Work 41 (2012) 737-744
DOI: 10.3233/WOR-2012-0234-737
IOS Press

From needs to requirements for computer systems: the added value of ergonomics in needs analysis

Stanislas Couix[a,c*], Françoise Darses[b] and Cecilia De-La-Garza[c]
[a] *Centre de Recherche sur le Travail et le Développement, Conservatoire National des Arts et Métiers, 41 rue Gay Lussac, 75005 Paris, France*
[b] *Institut de Recherche Biomédicale des Armées, Ministère de la Défense, Bretigny sur Orge, France*
[c] *Management des Risques Industriels, EDF R&D, 1 av. du Général De Gaulle, 92141 Clamart, France*

Abstract. It is widely recognised that ergonomists must contribute during needs analysis. However, few studies have investigated the specific contributions of ergonomists at this stage of the design process. In this study, this contribution is studied through the requirement document produced by the design team. For each requirement, the source (*i.e.* who formulated the requirement), justification (why the requirement is needed), type (functional, interaction, operational, physical, organizational), and scope (entire system or part thereof) were analysed. Results indicate that the various actors are complementary and work collectively to define the various dimensions of the system. With end-users, the ergonomist worked on the global aspects of the system: function, conditions of use and organizational dimension. Alone, he defined the global interaction of the system. The various functions derived from the global function were defined in collaboration with engineers. However, while engineers contributed to defining how these functions would work, as well as their technical conditions of use, the ergonomist focused on their purpose, and, with end-users, on their organizational aspects. Finally, results suggest that neither the ergonomist's specific knowledge in ergonomics, nor work analysis were sufficient to derive his requirements; both are mandatory.

Keywords: ergonomics, design, needs analysis, requirements

1. Strengthening the integration of ergonomics in the needs analysis process

Avoiding the considerable cost of late alterations is a key challenge in the design of computer-based systems [12, 25]. This is the reason why there is a growing interest in the industry to adopt a user-centered approach starting from the earliest phases of the design process, especially in the process of needs analysis.

Such is the case at EDF, the main provider of electricity in France. In this company, any change of computer-based systems belonging to the nuclear park must be designed and assessed in terms of its impact on the activity of the workers involved. The contribution of ergonomics to needs analysis was studied in the design of an industrial computer-based system intended for use by control room operators. The system, called Operating Aid for Sensitives Transients (OAST) aims to enhance the reliability and to speed up manual operations in the "sensitive transients" phase of the reactor.

Although there are standards that help involve ergonomics in computer systems design for nuclear industry (*e.g.*, [17, 23]), the contribution of ergonomics remains poorly understood, generally reduced to defining the color and the size of the interface. Accordingly, the added value of an ergonomic work analysis is not always seen by system designers, and its results remain most often underexploited [13, 20]. The ergonomist is identified as a partner, but his or her concrete contribution to the design process is not

---

[*] Corresponding author. E-mail: stanislas.couix@cnam.fr.

clearly identified. Some authors have investigated how ergonomists may be involved in the formulation of requirements [19, 27]. But these studies mostly deal with the social dimension of requirements, focusing on how they are accepted by the various stakeholders. They do not address the crucial issue of specific role of ergonomists in needs analysis.

Yet, ergonomics plays a vital role in the analysis of users' needs. Needs analysis is an essential step in a design project. It refers to a process ranging from the identification of user needs to the definition of system requirements and specifications [22]. Thus, it determines both the course of the project and the artifact itself (*e.g,* [5, 8, 16]). Three fields display some focus on needs analysis: product design, systems engineering and ergonomics. Product design has a long tradition of needs analysis, more often called "value analysis" and "functional analysis" [28]. Systems engineering has developed processes and methods within a global framework named "requirement engineering" [2]. Ergonomics is by nature the user-centered science of design. But, whereas systems engineering or product design can do without ergonomics to design and produce an artifact, the opposite is not true: ergonomics is always closely dependent on other disciplines.

