Soft Systems Engineering Tools in Requirements Elicitation

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Abstract: - **Humans beings are the main actors in any system created in the Information and Communication Technology. From system conception to its discard, humans are present. Humans are the system designers, system developers, system users and humans are affected by the system, positively or negatively. Although human is the main actor, several systems engineering methods do not include humans' aspects during the system development. Given the cost involved in system changes after understand its requirements, one must include the human dimension in system requirements elicitation phase. This requirements engineering process is a system inside the system to be treated, it is a system where the components are humans activities. This paper deals with the use of soft system approach in the elicitation process and discusses a perspective of method selection, as a way to identify human requirements for reduce the discrepancy between the expected features of a system and the ones perceived.**

Key-Words: - **Human Factors, Requirements Elicitation, Requirements Engineering, System Engineering, System Thinking, Soft Systems,**

1 Introduction

Systems Engineering, differentially from others traditional engineering disciplines, do not follow a fundamental phenomenon's set based in physical properties and relations. Instead, it deals with the necessary knowledge to manage these phenomenon's, dealing with the system emergent properties, looking for a way to get control about the system entropy [1], [2].

Requirements Engineering is another engineering discipline alone, crucial in the development of any product or service. This Engineering has a life cycle that leads Systems Engineer in the process of requirements elicitation, negotiation, documentation and validation of the systems to be developed. Systems Engineer makes use of this process to execute a task that Kossiakoff and Sweet [3] calls Concept Definition phase, and INCOSE [4] calls Concept Stage. Both refer to the initial phase of various life cycle models placed by engineering statements to systems development.

The development process used by engineers to create Information and Communication Technology (ICT) Systems – whether Agile, eXtreme Programming, Prototyping, Rational Unified Process, or any other method – is irrelevant to the need for understanding the System Requirements [5]. The importance of correct requirements understanding has already been pointed out in terms of software development cost at the end of the 1980s, when Boehm and Papaccio [6] argued that to correct defects that were found after System delivery has a cost 50 to 200 times greater than if these defects had been identified in the early stages of the life cycle. The Software System industry still has problems when requirements are the subject, as pointed by Firesmith [7], the software industry data suggests that nearly 80% of the software rework may be assigned to requirements problems. Another importance about corrected requirements understanding is the knowledge resulted by this process, which is subsidy for various other phases of System life cycle [4].

Systems made by humans are technical and technological triumphs, bringing to humanity products and processes never seen before. Many of these systems have human and social interfaces that demand a series of conditions that are recognized by engineering, that use approaches to treat the humans factors involved in all System life cycle [8], [9], [10].

Engineering must avoid human error in systems built by man. This demand has led Requirement Engineering to identify human factors, and Systems Engineering to consider then in their projects. However, in doing so, the human appears in the Systems as another component representing the cognitive and ergonomics aspects of a System consisting of user, product and environment [2], [11], [12]. To improve the human-system interaction, much has been done in what concerns the Systems usability, but we must go beyond.

The progress that humans are getting in building tools, methods and artifacts are promoting an increasingly revolution in humanity, passing through Stone Age, Bronze Age, Iron Age and, as stated by Ackoff [13], the Machine Age and the Systems Age, our age today.

Go beyond human factors in ICT Systems design is a necessary action since we must not repeat, in Systems Age what Ackoff stated to be the great irony that occurred in the Machine Age, where the humans creations, to free man from work, have led to a dehumanization [13], [14].

This paper proposes the use of Consensual Methods as Soft Systems Engineering Tools to identify humans' requirements in the requirement elicitation process. Furthermore, a perspective to Consensual Methods selection is presented. This session introduces the need for going beyond human factors in ICT Systems development. Second session presents the motivation to develop this work; third session proposes an approach to go beyond human factors; session four focus the approach at Requirement Elicitation and session five presents the Consensual Methods used by Soft System Engineering School; session six illustrates a perspective to a Consensual Method selection on the basis of System life cycle demands, and it is followed by final considerations, that comments some works in progress, acknowledges and references.

2 Systems and Requirements

The word System has a subjective nature, and refers to organization forms recognized by humans. The constructivist view of reality determines that a system does not exist in real world regardless human mind [1].

Life on Earth can be considered as complexes interconnections between two Systems that humans can recognize: The Natural Systems and the Systems created by humans. Checkland [15] classifies the Systems created by humans in three distinct classes: Designed Physical Systems, Designed Abstract Systems and Human Activity Systems.

It is possible to investigate, describe and learn from Natural Systems, create and use Physical and Abstracts Systems and use Engineering methods to deal with Human Activity Systems. In all this classes, there is a search for controlling their emerging properties. Systems Engineering works to deal with this control, synthesizing Systems that have the desired properties and eliminating or reducing the unwanted ones, leading the Engineering in control of complex Systems, where the elements are diverse and have intricate inter-relationships [2], [3]. Hitchins [2] defines System Engineering as the art and science of creating whole solutions to complex problems, and this is the definition adopted by the authors of this paper.

2.1 System Theory

Ideas as holism as an interdisciplinary science and the growing recognition of existence and utility of isomorphism between disciplines has created a awareness that certain concepts, ideas, principles and methods, were applicable to Systems in general. Klir [17] argued that this led to the concept of General Systems, General Systems Theory and Systems Theory; he also stated that the term General Systems Theory is due to Ludwig Von Bertalanffy, who has used it in speeches in the '30s, although the presence of the term in his book took place just after Second World War.

Skyttner [1] states that System Theory deals, in an abstract way, with Systems general properties, regardless physical forms or application domains. It provides a way to abstract reality, simplifying and at the same time capturing system multidimensionality. As an epistemology, it structures not only thinking about reality, but also thinking about the own thinking. As an applied science, it is a metadiscipline, with content capable of being transferred from discipline to discipline.

Systems Theory is knowledge about knowledge and attempts to add and integrate those aspects that seen to be not adequately addressed by the classic science, the science of the Machine Age.

