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Liinasuo, Marja; Lastusilta, Toni; Savolainen, Jouni; Kuula, Timo

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Human Factors in Software Projects for Complex Industrial Processes

Marja Liinasuo(✉), Toni Lastusilta, Jouni Savolainen, and Timo Kuula

VTT Technical Research Centre of Finland Ltd, Vuorimiehentie 3, P.O. Box 1000, Espoo, Finland
{marja.liinasuo, toni.lastusilta, jouni.savolainen, timo.kuula}@vtt.fi

Abstract. Process industry has a need to increase product quality while also reducing operating costs and environmental footprint. However, a plant comprises of a complex set of dynamic processes, as well as human operators that control the processes. The best improvement is achieved by an extensive intervention of both aspects. In practice, human factor aspects have often a marginal role in carrying out a technical project. This has not been the case in the present, EU-funded project. The systematic inclusion of human factors perspective requires parallel and collaborative proceeding of technical development and human factors. The flexible approach is central as the human matters not only affects technical development but is also involved with the usage context of the new technical solution.

Keywords: Human factors · Process industry · Optimization

1 Introduction

Process industry has a need to increase operating efficiency while reducing environmental footprint and maintaining an adequate product quality. However, a plant comprises of a complex set of dynamic processes, as well as human operators that control the processes. The best improvement is achieved by an extensive intervention of both aspects. Typically, large processes are split into sub-processes, which are controlled separately. In some cases, there exists a higher level of automation monitoring the whole plant, but in others this is not the case. Especially, if the sub-processes are heavily connected, a plant-wide monitoring and control system is especially useful. Therefore, to start with, a technical plant-wide monitoring and control system is many times the best way to improve the performance of a plant. Hence, the result of this should be that the whole operation of the plant is optimized using the present processes as effectively as possible.

In an EU funded project COCOP (Coordinating Optimisation of Complex Industrial Processes) [1], the target is to develop a plant-wide optimization system for process industry. The new system is to be model-based and predictive. The core concept is to decompose a large optimization problem into smaller sub-process

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optimization problems and to coordinate these for a plant-wide optimized result. The optimization system will be piloted in two specific plants: a steel factory and copper smelter.

Such a system is a novelty and thus, in addition to the development of the optimization system, the human share of the work should be taken into account.

Technology-driven projects usually have their own proven methodology or procedures to follow, resulting in a good solution (if the development is performed by experts). Likewise, human centric (human factors) related research has its own methods, which enable the finding of relevant and qualitative data that is important in producing a system, which is meaningful and easy to use for its users. Furthermore, if possible, human factors is involved with other factors affecting the usage of the system, such as work processes, which may be affected with the new tool.

An issue is how to ensure collaboration between the technical and human factors experts in a technical development process. Such collaboration is needed in technical projects, which aim to consider also human related matters in the development of a technological solution. Such an aim is not trivial. It has been shown that, for instance, without human factors approach, a development project may become more costly, the solution may have low user-friendliness, and end users can have insufficient knowledge of safe usage and potential risks of the new tool [2].

In this paper, we will describe how human factors approach has been utilized in the essentially technical COCOP project, and we will discuss the possibilities of different types of software projects, combined with the characteristics of an efficient human factors approach.

2 Human Factors in COCOP Software Project

One of the human factor prerequisites for a technical project with an efficient share of human factors is fulfilled in this project. That prerequisite is that in the beginning of the project, the human factors experts have the task to understand the user perspective and the usage context of the new technological solution, i.e. in this case the new system. Human factors experts could then become acquainted with the main qualities of the work, important to take into account in project decisions, including the technical ones.

Firstly, the performed user interviews in the beginning of the project enabled the acquisition of information relevant for the identification of core matters in the future usage of the new system. Such a matter is, for instance, core qualities of work, as they may affect both the qualities of the new system as well as the context in which the new systems will be used. Among other things, it was found out that in one plant, the work of operators is mainly problem solving. This information can be used in the development process by concentrating on the identification of operator problems. Finding solutions for operators' problems may be relevant for the development of the optimization system. Furthermore, later in the project, this can be used in supporting user acceptance by emphasizing how the new system supports operator problem solving.