Moreover, project managers must plan and choose between the various sources of expertise needed in the design process. Thus, they must know the scope of ergonomics in order to be aware of what kind of input ergonomists are able to provide in design. Project managers also need to figure out the stages in which ergonomists can act in order to allocate tasks and schedule the design process.

Accordingly, the challenge is twofold. First, it is to increase the visibility of the contribution of ergonomics to system design to project managers, and to impose ergonomics as a key partner of the needs analysis stage. Second, it is to enhance the knowledge, models and methods of ergonomics in the field of systems design.

2. From "needs" to "requirements" and "specifications": some key concepts

In user-centered design, requirements and specifications stem from the actual needs of users [17, 19, 22]. An "ergonomic" needs analysis requires addressing two points. First, the process of *needs identification*, as it is conducted by ergonomists. Second, the effective translation of these "ergonomic" needs into system requirements and specifications. In this section, we describe concepts and frameworks used to analyze the contribution of ergonomists to needs analysis.

2.1. Needs: a definition from an ergonomic viewpoint

In spite of the large amount of literature available on needs analysis and its importance in design, few clear definition have been proposed. In product design, needs often refer to what the customer wants. However, customers usually formulate their needs in terms of expected functions or features of the future system, as for instance: "I need a system to safely land humans on Mars". In user-centered design, the system's expected functions or features are system requirements, not needs.

In ergonomics, the users' *needs* are defined according the properties of a basic work activity, which must be retained in the target work situation:

- The goals and tasks that must be performed, the strategies of operators (those to be make more reliable and those which must be kept as they are), the means to achieve the task goals and related challenges [4, 6].
- Socio-organisational and technical constraints (as for instance, software constraints) which will frame the future system [4, 11, 17].
- Physical and cognitive characteristics of the future users (e.g., [4, 17, 21].

All these properties are, most of time, elicited by an ergonomist, through a work analysis. Yet, the ergonomist may also call on his/her own expertise and knowledge in human factors in order to formulate requirements.

Based on this definition of "needs", we propose that a need is any element without which a system (composed of humans and machines) might not achieve its goals. Compared to requirements, a need is a picture of the current situation. This is why the needs are usually not formulated by the user himself, but elicited by the ergonomist, who will translate needs into requirements.

2.2. Requirements as a response to users' needs

Once *needs* are identified, they must be translated into *requirements*, so as to be used by designers. Requirements describe what the system should do (for example, "the system shall allow operators to reach valve X") or property that it should have (for example, "the system shall support the weight of three equipped operators") to meet users' needs [3, 8]. Formulating a *requirement* leads to reducing the set of possible technical solutions. But, as in the case of "*needs*" (see section above), a *requirement* remains independent from the technical solution. It has to be stressed that a requirement may be expressed by the user him/herself, or by the designer, or by the ergonomist.

There is a classical distinction between functional requirements, that describe what the user can do with the device, and the non-functional requirements (e.g. [24]), that can be subdivided as follows [8, 21]:

- Operational requirements: these describe system performance in terms of efficiency, reliability, safety, etc.
- Physical requirements: these define the system components, their relationships, their size, appearance, etc. In computer systems, physical requirements refer to both hardware and software.
- Organizational requirements: these present the organizational components of the system, *e.g.* the number of operators, training, managerial relations, etc.
- Interaction requirements: these describe how the users will likely interact with the future system. They are directly linked to system usability.

Requirements can also be distinguished according to their scope [8]: global vs. narrow. Global requirements refer to requirements describing global function or features applying to the entire system. For example, "the system shall be easy to operate for users who are not skilled with computers". Narrow requirements only apply to some parts of the system. In software, where there are no parts as such, these requirements refers to the various functions of the system. For example, "calculation duration shall be short". As global requirements apply to the whole system, narrow requirements must comply with them.

2.3. Translating requirement into specification

The *requirements* are translated into *specifications* for the design team. This results in expressing precisely the elements of the technical solution. It must be noted that some *requirements* will not be considered in the solution and will be eliminated. Unlike a requirement, a *specification* is strictly qualified and/or quantified [18]. For example, the *requirement* "the system must support the weight of three equipped operators" will be translated into the following *specification*: "the system shall support at least 400 kg". In this paper, results related to the contribution of ergonomists to the specification will not be presented.