2.2 System Thinking

Systems ideas provide a way of thinking about any kind of problem. System Thinking is how System Theory is put into motion to thinking problems. System Theory has its laws and principles that are a kind of language framework of Systems ideas, a holistic language. A language of Systems, interaction and design, that enables to understand and frame problems [15], [18].

Checkland [15] states that Systems Thinking is not itself a discipline, except to the extent that there will be few people whose professional concern is with Systems concepts as such.

The words holism and systemic, so frequently used in the Systems movement, are founded on understanding the concept of wholeness, focused on

System view, surrounding environment and the contextual frameworks within which Systems exist.

Descartes's dictum that every problem should be broken down into as many separate simple parts as possible – reductive analysis – is the most successful technique that has ever been used in science. System Thinking is an approach to problems where reductionist method of science cannot cope, and Hitchins [2] states that it came to the attention of the Engineering, which had experiencing difficulties in applying their engineering practices (reductionism and determinism) to Systems that included humans.

Kralj [19] states that forgetting about the context is very easy. Usually engineers are specialists in parts of reality, and the contact with others parts of this reality make them strangers. However, parts of reality do matter, as there are interdependence between these parts of reality, otherwise it would not be a reality, meaning that context matters even more than parts alone. This way of thinking about problems, not only separates the parts of the problem, but also considers the parts as a major problem, and their relationship.

Ackoff [20] suggests three ways in which problems can be addressed: They can be resolved, solved or dissolved. To resolve a problem is to find an answer that is "good enough"; one witch satisfies it. To solve a problem is to find the correct answer, as in solving an equation. To dissolve a problem is to change the situation in some way such that the problem disappears.

Hitchins [2] states that there are two approaches, two System Engineer Schools, to treat a problem:

1. *Hard Systems School*: Its concern to create systems that can be introduced in a problematic situation to solve the problem.
2. *Soft Systems School*: Its concern to look at the problem symptoms and try to repair, decrease or work around it, in order to suppress the symptoms to resolve the problem. The result is not a new System, but one that has been "mended", "repaired", "enhanced", "improved", etc.

The first school is characterized by the concept of Hard System Solution, where the solution has a clear purpose and will be developed, delivery, put to work, supported and eventually replaced at the end of its life cycle. While recognizing the importance of interaction and process, this school emphasized functional, structural and architectural aspects of the solutions. The Soft System Solution characterizes the second school, which investigates the problem to be treated, seeking to understand the problem nature, looking for practical experiences and interactions with the problem, trying to understand the situation and propose solutions to improve the situation [2].

Checkland [21] points out that in literature there are statements that Hard approach is appropriate for well-defined technical problems and that Soft approach is suitable for situation of unclear definition, situations involving human and cultural aspects. He argues that these definitions do not characterize correctly the difference between Hard and Soft approach, since the right idea is regarded as how the word System is used, which is related to a perception that people have of the System. An engineer can use the Hard approach with problems that he can observe and treat with traditional Engineering methods. It is related to Hard Systems (Natural Systems, Abstract Systems and Physical systems), but this approach may not have successful when applied to problems where complexity and confusion are observed, where there is not a consensus between the people involved in the problematic situation about the problem definition that is causing the situation being experienced.

The goal of Soft approach is to determine the problem, since different people involved with the problematic situation have different priorities issues. Such issues are not resolved by a single decision-maker, but by group decision-making [19].

2.3 Requirements

System Engineering has several life cycle models, and, in all of them, the initial phase is a Requirement Process. In this process, the Elicitation phase gives the elements to System Engineer understand the problem to be treated. To do it, the engineer needs draw upon the knowledge and experience of the organization directors, managers, employees, etc., that have a problematic situation, i.e., that are demanding a System.

The System Engineer needs to talk with people that are demanding the new Systems and to the people that will be affected, positively or not, by the system. Usually all these people are organized in groups, formals or not, with different purposes; such that the whole has no clear purpose and the groups pull in different and often conflicting directions.

The elicitation phase is essentially a Human Activity System; the use of Soft Systems approach can bring some degree of order to the situation of multiple demands, purposes, issues and problems. This approach can give order to the Requirements Gathering Process, and achieve a point where designs and solution can be manifested, and the System Engineer can identify the three requirements types that Kano [22], [23], [24] states that must be present on any products or services. These requirements types are:

1) *Normal requirements*: These are the requirements that are explicitly required. Requirements identified when the engineer ask to people involved with the System what they wish.
2) *Expected requirements*: These requirements are so basic that sometimes people may fail to mention them, because they think that it is unnecessary request them explicitly. A System without these requirements is very dissatisfying, but meeting these requirements often goes unnoticed.
3) *Exciting requirements*: These requirements are the ones that, if not present in the System, their absence will not be perceived, will not dissatisfy the people with interests in the System. As this requirements are not formalized by requirement process participants, i.e., they are not apt to voice them, it is the engineer responsibility to explore the problem and opportunities to uncover such unspoken desires. For example, as the engineer increase his knowledge about users needs and the problematic situation, he can use his experience to propose features that were not requested but that can improve the system efficiency and effectiveness.

These requirements allows the engineer to understand how meeting or exceeding the stakeholders expectation affects satisfaction in their relationship with the System. The presence of these three types of requirements, and the identification and consideration of human dimensions, are essential for people involved with System development feel welcomed by the System. The engineer may draw upon a variety of methods to extract requirements, but to respect the human and get the information from stakeholders to development the System he needs to develop a consensus from the representative group of individuals. In addition, the engineer must consider what Kumlander [25] states about requirements: “the requirements of a system are not perfect”. Usually the requirements have an uncertainty, due to errors and loss of information and due to changes during the development of a System, because of new regulations or decisions that have to be adopted.

