Beyond Human Factors

Marcel J. Simonette, Fabio Sanches, Edison Spina

Abstract— In any system created by the Information and Communication Technology (ICT) man is main actor. From conception to system discard, man is the system designer, system developer, system user and man is affect by the system, positively or negatively. Although man is the main actor, several systems engineering methods do not include the human in the system development. Given the cost involved in system changes after understand its requirements; we must include the humanism already in system requirements elicitation. This requirements engineering process is a system inside the system to be treated, a system where the components are human activities. This paper propose the use of soft system approach to this process, as a way to identify human requirements for reduce the discrepancy between the expected systems features and the ones that will be perceived.

Keywords— Human Factor, Requirements elicitation, System Engineering, System Thinking.

I. 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 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 development. System 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 the engineering statements to system information development.

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The development process that will be used in a system created by ICT – whether agile, eXtreme Programming, prototyping, the Rational Unified Process, or any other method – is irrelevant to the need for understanding the system requirements. The knowledge resulted by requirement process is subsidy for various other phases of system life cycle [4].

Men made systems 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 human factors involved in all system life cycle [6], [7], [8].

Engineering must avoid human error in systems built by man. This demand has led Requirement Engineering identify the human factors and Systems Engineering to consider then in their projects. However, in doing so, man appears in the systems as another component. A component representing the cognitive and ergonomics aspects of a system consisting of user, product and environment. To improve the human-system interaction, much has been done in what concerns the systems usability, but we must go beyond [2], [9], [10].

Go beyond human factors in ICT systems design is a necessary action. It is necessary because we must not repeat in the Age of Systems what Ackoff [11], [12] stated to be the great irony that occurred in the Machine Age, where the creations of man to free man from work led to dehumanization.

This paper proposes the study of methods that may help to identify humanist requirements in the requirement elicitation process. This session, introductory, introduce the need of going beyond human factors in information systems development; second session presents the state of art that motivate this research; third session propose a approach to be used to go beyond human factor identification and implementation in ICT systems development; session four focus the approach in requirement gathering and it is followed by final considerations, that comments some works in progress, by acknowledges and by references

II. Systems and Requirements

The word system has a subjective nature. It is used to refer organization forms that are associated to the way that man recognize then; 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 man can recognize: Natural systems and systems created by man. Checkland [13] classifies the systems created by man 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 tries to use engineering methods to deal with human activity systems. In all this classes, there is a search for control their emerging properties and Systems Engineering works to have this control, synthesizing systems that have the desired properties and eliminating or reducing the unwanted ones, leading the engineering in the treatment 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.

A. *System Theory*

Skyttner [1] states that System Theory deals, in an abstract way, with systems general properties, regardless physical forms or application domains.

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

B. *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. Language of systems, interaction and design that enable to understand and frame problems [13], [14].

Checkland [13] states that Systems Thinking is not itself a discipline, except to the extent that there will be a few people whose professional concern is with systems concepts as such.

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 people.

The way of thinking about a problem is not only separates the parts of the problem, but considers the parts as a major problem. This is the approach to understand not only the systems to be development, but to understand the basic resources that are used by ICTs, the electronic infrastructure (e-Infrastructure); that are resources related to computers organized into networks, which together constitute a large computing and storage power.

Ackoff [15] 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. To solve a problem is 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 so much a new system, as 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 second school 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 [16] points out that in literature 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 the word system is used, which is related to a perception people have of the system. The hard approach may be used with problems that the engineer can observe and treat with engineering methods. It is related to hard systems (natural systems, abstract systems and physical systems), but this approach is not successful when applied to systems where complexity and confusion are observed, where there is a complexity of accurately identify the goal of the system, the soft systems; systems that have components that are human activities.

C. *Requirements*

In the requirement process, the elicitation phase concerns itself with people. This requirement gathering process needs draw upon the knowledge and experience of the organization directors, managers, employees, etc., that are demanding the 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.