3. Method

The contribution of the following stakeholders in the needs analysis process is analyzed: the ergonomist, the engineers and the users. Their contribution was studied through a thematic content analysis [3] of the *requirement document* which was produced at the end of the OAST project. This document is the result of an iterative and collective process, during which several versions of requirements were produced and discussed by the ergonomist, the users and the engineers involved in the project. Only the final version of the requirement document in analyzed in the study.

3.1. Data collection

All end-users' *needs* and *requirements* were identified and collected during the first part of the design process (33 months). Various data collection techniques were used :

- observation of real and simulated work
- analysis of operational return of experience
- semi-directed interviews
- questionnaires
- presentation of a paper mock-up to end-users.

Then, *needs* had to be translated into requirements by the ergonomist. During fieldwork, users were encouraged to elicit requirements. Engineers also elicited requirement during design meetings.

3.2. Data

The requirements document is a 45-page document. It contains 59 requirements. Requirements are systematically formulated in this way "system shall..." or "users can use system to...".

The document also describes why every requirement is needed, and whether it is expressed by users, engineers, or the ergonomist.

3.3. Data analysis

Every requirement was analyzed according to four dimensions : SOURCE, JUSTIFICATION, TYPE, and SCOPE.

SOURCE refers to the actor who discovered or formulated the requirement. SOURCE can be engineers, end-users or the ergonomist.

JUSTIFICATION describe why a requirement is needed, *i.e.* the need behind the requirement. There are four types of JUSTIFICATION :

- limitations of the current system,
- users' cognitive or physical characteristics,
- organizational or technical constraints,
- specific knowledge of SOURCE. For example, for the ergonomist, "specific knowledge" refers to his knowledge in the general functioning of humans, and his knowledge in HCI.

According to section 2, there are five main TYPE of requirements: functional, interaction, operational, physical, and organizational.

The SCOPE refers to whether the requirement applies to the entire system (global scope) or part thereof (narrow scope), *i.e.* to its functions.

To highlight special relationships between some of the four variables, we first performed an exploratory multiple correspondence analysis (MCA). As these results were not exploitable, pairwise analysis was carried out on the variables using Cramér's V2 [9] to evaluate the strength of the relationship. Relationships between two modalities of separated variables were assessed using association rates (AR). Cramer's V2 and AR's were used since these are the equivalent of correlations for nominal variables. AR's and Cramer's V2 were only used when there was a sufficient difference in the number of requirements between modalities of one of the two variables.

The strength of V2 is considered weak or negligible when V2<.04, strong when V2>.16 and intermediate for values in between. There is no relationship between modalities when AR=0, an attraction when AR>0 and a repulsion when AR<0. Attraction or repulsion is considered significant when AR>|.2|.

4. Results

Our results highlight that the ergonomist provided most of the requirements (n=44), followed by users (n=9) and engineers (n=6). These results will be further detailed in this section.

4.1. Actors do not formulate the same type of requirements

All SOURCES have not identified requirements of every TYPE The ergonomist did not formulate any physical requirement, users did not identify any interaction requirement, and engineers only defined physical and operational requirements. There is a strong relationship between the SOURCE and the TYPE of requirement (V2=.4). Thus, it seems that the various actors did not formulate the same types of requirement (table 1).

Table 1
Association rates between TYPE and SOURCE of requirements.

TYPE/SOURCE	Ergonomist	Engineers	Users
Functional	.20 *(n=31)*	-1 *(n=0)*	-.25 *(n=4)*
Interaction	.34 *(n=5)*	-1 *(n=0)*	-1 *(n=0)*
Operational	-.46 *(n=2)*	.97 *(n=1)*	1.62 *(n=2)*
Physical	-1 *(n=0)*	7.19 *(n=5)*	.09 *(n=1)*
organizational	.01 *(n=6)*	-1 *(n=0)*	.64 *(n=2)*

Compared to other actors, users mostly contributed by formulating operational (AR=1.62) and organizational (AR=.64) requirements. These operational requirements focus on the system's conditions of use. These organizational requirements relate to the training needs and the shared allocation of tasks between the various users (*i.e.* who performs what).