Considering the human is beyond the considerations that exist on human factors literature [8], [9], [10]. Human factor specialists still add value to Systems development, but it is necessary to go beyond human factor and have humans' dimensions, as values and intentions, identified in the beginning of System design, in the Requirement Elicitation phase. The costs to change System Requirements after the beginning of its implementation, and the Robertson and Robertson [5] claim that a product or project fail unless there are correct understandings of the Systems requirements, by engineer and by the people that are demanding the System, justifies the capturing of human dimensions in the beginning of the Requirement Process.

3 An approach to go beyond human factors

During the 1940s began the Systems Age. An Age concerned with systems that allow choice of both meanings and purposes, and has humanization as one of the central problems [13], [14], [20].

Skyttner [1] states that to understand humans and environment as part of a System of interactions, it is necessary to study this interaction in multiple perspectives and holistically.

The application of System Thinking Methods and System Theory Principles and Laws can provide valuable tools to a System Engineer. Tools through which he can see the System, the environment and the social and technical context in which the System will be used.

3.1 Sociotechnical System

Eric Trist and Fred Emery, who worked together as consultants at the Tavistock Institute in UK, have created the term Sociotechnical System to describe the interactions between two Systems: the technological and the social [26].

Ackoff and Trist [27] stated that Systems researchers treat humans as statistics-generating machines, or as entities that respond to stimuli in mechanical ways, and that, sometimes, human beings are simply excluded from the models. Sociotechnical Systems includes humans and technologic knowledge necessary to understand how a System should reach its major goal: include humans as part of the System, a System that generally is controlled by rules and policies from organizations. The human performance must be seen as embedded in a work environment shaped in subtle ways by technology and human behavior [28].

3.1.1 ICT Social and Technologic Infrastructure

ICTs Systems must be made considering human, social institutions and technology. It is a Sociotechnical System, where there is a social infrastructure (human and social institutions), and a technology infrastructure. The consideration of these two infrastructures is crucial in order to identify the correct factors for the quality of services and to identify the stakeholders' expectations, to give them the experience that they expects, surprising them whenever it is possible [2], [29], [30].

Electronic infrastructures (e-Infrastructures) are the basic resources used by ICTs. These resources are computers organized into networks, which together constitute a large computing and storage power, allowing that resources, facilities and services be provided to educational and researcher communities to conduct projects together, promoting, changing end preserving knowledge [31], [32].

The social impact of ICTs technology is present not only in academic context; it is changing the world society as well, as the e-infrastructure allows ICTs to create Systems in which communication and business operations are almost immediate. As a example, e-infrastructure connect global cities as Tokyo, London and New York - cities that are headquarters of world's greatest companies and of the most important stock exchanges, the technology closes a nearly uninterrupted daily round of global market shares.

3.1.2 ICT Complexity

Considering ICT e-infrastructure alone, a computer grid, for example, it is only a technological artifact. It has a purpose, meaning, only when one or more people use it to accomplish some task, as information search or data process to solve problems.

The technological, human and social components of an e-infrastructure system cannot be seen only as the sum of its components. There is a complex interaction among them and emergent properties; that emerges from the System as a whole, not specifically from any of its components.

Another issue that contributes to ICT System complexity is that many of the Systems used today were not develop in an integrated way. They were put together in a gradual way, resulting in a kind of patchwork, with new and old technologies, people and social institutions. New designs must respect this scenario, considering new and old technologies, and the several actors (as user, consumers and social institutions). These actors want to optimize their decisions, thinking in their own subsystems, proposes and interests [33].

3.2 Beyond human factors

Sociotechnical Systems have an intrinsic complexity, and the traditional engineering approach have difficulties in handling with it, both in human mapping (its values, intentions, etc.) as in social institutions purposes mapping, which often are seen only as part of the context, without belong directly to the System. The reductionism, a characteristic of the traditional approach ends up treating human and social dimensions as constants, or some times, ignore them.

The Soft Systems approach addresses the requirements to understand the problem domain of the ICT Systems and helps to identify the human and social dimensions. The former is because the activity to understand the problem domain is essentially an activity where the components are human activities, and the second because there is an intrinsic complexity of accurately identify human and social dimension during all the System life.

The approach to go beyond human factors is the use of Soft System Methods with an evolutionary approach strategy, as proposed by Soares [34]. The evolutionary approach (Fig. 1) deals with the interaction between reality and thought, and the interaction between problem and solution. Soares sets solution as overcoming restrictions or improvements in an existing reality through an action, considering solution as an indicative of an improvement, i.e., a response that satisfies, but does not solve the problem. From the two interactions exposed above, there are four actions that generate a cycle to resolve (not always solve) a problem. These actions are as follows:

- *Understanding*: When the engineer constructs an understanding, an abstract representation of a real problem;
- *Design*: When the engineer creates a response to the problem that satisfies the problem in thought dimension;
- *Implementation:* The construction of the response to the problem in terms of reality;
- *Use:* Set up of a response to the problem, in the environment of the problem.

The set up of a response to the problem may cause changes in reality, emerging scenarios not previously determined, giving rise to new demands, as there is a problem re-definition. The treatment sequence of the problems leads to an evolutionary spiral (Fig.1), which keeps track of the steps taken in identifying the human and social dimensions. This control is a fundamental tool in the requirement process [5], [34], [35].

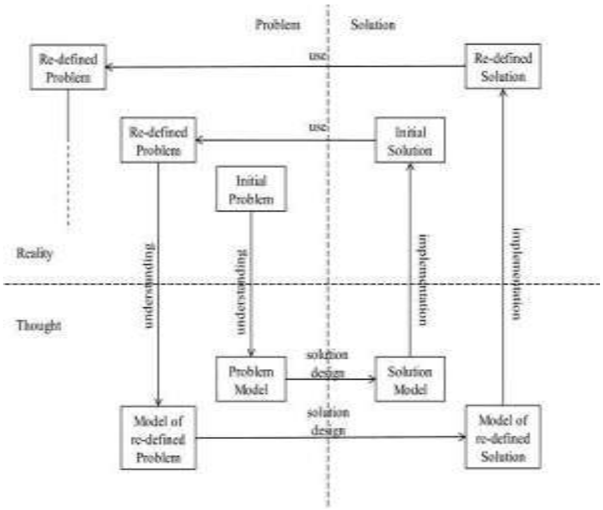

Fig.1 - Evolutionary spiral representation [34].

