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A Conceptual Descriptive-Comparative Study of Models and Standards of Processes in SE, SwE, and IT Disciplines Using the Theory of Systems

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ABSTRACT

The increasing design, manufacturing, and provision complexity of high-quality, cost-efficient and trustworthy products and services has demanded the exchange of best organizational practices in worldwide organizations. While that such a realization has been available to organizations via models and standards of processes, the myriad of them and their heavy conceptual density has obscured their comprehension and practitioners are confused in their correct organizational selection, evaluation, and deployment tasks. Thus, with the ultimate aim to improve the task understanding of such schemes by reducing its business process understanding complexity, in this article we use a conceptual systemic model of a generic business organization derived from the theory of systems to describe and compare two main models (CMMI/SE/SwE, 2002; ITIL V.3, 2007) and four main standards (ISO/IEC 15288, 2002; ISO/IEC 12207, 1995; ISO/IEC 15504, 2005; ISO/IEC 20000, 2006) of processes. Description and comparison are realized through a mapping of them onto the systemic model.

Keywords: *ISO; information technology; software engineering; standards and models of process; systems engineering; theory of systems*

INTRODUCTION

Competitive market pressures in worldwide business firms, because of an accelerated scientific, technological, and human-development progress[1] (Bar-Yam et al., 2004) have fostered the consumer' demands for better and cheaper products and services (e.g., designed with more functional capabilities and offered in more market competitive prices). Consequently, in order to design and manufacture, as well as provision and operate competitive high-quality technical, cost-efficient and trustworthy products and services, worldwide business firms are faced with the intra and inter organizational need to integrate multiple engineering and managerial systems and business processes (Sage & Cupan, 2001).

Such a demanded intra and inter business process integration, in turn, has introduced an engineering and managerial *business process performance complexity* in organizations (but experimented by technical and business managers), and an engineering and managerial *business process understanding complexity* in practitioners (experimented by technical and business managers as well as business process consultants). A *business process performance complexity* in this context is defined as the structural[2] and/or dynamic system's complexity (Sterman, 1999) that confronts technical and business managers to achieve the system organizational performance goals (e.g., efficiency, efficacy, and effectiveness organizational metrics). In similar mode, a *business process understanding complexity* is defined as the structural and/or dynamic system's complexity that confronts technical and business managers (and business consultants) to acquire a holistic view of such a system under a learning focus.

Manifestations of such raising *business process performance* and *business process understanding complexities* are: (i) critical failures (by cancellations, interruptions, partial use, or early disposal) of enterprises information systems implementations (Standish Group, 2003; CIO UK, 2007); (ii) the apparition (and necessary retirement in the market) of defective products[3] (as tires, toys, software); and (iii) system downtimes and/or low efficiency and effectiveness in critical services such as electricity, nuclear plants, health services, and governmental services (Bar-Yam, 2003).

Consequently, some researchers have proposed the notion of complex system of systems (SoS) (Manthorpe, 1996; Carlock & Fenton, 2001; Sage & Cuppan, 2001) and others have helped to organize such a novel construct (Keating et al., 2003; Bar-Yam et al., 2004), as a conceptual tool to cope with that we call a *business process performance complexity* and a *business process understanding complexity*. Worldwide business firms, then, can be considered SoS and, as such, are comprised of a large variety of self-purposeful internal and external system components and forward and backward system interactions that generate unexpected emergent behaviors in multiple scales. Also, as SoS, the design/engineering and manufacturing/provision complexity of products/services is manifested by the variety of processes, machines/tools, materials, and system-component designs, as well as for the high-quality, cost-efficiency relationships, and value expectations demanded from the competitive worldwide markets. In turn, managerial process complexity is manifested by the disparate business internal and external process to be coordinated to meet the time to market, competitive prices, market-sharing, distribution scope and environmental and ethical organizational objectives, between other financial and strategic organizational objectives to meet (Farr & Buede, 2003). Furthermore, other authors have introduced the notion of complex software-intensive systems (Boehm & Lane, 2006) and complex IT-based organizational systems (Mora et al., 2008) which are characterized by having: *"(i) many heterogeneous ICT (client and server hardware, operating systems, middleware, network and telecommunication equipment, and business systems applications), (ii) a large variety of specialized human resources for their engineering, management and operation, (iii) a worldwide scope, (iv) geographically distributed operational and managerial users, (v) core business processes supported, (vi) a huge financial budget for organizational deployment, and (vii) a critical interdependence on ICT.*" And, because such CITOS are critical-mission systems for large-scale organizations and, according to Gartner's consultants Hunter and Blosch (2003, quoted in Mora et al., 2008), these CITOS "*no longer merely depend on information systems ... [but] the systems are* *the business,*" the need for a better engineering and management process practices based in IT becomes critical in present times.

Under this new business and engineering context, global and large-scale business firms have fostered the development of best organizational practices (Arnold & Lawson, 2004). The purpose is to improve the definition, coordination and execution of business processes and to avoid critical failures in the manufacturing of products and the provision of services. Best practices have been documented (via a deep re-design, analysis, discussion, evaluation, authorization and updating of organizational activities) through models and/or standards of processes by international organizations for the disciplines of systems engineering (SE), software engineering (SwE) and information systems (IS). Some models and standards come from organizations with a global scope (like ISO: International Organization for Standardization in Switzerland), but others limit their influences in some countries or regions (like SEI-CMU in USA, Canada, and Australia, or British Standard Office in UK). While both types of organizations can differ in their geographic scopes, both keep a similar efficacy purpose: to make available to them a set of generic business processes (technical, managerial, support, and enterprise) which come from the best international practices to correct and improve their organizational process, with the expected outcome to hold, correct, and improve the quality, value, and cost-efficiency issues of the generated products and services.

However, because of (i) the available myriad of models and standards reported in these three disciplines, (ii) the planned convergence for SE and SwE models and standards, and (iii) the critical role played by emergent CITOS in organizations in nowadays, we argue that a correct understanding and organizational deployment of such standards and models of process has been obscured by an inherent *business process complexity understanding* of the engineering and managerial process to be coordinated and the standards and models to be used for such an aim. *Business process understanding complexity* is manifested by a high density of concepts and interrelationships in the models and standards (Roedler, 2006) and by a lack of an integrated/holistic SE, SwE, and IS view of them (Mora et al., 2007a). According to a SEI (2006) statement that points out which *"... in the current marketplace, there are maturity models, standards, methodologies, and guidelines that can help an organization improve the way it does business. However, most available improvement approaches focus on a specific part of the business and do not take a systemic approach to the problems that most organizations are facing,*" and, with the ultimate aim to improve their *business process understanding complexity*, in this article, we report the development and application of a systemic model to describe and compare standards and models of process based in the theory of systems (Ackoff, 1971; Gelman & Garcia, 1989; Mora et al., 2003) by using a conceptual design research approach (Glass et al., 2004; Hevner et al., 2004; Mora & Gelman, 2008). The study's research purpose is limited to access the *business process completeness* and the *business process balance* levels, which are introduced as a guidance of indicators for the selection and evaluation of standards and models of processes. The empirical assessment of the *business process understanding complexity* construct is planned for a subsequent study.

Usefulness of this systemic model is illustrated with the description and comparison of two main models [CMMI/SE/SwE:2002 (SEI, 2002), ITIL V.3:2007 (OGC, 2007)] and four main standards [ISO/IEC 15288:2002 (ISO, 2002), ISO/IEC 12207:1995 (ISO, 1995), ISO/IEC 15504:2005 (ISO, 2005), ISO/IEC 20000:2006 (ISO, 2006a, 2006b)]. The remainder of this article continues as follows: firstly, a general overview of the conceptual design research approach and the face validation process conducted by a panel of experts are reported. Secondly, the rationale of the systemic concepts, which are used in the design of the pro formas to systemically describe and compare the standards and models, is reported. Finally, the application of the systemic descriptive-comparison model is presented and their main findings are discussed. Findings suggest the adequacy of the systems approach for such an aim.

The Conceptual Research Method

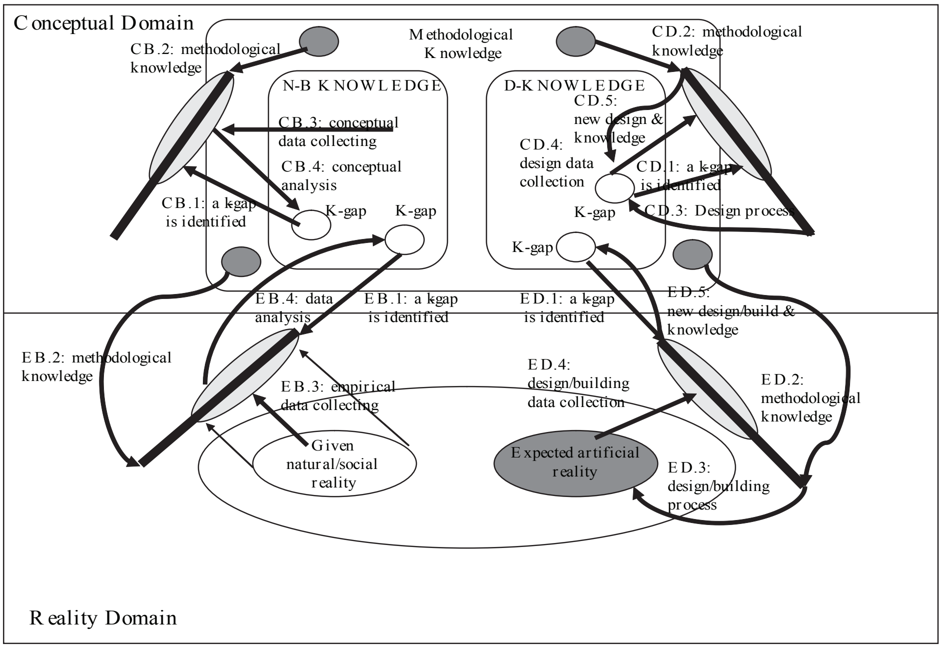
Conceptual research has been extensively used in the disciplines of IS and SwE as a non-empirical research method (Glass et al., 2004). Nevertheless, its principles and methods have been implicitly used and its scientific value has been obscured when is compared with empirical research methods which address tangible subjects and objects of study. In a recent systemic (Checkland, 2000) taxonomy of research methods (Mora & Gelman, 2008), where are related the situational areas under study (A's), the knowledge known on such situations (F's) and the known knowledge on methodological issues (M's) to study the A's, two criteria are used to classify them: (i) the conceptual vs. reality dimension and (ii) the natural/behavioral vs. purposeful design dimension. Both criteria divide the spectrum of research methods in the following four quadrants: (Q1) the conceptual behavioral research, (Q2) the conceptual design research, (Q3) the empirical behavioral research, and (Q4) the empirical design research.