Engineers mostly identified physical (AR=7,19) and operational (AR=.79) requirements. These physical requirements focus on the software side of the system, and the single operational requirement relates to the technical conditions the system must meet to be operational.

Finally, the ergonomist formulated mainly functional (AR=.22) and interaction (AR=.34) requirements. The former relate to functions aiming at assisting users performing their tasks and the latter relate to the usability of the system.

As a first conclusion, it appears that the various actors were very complementary. Users mainly reported requirements regarding the concrete use of the system. Engineers mostly helped in defining what was to be "inside" the system. The ergonomist focused his work on functional and interaction aspects of the system, *i.e.* on its utility and usability.

4.2. Actors do not define requirements with the same scope

All SOURCES formulated both narrow and global requirements. However, there is an intermediate link between these two variables (V2=.09). Based on the association rates (table 2) it seems that the various actors did not express requirements with the same scope. Engineers mostly identified narrow requirements (AR=.26). Users mainly formulated global requirements (AR=.97). They identified only few narrow requirements (n=3).

Table 2
Association rates between SCOPE and SOURCE of requirements.

SCOPE	Ergonomist	Engineers	Users
Narrow scope	.07 *(n=31)*	.26 *(n=5)*	-.5 *(n=3)*
Global scope	-.13 *(n=13)*	-.51 *(n=1)*	.97 *(n=6)*

Finally, even if he expressed most of the global requirements (n=31), the ergonomist participated equally to the definition of narrow and global scope requirements. As the users also do, the ergonomist helped defining the guidelines of the system use, while he contributed, with the engineers to design the various parts of the system.

The ergonomist occupies an intermediate position between (i) the engineers, who mostly helped in defining the various parts of the system, and (ii) the users who helped guide the overall design. In defining the various parts, as well as the global aspects of the system, the ergonomist provides a link between these two levels of system design. Doing so, he translates general guidelines into concrete solutions. For example, during a design meeting, users formulated the following functional requirement "decision-making tasks shall be assisted but not performed by the system". The ergonomist translated this global requirement into several system functions, *i.e.* narrow-scope functional requirements.

4.3. Actors participated differently depending on the scope of requirements

Looking only at the global SCOPE requirements, the previous results can be further elaborated on (table 3).

At the global level, functional and operational aspects of the system were mainly defined by the ergonomist (n=4 and n=2, table 3) and the users (n=3 and n=2). Global-scope functional requirements refer to guidelines of what kind of functions the system will provide. For example, "*the system must provide operators with a way to make them understand its mode of operation*". However, at the functional level, there is a huge difference according to the person who formulated the requirement. Functional requirements formulated were formulated in a positive way by the ergonomist, while the users requirement are formulated negatively. For example, "*the system must not become a spy for managers and executives*". It seems that the ergonomist reported general guidelines he thoughts would be useful to users, while users reported on what they did not want.

Table 3
Type of global SCOPE requirement according to their source.

TYPE/SOURCE	Ergonomist	Engineers	Users
Functional	57.1% *(n=4)*	0	42.9% *(n=3)*
Interaction	100% *(n=5)*	0	0
Operational	50% *(n=2)*	0	50% *(n=2)*
Physical	0	50% *(n=1)*	50% *(n=1)*
Organizational	100% *(n=2)*	0	0

Interaction and organizational requirements were all identified by the ergonomist (n=5, table 3). At the global level, organizational requirements refer only to training requirements. Interaction requirement relates to generic guidelines for the interaction with the system. For example, "*the system shall operate with few manual entries from the operators*".

Finally, physical requirement were formulated both by users and engineers (n=1 and n=1). More precisely, engineers defined the technological aspects of the system and users defined where the system would be in the control room.