Although the identification of human and social dimension during all the System life is important to the System success during all the life cycle, the first step of the process is crucial.

4 The Beginning: Requirements Gathering

The human and social institutions mapping must be done at the beginning of the system life cycle, when the System Engineer is identifying the needs that the System should meet, the problem domain, i.e., the System Requirements.

Understanding the System Requirements is the first step to determine the System construction possibilities and the engineer must be very careful in this activity. If mistakes occurs in this early phase of the requirement process, the System will have to be adjust later, or will become obsolete before its time, or will be reject by users or, even, the System will fails in order to bring the benefits expected from it. Such mistakes also raise development and deployment costs and, several times, causes non-compliance with agreed deadlines [5], [36], [37].

The generic practices addressed by live cycles models may, or may not, be applied to an organization. Recommendations to adapt the activities described by these models to the situation where they will be applied are common, and depend on people decisions and judgments, that take many organizations to have their own approach; as this scenario can lead to a situation where each organization has its model, the Engineering has its standards.

The standards for Systems Engineering proclaim that the steps in a life cycle had to correspond to the progressive transitions in the principal System Engineering activities and be capable of being mapped into the principals' life cycle models in use by the System Engineering community. A life cycle model that serves as a framework to this work is the one proposed by the international standard ISO/IEC 15288: Systems Engineering – System Life Cycle Processes [38].

INCOSE Systems Engineering Handbook [4] states an analysis of the System life cycle process per ISO/IEC 15288, showing the process of the life cycle that are inputs to others. In this analysis, the processes: Requirements Analysis, Architectural Design, Implementation, Verification, Validation, Operation, Maintenance, Disposal, Decision-making, Risk Management, Configuration Management, Information Management and Quality Management are dependents from the Requirements Definition Process, that is the first process in life cycle process per ISO/IEC 15288.

A proposal to reduce users' dissatisfaction, respecting the human aspects and getting the necessary information to System development is the use of Consensual Methods to get consensus about the Systems Requirements from all the people that have interests in the system. The consensual processes deal with the human activities involved in identifying the requirements and the human and social dimensions, seeking to reduce the discrepancy between the expected Systems features and the ones that will be perceived by the users. The Requirement Elicitation needs to go beyond the human factors that the Engineering usually indentify in this phase and then users can feel welcomed by the system.

5 Consensual Methods

Following are related the Consensual Methods used by the authors in their work. Hitchins [2] stated that these methods are specifically to the front end of the Systems methodology, they are: Brainstorming, Nominal Group Technique, Idea Writing, Warfield's Interpretive Structural Modeling, Checkland's Soft Systems Methodology, Hitchins' Rigorous Soft Method.

5.1 Brainstorming

This is an approach in which a selected group of people is encouraged by a moderator to come up with ideas in response to a topic or a trigger question. [2], [39].

5.2 Nominal Group Technique (NGT)

This technique is similar to Brainstorming. A moderator introduces a problematic situation to a group of people and asks to participants to write down their ideas about the problem on a sheet of paper. After a suitable delay for the people generate their ideas, all participants read their ideas and the moderator, or an assistant, write them in a flip chart. With all the ideas written, the moderator conducts a discussion about these ideas, and then the participants are invited to rank all ideas. An idea-ordered list is generated and this constitutes the ideas that have been produced by the group as whole [2], [39].

5.3 Idea Writing

This method takes TGN a little farther. The moderator introduces the theme, and the participants are asked to write their ideas, suggestions, etc., in a paper. After two or three minutes, the moderator asks to which participant to pass his sheet for another person, pass the sheet to two people on the left, for example. Who receives the sheet can see the ideas already written, which may lead him (her) to a new set of ideas. After a short time, the moderator asked for the sheet recirculation, this time, a different number of people. The process is repeated for about 30 minutes, or until the moderator notes that most people do not have more ideas. There are two purposes in this strategy: encourage the ideas emergence within the working group and hide the origin of a particular idea. The lists of ideas are worked later through Brainstorming or TGN to generate an action plan [2]

5.4 Warfield's Interpretive Structural Modeling (ISM)

It is as a computer-assisted learning process that enables individuals or groups to map complex relationships between many elements, providing a fundamental understanding and the development of action courses to treat a problem. Hitchins [2] argues that ISM is essentially context free, and that computer support is not essential, because it can be executed using only a pen and a paper. An ISM session starts with a set of elements (entities) to which a relationship must be establish. These entities are identifying using other methods; Hitchins [2] suggests the use of the TGN. The result of ISM is a kind of graph, where the entities are nodes and the relations are edges. All process can consume a lot of time, especially when there are many divergences between the group members. Therefore, this time is important. It is essential for participants to understand and recognize the arguments of each other, reaching the consensus [40], [41].

5.5 Checkland's Soft Systems Methodology (SSM)

This method promotes the understanding of a problematic situation through the interaction between the people involved in the problematic situation. It promotes the agreement of the multiple problem views and multiple interests, and can be represented by a model of seven stages. The stages one and two explores the problematic situation (unstructured) and express it in a rich picture. Stage three are the root definition of the relevant systems describing six aspect of the problem, which are called CATWOE, they are: Customers, Actors, Transformation process, Worldview, Owner and Environment constrains. In stage four, the conceptual models of the relevant systems are developed and in stage 5 the conceptual model are compared with the perceptions of the real situation. In stage six, an action plan is developed to the changes that are feasible and desirable; and in stage seven, the action plan is implemented. As a method developed from the Soft Systems Thinking, SSM does not produce a final answer to the problematic situation, it seeks to understand the problem situation and find the best possible response [2], [16].