The conceptual dimension accounts for the organized and verifiable/falsifiable subsystem of concepts (e.g., knowledge) on the reality and of itself. The reality dimension (Bhaskar, 1975; Mingers, 2000) accounts for the stratified domains of: (i) observable and not observable events (the empirical and actual domains), and the (ii) broader reality domain of physical and social product-producer generative structures and mechanisms. The scientific knowledge (e.g., the conceptual domain) is socially generated by human beings in concordance with the reality (the truth criteria) and is temporal and relative (Bhaskar, 1975). However, reality existence is independent of human beings from a critical realism philosophical stance. Thus, when we conduct conceptual research we address knowledge objects mapped to a reality and when we perform reality-based research (e.g., empirical) we address real subjects or objects. On the other hand, both conceptual and real entities generated by the nature and social structures and mechanisms can be studied without or with an intervening or modifying purpose. In the former case, we explore, describe, predict, explain, or evaluate conceptual or real entities, and, in the latter, we purposely design, build, and test conceptual or real artifacts (Hevner et al., 2004). This article can be classified both as a *conceptual design research* (Q2) by the design of a systemic model to describe and compare standards and models of processes, and as a *conceptual behavioral research* (Q1) by the utilization of such a model to describe the schemes. *Figure 1* illustrates the general research methodological framework.

In Mora et al. (2007b, 2007c) the systemic model was designed by applying the following four activities of Q2: CD.1 knowledge gap identification, CD.2 methodological knowledge (conceptual purposeful design), CD.3 conceptual design, CD.4 design data collection, and CD.5 analysis and synthesis where a new conceptual artifact outcome is generated [e.g., a construct, framework/model/theory, method, or system/component (not instanced in a real object)]. Validation is exercised in all five steps: a relevance validity assessment of the knowledge gap in CD.1 and CD.2, a methodological validity assessment in CD.3, CD.4, and CD.5 through a face validity instrument used with two schemes (ISO/IEC 15288 and CMMI/SE).

In contrast to empirical research methods, the validation procedures used in conceptual research can be one of the following: numerical mathematical analysis, mathematical/theorem proof, logical argumentation, or a face validation by a panel of experts. Model validation used in the conceptual design approach was face validation. A panel of four experts participated in the validation. Two experts own an academic joint expertise of 10 years of teaching graduate courses related to standards and models of processes in software engineering. The other two evaluators were invited for their practical knowledge in systems engineering and IT projects with an approximate 30-year joint expertise in IT and SE consulting activities. Because no specific instrument was located in

Figure 1. Conceptual research framework



the literature to conduct a model face validation, an instrument previously used to validate conceptual models in several M.Sc. theses was used. Model validation was tested with the description and comparison of the CMMI/SE model and the ISO/IEC 15288 standard. *Table 1* reports the items used in the validation step and their scores.

In this study, then, we apply the four activities of Q1: CB.1 knowledge gap identification, CB.2 methodological knowledge (e.g., conceptual exploratory review, conceptual descriptive-comparative review or conceptual tutorial review), CB.3 conceptual data collecting, and CB.4 conceptual analysis and synthesis where an exploratory, descriptive-comparative, or tutorial conceptual outcome is generated. Q1 was used for a descriptive/comparative purpose.

Knowledge gaps are reported in the related work section as well as in the introduction section. Methodological knowledge is realized through the utilization of a conceptual descriptive-comparative review approach. Conceptual data collecting was conducted by a systematic reading of the original documents of the three models (CMMI/SE:2002, CMMI/SwE:2002, ITIL V.3:2007) and the three standards (ISO/IEC 15288:2002, ISO/IEC 12207:1995, ISO/IEC 20000:2006) and by an identification of the items required in the systemic model. Finally, the conceptual descriptive-comparative analysis and synthesis of findings was conducted by the two lead authors, broadly reviewed by a third co-author and validated by the remainder two co-authors. The joint-academic expertise of the full research team in systems approach is about 40 years, and 20 years in standards and models of processes.

RELATED WORK

The systems approach has been implicitly used to study organizations as general systems but few papers have reported formal or semi-formal definitions of such constructs (Ackoff, 1971; Feigenbaum, 1968; Wand & Woo, 1991; Gelman & Negroe, 1991; Mora et al., 2003). In

Table 1. Model face validation in conceptual research

CONCEPTUAL INSTRUMENT[1] FOR MODEL FACE VALIDATION						Panel of International Experts					
	Total disagreement				Total agreement	Academic 01	Academic 02	Consultant 01	Consultant 02	Mean	Desv.Std.
I.1 The designed conceptual model is supported by core theoretical foundations regarding the topic under study.	1	2	3	4	5	*5*	*5*	*5*	*4*	**4.75**	**0.50**
I.2 The theoretical foundations used for developing the designed conceptual model are relevant to the topic under study.	1	2	3	4	5	*5*	*5*	*5*	*4*	**4.75**	**0.50**
I.3 There are no critical omissions in the literature used for developing the designed conceptual model.	1	2	3	4	5	*5*	*5*	*5*	*4*	**4.75**	**0.50**
I.4 The designed conceptual model is logically coherent to the purpose to the reality of study.	1	2	3	4	5	*4*	*5*	*5*	*5*	**4.75**	**0.50**
I.5 The designed conceptual model is adequate to the purpose of study.	1	2	3	4	5	*4*	*5*	*5*	*5*	**4.75**	**0.50**
I.6 The outcome (i.e. the designed conceptual model) is congruent with the underlying epistemological philosophy used for its development among positivist, interpretative, critical or critical realism.	1	2	3	4	5	*5*	*4*	*5*	*4*	**4.50**	**0.58**
I.7 The designed conceptual model reports original findings and contributes to the knowledge discipline.	1	2	3	4	5	*5*	*5*	*5*	*4*	**4.75**	**0.50**
I.8 The designed conceptual model is reported using an appropriate scientific style of writing.	1	2	3	4	5	*5*	*4*	*5*	*4*	**4.50**	**0.58**
Mean						**4.75**	**4.75**	**5.00**	**4.25**	**4.67**	
Desv.Std.						**0.46**	**0.46**	**0.00**	**0.46**	**0.47**	

[1] Six international researchers enrolled in ISWorld list theoretically validated this instrument in 2003.

the case of models and standards of processes, these have been studied individually (Gray, 1996; Garcia, 1998; Humphrey, 1998; Arnold & Lawson, 2004; Curtis, Phillips, & Weszka, 2001; Menezes, 2002) and comparatively (Sheard & Lake, 1998; Johnson & Dindo, 1998; Wright, 1998; Paulk, 1995, 1998, 1999; Halvorsen & Conrado, 2000; Minnich, 2002; Boehm & Vasili, 2005). While both kinds of studies on standards and models of processes have been useful to describe the main categories of processes, contrast directly two or more schemes, identify their focus of application, strengths and weaknesses, similarities and differences, and their fitness with a particular SE or SwE development approach, all of them have not used a normative-generic systemic model of a worldwide organization to estimate their *process completeness* and *process balance* constructs, neither to estimate their inherent *business process understanding complexity* in practitioners.

For instance, other descriptive and/or comparative studies on standards and models of processes (Sheard & Lake, 1998; Minnich, 2002) have identified core similarities and differences between such schemes. Main similarities are: (i) both provide a map of generic processes from the best international practices, (ii) both establish what and must be instructions rather than how specific procedures, and (iii) both do not impose a mandatory life-cycle of processes but suggest a demonstrative one that is usually taken as a basement. Thus, implementers must complement such recommendations with detailed procedures and profiles of the deliverables. In the case of main differences: (i) the models (at least the early reported) have been focused on process improvement efforts (and consequently include a capability maturity level assessment such as CMMI), while the standards are focused on an overall complain/not complain general assessment (e.g., ISO/IEC 12207), (ii) the models are used under an agreement between companies to legitimate their industrial acceptance (e.g., CMMI in the Americas), while the standards are used under a usually obligatory implicit country-based agreement (e.g., ISO/IEC 15504 in Europe), and (iii) the models can be originated from any organization, while the standards are strongly endorsed by nations.