Looking only at narrow-SCOPE requirements, as in the global level, engineers focused their work on physical requirements (n=4). They also defined one operational requirement.

Table 4
TYPE of narrow SCOPE requirement according to their SOURCE.

TYPE/SOURCE	Ergonomist	Engineers	Users
Functional	96,4% *(n=27)*	0	3,6% *(n=1)*
Interaction	0	0	0
Operational	0	100% *(n=1)*	0
Physical	0	100% *(n=4)*	0
organizational	66,7% *(n=4)*	0	33,3% *(n=2)*

The ergonomist defined most of the functional (n=27) and organizational (n=4) requirements whereas users helped him modestly (n=1 and n=2). Thus, the ergonomist played a major role in translating functional guidelines into functions. In other words, he defined more precisely all the user functions of the system based on the guidelines he defined with the users.

4.4. Actors do not justify their requirements in the same way

There is a strong relationship between the source of the requirements and the justification used to promote them (V2=.21). Thus, the various actors do not justify requirements the same way (table 5).

Table 5
Association rates between JUSTIFICATION and SOURCE of requirements.

JUSTIFICATION /SOURCE	Ergonomist	Engineers	Users
Limitations of current system	.24 *(n=12)*	-1 *(n=0)*	-.5 *(n=1)*
User characteristics	-.62 *(n=2)*	-1 *(n=0)*	3.68 *(n=5)*
organizational or technical constraints	-.11 *(n=14)*	.87 *(n=4)*	-.06 *(n=3)*
Knowledge	.20 *(n=16)*	-.09 *(n=2)*	-1 *(n=0)*

Compared to other actors, users mainly justify their requirements by their own characteristics (AR=3.68). Theses characteristics refers mainly to their preferences. For example, users want to be able to setthe threshold of system alarms because some of them prefer to have higher or lower threshold rather than the threshold defined by the ergonomist.

Engineers mainly justified requirements by constraints of the work situation (AR=.87). Only technical constraints were used by engineers to justify their requirements.

Requirements formulated by the ergonomist were mainly justified by his own knowledge and expertise in ergonomics (AR=.20) and the limitations of the current system identified during fieldwork (AR=.24). The expertise refers mostly to knowledge in the use of computer systems and manual tracking tasks like driving or piloting. Limitations of the actual system relate to the difficulties of the operators observed during fieldwork. However, justifications also refer to the need to make safer some of operators' tasks.

This last result indicates that the ergonomist seems to be in a good position to detect difficulties related to current systems. For the operators, some difficulties can be non-conscious. Actually, when facing difficulties, operators develop new strategies that may not be optimal, *e.g.* in terms of productivity. However, these strategies are totally incorporated in operator activity. Thus, it is difficult for operators to verbalize them. Actual work analysis can enable us to discover these strategies and the underlying difficulties.

Looking only at the justification used by the ergonomist, further details can be provided. According to the type of requirement, the ergonomist used different kinds of justification (V2=.11, table 6).

Functional requirements formulated by the ergonomist were mostly justified by the limitations of the current system which he identified during fieldwork (AR=.18) and based on his knowledge (AR=.06). In other words, some functions identified by the ergonomist stem from the difficulties encountered by operators, and some come from his expertise. The ergonomist justifies the utility of new functions because those are useful in similar tasks and work situations.

Interaction requirements were mainly justified by the user's characteristics (AR=3.4), by the organizational constraints of the situation (AR=.26) and by the ergonomist's expertise in HCI (AR=.1).

The ergonomist justified operational requirements only by the limitations of the current system (AR=2.67).

Finally, organizational requirements were mainly justified by the organizational constraints identified during fieldwork (AR=1.1).

Table 6
Association rates between JUSTIFICATION and TYPE of ergonomist's requirements.