Secondly, an entity of its own is the characterization of the qualities that the users of the new system find important. Interviews related to this were also conducted in the beginning of the project. When including such qualities in the new system, the system

may even perform better, based on, for instance, tacit knowledge users have about their work. Additionally, when users can contribute to the development of the new system, it will be better accepted.

Furthermore, some important questions were answered already in the beginning of the project. For instance, the role of the future user is not self-evident. It was decided that the user will have the choice of accepting or rejecting the suggestion made by the optimization system. When the role is set, interviews allow the probing of the meaning of this role to the operator. We found that the sense of autonomy is important for operators in one plant. This is an important piece of information as the new system is to guide process control towards the "general good" (plant-wide optimization) instead of "local good" (sub-process optimization), which is presently the target to operators. If the system only suggests and does not make decisions on behalf of the factory operators, users controlling the process are key personnel in the success of the new system. If the system is not used, the sophistication of the solution has no effect on improving the production process.

Solid framework is needed to ensure all relevant factors are taken into account. So far, this is performed by dividing the human factors related matters into two main categories, the ones between the user and the new system, and the ones between users and the usage context. The matters to be done in collaboration with the technical experts belong to the first category, such as user interface qualities and functionalities preferred by users. The matters, which require discussion with the target company, belong to the latter one, such as anticipated changes in the proceeding of work, and the need for training related to plant-wide processes and the new system.

Presently, the development of the plant-wide optimization system is ongoing. During the development process of the new system, participatory design is planned to take place in order to ensure that the new system will be easy to use and will be visually and functionally embedded with the presently used system.

Later on, when the new system is almost finalized, it will be reasonable to test, or rather, validate the new system with users. This way the final system will be refined to suit in the usage of real life.

3 Flexibility in the Human Factors Approach

In order to succeed in collaboration with the different parties of the project and to talk the language of various stakeholders of the companies to which the new system will be implemented, human factors should not withdraw from discussions behind its own concepts and approaches.

In this project, this principle is followed. We have been using the concept of Key Performance Indicator (KPI). It is used, e.g., for marketing and for measuring business benefits, but in our project it has been used to measure the successfulness of the usage of the new system. To be precise, one KPIs is the frequency of the acceptance of the suggestions provided by the new optimization system.

Moreover, the important matters to be taken into account are expressed in the form of "human factors requirements". This is in accordance with the proceeding of technical development process. As the format of these requirements is the same as the one used by the technical experts, the human factors related requirements become more

commonly understood in the project. Especially the features in the user interface, important for usability, are good to express in the same format as other, more technical qualities. Hence, these requirements are taken into account in software development like any other requirement.

Still another factor, perhaps not planned but as a serendipity, is that in human factors meetings, also some representatives of a more technical approach participate. This ensures that aspects important for the technical development are taken into account in human factors' share of the project and, last but not least, the language used by human factors is to a large extent the one used in the technical meetings as well.

4 Discussion

The realization of human factors has been successful in the project, based on the good project plan and cooperative interdisciplinary project members.

Possibilities for improvement exist as well. The definition of requirements has been rather cumbersome and we do not yet know how well the human factors requirements can be taken into account in the technical development process. The part of human factors matters not used by technical project partners could have also been described, in a more simple way, without the format of requirements but rather by describing in the project meetings the plans, and in deliverables the results, with plain words.

Furthermore, the interaction between technical and human factors experts could be more frequent, regarding the way important matters are discussed about in the project. Presently, some information has been acquired through informal discussions, as part of the workrooms of technical experts are physically located near the ones of some human factors experts. This setting is quite vulnerable to changes in seating and personnel.

4.1 Development Process in a Traditional Software Project

Traditional software project management can be characterized by long-term and detailed project plans, detailed requirements specifications, and no design work before all the requirements, analysis, and design documents are completed [3]. Furthermore, they are based on cost- and risk-control, as well as, predictability [3]. The most famous of this type of development process is the waterfall model. In its fundamental form, it includes the steps of gathering requirements, designing, implementation, verification and maintenance. The first step is sometimes referred to as requirements engineering in which requirements are gathered, defined, documented and maintained. A requirement is, based on Brennan [4], as follows:

1. A condition or capability needed by a stakeholder to solve a problem or achieve an objective.
2. A condition or capability that must be met or possessed by a solution or solution component to satisfy a contract, standard, specification, or other formally imposed documents.
3. A documented representation of a condition or capability as in (1) or (2).