Our study enhances previous ones through the introduction of a normative-generic systemic model of a business organization that is used to describe and compare the *business process completeness* and *business process balance* of standards and models of processes, as well as the next research goal to assess the *understanding complexity* on such schemes by potential practitioners. *Business process completeness* is defined as the extent of a standard or model fulfills the business process of the organizational subsystems of the generic systemic organization. The categorical scale used is very weak, weak, moderate, strong, and very strong business process completeness. *Business process balance* is defined as the extent of a standard or model provides an equilibrated support for all organizational subsystems of the generic systemic organization. The categorical scale used is very weak, weak, moderate, strong, and very strong business process balance. A high *business process completeness* does not imply a high *business process balance* for a standard or model and vice versa. In the former case, a standard or model could to have a high support for all organizational subsystems but some of them could be redundant. In the latter case, a standard or model could provide similar support for all organizational subsystems but for some organizational subsystems this could be insufficient (e.g., low value). The *business process understanding complexity* construct empirical assessment is planned for a further research.

DESCRIPTION AND COMPARISON OF MODELS AND STANDARDS OF PROCESSES

The Rationale of the Systemic Building-Blocks Constructs of the Normative-Generic Model of an Organization

According to Mora et al. (2007b), the ISO 9000:2000 series of standards (ISO, 2007) contains two principles (Principle 4 and 5) which endorse respectively the process approach and the systems approach as critical management paradigms. Principle 4's rationale states that the resources and activities are managed as processes. In turn, the Principle 5's rationale sets forth that the process be organized via a systems view. Furthermore, the ISO 9000:2000 standard remarks that while "… *the way in which the organization manage its processes is obviously to affect its final (quality of) product*"

(ISO, 2007), these standards "… *concerns the way an organization goes about its work … concern processes not products – at least not directly*" (ISO, 2006). Hence, the concepts of process, system, and product/service and their conceptual interrelationships become critical for understanding the different standards and models under study. In Mora et al. (2007c) are reported three appendices. First appendix reports the systemic definition of the concepts system, subsystem, component and suprasystem/entourage. These concepts are used in the second appendix to define the concepts of organization, organizational subsystem, business process and subprocess, business activity, product and service. Finally, in the third appendix, previous concepts are used to define a pro forma of a generic organization as a system. The latter definitions are rooted in the classic cybernetic paradigm (Gelman & Negroe, 1982) and extended to include the information systems subsystem concept (Mora et al., 2003). *Tables 2* and *3* update the definitions reported in the first and second appendices aforementioned. *Table 4* illustrates the cybernetic organizational model mapped to the Porter and Millar (1985) business process model where the IT service processes are explicitly added to the original model.

Definitions in *Table 2* (Mora et al., 2007b, 2007c) are rooted in theory of systems (Ackoff, 1971) and are based in formal definitions reported in Gelman and Garcia (1989) and Mora et al. (2003), and other semiformal definitions (Gelman et al., 2005; Mora et al., 2008). Concepts in *Table 3* (Mora et al., 2007b, 2007c) emerge from an analysis of relationships between the concepts of process, service and system in the context of standards and models of process.

Despite multiple definitions of process, main shared attributes can be identified: (i) an overall purpose (transform inputs in outputs), (ii) interrelated activities, and (iii) the utilization of human and material resources, procedures, and methods. Similarly, even though there is no one standard definition of service, several shared attributes can be also identified: (i) intangibility, (ii) non-storable, (iii) ongoing realization, and (iv) a mandatory participation of people to determine the value attribute. We argue that only the human beings can assess a value scale on services (even though such services can usually include machine-based metrics), while that automated processes (by using artificial devices) can assess the quality attributes of products (e.g., to fit some agreed physical specifications). Then, main distinctions between a product and a service are: (i) the tangibility-intangibility dichotomy which leads to the quality (e.g., the attributes expected in the

Table 2. Definitions of core system concepts

ID	CONCEPT	CONCEPTUAL DEFINITION
R1	**S: system**	is a whole into a wider <SS: suprasystem> or <ENT: entourage> that can be modeled with mandatory <A: attributes: a1,a2,a3,a4,a5> (where <a1: purpose>, <a2: function>, <a3: inputs>, <a4: outputs> and <a5:outcomes>) that are co-produced by at least two parts called <sB: subsystems> and the <R: relationships: R1, R2, …> between this whole, their parts, attributes and/or its suprasystem.
	sB: subsystem	is a <S: system> that is part of a <S: system> and that is decomposable in at least two or more <sB: subsystem> or <C: components>.
R3	**C: component**	is a constituent of a <sB: subsystem> that is not decomposable (from a modeling viewpoint).
R4	**SS: suprasystem**	is a <S: system> that contains to the system of interest under observation.
R4'	**ENT: entourage**	is the supra-system without the system under study.
R4"	**W: world**	is the entourage of the suprasystem.

Table 3. Definitions of organizational concepts as systems

ID	CONCEPT	CONCEPTUAL DEFINITION
R5	**O: organization**	is a <S: system> composed of three <OsB: organizational subsystems: driver, driven and IS subsystems>, into in a wider <OSS: organization suprasystem>, and with the generic attribute of <a1:purpose: "to provide valued outcomes for external systems"> additionally to other attributes.
R6	**OsB: organizational subsystem**	is a <sB: subsystem> composed of three subsystems called <BP: business process: control, operational and informational>.
R7	**BP: business process**	is a <sB: subsystem> of an <OsB: organizational subsystem> composed of at least two or more subsystems called <BsP: business subprocess> or components called <BA: business activities>, and with the additional mandatory attributes <a6: mechanisms> and <a7: controls>.
R8	**BsP: business subprocess**	is a <:BP: business process> into a <BP: business process>.
R9	**BA: business activity**	is a <C: component> into a <BP: business process> or <BsP: business subprocess> with the additional mandatory attributes <a6: tasks>, <a5:7personnel>, <a8: tools & infrastructure>, <a9: methods & procedures> and <a10: socio-political mechanisms & structures>.
R10	**Sv: service**	is an intangible, and time-continuously but period-limited <a4: people-oriented valued outcomes> from <a3: outputs: acts> of a <BA: business activity>, a <BP: business process>, an < OsB: organizational sub-system> or an <O: organization>.
R11	**Pr: product**	is a tangible, and discrete <a4: machine-oriented valued outcome> from <a3: outputs: matter> of a <BA: business activity>, a <BP: business process>, an <OsB: organizational sub-system> or an <O: organization>.

Table 4. *Mapping of the Porter-Millar business process model onto the systemic model*

SYSTEMIC MODEL OF A GENERIC ORGANIZATION		PORTER-MILLAR BUSINESS PROCESS MODEL OF A GENERIC ORGANIZATION	
[<OsB1: driver-organizational subsystem>]	**<OBP1: control business process >]**	**<STRATEGIC PROCESS>**	**SUPPORT PROCESSES**
		<FINANCIAL PROCESS>	
	[<OBP2: operational business process >]	**<HUMAN RESOURCES PROCESS>**	
		<ADMINISTRATIVE – LEGAL PROCES>	
	[<OBP3: informational business process>]	**<IT SERVICE for MANAGEMENT PROCESS>**	
[<OsB2: driven-organizational subsystem>]	**[<OBP1: control business process >]**	**<IN PUT LOGISTIC PROCESS>**	**PRIMARY PROCESSES**
		<OUTPUT LOGISTIC PROCESS>	
	[<OBP2: operational business process >]	**<OPERATION PROCESS>**	
	[<OBP3: informational business process >]	**<IT SERVICE for OPERATION PROCESS>**	
[<OsB3: IS-organizational subsystem>]	**[<OBP1: control business process >]**	**<IT SERVICE MANAGEMENT PROCESS>**	**IT SERVICE PROCESSES**
	[<OBP2: operational business process >]	**<IT SERVICE ENGINEERING PROCESS>**	
	[<OBP3: informational business process >]	**<IT SUPPORT PROCESS>**	

product) versus the value (e.g., the benefits to the quality-prices rate perceived from a customers' perspective), and (ii) the time-discrete utilization of products versus the ongoing experience of services (Teboul, 2007). Concepts reported in *Tables 2* and *3,* then, help to dissolve the conceptual omission of the responsible entity that generates a service: a process or a system. We argue that the concept of system (Gelman & Garcia, 1989) is the logical concept to link process and service/product constructs. Similar conceptualizations are being developed also in the SSME's research stream under the notion of service systems (Spohrer et al., 2007). Hence, we claim that these concepts can be used as conceptual building blocks to describe and compare standards and models of processes.

The Systemic Normative-Generic Model of an Organization

For applying the conceptual building blocks and their interrelationships, we define a set of pro formas (Andoh-Baidoo et al., 2004) for each concept. Pro formas for the concepts system, supra-system, subsystem, component, entourage, and world, as well as for organization, organizational subsystem, business process sub-process and business activity are reported in the *Appendices A* and *B*. Pro formas and the systemic definitions enable us to develop a multi-scale systemic comparison of the standards and models of processes. Because the generic model is mapped onto a very strong and validated business process model (Porter & Millar, 1985), we claim this strategy is better than a direct comparison between them because there is a common normative model against to each standard or model can be compared and because this is useful to estimate an absolute *process completeness* and *process balance* levels. In the opposite case, the assessment would be relative against the considered best model or standard.

The Systemic Description and Comparison of Standards and Models of Processes

In this article, we report the description and comparison of two models (CMMI/SE:2002, CMMI/SwE:2002, ITIL V.3:2007) and four standards (ISO/IEC 15288:2002, ISO/IEC 12207:1995, ISO/IEC 15504:2005, and ISO/IEC 20000:2006) of processes. Description and comparison details are reported in the *Appendix C* but a summary of them is reported in *Table 5*. The symbols: **●, ⊙, ⦿, ○, and** ○**,** corresponds directly to the categories of very strong, strong, moderate, weak and very weak.