JUSTIFICATION /TYPE	Functional	Interaction	Operational	organizational
Limitations of current system	.18 *(n=10)*	-1 *(n=0)*	2.67 *(n=2)*	-1 *(n=0)*
User characteristics	-.29 *(n=1)*	3.4 *(n=1)*	-1 *(n=0)*	-1 *(n=0)*
organizational or technical constraints	-.19 *(n=8)*	.26 *(n=2)*	-1 *(n=0)*	1.1 *(n=4)*
Knowledge	.06 *(n=12)*	.1 *(n=2)*	-1 *(n=0)*	-.08 *(n=2)*

Limitations of the actual system, user characteristics, and organizational or technical constraints are justifications which stem from the fieldwork analysis done by the ergonomist. Thus, except for functional requirements, it seems that justifications used by the ergonomist to argue for all his requirements are based on findings from the field.

5. Conclusion

As is already pointed out in the literature, ergonomists can help to define the global guidelines and the various parts of a system [10, 11, 14, 26], especially in its functions, interaction and organizational aspects [1, 4, 6, 8]. This exploratory and empirical study extends these statements and provides a deeper understanding of ergonomists' contribution in the process of requirements analysis.

First, the study shows that the various actors are complementary and work collectively to define the various dimensions of the system. With end-users, the ergonomist works on the global requirements that guide narrower requirements and specifications. They collaboratively defined important design guidelines of the system: its general purpose (functional dimension), global conditions of use (operational dimension), and organizational aspects (*e.g.*, task allocation between operators). Without anyone's help, the ergonomist defined the global guidelines for user interaction with the system. The various functions (narrow requirements) derived from the general purpose were defined in collaboration with engineers. However, while engineers contributed to determine how these functions run as well as their technical conditions of use, the ergonomist focused on their purpose, and, with end-users, on their organizational aspects. Therefore, cooperation between these three stakeholders should be encouraged in the early stages of design. Cooperation could be promoted by clarifying the roles of the actors and by organising multidisciplinary design meetings. However, the study fails to show the full scope of cooperation between engineers and ergonomist, especially in the statement of functional requirement. Even if functional requirements are formulated by the ergonomist, he has to check with the engineers that the functions are technically feasible. Thus, a tight cooperation is needed between them.

Second, the study confirms findings from a case study published by [19] and goes into details. More precisely, it shows that neither the ergonomist's specific knowledge in ergonomics, nor work analysis, were sufficient to derive ergonomist's requirements. Both are mandatory. The ergonomist relies heavily on findings from the field to justify most organisational, interaction and operational requirements and some functions. His knowledge and expertise in ergonomics is nevertheless important to define new functions and to derive interaction guidelines. Moreover, this result indicates that presence of the ergonomist during the whole process of needs analysis is mandatory to take advantage of his or her special knowledge. This view contrasts with the Human Factors tradition in design in which designer have access to ergonomics or Human Factors knowledge through reading norms and guidelines [8]. Some studies have reported the difficulties faced by designers in using ergonomics knowledge this way and its inefficiency [7, 15, 27]. When directly integrated in the design team the ergonomist can translate Human Factors and his specific knowledge into usable form by other designers, i.e. into requirement adapted to the ongoing design project [8].

Acknowledgements

The authors would like to thank J. Nelson for proofreading this paper.

References

[1] M. Anastassova, L'analyse ergonomique des besoins en amont de la conception de technologies emergentes – le cas de la réalité augmentée pour la formation à la maintenance automobile, Ph D. Dissertation, Université Paris Descartes, 2007.

[2] T.A. Bahill and F.F. Dean, Discovering system requirements, in: A.P. Sage and W.B. Rouse, eds., John Wiley & Sons, New York, 2009, pp. 205-226.

[3] L. Bardin, L'analyse de contenu, Presses Universitaires de France, Paris, 1998.

[4] J.M.C. Bastien, D.L. Scapin, La conception de logiciels interactifs centrée sur l'utilisateurs : étapes et méthodes, in: Ergonomie, P. Falzon, ed., Presses Universitaires de France, Paris, 2004, pp. 451-462.