5.6 Hitchins' Rigorous Soft Method (RSM):

As SSM, this method is based around the General-Purpose Problem-solving Paradigm and is context free. The people who are experiencing a problem, and have knowledge about it, provide information about it in meetings with the Systems Engineer. This investigation, which search for dysfunction sources related to the problem, can create a lot of information and data. In a way different from the SSM, RSM employs tools and methods for treating, organize and process information, where the action of "process" implies in a gradual reduction of the problematic situation by ordering the data, transforming them into information for the treatment of the problem. RSM has seven steps [2]:

1) *Nominate Issue & Issue domain*, where the problem issue are identified and a description of the situation are made;
2) *Identify Issue Symptoms & Factors*, that identify the symptoms of the problem, and the factors that make them significant to be explored;
3) *Generate implicit systems*, each symptom implies the existence of at least one implicit system in the problem situation;
4) *Group into Containing System*, in this step the implicit systems are aggregated to form clusters, one cluster for each symptom, named containing system, that can generate a hierarchy of systems, highlighting issues related to the problem;
5) *Understanding Containing Systems, interactions, imbalances*, in this step the interactions between the containing systems are evaluated;
6) *Propose Containing Systems Imbalance resolution*, this step use the differences between an ideal world, where the symptoms does not exist, and the real world, to propose sociotechnical solutions to the imbalances identified in the previous step;
7) *Verify proposal against original symptoms*, in this step the system model are tested to see if they would, if implemented, eliminate the symptoms' identified in step two and the imbalance found in step six. This model could also be tested for cultural acceptability by the people that are experiencing the problem.

6 Perspectives of Method Selection

The diversity of people involved in an ICT system development is a reality that Engineering must deal. Zhang [42] states that it is impractical to limit the diversity of people involved in a requirement process, and that, however, the methods to develop requirements are under the Engineer's control.

6.1 Perspectives

Kossiakoff and Sweet [3] stated that the function of system engineering is to guide the engineering of complex Systems, and that System Engineering is an inherent part of project management - the part that is concerned with guiding the Engineering effort itself. ICT Systems must take System Engineer approach as to deal with the System complexity increase.

Kossiakoff and Sweet [3] had structured a life cycle model that corresponds to significant transitions in Systems Engineering activities. They did it comparing three standards life cycle models: Department of defense Model (DoD 5000), International model ISO/IEC 15288 and National Society of Professional Engineers model (NSPE). This life cycle model, adopted as a life cycle framework to this work, has three brad stages, with eight distinct phases:

- *Concept Development Stage*: With the phases: Needs Analysis, Concept Exploration and Concept Definition;
- *Engineering Development Stage*: With the phases: Advanced Development, Engineering Design and Integration & Evaluation;
- *Post development*: With the phase: Production and Operation & Support

The five phases of the Concept Development stage (the Requirement Process) are shown in Table 1, with its main activities, purpose and inputs.

	Main Activity	Primary Purpose	Inputs
Advanced Development	Risk Abatement	Identification and reduction of development risks.	System functional specification and defined system concept
Engineering Design	Component Engineering	Ensuring that individual's components faithfully implements the functional and compatibility requirements.	System design specification and validated development model
Integration & Evaluation	System Integration	Ensure that all interfaces are fit and components interactions are compatible with functional requirements.	Test & Evaluation Plan and Engineered Prototype
Production	Production Process	Diagnose the source of problems and find effective solution.	Production specification and production systems
Operation & Support	Logistic Support System	Continuous training programs for operators and maintenance personnel.	Operation & Maintenance documents and installed operational system

Table 1: List of life cycle phases after the Concept Development stage.

6.2 Method Selection

The use of Consensus Methods to get consensus from the people about the Systems requirements are the proposal to reduce people dissatisfaction about Requirement Process, respecting the human aspects and getting the necessary information to development a System. However, to be adherent to the System life cycle process, these Consensual Methods also need to have outputs to the process that are dependents of the requirement definition process.

The comparison of Consensual Methods outputs considering the life cycle phases stated by Kossiakoff and Sweet [3] that follow the Concept Development stage is the technique proposed to choose the Consensual Method, or Methods, which better provides information to subsequent life cycle phases.

6.3 Table of Method Selection

To understand the appropriate use of the different Consensual Methods, the authors have constructed a table (Table 2) that summarize the adherence level of a Consensual Method to life cycle model phases demands proposed by Kossiakoff and Sweet [3]. The authors experience in dealing with these methods form the situational context, which is listed in the first cell of the table left column. The Consensual Methods are listed in the top row, and represents different ways to gathering the requirements.

+++: Method recognize the phase issues and provide means to deal with it; ++: Method support the phase issues but not as strongly as the previous one; +: Method address the phase necessity but weak or indirectly; -: Method does not address the phase issues.	Brainstorming	Nominal Group Technique (NGT)	Idea Writing	Interpretive Structural Modeling (ISM)	Soft Systems Methodology (SSM)	Rigorous Soft Method (RSM)
Advanced Development	+++	+++	+++	+++	+++	+++
Engineering Design	++	++	++	+++	++	+++
Integration & Evaluation	-	-	-	+	++	+++
Production	++	++	++	-	++	+++
Operation & Support	-	-	-	+	+	+++

Table 2: Table of Method Selection.

|The Table of Method Selection is illustrative, rather the comprehensive. It is based in empirical findings from authors' experience. It provides a practical starting point for organizing an approach to the requirements elicitation, or, as posted by Kossiakoff and Sweet [3], the Needs Analysis and Concept Exploration phases.

7 Final Considerations

From the perspective of comparing the Consensual Methods taking in consideration the life cycle phases, presented in table 2, the method that provides more information for the life cycle phases that that follows the requirements elicitation is Hitchins' Rigorous Soft Method (RSM). As a Consensual Method, it promotes consensus among people about the System requirements, in such a way that people feel welcomed by the process

Humans being have personality, hopes, fears, dreams, values, and intentions. Do not consider these human dimensions to build systems ultimately dehumanize human-system interaction, and is costly!