Assessments reported in *Table 5* are based in the conceptual analysis conducted by the two lead authors and validated by the other three co-authors on the data reported in *Appendix C*. Such descriptions and comparisons are conducted in the organization level of the cybernetic organizational model with initial descriptions and comparisons in the organizational subsystem level (e.g., the driver, the driven and the information organizational subsystems). The analysis was conducted under the premise of an organization interested to deploy a standard or model to manufacture and provision products and services strongly based in IT. Furthermore, CMMI, ISO/IEC 15288 and ISO/IEC 15504 claim to be a model/standard for any kind of system/product. Through the generation of the systemic pro formas and their interpretation by the two lead authors, and the additional validation of the validation team, we can summarize the following core findings as follows:

- **Business process completeness on the Porter-Millar's support process:** The six schemes are focused on the core processes related to the lifecycle of man-made systems and related support process. Furthermore, all of them claim to be useful for guiding the design and manufacturing/provision of any kind of system or product/service where software or IT be a core component. However, while this aim is worthy, its overall extent of business process completeness when the whole organization is

Table 5. Business process completeness and balance assessment summary

SYSTEMIC MODEL	PORTER & MILLAR BUSINESS PROCESS MODEL	CMMI/SE/SwE: 2002 Models	ISO/IEC 15288:2002 Standard	ISO/IEC 12207:1995 Standard	ISO/IEC 15504:2006 Standard	ISO/IEC 20000:2005 Standard	ITIL V.3 : 2007 Model
[<OsB1: driver-organizational subsystem>]	<STRATEGIC MGT>	◉	⊙	○	◉	◉	●
	<FINANCIAL MGT>	○	◉	○	⊙	◉	●
	<HR MGT>	◉	⊙	◉	●	⊙	⊙
	<ADM-LEGAL MGT>	◉	◉	◉	◉	●	●
	<ITSfM>	○	⊙	○	○	◉	●
	BUSINESS PROCESS COMPLETENESS	⊙	⊙	○	◉	◉	◉
[<OsB2: driven-org. subsystem>]	<INPUT LOGISTIC>	◉	●	◉	◉	◉	●
	<OPERATIONS>	◉	●	◉	◉	◉	◉
	<OUTPUT LOGISTIC>	◉	◉	◉	◉	●	●
	<ITSfO>	○	⊙	○	○	●	●
	BUSINESS PROCESS COMPLETENESS	◉	◉	◉	◉	◉	●
[<OsB3: is-org subsystem.>]	<IT SERVICE MANAGEMENT>	○	○	○	○	◉	●
	<IT SERVICE ENGINEERING>	○	○	○	○	◉	◉
	<IT SERVICE SUPPORT >	○	○	○	○	●	●
	BUSINESS PROCESS COMPLETENESS	○	○	○	○	◉	●
M1	BUSINESS PROCESS COMPLETENESS WITHOUT OsB3	◉	◉	⊙	◉	◉	◉
		Strong	Strong	Moderated	Strong	Strong	Strong
M1'	OVERALL BUSINESS PROCESS COMPLETENESS	⊙	⊙	○	⊙	◉	◉
		Moderated	Moderated	Weak	Moderated	Strong	Strong
M2'	BUSINESS PROCESS BALANCE WITHOUT OsB3	◉	◉	⊙	◉	◉	◉
		Strong	Strong	Moderated	Strong	Strong	Strong
M2	OVERALL BUSINESS PROCESS BALANCE	⊙	⊙	○	⊙	◉	◉
		Moderated	Moderated	Weak	Moderated	Strong	Strong

considered is not so strong in some standards/models. For instance, the ISO/IEC 12207:1995 standard while mainly focused on software products or services also addresses systems that contain software, so its overall completeness should at least be strong. Futhermore, by using the combined systemic and classic process-based organization model (Porter & Millar, 1985), the core strategic management and financial processes are not included or moderately included in the ISO/IEC 12207:1995 and ISO/IEC 15288:2002 schemes. In contrast, others explicitly address such aims through the organizational alignment and financial management processes. Best explicit addressing is realized for the ISO/IEC 20000:2005 and ITIL V.3:2007 schemes. While the strategic process and its links with the remainder process are not considered, the business value of standards and models of process and its full and correct deployment can be obfuscated. For the case of financial management process, two of the oldest schemes (CMMI/SE/SwE and ISO/IEC 12207:1995) do not explicitly treat it. In contrast, the other four schemes address this important process. Best addressing is from ITIL V.3:2007 followed of ISO/IEC 20000:2006 and ISO/IEC 15288:2002. Latter scheme treats this as the investment management process. Regarding the human resources process, while all of them consider the topic of training and competent human resources (e.g., moderate completeness), only the ISO/IEC 15504:2006 addresses explicitly and adds the KM process. Other worthy effort is considered by CMMI/SE/SwE:2002 model, which assigns to organizational training a strategic focus. The existence of the CMM-People is a proof of this strategic aim but its incorporation into CMMI/SE/SwE:2002 model is not implicit. The completeness on the administrative-legal process is strong for the first four schemes (CMMI/SE/SwE:2002, ISO/IEC 15288:2002, ISO/IEC 12207:1995, ISO/IEC 15504:2006) and very strong in the service-oriented new schemes (ISO/IEC 20000:2005 and ITIL V.3:2007). This happens because the existence of an explicit service level management process in both standards with strong legal considerations. Finally, the IT service for management process is not explicitly addressed in all standards except for the ISO/IEC 20000:2005, and the ITIL V.3:2007, given their aim. However, ISO/IEC 15288:2002 standard considers a general information management process, and the others should address it given the relevance of the IT services process for the modern business firms. Hence, the business process completeness metric for the Porter-Millar support process is strong for ITIL V.3:2007 model, the ISO/IEC 20000:2005, and ISO/IEC 15504:2006 standards, moderated in the CMMI/SE/SwE model, and ISO/IEC 15288:2002 standard, and weak in ISO/IEC 12207:1995 standard by the lack of strategic and financial management processes.

- **Business process completeness on the Porter-Millar's primary process:** Being the six schemes focused on the core processes are related to the lifecycle of man-made systems, it is not an unexpected result a strong completeness assessment in almost all schemes (five of them). ITIL V.3:2007 model is the most complete (e.g., very strong). However, despite such a high assessment for ITIL V.3:2007 model, and the existence of the service release and deployment management process, being this one the core engineering process where the service is built, its general treatment into the high density of the remainder of processes is obfuscated. The relationships of this process with the service design process are critical for a final high-quality, cost-efficient, and trustworthy service, and should be clearly established in the standard. Similarly to its antecessor model (e.g., ITIL V.2, which is enhanced in the new ISO/IEC 20000:2005 standard), this process is weakly elaborated from a systems engineering view. Regarding other processes, the input and output logistic ones, are also strongly completed. The existence of specific process to treat with suppliers or performing as such ones reinforces both processes. CMMI/SE/SwE does not distinguish between suppliers and customers' agreement process. The remainder schemes consider both views: when the organization buys products/services and when it sells them. ITIL V.3:2007 model and ISO/IEC 20000:2005 standard are the most completed schemes by introducing specific service level management and business customers' relationships processes to manage the output logistic process, as well as the supplier management and business supplier relationships to treat with the input logistic process. Regarding the IT service for operations process, the completeness assessed is similar to the ITSfM process: these ones are not explicitly addressed except for ISO/IEC 20000:2005 standard, and ITIL V.3:2007 model. ISO/IEC 15288:2002 standard considers also a general information management process into the project management category. Hence, the business process completeness metric for the Porter-Millar primary process is strong for five schemes and very strong for ITIL V.3:2007 model.

- **Business process completeness on the Porter-Millar's IT support process:** Our analysis reveals the explicit lack of IT service management, IT service engineering, and IT service support process as a mandatory and relevant component of the standards and models of processes, except for the two designed for such an aim (e.g., ISO/IEC 20000:2005 and ITIL V.3:2007). We consider that under the new business environment characterized by a strong competitive pressure for high quality, cost-efficient, and trustworthy products and services, and the increasing engineering and managerial complexity for achieving them, as well as the increasing dependency of IT services, such a kind of process becomes relevant to be included in updated versions of the models and standards. Hence, the business process completeness metric for the extended Porter-Millar IT service process is strong ISO/IEC 20000:2005, very strong for ITIL V.3:2007 model, and weak for the remainder schemes. The well-structured lifecycle view with design, transition and operation, guided by the strategic and continual improvement service process of ITIL.V3:2007, enhances its antecessor ITIL V.2:2000 model, which is the underlying framework for the ISO/IEC 20000:2005 standard.
- **Overall business process completeness:** Based in the previous assessments, and the fact of the lack of explicit IT service process in most schemes, it is adequate to divide the overall evaluation without and with the OsB3 (e.g., the IS-organizational subsystem). For the first case, five of the six schemes are considered with strong business process completeness and one with a moderated assessment (for ISO/IEC 12207:1995 standard). For the second case, when the OsB3 organizational subsystem is included in the evaluation, the two IT service-oriented schemes keep a strong assessment, but the others reduce it to a moderate assessment (CMMI/SE/SwE model, and ISO/IEC 15228:2002, ISO/IEC 15504:2005 standards) and an overall weak business process completeness assessment (ISO/IEC 12207:1995 standard).
- **Overall business process balance:** Similarly to the business process completeness, the assessment can be divided without and with the OsB3 subsystem. In the former case, five schemes qualify with a strong balance and only ISO/IEC 12207:1995 standard is assessed as moderated. In the latter case, the process balance assessment is reduced to moderate in three schemes: CMMI/SE/SwE model, and ISO/IEC 15288:2002, ISO/IEC 15504:2005 standards. ISO/IEC 12207:1995 standard balance process is assessed as weak. The

two IT service-oriented schemes keep a strong assessment. These results are not unexpected. ITIL-based models and standards are of the most updated (e.g., 2005 and 2007 years) and both are based in the new business philosophy of service science, engineering, and management (Spohrer et al., 2007). We consider that the remainder standards and models will follow this approach in short time. For instance, the new planned CMMI-SVC model is being designed for such an aim. In turn, the low scores for ISO/IEC 12207:1995 can explain the two core amendments published in 2001 and 2004. Improvements in the ISO/IEC 12207:1995 standard are clearly exhibited in ISO/IEC 15504:2005:Part 5 standard, which uses the new ISO/IEC 12207:2004 version as an exemplary model for assessment. The problem is the lack of a full document of this standard where all amendments are seamlessly integrated in the previous knowledge. We estimate (by anecdotic but academic sources given the textbook literature on the topic) that main organizational deployments are still using ISO/IEC 12207:1995 version.