[5] D. Beevis, Ergonomics – costs and benefits revisited, Applied Ergonomics 34 (2003), 491-496.

[6] J.-M. Burkhardt and J.-C. Sperandio, Ergonomie et conception informatique, in: Ergonomie, P. Falzon, ed., Presses Universitaires de France, Paris, 2004, pp. 437-450.

[7] C.M. Burns and K.J. Vicente, Judgments about the value and cost of human factors information in design, Information processing and management 32 (1996), 259-271.

[8] A. Chapanis, Human factors in systems engineering, Wiley interscience, New York, 1996.

[9] H. Cramér, Mathematical methods of statistics, Princeton University Press, Princeton, 1999.

[10] F. Daniellou and M. Naël, Ergonomie, Techniques de l'ingénieur 3 (1995), T3100.1-T3100.23.

[11] F. Daniellou, L'ergonomie dans la conduite de projets de conception de systèmes de travail, in: Ergonomie, P. Falzon, ed., Presses Universitaires de France, Paris, 2004, pp. 353-373.

[12] K. Ewusi-Mensah, Critical issues in abandoned information systems development projects. What is about IS development project that male them susceptible to cancellations?, Communications of the ACM 40 (1997), 74-80.

[13] T. Fevrier-Quesada, F. Darses and M. Lewkowicz, Une démarche centrée utilisateur pour la conception d'un portail coopératif d'aide à l'innovation, Ingénierie des systèmes d'information 8 (2003), 11-31.

[14] A. Garrigou, J.-F. Thibault, M. Jackson and F. Mascia, Contributions et démarche de l'ergonomie dans les processus de conception, Pistes 3 (2001).

[15] C. Haslegrave and K. Holmes, Integrating ergonomics and engineering in the technical design process, Applied ergonomics 25 (1994), 211-220.

[16] H.W. Hendrick, Determining the cost-benefits of ergonomics projects and factors that lead to their success, Applied Ergonomics 34 (2003), 419-427.

[17] ISO 13407, Processus de conception centrée sur l'opérateur humain pour les systèmes interactifs, International Standards Organisation, Genève, 1999.

[18] M. Jackson and P. Zave, Deriving specifications from requirements: an example, in: Proceedings of the 17th international conference on software engineering, ACM, New York, 1995, pp.15-24.

[19] F. Lamonde, L'intervention ergonomique, un regard sur la pratique professionnelle, Octarès, Toulouse, France, 2000.

[20] G. Lindgaard, R. Dillon, P. Trbovich, R. White, G. Fernandes, S. Lundahl and A. Pinnameneni, User needs analysis and requirements engineering: theory and practice, Interacting with computers 18 (2006), 47-70.

[21] M. Maguire, User-centred requirements handbook, RESPECT consortium, 1998.

[22] M. Maguire and N. Bevan, User requirements analysis: a review of supporting methods, in: Proceedings of IFIP 17th World Computer Congress, J. Hammond, T. Gross and J. Wesson, eds., Kluwer, Montreal, 2002, pp. 131-148.

[23] NUREG-0711 Rev. 2, Human Factors Engineering Program Review Model, U.S. Nuclear Regulatory Commission, Washington, 2004.

[24] S. Robertson, Requirement trawling; techniques for discovering requirements, International journal of human-computer studies 55 (2001), 405-421.

[25] A. Sutcliffe, User-centred requirement engineering, Springer Verlag, London, 2002.

[26] A. Tranvan, A. Landry, M. Christian, Place des orientations stratégiques dans la conception, in: Actes du 43ème congrès de la Société d'Ergonomie de Langue Française, ANACT, Paris, 2008.

[27] I.A. Wulff, R.H. Westgaard and B. Rasmussen, Ergonomic criteria in large-scale engineering design - II evaluating and applying requirements in the real world of design, Applied Ergonomics 30 (1999), 207-221.

[28] B. Yannou, Analyse fonctionnelle et analyse de la valeur, in: Conception de produits mécaniques, M Tollenaere, ed., Hermès Science, Paris, 1998, pp. 77-104.