which problems were logged Percent of workarounds defined for open problems Percent of problems logged as part of the proactive problem management activity Number of problems for which a satisfactory resolution that addressed root causes were	Deliver, Service and Support (DSS) - DSS03 Manage Problems	Managed IT-related business risk Delivery of IT services in line with business requirements Optimization of IT assets, resources and capabilities

Measure	COBIT Process	Associated IT-related Goals
found		Availability of reliable and useful information for decision making
Percent of IT services meeting uptime requirements Percent of successful and timely restoration from backup or alternate media copies Percent of backup media transferred and stored securely Number of critical business systems not covered by the plan Number of exercises and tests that have achieved recovery objectives Frequency of tests Percent of agreed-on improvements to the plan that have been reflected in the plan Percent of issues identified that have been subsequently addressed in the plan Percent of internal and external stakeholders that have received training Percent of issues identified that have been subsequently addressed in the training materials	Deliver, Service and Support (DSS) - DSS04 Manage Continuity	Managed IT-related business risk Delivery of IT services in line with business requirements Availability of reliable and useful information for decision making
Number of vulnerabilities discovered Number of firewall breaches Percent of individuals receiving awareness training relating to use of endpoint devices Number of incidents involving endpoint devices Number of unauthorized devices detected on the network or in the end-user environment Average time between change and update of accounts Number of accounts (vs. number of authorized users/staff) Percent of periodic tests of environmental security devices Average rating for physical security assessments Number of physical security-related incidents Number of incidents relating to unauthorized access to information	Deliver, Service and Support (DSS) - DSS05 Manage Security Services	IT compliance and support for business compliance with external laws and regulations Managed IT-related business risk Security of information, processing infrastructure and applications
Percent of completed inventory of critical processes and key controls Percent of coverage of key controls within test plans Number of incidents and audit report findings indicating failure of key controls Percent of business process roles with assigned access rights and levels of authority Percent of business process roles with clear separation of duties Number of incidents and audit findings due to access or separation of duties violations Percent of completeness of traceable transaction log Number of incidents where transaction history cannot be recovered	Deliver, Service and Support (DSS) - DSS06 Manage Business Process Controls	Managed IT-related business risk Delivery of IT services in line with business requirements
Percent of goals and metrics approved by stakeholders Percent of processes with defined goals and metrics Percent of processes with effectiveness of goals and metrics reviewed and improved Percent of critical processes monitored	Monitor, Evaluate and Assess (MEA) - MEA01 Monitor, Evaluate and Assess Performance and Conformance	Managed IT-related business risk Delivery of IT services in line with business requirements Optimization of IT assets, resources

Measure	COBIT Process	Associated IT-related Goals
Percent of goals and metrics aligned to enterprise monitoring system Percent of performance reports delivered as scheduled		and capabilities IT compliance with internal policies
Percent of processes with assured output meeting targets within tolerances Percent of processes assured as compliant with internal control targets Percent of assurance initiatives following approved assurance program and plan standards Percent of processes receiving independent review Number of weaknesses identified by external qualification and certification reports Number of major internal control breaches Time between internal control deficiency occurrence and reporting	Monitor, Evaluate and Assess (MEA) - MEA02 Monitor, Evaluate and Assess the System of Internal Control	IT compliance and support for business compliance with external laws and regulations Managed IT-related business risk IT compliance with internal policies
Average time lag between identification of external compliance issues and resolution Frequency of compliance reviews Number of critical non-compliance issues identified per year Percent of process owners signing off, confirming compliance	Monitor, Evaluate and Assess (MEA) - MEA03 Monitor, Evaluate and Assess Compliance with External Requirements	IT compliance and support for business compliance with external laws and regulations Managed IT-related business risk