- **Implications for IS discipline.** Space and time limitations preclude a deep discussion. Our general and core observation is that, in order for the standards and models studied in this paper to be used and deployed jointly with ITIL-based models and standards, a deep managerial effort will be required to harmonize them. Another core observation is the necessary inclusion in the graduate IS/IT programs of the models/standards topics as mandatory. In the meanwhile, IS/IT practitioners have been alerted to be cautious, given the large economical, human, and organizational resources required to implement successfully such standards and models.

CONCLUSION

We have argued that modern firms are complex systems of systems (SoS) regarding to the engineering and management of their processes to deliver cost-effective, trustworthy, and high-quality products and services. Consequently, the organizations have developed and fostered the exchange of "best practices" through the concepts of standards and models of processes. However, the myriad of them is causing a *business process understanding complexity* that obfuscates their correct deployment. Then, we have posed the utilization of the theory of systems for treating such an understanding problematic situation. Our plausible realization was illustrated with the definition of a systemic model of organization, organizational subsystem and business process, and the model was applied to describe and compare four standards and two models of process. We consider that our systemic model is useful to acquire a holistic view of such schemes through a high-level mapping of the supported organizational processes. This task allows us to assess a *business process completeness* and *business process balance* metrics that can be used as guidance indicators for the selection and evaluation of such schemes. We will continue this research with: (i) studies on specific models/standards under a more fine-granularity level of analysis and with (ii) studies on the semi-automation of such an analysis through ontologies and reasoning computer-based tools.

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ENDNOTES

[1] At least in well-developed economies and partially in emergent ones.

[2] A complex entity or situation is structurally complex by the large number of relevant elements and interrelationships that affect its behavior and/or dynamically complex by the non-trivial (non lineal and not deterministic ones) forward and backward interactions between their (few or many) elements (Sterman, 1999).

[3] Documented in several internacional news and TV programs.

APPENDIX A. PRO FORMAS OF THE CORE CONCEPTUAL BUILDING-BLOCKS TO STUDY ENTITIES AS SYSTEMS.

CONCEPT	DEFAULT VALUE	DESCRIPTION
[<S: system>]	**= [S(X)]**	**The X thing that is modeled as a system.**
[<SS: supra-system>]	**= [SS(S(X))]**	The next up system called supra-system that contains to the modeled S(X) under study.
[<ENT: entourage>]	**= [ENT(S(X))]**	The supra-system without the modeled S(X) under study.
[<W: world>]	**= [W(S(X))] = [ENT (SS(S(X))]**	The most up system to be considered in the study without the supra-system of the system under study.
[<A: attributes>]	**= [a1+a2+a3+ a4 + a5 + (a6 + a7 + …)]**	The attributes that are defining the system.
[<a1: purpose>]	**= [<a1: "to achieve its outcomes" >]**	The effectiveness mission of the system.
[<a2: function>]	**= [<a2: "to achieve efficiently its outputs">]**	The efficacy mission of the system.
[<a3: inputs>]	**= [<a3: [{ energy-matter | information-knowledge | acts }^{n}]>]**	The system's input flows.
[<a4: outputs>]	**= [<a4: [{ energy-matter | information-knowledge | acts }^{n}]>]**	The system's output flows.

<table>
<tr><td>[<a5: outcomes>]</td><td>= [<a5: [{ PoV} | MoV } ^{n}] >]</td><td>The expected consequences to be generated by the system's outputs. PoV and MoV are respectively people-oriented and machine-oriented valued features.</td></tr>
<tr><td>• …</td><td>…</td><td>Other possible attributes.</td></tr>
<tr><td>[[<sB: subsystems>] |
[<C: components>]]</td><td>= [[sB(X1) | C(X1)] + [sB(X2) | C(X2)] +
([sB(X3) | C(X3)] + …)]</td><td>The main constituents of the system.</td></tr>
<tr><td>[[sB1 | C1]]</td><td>= [sB(X1) | C(X1)]</td><td>The first constituent of the system.</td></tr>
<tr><td>[[sB2 | C2]]</td><td>= [sB(X2) | C(X2)]</td><td>The second constituent of the system.</td></tr>
<tr><td>…</td><td>…</td><td>Other system's constituents.</td></tr>
<tr><td>[<R: relationships>]</td><td>= [R1 + (R2 + …)]</td><td>Relationships between the system's parts, attributes and/or its supra-system and entourage.</td></tr>
</table>

<table>
<tr><th>CONCEPT</th><th>DEFAULT INSTANCE</th><th>DESCRIPTION</th></tr>
<tr><td>[<sB: subsystem>]</td><td>= [sB(X?)]</td><td>The subsystem to be modeled.</td></tr>
<tr><td>[<S: system>]</td><td>= [S(X)]</td><td>The owner system of the subsystem.</td></tr>
<tr><td>[<A: attributes>]</td><td>= [a1+a2+a3+ a4 + a5 + (a6 + a7 + …)]</td><td>The attributes that are defining the subsystem.</td></tr>
<tr><td>[<a1: purpose>]</td><td>= [<a1: "to achieve its outcomes" >]</td><td>The effectiveness mission of the subsystem.</td></tr>
<tr><td>[<a2: function>]</td><td>= [<a2: "to achieve efficiently its outputs">]</td><td>The efficacy mission of the subsystem.</td></tr>
<tr><td>[<a3: inputs>]</td><td>= [<a3: [{ energy-matter | information-knowledge | acts }^{n}]>]</td><td>The subsystem's input flows.</td></tr>
<tr><td>[<a4: outputs>]</td><td>= [<a4: [{ energy-matter | information-knowledge | acts }^{n}]>]</td><td>The subsystem's output flows.</td></tr>
<tr><td>[<a5: outcomes>]</td><td>= [<a5: [{ PoV} | MoV } ^{n}] >]</td><td>The expected consequences to be generated by the subsystem's outputs. PoV and MoV are respectively people-oriented and machine-oriented valued features.</td></tr>
<tr><td>• …</td><td>…</td><td>Other possible attributes.</td></tr>
<tr><td>[[<sB: subsystems>] |
[<C: components>]]</td><td>= [[sB(X1) | C(X1)] + [sB(X2) | C(X2)] +
([sB(X3) | C(X3)] + …)]</td><td>The main constituents of the subsystem.</td></tr>
<tr><td>[[sB1 | C1]]</td><td>= [sB(X1) | C(X1)]</td><td>The first constituent of the subsystem.</td></tr>
<tr><td>[[sB2 | C2]]</td><td>= [sB(X2) | C(X2)]</td><td>The second constituent of the subsystem.</td></tr>
<tr><td>…</td><td>…</td><td>Other subsystem's constituents.</td></tr>
<tr><td>[<R: relationships>]</td><td>= [R1 + (R2 + …)]</td><td>Relationships between the system's parts, attributes and/or its supra-system and entourage.</td></tr>
</table>

<table>
<tr><th>CONCEPT</th><th>DEFAULT INSTANCE</th><th>DESCRIPTION</th></tr>
<tr><td>[<C: component>]</td><td>= [C(X?)]</td><td>The component to be modeled.</td></tr>
<tr><td>[<sB: subsystem> | <S: system>]</td><td>= [sB(X?) | S(X)]</td><td>The owner subsystem or system that contains to the component.</td></tr>
</table>

<table>
<tr><td>[<A: attributes>]</td><td>= [a1+a2+a3+ a4 + a5 + (a6 + a7 + …)]</td><td>The attributes that are defining the component.</td></tr>
<tr><td>[<a1: purpose>]</td><td>= [<a1: "to achieve its outcomes" >]</td><td>The effectiveness mission of the component.</td></tr>
<tr><td>[<a2: function>]</td><td>= [<a2: "to achieve efficiently its outputs">]</td><td>The efficacy mission of the component.</td></tr>
<tr><td>[<a3: inputs>]</td><td>= [<a3: [{ energy-matter | information-knowledge | acts }^{n}]>]</td><td>The component's input flows</td></tr>
<tr><td>[<a4: outputs>]</td><td>= [<a4: [{ energy-matter | information-knowledge | acts }^{n}]>]</td><td>The component's output flows</td></tr>
<tr><td>[<a5: outcomes>]</td><td>= [<a5: [{ PoV} | MoV } ^{n}] >]</td><td>The expected consequences to be generated by the component's outputs. PoV and MoV are respectively people-oriented and machine-oriented valued features.</td></tr>
<tr><td>• …</td><td></td><td>Other possible attributes.</td></tr>
<tr><td>[<R: relationships>]</td><td>= [R1 + (R2 + …)]</td><td>Relationships between the component's attributes and its wider system.</td></tr>
</table>