Authors work seeks to validate the approach proposed, using RSM to considering humans and social institution during all system life cycle and, at this moment, the work is been applied to the followings authors' projects:

- *Soft Approach and Engineering Standards*. The near absence of reflection on humanism in system life cycle, leads to a system development with focus much more on functionality and usability than in humanities and social interfaces. Nevertheless, this reflection on human dimensions must not exist by itself; it must be supported in engineering standards like IEEE and ISO/IEC ones. The authors are working s in correlating the RSM with the life cycle standards ISO/IEC 15288 and IEEE 1220;
- *e-Infrastructure as sociotechnical systems*. KNOMA (the authors' laboratory at Escola Politécnica-USP) is a partner of the BELIEF-II Project, from Seventh Framework Program (FP7), and work in a key issue of the e-Infrastructure: The regard with humans, social institutions and technology. The sociotechnical view is crucial in order to identify the correct quality factors and the expectations of actors of the social infrastructure, to give the experience that these actors expect, surprising them whenever it is possible. A special topic in this project is the use of RSM to address e-Infrastructure projects at Amazon, respecting

the regional characteristics, and human and cultural dimensions;

- *ALCUE UNIT Model*. KNOMA is a partner of VertebrALCUE project, from ALFA III Program. One of the main project activities to its partners is to build an ALCUE UNIT; this is a key activity to build a cooperation infrastructure between high education entities. KNOMA ALCUE UNIT has a thematic focus in modeling e-Infrastructure as sociotechnical system, and building a network that will allow information exchange on mobility of teacher, students, and researchers interested on e-Infrastructure as sociotechnical systems subject. To build this information network, RSM is used and e-Infrastructure concept is applied, interconnecting computing resources that will permit information dissemination.

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- BELIEF-II (**Bringing Europe's eLectronic Infrastructures to Expanding Frontiers - Phase II** http://www.beliefproject.org) is an EU FP7 project with the aim of supporting the goals of e-Infrastructure projects to maximize synergies in specific application areas between research**,** scientific and industrial communities.
- VertebrALCUE: The **VertebrALCUE** Project (http://www.vertebralcue.org) is an ALFA III Program project that aims to contribute to the development process of the regional integration among Latin American Higher Education Systems (HES´s) and the implementing process of the Common Area of Higher Education between Latin America, the Caribbean and the European Union (ALCUE in Spanish) by exploring and strengthening different levels of articulation of Latin America-Latin America and EU-Latin America academic cooperation through the design and implementation of a cooperation infrastructure at institutional, national and regional level.

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Issue 1, Volume 4, 2010

3D Kinematics of a Tentacle Robot

by Giuseppe Boccolato, Florin Manta, Sorin Dumitru, Dorian Cojocaru

Abstract: This paper deals with the control problem of a class of tentacle arms. A tentacle robot produces changes of configuration using a continuous backbone made of sections which bend. The lack of discrete joints is a serious and difficult issue in the determination of the robot's shape. A tentacle arm has a variable length and theoretically it can achieve any position and orientation in 3D space. In order to get a better control in the constraint operator space, it is possible to increase the length of the tentacle. A tentacle arm prototype was designed and the practical realization is now running.

Keywords:
Tentacle robot, motion control, modelling
Full Paper, pp. 1-8

Hydropower Preventive Monitoring Action Plan Prophylactic

by Marius-Constantin Popescu, Nikos E. Mastorakis

Abstract: Hydropower generators operation can be automatically optimized based on a correct determination of the main performance indices. The same approach is operable for rehabilitation studies. The most important application refers at small and very small hydropower stations, operating completely automatically, and individual or in a waterfall. There were established resistors parameters, adjustment characteristics, efficiency characteristics at different operation regime, and main types of losses at different regime. It is generated a computer of modeling process, considering these parameters, utilizable in mentioned applications. The numerical example is presented for a small hydropower generator type HVS 288/159-8, working in a hydropower station on the Jiu River. Determining the performance generators goes into hydropower plants is a major landmark in both prophylactic legally and in terms of energy efficiency due to rehabilitation or re-engineering processes.

Keywords:
Hydropower, Components, Parameters

Issue 2, Volume 4, 2010

Improving the Prediction Accuracy of Recurrent Neural Network by a PID Controller

by Ryad Zemouri, Rafael Gouriveau, Paul Ciprian Patic

Abstract: In maintenance field, prognostic is recognized as a key feature as the prediction of the remaining useful life of a system which allows avoiding inopportune maintenance spending. Assuming that it can be difficult to provide models for that purpose, artificial neural networks appear to be well suited. In this paper, an approach combining a Recurrent Radial Basis Function network (RRBF) and a proportional integral derivative controller (PID) is proposed in order to improve the accuracy of predictions. The PID controller attempts to correct the error between the real process variable and the neural network predictions.

Keywords:
Maintenance, prognostic, error of prediction, neural network, RRBF, PID
Full Paper, pp. 19-34

Testing Robotic Manipulators: Improvement and Experience

by Yaser Maddahi, Nariman Sepehri, Hasan Ghorabi, Ali Maddahi

Abstract: In today's world of flexible automation, users should be able to rely on the performance of robots. The ISO 9283 presents the criteria and related testing methods to determine performance characteristics of industrial manipulators. This paper reports on the process of experimental evaluation, improvement and objective/quantitative comparison among different performance indices of two types of robots: a revolute robot and a prismatic robot. Using certified technical standards, these indices are calculated based on experimental analyses. Additionally in order to further improve the functionality of robots, risk assessment of robot is done using IEC

evaluation, Preventive tests
Full Paper, pp. 9-18

Issue 3, Volume 4, 2010

The Development and Use Supporting of Renewable Energy Sources in Terms of Czech Companies
by Renata Myskova