Using appropriate methods to progressively increase order to the requirements gathering process, and achieve a point where specific designs and solution can be manifested, the system engineering has an approach to achieve the three requirements types that Kano [17], [18], [19] states that must be present on a product or service. This requirements allows the engineering to understand how meeting or exceeding the stakeholders expectation affects satisfaction in the relationship with the system. These requirements types are:

1) *Normal requirements*: These are the requirements that are explicitly required.
2) *Expected requirements*: These requirements are so basic that sometimes the stakeholders may fail to mention them, because they think that it was 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 stakeholder. 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 items. For example, as the engineer increase his knowledge about users needs, he can use his experience to propose features that were not requested but that can improve the system efficiency and effectiveness.

The importance of correct requirements understanding has already been pointed out in terms of cost of software development at the end of the 1980s, when Boehm and Papaccio [20] argued that to correct defects that are found after the system delivery has a cost 50 to 200 more than if these defects had been identified in the early stages of the life cycle. Software system industry still has problems when requirements are the subject, as pointed at [21], the software industry data suggests that nearly 80% of the rework of software may be assigned to requirements problems.

Robertson and Robertson [5] stated that the product or project will fail unless there are a correct understanding of the systems requirements, and that people who are demanding the system understanding them too.

D. *Socio-technical Systems*

ICTs systems are made considering man, social institutions and technology. It is a socio-technical system, a system in which there is a social infrastructure (man 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 which are the stakeholders' expectations, to give them the experience that they expects, surprising them whenever it is possible [2], [23], [24].

III. An Approach to Go Beyond Human Factors

Ackoff [11] stated that in the 40th years of twenty century 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. He also stated that in this Age the central principle of the systems thinking is synthesis [11], [12], [15].

The application of System Thinking methods and principles and laws of System Theory to the systems projects can provide to the system engineer a valuable lens through which he can see the system, the environment and the context in which the system will be used. Adams and Mun [14] and Hitchins [2] stated that is the synthesis, in opposition to the Cartesian reductionism, the path to be used by Systems Engineering for the treatment of issues involving system design.

Socio-technical systems have intrinsic complexity and the traditional engineering approach have difficulties in handling these systems, 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.

Every system made by man has a life cycle, even if it is not formally defined. Life cycle models subdivide system life into steps that separate major decision milestones as: Developing, production, usage, decommissioning and disposal. To produce successful information systems it is necessary to give to its users the experience that they expects (normal and expected requirements), surprising them whenever it is possible (exciting requirements), and respect the human and social dimension during all the system life cycle.

The soft systems approach addresses the requirements to understand the problem domain of the information systems (requirement elicitation) and helps to identify the human and social dimension. The former is because the activity to understand the problem domain is essentially an activity that 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, and resolve the problem of identifying the human and social dimension, is use soft system approach in an interaction strategy in various development stages. Each stage is a problem to be resolved (not always solved) and the solution has a cycle composed of: understanding, solution design, implementation and use of the solution. The solution use may cause changes in reality, giving rise to new demands, as we have a problem re-definition, the treatment sequence of the problems leads to an evolutionary spiral (fig. 1) that keeps track of the system development steps, it is a fundamental tool in the requirement process [5], [25], [26].

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.

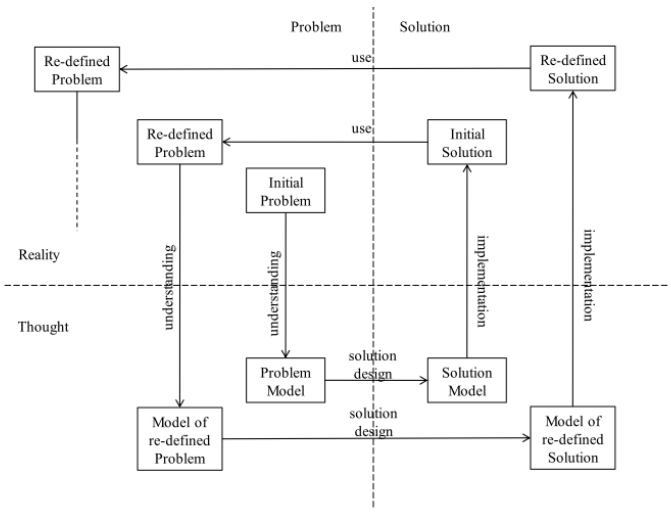

Fig. 1 evolutionary spiral representation [25]

IV. 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 there are mistakes in this initial phase of the requirement process, as failures to indentify all requirements or poor requirements quality, for example, the system must be corrected later, or become obsolete before time, or reject by users or, even, the system fails in order to bring the benefits expected from it. Such errors also raise development and deployment costs and, several times, causes non-compliance with agreed deadlines [3], [5], [20], [27], [28].