<table>
<tr><th>CONCEPT</th><th>DEFAULT VALUE</th><th>DESCRIPTION</th></tr>
<tr><td>[<SS: suprasystem>]</td><td>= [SS(S(X))]</td><td>The next up system that contains to the modeled system under study.</td></tr>
<tr><td>[<S: system>]</td><td>= [S(X)]</td><td>The system under study that is a constituent of the suprasystem.</td></tr>
<tr><td>[<ENT: entourage>]</td><td>= [ENT(SS(S(X)))] = [W(S(X)]</td><td>The supra-system without the modeled S(X) under study.</td></tr>
<tr><td>[<W: world>]</td><td>= [W(S(X))] = [ENT (SS(S(X))]</td><td>The most up system to be considered in the study without the supra-system of the system under study.</td></tr>
<tr><td>[<A: attributes>]</td><td>= [a1+a2+a3+ a4 + a5 + (a6 + a7 + …)]</td><td>The attributes that are defining the supra-system.</td></tr>
<tr><td>[<a1: purpose>]</td><td>= [<a1: "to achieve its outcomes" >]</td><td>The effectiveness mission of the supra-system.</td></tr>
<tr><td>[<a2: function>]</td><td>= [<a2: "to achieve efficiently its outputs">]</td><td>The efficacy mission of the supra-system.</td></tr>
<tr><td>[<a3: inputs>]</td><td>= [<a3: [{ energy-matter | information-knowledge | acts }^{n}]>]</td><td>The supra-system's input flows.</td></tr>
<tr><td>[<a4: outputs>]</td><td>= [<a4: [{ energy-matter | information-knowledge | acts }^{n}]>]</td><td>The supra-system's output flows.</td></tr>
<tr><td>[<a5: outcomes>]</td><td>= [<a5: [{ PoV} | MoV } ^{n}] >]</td><td>The expected consequences to be generated by the supra-system's outputs. PoV and MoV are respectively people-oriented and machine-oriented valued features.</td></tr>
<tr><td>• …</td><td></td><td>Other possible attributes.</td></tr>
<tr><td>[[sB: <subsystems>] | [C: <components>]]</td><td>= [[sB(X1)] + [sB(X2) | C(X2)] + ([sB(X3) | C(X3)] + …)]</td><td>The main constituents of the supra-system.</td></tr>
<tr><td>[sB1]</td><td>= [sB(X1)] = [S(X)]</td><td>The system S is the first constituent of the supra-system.</td></tr>
<tr><td>[[sB2 | C2]]</td><td>= [sB(X2) | C(X2)]</td><td>The second constituent.</td></tr>
<tr><td>…</td><td>…</td><td>Other supra-system's constituents.</td></tr>
<tr><td>[<R: relationships>]</td><td>= [R1 + (R2 + …)]</td><td>Relationships between the supra-system's parts, attributes and its wider system.</td></tr>
</table>

<table>
<tr><th>CONCEPT</th><th>DEFAULT VALUE</th><th>DESCRIPTION</th></tr>
<tr><td>[<W: world>]</td><td>= [W(S(X))]</td><td>The most up system to be considered in the study without the supra-system of the system under study.</td></tr>
<tr><td>[<S: system>]</td><td>= [S(X)]</td><td>The system under study that is a constituent of the suprasystem into the world.</td></tr>
<tr><td>[<SS: supra-system>]</td><td>= [SS(S(X))]</td><td>The next up system called supra-system that contains to the modeled S(X) under study.</td></tr>
<tr><td>[<ENT: entourage>]</td><td>= [ENT(S(X))]</td><td>The supra-system without the modeled S(X) under study.</td></tr>
<tr><td>[<A: attributes>]</td><td>= [a1 (+ a2+ …)]</td><td>The attributes that are defining the world.</td></tr>
<tr><td>[<a1: purpose>]</td><td>= [<a1: "to be a system" >]</td><td>The effectiveness mission of the world.</td></tr>
<tr><td>• …</td><td></td><td>Other possible attributes.</td></tr>
<tr><td>[[sB: <subsystems>] | [C: <components>]]</td><td>= [[sB(X1)] + [sB(X2) | C(X2)] + ([sB(X3) | C(X3)] + …)]</td><td>The main constituents of the world.</td></tr>
<tr><td>[sB1]</td><td>= [sB(X1)] = [SS(S(X))]</td><td>The supra-system SS(S(X) is the first constituent of the world that is modeled as a closed system.</td></tr>
<tr><td>[[sB2 | C2]]</td><td>= [sB(X2) | C(X2)]</td><td>The second constituent.</td></tr>
<tr><td>…</td><td>…</td><td>Other world's constituents.</td></tr>
<tr><td>[<R: relationships>]</td><td>= [R1 + (R2 + …)]</td><td>Relationships between the world's parts and attributes.</td></tr>
</table>

APPENDIX B. PRO FORMAS OF THE SYSTEMIC CONCEPTUAL BUILDING-BLOCKS FOR MODELING AN ORGANIZATION.

<table>
<tr><th>CONCEPT</th><th>GENERIC VALUE</th><th>DESCRIPTION</th></tr>
<tr><td>[<O: organization>]</td><td>= [O(X)]</td><td>The X thing to be modeled as a systemic organization.</td></tr>
<tr><td>[<OOS: organizational supra-system>]</td><td>= [OSS(O(X))]</td><td>The next up system called supra-system that contains to the modeled O(X) under study.</td></tr>
<tr><td>[<OENT: organizational entourage>]</td><td>= [OENT(O(X))]</td><td>The supra-system without the modeled O(X) under study.</td></tr>
<tr><td>[<OW: organizational world>]</td><td>= [OW(O(X))]</td><td>The most up system to be considered in the study without the supra-system of the system under study.</td></tr>
<tr><td>[<A: attributes>]</td><td>= [a1+a2+a3+ a4 + a5 + (a6 + …)]</td><td>The attributes that are defining the organization.</td></tr>
<tr><td>[<a1: purpose>]</td><td>= [<a1: "to provide valued outcomes">]</td><td>The effectiveness mission of the organization.</td></tr>
<tr><td>[<a2: function>]</td><td>= [<a2: "to achieve efficiently its outputs">]</td><td>The efficacy mission of the organization.</td></tr>
<tr><td>[<a3: inputs>]</td><td>= [<a3: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}] >]</td><td>The organization's input flows.</td></tr>
<tr><td>[<a4: outputs>]</td><td>= [<a4: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}] >]</td><td>The organization's output flows.</td></tr>
<tr><td>[<a5: outcomes>]</td><td>= [<a5: [{ <PoV: service> } | <MoV: product >} ^{n}] >]</td><td>The expected consequences to be generated by the organizational system's outputs. PoV and MoV are respectively people-oriented and machine-oriented valued features.</td></tr>
<tr><td>• …</td><td></td><td>Other possible attributes.</td></tr>
<tr><td>[[sB: <subsystems>] | [C: <components>]] = [<OsB: organizational subsystem>]</td><td>= [OsB(X1)] + [OsB(X2)] + [OsB(X3)]</td><td>The main constituents of the organization.</td></tr>
</table>

[<OsB1: driver-organizational subsystem>]	= [<OsB(X1): [strategic management + financial management + human resources management + administrative-legal management + IT service for management] >]	The organizational subsystem responsible to perform the support business processes. In the Porter-Miller organizational model, this subsystem corresponds to the following support processes: **strategic management, financial management, human resources management, administrative & legal management, and IT service for management.**
[<OsB2: driver-organizational subsystem>]	= [<OsB(X2): [input logistic + operations + output logistic + IT service for operations] >]	The organizational subsystem responsible to perform the primary business processes. In the Porter-Miller organizational model, this subsystems corresponds to the following primary processes**: input logistic, operations, output logistic and IT service for operations.**
[<OsB3: informational-organizational subsystem>]	= [<OsB(X3): [IT service management and engineering] >]	The organizational subsystem responsible to support the informational business processes. In the Porter-Miller organizational model, this is not reported explicitly. We call it the **IT service management and engineering processes (ITSM&E).**
[<R: relationships>]	= [R1 + (R2 + …)]	Relationships between the organizational parts, attributes, and/or its supra-system and world.

CONCEPT	DEFAULT INSTANCE	DESCRIPTION
[<OsB: organizational subsystem>]	= [OsB(X1) | OsB(X2) | OsB(X3)]	**The organizational subsystem to be modeled.**
[<O: organization>]	= [O(X)]	The organization to which belongs the organizational subsystem.
[<A: attributes>]	= [a1+a2+a3+ a4 + a5 + (a6 + …)]	The attributes that are defining the organizational subsystem.
[<a1: purpose>]	= [<a1: "to provide valued outcomes">]	The effectiveness mission of the organization.
[<a2: function>]	= [<a2: "to achieve efficiently its outputs">]	The efficacy mission of the organizational subsystem.
[<a3: inputs>]	= [<a3: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}] >]	The organizational subsystem's input flows.
[<a4: outputs>]	= [<a4: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}] >]	The organizational subsystem's output flows.
[<a5: outcomes>]	= [<a5: [{ <PoV: service> } | <MoV: product >} ^{n}] >]	The expected consequences to be generated by the organizational subsystem's outputs. PoV and MoV are respectively people-oriented and machine-oriented valued features.
• …	…	Other possible attributes.
[<BP: organizational business processes>]	= [BP1] + [BP2] + [BP3]	The main constituents of the organizational subsystem.
[BP1]	= [<BP1: control business processes>]	The business process responsible for controlling the operational processes into an organizational subsystem.
[BP2]	= [<BP2: operational business processes>]	The business process responsible for doing the core activities into an organizational subsystem
[BP3]	= [<BP3: informational business processes>]	The business process responsible for providing the informational support into an organizational subsystem.