Abstract: Renewable energy sources are used only partially in the Czech Republic; the Czech energy mix still consists mostly of primary sources of energy. Better use and expansion of renewable energy is linked to their financial demand, at the time of purchase and at the time of their use. The aim of this article is to specify the activities in the field of renewable resources which are economically interesting for entrepreneurial subjects, to describe the situation in the field of renewable energy in the Czech Republic, and analyze the possibility of financial support for their development and the reasons why these funds are utilized.
Keywords:
Renewable energy resources, sustainable development, project financing for the support of renewable energy resources
Full Paper, pp. 55-64

Soft Systems Engineering Tools in Requirements Elicitation
by Marcel J. Simonette, Fabio L. L. Sanches, Edison Spina

Abstract: Humans beings are the main actors in any system created in the Information and Communication Technology. From system conception to its discard, humans are present. Humans are the system designers, system developers, system users and humans are affected by the system, positively or negatively. Although human is the main actor, several systems engineering methods do not include humans' aspects during the system development. Given the cost involved in system changes after understand its requirements, one must include the human dimension in system requirements elicitation phase. This requirements engineering process is a system inside the system to be treated, it is a system where the components are humans activities. This paper deals with the use of soft system approach in the elicitation process and discusses a perspective of method selection, as a way to identify humanrequirements for reduce the discrepancy between the expected features of a system and the ones perceived.
Keywords: Human Factors, Requirements Elicitation, Requirements Engineering, System Engineering, System Thinking, Soft Systems

Full Paper, pp. 65-75

31010 standard and FMEA approach. Performance indices are compared after and before applying the correction actions obtained from risk assessment. The results show that the accuracy and repeatability of both robots are substantially enhanced after correcting the design and applying the changes on manufactured robots. The main contribution of this paper is the design improvement of robotic workability using FMEA method as well as the calculation of performance indices using experiments and following the international standards.
Keywords:
Manipulators, Accuracy, Repeatability, Tracking, Design Validation, Risk Management, Load Capacity
Full Paper, pp. 35-45

Risks Influences and Sustainable Multihazard Design on Built Environment
by Razvan Oprita

Abstract: The notion of risk is reported on local and transitory phenomenon that through them actions are remodeling the ecological system, affecting the built environment and endangers the human life. Risks are nature generated like earthquakes, floods, winds and fires; and human generated like terrorism. Defining and understanding risks and the problems that each of them raises on built environment is essential because they are changing human environment and the way of life. Each risk has its own characteristics and raises specific problems. A multi hazard approach of design teams is required for a proper mitigation assessment of the impacts on built environment. An investigation of built environment affected by risks leads to definition of specific measures for each risk category as well as commune measures for mitigation. Structural modification of the built environment outlook trough multihazard design and taken into consideration modern people needs can lead to remodeling of urban landscape with benefic effects on socialization needs and protection of humans.
Keywords:
Risk mitigation assessment, built environment, multihazard design, urban environment
Full Paper, pp. 46-53

Issue 4, Volume 4, 2010

Housing Market and Financial Crisis
by M. Lopreite, A. Scarpino

Analysis the Impact of Enterprise Resource Planning Systems on Organizational Effectiveness

by Amin Amid, Mehdi Bagheri, Saeed Ghasrodashti

Abstract: Enterprise Resource Planning (ERP) Systems exist to create effectiveness organizations but measurement of this is so difficult. Effectiveness is multiconcept. Three variables affect organizational effectiveness such as defined casual, intervening and end-result. In this article at the first, we review measurement methods that have a full fitness with these variables. After that, we try to use this variables and ERPs benefit to study differential impact of these systems on effectiveness. In addition, we investigate the effectiveness measurement methods that calculating the affects of ERPs on organizational effectiveness and introduce the appropriate methods that adjust better with these systems. At the last, we suggest the management guideline for implementing ERPs.

Keywords: Enterprise Resource Planning, Organizational Effectiveness, Casual, Intervening and End Result Variables

Full Paper, pp. 76-86

Partially Decoupled DMC System

by P. Skupin, W. Klopot, T. Klopot

Abstract: This paper presents on the application of the partial decoupling control for the nonlinear MIMO hydraulic plant composed of two tanks connected with each other. In order to make the plant more challenging for control the first tank has variable cross sectional area and there has been applied additional interaction for input flow streams. By means of the three port valves some fraction of the first flow stream (F1) is fed into the second tank and some fraction of the second flow stream (F2) is fed into the first tank resulting in the smaller relative degrees in the cross channels of the nonlinear plant. The goals of the control algorithm were maintenance of the both liquid levels (H1, H2) at preset values and elimination of the interactions between control loops. The application of the partial decoupling matrix of constant elements together with the DMC controller for the first tank and PI controller for the second tank (of constant cross sectional area) gave satisfactory results – smaller interactions between control loops. Moreover, it has been studied the quality of control in the presence of the additional disturbances for the system with active or non-active decoupling mechanism. The plant was disturbed by two oscillating sinusoidally with nonzero mean input flow streams (F3, F4) for the first and second tank respectively. The simulation results have shown that the decoupling mechanism improves quality of control in the presence of the disturbances.

Keywords: Adaptive control, DMC (Dynamic Matrix Control), Partial decoupling, Predictive control, Nonlinear plant

Abstract: In times when the financial and economic crisis is experimented after the Great Depression, this event has had serious consequences on the real estate sector and consequently on very vast urban areas. The process of the “urbanised reutilization” that has produced the contemporary city began quickly there. The city changed in consequence of the market and it is the same market that redefined the terms of the interventions ex-post. After subprime loans market crash where it was thought to have endless possibilities of growth, are we able to define the consequences that the crisis will have on the post-contemporary cities of Europe? Is it possible to foresee sceneries or visions of intervention and try to identify models of development without excessive waste of resources? We can start analyzing the cases that have before others restarted to go up the economic cycle again, and verify how this affected the processes of transformation of the post-contemporary city.