When gathering requirements, various approaches can be utilized, e.g. questionnaires, following people around/observation, models, use cases/scenarios/user stories, document analysis, reverse engineering and tools (e.g. user stories and requirements management) [5].

In the waterfall model, one proceeds to the next step only when the preceding step is completed, which makes the model quite rigid, and which has induced variations of the model. In fact, the waterfall model has been so widely criticized that altogether alternative approaches, for example agile software methods, are widely used, especially in the software engineering domain.

In a development process like this, human factors is easily left out or it may only have a marginal role, as there is no explicit role for human factors. The easiest way to proceed for human factors in this line is to focus on user interface related requirements, related to usability; matters beyond that are more difficult to realize through the requirements. Interestingly, the human factors share in COCOP project resembles traditional software project, as the aim has been to define all future tasks in the form of requirements.

4.2 Development Process in an Agile Software Project

The agile software development refers to a set of methods and practices, aiming at flexible and rapid development process with specific principles. Agile manifesto for software development has the following four key points:

1. Individuals and interactions over processes and tools;
2. Working software over comprehensive documentation;
3. Customer collaboration over contract negotiation;
4. Responding to change over following a plan [6].

Hence, the agile method is based on teamwork and bringing value to the customer.

Several tools can be used to achieve project goals and in the following, some commonly used are described [3]. Requirements are recorded in use cases and user stories are continuously improved. The product backlog is a list of items to be implemented. The release plan is a simple calendar schedule showing when each fixed-length iteration starts and ends. At a minimum, the release plan will have a number of iterations that implements features from the backlog and a release iteration at the end of the project.

Human factors has an easier entry to agile software project as in agile development process, the approach is open and frequent collaboration takes place. Especially the usage of other than requirements in guiding the development facilitates the inclusion of human factors approach. For instance, the usage of use cases or scenarios in frequent meetings provide a way to affect development in a form understandable to all stakeholders, irrespective of their educational or experiential background.

However, human factors approach is not as flexible as a pure agile software development process. The methodology used in human factors is often cumbersome. For instance, in order to acquire understanding about work and task qualities of the future users of the new system, interviews are often used to gain deeper insight. They take time to perform, then they need to be transcribed and analyzed, and eventually, the

results are to be concluded. Thus, quick turns in the development process are hard to take into account unless there are abundantly resources available for this work. On the other hand, the role of human factors in the context of new system development is to provide human or usage centric information to the project and such information is probably of such nature that it does not become obsolete during the development process, even if changes in the course of development would take place. Last but not least, human factors experts have a different overall perspective and may therefore more easily identify some issue or matter that needs to be tackled. This supports the choice of an agile development process over a traditional one.

5 Conclusions

In the development of a technical system, the flexible and effective inclusion of human factors perspective is challenging but possible. It requires a development process shared in the whole project group. Preferably, there is a technical representative taking part in human factors work to ensure smooth cooperation and collaboration. Human factors part should be defined clearly, so that all stakeholders understand the meaning and importance of it. Furthermore, time should be reserved for the technical team, end users and other relevant stakeholders to perform work initiated by human factors.

The scope of human factors is rather large, as it aims not only in affecting technical solution but also in the understanding of user and usage context. Agile methods, contrasting to traditional development methods, seem promising as they appear to provide methodology common to the whole development process and entry points to human factors approach. Especially flexibility in the proceeding of the project and resources for human factors in several points through the project seem important aspects for human factors, coinciding the principles of agile development.

The project is ongoing and the present ideas are not yet fully tested. Furthermore, the way to express human factors input to the technical development process is here left open; possibly, a combination of several types of means are needed. Future work shows how well these points truly serve the inclusion of human factors approach to the development process as a whole. Furthermore, it will suggest ways to transfer the human factors knowledge in the best possible ways to the technical development group.

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