<table>
<tr><td>[<R: relationships>]</td><td>= [R1 + (R2 + …)]</td><td>Relationships between the organizational subsystem parts, attributes and/or its wider system.</td></tr>
</table>

<table>
<tr><th>CONCEPT</th><th>DEFAULT INSTANCE</th><th>DESCRIPTION</th></tr>
<tr><td>[[<BP: business process>] | [<BsP: business subprocess>]]</td><td>= [BP1 | BsP1]</td><td>The business process or subprocess to be modeled.</td></tr>
<tr><td>[[<OsB: organizational subsystem>] | [<BP: business process>]]</td><td>= [OsB | BP]</td><td>The owner organizational subsystem or business process of the BP or BsP that is being modeled.</td></tr>
<tr><td>[<A: attributes>]</td><td>= [a1+a2+a3+ a4 + a5 + a6 + a7 + (a8+ …)]</td><td>The attributes that are defining the business process or subprocess.</td></tr>
<tr><td>[<a1: purpose>]</td><td>= [<a1: "to provide valued outcomes">]</td><td>The effectiveness mission of the organization.</td></tr>
<tr><td>[<a2: function>]</td><td>= [<a2: "to achieve efficiently its outputs">]</td><td>The efficacy mission of the business process or subprocess.</td></tr>
<tr><td>[<a3: inputs>]</td><td>= [<a3: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}] >]</td><td>The organizational business process or subprocess' input flows.</td></tr>
<tr><td>[<a4: outputs>]</td><td>= [<a4: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}] >]</td><td>The organizational business process or subprocess' output flows.</td></tr>
<tr><td>[<a5: outcomes>]</td><td>= [<a5: [{ <PoV: service> } | <MoV: product >} ^{n}] >]</td><td>The expected consequences to be generated by the organizational business process or subprocess' outputs. PoV and MoV are respectively people-oriented and machine-oriented valued features.</td></tr>
<tr><td>[<a6: mechanisms>]</td><td>= [<a6: [{ [people | tools | machines] }^{n}]>]</td><td>The organizational process' resources used for generating the outputs.</td></tr>
<tr><td>[<a7: controls>]</td><td>= [<a7: [{ [information | knowledge}^{n}]>]</td><td>The organizational process' resources used for controlling the generation of outputs.</td></tr>
<tr><td>…</td><td>…</td><td>Other possible attributes.</td></tr>
<tr><td>[[<BsP: business subprocesses>] | [<BA: business activities>]]</td><td>= [BsP1 | BA1] + [BsP2 | BA2] + ([BP3 | BA3] + …)</td><td>The main constituents of the organizational business process or subprocess.</td></tr>
<tr><td>[BsP1 | BA1]</td><td>= [BsP1 | BA1]</td><td>The first business subprocess or activity.</td></tr>
<tr><td>[BsP2 | BA2]</td><td>= [BsP2 | BA2]</td><td>The second business subprocess or activity.</td></tr>
<tr><td>…</td><td>…</td><td>Other possible business subprocess or activity.</td></tr>
<tr><td>[<R: relationships>]</td><td>= [R1 + (R2 + …)]</td><td>Relationships between the business process' parts, attributes and/or its wider system.</td></tr>
</table>

<table>
<tr><th>CONCEPT</th><th>DEFAULT INSTANCE</th><th>DESCRIPTION</th></tr>
<tr><td>[<BA: business activity>]</td><td>= [BA]</td><td>The business activity to be modeled.</td></tr>
</table>

[[<BP: business process>] | [<BsP: business sub-process>]]	**= [BP | BsP]**	The owner organizational business process or subprocess of the BA that is being modeled.
[<A: attributes>]	**= [a1+a2+a3+ a4 + a5 + a6 + a7 + (a8+ …)]**	The attributes that are defining the business activity.
[<a1: purpose>]	**= [<a1: "to provide valued outcomes">]**	The effectiveness mission of the business activity.
[<a2: function>]	**= [<a2: "to achieve efficiently its outputs">]**	The efficacy mission of the business activity.
[<a3: inputs>]	**= [<a3: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}] >]**	The organizational business activity's input flows.
[<a4: outputs>]	**= [<a4: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}] >]**	The organizational business activity's output flows.
[<a5: outcomes>]	**= [<a5: [{ <PoV: service> } | <MoV: product >} ^{n}] >]**	The expected consequences to be generated by the organizational business activity's outputs. PoV and MoV are respectively people-oriented and machine-oriented valued features.
[<a6: tasks>]	**= [t1 + t2 + (…)]**	The logical unitary workloads required to complete the BA. At least two are required.
[<a7: personnel>]	**= [p1 + (…)]**	The people required for that the BA be performed. At least one person is required.
[<a8: tools & infra-structure>]	**= [t&i1 + (…)]**	The tools and physical infrastructure required for that the BA be performed.
[<a9: methods & procedures>]	**= [m&p1 + (…)]**	The methods and procedures about how the BA must be performed.
[<a10: socio-political mechanisms & structures>]	**= [spm&s1 + (…)]**	The socio-political influences (modeled as socio-political norms, values and beliefs) that affect the BA execution.
[<R: relationships>]	**= [R1 + (R2 + …)]**	Relationships between the business activity's attributes and/or its wider system.

APPENDIX C. SYSTEMIC DESCRIPTION AND COMPARISON OF THE MODELS AND STANDARDS OF PROCESSES.

Table C.1 *Description and comparison of models and standards in the organizational level. Please see following pages.*

SYSTEMIC CONCEPT	Systemic Map of the CMMI/SE/SwE: 2002 Models	Systemic Map of the ISO/IEC 15288:2002 Standard	Systemic Map of the ISO/IEC 12207:1995 Standard	Systemic Map of the ISO/IEC 15504:2006 Standard	Systemic Map of the ISO/IEC 20000:2005 Standard	Systemic Map of the ITIL V.3 : 2007 Model
[<O: organization>]	[<O: "is typically an administrative structure in which people collectively manage one or more projects as a whole, and whose projects share a senior manager and operate under the same policies">]	[<O: "a group of people and facilities with an arrangement of responsibilities, authorities and relationships" >]	[<O: "is a body of persons organized for some specific purpose, as a club, union, corporation, or society" and is called a "party" when enters into a contract>]	[<O: "an organizational unit deploys one or more processes that have a coherent process context and operates within a coherent set of business goals">]	[<O: "a service provider is the organization aiming to achieve ISO/IEC 20000">]	[<O: "a company, legal entity or other institution … any entity that has People, Resources and Budgets" | "Business unit: a segment of the business that has its own Plans, Metrics, Incomes and Costs … owns Assets and uses these to create value for Customers in the form of goods and services">]
[<OSS: organizational supra-system>]	[<OSS: "Enterprise: the full composition of companies" that belongs the O>]	[<OSS: "Enterprise: the part of an organization with responsibility to acquire and to supply products and/or services according to agreements">]	[<OSS: "Enterprise: a system of at least two parties">]	[<OSS: "larger organization: the organization that contains to the organizational unit">]	[<OSS: "business: the organization that that receives the provided services of the service provider ">]	[<OSS: "business: an overall corporate entity or Organization formed of a number of Business Unit ">]
[<a1: purpose: [„to provide valued outcomes"]>]	[<a1: "to help to deliver products or services through ensuring stable, capable, and mature processes">]	[<a1: "… establishes a common framework for describing the life cycle of systems created by humans … with the ultimate goal of achieving customer satisfaction">]	[<a1: "… establishes a common framework for software life cycle processes … applied during the acquisition of a system that contains software, a stand-alone software product, and software service, and during the supply, development, operation, and maintenance of software products" >]	[<a1: "… provides a framework for the assessment of process capability" + "understanding of the state of process" + "process improvement" >]	[<a1: "to provide an industry consensus on quality standards for IT service management processes … (that) deliver the best possible service to meet a customer's business needs within agreed resource levels, i.e. service that is professional, cost-effective and with risks which are understood and managed" >]	[<a1: "the objective of the ITIL Service Management practice framework is to provide services to business customers that are fit for purpose, stable and that are so reliable, the business view them as a trusted utility" >]