Keywords: Housing market, economic cycle, business, panic, animal spirits, urbanization

Full Paper, pp. 105-113

Novel Mobile Robot Path Planning Algorithm

by Hachour Ouarda

Abstract: In this present work we propose a novel mobile robot path planning algorithm. Autonomous robots which work without human operators are required in robotic fields. In order to achieve tasks, autonomous robots have to be intelligent and should decide their own action. When the autonomous robot decides its action, it is necessary to plan optimally depending on their tasks. More, when a robot moves from a point to a target point in its given environment, it is necessary to plan an optimal or feasible path avoiding obstacles in its way and answer to some criterion of autonomy requirements such as : thermal, energy, time, and safety for example. First, we assume that the goal position is unknown. Secondly, only obstacles in the “relevant” area (according to the logical position) are consider, i.e. the obstacles that are far, or in the direction opposite to the movement of the robot are not relevant. In this context, a full range of “main sub_position concepts” for vehicle control have been investigated by the execution of the asked mission. These feasible sub_position works demonstrate that obstacle detection and collision avoidance

Full Paper, pp. 87-94

Prevision Model of the Regional Development of Tourism in Barsei Plain

by Adina Camarda, Doru Plesea, Codruta Adina Baltescu

Abstract: Between the economic-social developments that combine harmoniously the tourism in Barsei Plain there is a relationship of correspondence and reciprocity. The statement is based on the double implication that appears as a circuit, in the sense that the activities Specific to the tourism by their complexity contributes to the ensemble development of the region, while this development will determine at its turn the increase of the tourism circulation. In this context, appears the necessity of future anticipation, process by which it can be achieved the stability of the tourism phenomena that must be followed, with the purpose of obtaining better results, for achieving certain goals. This prevision process represents the basis for all the decisions concerning the tourism development strategy in Barsei Plain.

Keywords:
Region, tourism circulation, regional development, tourism phenomenon, prevision, emitting area, receiving area, tourism product, reception capacity, environment spore, trend

Full Paper, pp. 95-103

are improved with good results. While this model has been successful for the path planning problem, it is problematic for robots to react, act, decide, and to take a suitable action "high level reasoning". Much of the challenge of the mobile robots requires intelligence at subconscious level. In this context, the proposed path planning algorithm provides the robot the possibility to move from the initial position to the final position (target). The results are satisfactory to see the great number of environments treated.

Keywords: Intelligent Autonomous Mobile Robots, Path planning , reaction, decision, behavior.

Full Paper, pp. 114-123

The Proposed Grid Based Navigation Approach

by Hachour Ouarda

Abstract: Navigation is a major challenge for autonomous, mobile robots. The problem can basically be divided into positioning and path planning. In this paper we present a scheme for path finding, we focus on positioning. Starting out from an initial position in the grid, the mobile robot can autonomously head for destination cells in the grid. On its way it determines the current location in the grid using a connectivity_cell principle by picking up line-Crossing cells. This principle will be clarified in detail. A key ability needed by an utonomous, mobile robot is the possibility to navigate through the space. The focus is on the ability to move and on being self sufficient. The robot navigates on a grid which regularly divides the ground into rectangular cells. To carry out tasks in various environments as in space applications, the robot succeeds to reach its target without collisions. The proposed approach can deal a wide number of environments. This navigation approach has an advantage of adaptivity such that the intelligent autonomous mobile robot approach works perfectly even if an environment is unknown. The results are promising for next future work of this domain

Keywords: Intelligent Autonomous Systems, grid workspace, path planning, Obstacle avoiding, intelligence

Full Paper, pp. 124-133

A Genetic Learning Motion Planning of an Autonomous Mobile Robots

by Hachour Ouarda

Abstract: This paper describes how soft computing technology as Genetic Algorithms (GAs) can be applied for path planning of an Autonomous Mobile Robot (AMR). GAs are search algorithms based on the mechanics of natural genetics. They combine survival of the littlest among string structures with a structured yet randomized information exchange to form a search algorithm with some of the innovative flair of human search. The proposed GA approach has an advantage of adaptivity such that the GA works perfectly even if an environment is unknown. . These environments were randomly generated . While randomized, GAs are no simple random walk. They efficiently exploit historical information to speculate on new search points (sub path positions) with expected improved performance. We measure the number of generations of candidates. The coding of GA is to affect label 0 for free cell and 1 for hazardous cell. This way of work is very useful later if the substring is inherited to new generations by genetic operators. The objective is to find a feasible and flexible path from initial area source to destination target area, flexible because the user can change the position of obstacles it has no effect since the environment is unknown. This robust method can deal a wide number of environments and gives to our robot the autonomous decision of how to avoid obstacles and how to attend the target. More, the path planning procedure covers the environments structure and the propagate distances through free space from the source position. For any starting point within the environment representing the initial position of the mobile robot, the shortest path to the goal is traced. The results gotten of the GA on randomly generated terrains are very satisfactory and promising.

Keywords: Genetic Algorithm (GA), Motion Planning, Autonomy requirements, Autonomous Mobile Robot (AMR), Intelligence

Full Paper, pp. 134-144

Simulation and Modeling of a Column Industrial Robot Used in some Different Mounting Processes

by Paul Ciprian Patic, Lucia Pascale, Mihaita Ardeleanu, Florin Popa

Abstract: These column industrial robots are used largely in manipulation and mounting operations of a different spares with small and medium dimensions, with regulate forms, which is processed in flexible cells ready in star or circular way

of the components. The column Industrial Robots type represents a large used category, starting with the period of the beginning of automatic flexible manufacture. Starting from column industrial robot architecture one tries to find a simulation procedure for the designing of robots using two methods for resolve this problem. One of them is the polynomial interpolation of three degree method and the other used method is the connection of linear functions in parables. This work presents some determinations regarding the simulation of positions, speeds and accelerations which exists into a translation or rotation couple from a kind of robot.
Keywords: Industrial Robot, Automatic Processes, Column Industrial Robot, Design, Translation, Rotation

Full Paper, pp. 145-154