The generic practices addressed by live cycles model 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.

This scenario can be improved by standardization, where the steps in the life cycle had to correspond to the progressive transitions in the principal system engineering activities and be capable of being mapped into the principal life cycle models in use by the system engineering community. A life cycle model that serve as an framework is the one proposed by the international standard ISO/IEC 15288: *Systems Engineering – system life cycle processes* [29].

INCOSE Systems Engineering Handbook [5] 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 process threat the human activities involved in identifies the requirements and the human and social dimensions. Looking for 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.

A. Consensual Methods

Following are related the consensual methods used by the authors in their work. Hitchens [2] stated that this methods are specifically to the front end of the systems methodology, they are: Brainstorm [2], [30]; Nominal Group Technique (NGT) [2], [30], Warfield's interpretive structural modeling (ISM) [2], Checkland's Soft Systens Methology (SSM) [2], [16] and Hitchins' Rigorous Soft Method (RSM) [2].

V. Final Considerations

Man has personality, hopes, fears, dreams, values and intentions. Do not consider these human dimensions to build systems ultimately dehumanize human-system interaction.

Authors work seeks to validate the approach proposed, considering man and social institution during all system life cycle. At this moment, the work is concentrate on address requirements elicitation process as a system where the components are human activities. This approach is been applied to the followings authors' projects:

1) *Soft Approach and Engineering Standards*. Diminishes reflection about humanism in system life cycle, leads to a system development with focus much more on functionality and usability that in humanities and social interfaces. However, this reflection must not exist by itself; it must be supported in engineering standards like IEEE and ISO/IEC ones. The authors works in correlating the soft system methods with the life cycle standards ISO/IEC 15288 and IEEE 1220.
2) *e-Infrastructure as socio-technical systems*. KNOMA 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 man, social institutions and technology. The socio-technical view is crucial in order to identify the correct quality factors and the expectations of the social infrastructure, to give the experience that they expect, surprising them whenever it is possible. A special topic in this project is the use of SSM and RSM to address e-Infrastructure projects at Amazon, respecting the regional characteristics, and human and cultural dimensions.
3) *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 socio-technical system, and will build a network that will allow information exchange about mobility of teacher, students and researchers interested on e-Infrastructure as socio-technical systems subject. To build this information network, soft system approach (SSM) is used and e-Infrastructure concept is applied, interconnecting computing resources that will permit information dissemination.

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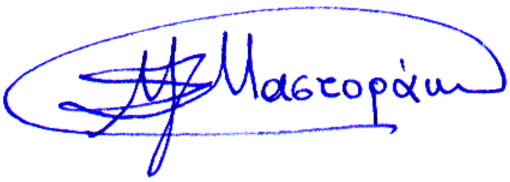
December 21, 2009

Dear Mr. Marcel Jacques Simonette,

We are pleased to inform you that your paper submitted to 3rd International Conference on Communications and Information Technology (CIT'09) is accepted for presentation in a regular session. The conference will be held at Vouliagmeni, Athens, Greece, December 29-31, 2009. All papers were rigorously peer reviewed. Please note that regular session papers will be published in the conference proceedings.
Title: Beyond Human Factors.
Authors: Marcel J. Simonette, Fabio Sanches, Edison Spina.
Your presence at the event would be a really great honour for NAUN. The NAUNconferences offer to researchers and university faculty members from all around the world the opportunity to rendezvous with colleagues, share new research advances and ideas, and set up new collaborations and research projects. Many well-known and distinguished scholars will attend the meeting. We cordially invite you to join this unique event. You will have the opportunity to attend it and to receive the proceedings with your paper. All the NAUN Conference Proceedings are available on-line for the academic community. The authors of the best papers of the conference will be invited to submit an extended and enhanced version of their paper for possible journal publication in reputable international journals after additional peer review. Updated information about the conference can be found at, http://www.naun.org/conferences/2009/cit
This letter is being sent to you for possible financial support from your department, as well as for VISA grant.
Best Regards



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