[<a2: function:["to achieve efficiently its outputs"]>]	**[<a2: "*to manage the development, acquisition, and maintenance of products or services*">]**	**[<2: "*… managing and performing the stages of a man-based system's life cycle*" >]**	**[<2: " *… providing a process … for defining, controlling, and improving software life cycle processes* " >]**	**[<a2: " *… planning, managing, monitoring, controlling and improving the acquisition, supply, development, operation, evolution and support of products and services* ">]**	**[<a2: "to provide process of *management system requirements + service management planning + new or changed services planning & implementing + service delivering + relationships + release + resolution + control* ">]**	**[<a2: "to provide *robust, mature and time-tested practices* into process of *service strategy + service design + service transition + service operation + continual service improvement* ">]**
[<a3: inputs flows>]	**[<a3: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}]>]**					
[<a4: outputs flows>]	**[<a4: [{ energy-matter(utilities, artifacts, money) | information-knowledge | acts }^{n}]>]**					
[<a5: outcomes>]	**[<a5: [{ [<PoV1: IT-based services> + <PoV2: capability process profile>] | [<MoV1: IT-based products>] }^{n}]>]**	**[<a5: [{ [<PoV1: IT-based services> + <PoV2: capability process profile>] | [<MoV1: IT-based products>] }^{n}]>]**	**[<a5: [{ [<PoV1: IT-based services> + <PoV2: complain-not-complain process profile>] | [<MoV1: IT-based products>]}^{n}]>]**	**[<a5: [{ [<PoV1: IT-based services> + <PoV2: capability process profile>] | [<MoV1: IT-based products>] }^{n}]>]**	**[<a5: [{ [<PoV1: IT-based services> + <PoV2: complain-not-complain process profile>] | [<MoV1: IT-based products>]}^{n}]>]**	**[<a5: [{ [<PoV1: IT-based services> + <PoV2: capability process profile>] | [<MoV1: IT-based products>] }^{n}]>]**

[<OsB1: driver-organizational subsystem>]	<STRATEGIC MGT: <Process Mgt: [OPF + OID]>>	<STRATEGIC MGT: <Enterprise P.: [SLCP.MGT + QUA. MGT]>>	<STRATEGIC MGT: <Organizational Life Cycle P.: not defined >>	<STRATEGIC MGT: <Manage-ment P. : [ORG.ALIG, QUA.MGT]>, <P. Improvement P.: [PRO.IMPROV]>>	<STRATEGIC MGT: <*Mgt. System Reqs.>, <*Service Mgt. P&I>>	<STRATEGIC MGT: <*Service Strategy: [STRAT.GEN]>>
	<FINANCIAL MGT: <Process Mgt: not defined>>	<FINANCIAL MGT: <Enterprise P.: [INV.MGT]>>	<FINANCIAL MGT: <Organizational Life Cycle P.: [INFRASTR]>>	<FINANCIAL MGT: <Resource & Infst. P.: [INFRASTR]>, <Reuse P.: [ASSET.MGT]>>	<FINANCIAL MGT: <*Service Delivering: [BUDGT.ACCT]>>	<FINANCIAL MGT: <*Service Strategy: [FIN.MGT]> >
	<HR MGT: <Process Mgt : [OT]>>	<HR MGT: <Enterprise P.: [RES.MGT]>>	<HR MGT: <Organizational Life Cycle P.: [TRAINING]>>	<HR MGT: <Resource & Infst. P.: [HR, TRAINING, KM]>>	<HR MGT: <*Mgt. System Reqs.: [Compe-tence, awareness & training]>>	<HR MGT: <*Org. Development>>
	<ADM-LEGAL MGT: <Process Mgt : [OPP + OPD]>>	<ADM-LEGAL MGT: <Enterprise P.: [RES.MGT+ EENV.MGT]>, <Project P.: [INF.MGT]>>	<ADM-LEGAL MGT: <Organizational Life Cycle P.: [MGT.PROC + IM-PROV.PROC]>>	<ADM-LEGAL MGT: <Management P. : [ORG.MGT + MEASRMNT]>, <P. Improvement P.: [PRO.ESTBLSH + PRO.ASSMT]>>	<ADM-LEGAL MGT: <*Service Delivering: [SvL.MGT + Sv.REP] >>	<ADM-LEGAL MGT: <*Service Design: [SvL.MGT]>, <*Continual Service Im-provement: [Sv.REP]>>
	<ITSfM: not defined>	<ITSfM: <Project P. : [INF.MGT]>>	<ITSfM: not defined>	<ITSfM: not defined>	<ITSfM: <*Service Delivering: [SvL.MGT + Sv.REP] >>	<ITSfM: <*Continual Service Im-provement: [Sv.MEASRMNT + Sv.ANLYS + Sv.REP + Sv.IMPROV]>>

[<OsB2: driven-organizational subsystem>]	<INPUT LOGISTIC: <Project Mgt: [PP+SAM+IPM+ RSKM+QPM]>	<INPUT LOGISTIC: <Agreement P. : [ACQ.PROC]>, <Project P.: [PROJ.PLAN, RSK. MGT]>>	<INPUT LOGISTIC: <Primary Life Cycle P. : [ACQ.PROC]>	<INPUT LOGISTIC: <Management P.: [RSK.MGT + PROJ.MGT]>	<INPUT LOGISTIC: <*Relationships: [SUPPLY.REL.MGT]>	<INPUT LOGISTIC: <*Service Design: [SUPPLY.MGT]>, <*Ser- vice Transition: [TRANS.PLAN.SUP + CHNG.MGT + Sv.ASSET.CM + Sv.KM]>>
	<OPERATIONS: <Engineering: [REQM +CRD + TS + PI + VER + VAL]>, <Support: [CM + PPQA + M&A + DAR + CAR]>>	<OPERATIONS: <Technical P. : [REQ.DEV + REQ.ANLYS + ARCH.DSGN + IMPLMNT + INTGRT + VERIF + TRANSITION + VALID + OPERAT + MANTNC + DISPOSAL]>, <Project P. : [PROJ.CTRL + DEC.MAK + CM + INF.MGT]>>	<OPERATIONS: <Primary Life Cycle P.: [DEV.PROC] >, <Supporting Life Cycle P.: [DOC+ CM+ QA+ VERIF+ VALID+ JOINT.REV+ AUD+ PROB.RES] >>	<OPERATIONS: <Primary Life Cycle P.: [REQ.ELIC + SYS.REQA + SYS.ARCH.DSGN + Sw.REQA + Sw.DSGN + Sw.CNST + Sw.INTGRT + Sw.TEST + SYS.INTGRT + SYS.TEST + Sw.INST + Sw.SYS.MANTNC] >, <Supporting Life Cycle P.: [QA+VERIF+ VALID+JOINT. REV+ AUD+ PRO.EVAL+ USAB+ DOC+ CM+ PROB.RES. MGT+ CHNG.MGT] >, <Reuse P.: [REU.PRO, DOM.ENG] >>	<OPERATIONS: <*Resolution: [INCDNT.MGT + PROB.MGT]>, <*Control: [CM + CHNG.MGT]>, <*New/Changed Services P&I>>	<OPERATIONS: <*Service Operation: [EVENT.MGT + REQST.FULLMT + INCDNT.MGT + PROB.MGT + ACCS.MGT + F.Sv.DESK + F.TECH.MGT + F.IT.OPER.MGT + F.APPLIC.MGT + F.MON.CTRL]>>
	<OUTPUT LOGIS- TIC: <Project Mgt: [PMC+ IPM+ RSKM+ QPM]>>	<OUTPUT LOGIS- TIC: <Agreement P.: [SUP.PROC]>, <Project P.: [PROC.ASSMT + PROC.CTRL+ RSK. MGT+ INF.MGT]>>	<OUTPUT LOGISTIC: <Primary Life Cycle P.: [SUPPORT + OPERAT + MANTC]>>>	<OUTPUT LOGISTIC: <Pri- mary Life Cycle P.: [SUPPORT + OPERAT]>>>	<OUTPUT LOGISTIC: <*Service Delivering: [CAPC.MGT + Sv.CONT.AVL.MGT + INF.SEC.MGT + SvL.MGT + Sv.REP] >, <*Release: [RLS.MGT]>, <*Relationships: [BUSS.REL.MGT]>>	<OUTPUT LOGISTIC: <*Service Transition: [VALID.TEST.MGT + REL.DEPLOY.MGT + EVAL.MGT + Sv.KM]>, <*Service Design: [SvL.MGT + Sv.CTLG.MGT + CAPC.MGT + AVL.MGT + INF.SEC.MGT + IT.Sv.CONT.MGT]>
	<ITSfO: not defined>	<ITSfO: <Project P. : [INF.MGT]>>	<ITSfO: not defined>	<ITSfO: not defined>	<ITSfO: embedded in the other processes >	<ITSfO: embedded in the other processes >

[<OsB3: is-org subsystem.>]	**<IT SERVICE MAN-AGEMENT: not defined>**	**<IT SERVICE MAN-AGEMENT: not defined>**	**<IT SERVICE MAN-AGEMENT: not defined>**	**<IT SERVICE MANAGEMENT: not defined>**	**<IT SERVICE MANAGEMENT: <*Mgt. System Reqs. >, <*Service Mgt. P&I>, <*Service Delivering>, <*Release>, <*Relationships>>**	**<IT SERVICE MANAGE-MENT: <* Service Strategy >, <*Service Transition>, <*Service Design>, <Continual Service Improve-ment>>**
	<IT SERVICE EN-GINEERING: not defined>	**<IT SERVICE ENGI-NEERING: not defined>**	**<IT SERVICE ENGI-NEERING: not defined>**	**<IT SERVICE ENGINEERING: not defined>**	**<IT SERVICE ENGINEERING: <*Service Delivering>, <*Resolution>, <*Control>, <New/Changed Services P&I>>**	**<IT SERVICE ENGINEER-ING: <*Service Transition>, <*Service Design>, <*Service Operation>>**
	<IT SERVICE SUP-PORT: not defined>	**<IT SERVICE SUP-PORT: not defined>**	**<IT SERVICE SUP-PORT: not defined>**	**<IT SERVICE SUPPORT: not defined>**	**<IT SERVICE SUPPORT: <*Control>>**	**<IT SERVICE SUPPORT: <*Service Transition>, <*Service Operation>>**

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