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Reengineering the Systems Development Process for User-Centred Design

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Abstract: Human-centred design has recently received growing awareness within several organisations. However, the successful deployment of a human-centred design approach is very complicated. It requires a shift of focus in the entire development process, by all participants in the process, away from a general focus on technology to a focus on usability. A very important tool for communicating the shift of general attitudes in a developing organisation is the system development model. This paper describes a general modelling approach especially useful for organisations to analyse their current development process and converting to a user-centred process. The procedures for reengineering system development work is particularly useful as it helps organisation to specify their user-centred design model at the same time as it teaches their developers user-centred design. This approach has been successfully applied at the Swedish National Tax Board, and the result of this case is described herein.

Keywords: Usability, user-centred design, iterative design, prototyping, system development process.

1 Introduction

The major goal for every professional involved in user interface development should be to develop systems that are *usable*. Usability has been defined in ISO 9241-Part 11 as the *extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use* [International Organisation for Standardisation, 1998]. To be able to reach these goals user-centred methods are preferable, whereas there is no guarantee for usable systems with a user-centred method.

Today, very few would question the relationship between usability and user-centred design (UCD). To be able to design a usable interface to a system, active user influence is essential. UCD must be won every day, and the discussion and development of processes, methods and tools for this are continuously needed in every organisation.

1.1 Designing for usability

According to Gould and Lewis user interface developers often tend to believe that good interface design is a question of getting it right the first time [Gould & Lewis, 1985]. Rather, to be able to design usable systems, continuous iterations are needed to be able to evaluate the usability with real users.

Gould et al. [1997] defined four basic principles for developing usable software based on observations from projects within their company, IBM:

- Early, and continual, focus on users: designers must understand who the users will be by directly studying their cognitive, behavioural, anthropometrical and attitudinal characteristics, in part by studying the nature of the work expected to be accomplished, and in part by making users part of the design team.
- Empirical measurement: intended users should actually use simulations and prototypes to carry out real work, and their performance and reactions should be observed, recorded and analysed.
- Iterative design: a cycle of design, test and measure, re-design, repeated as often as necessary.
- Integrated design: wherein all aspects of usability evolve together.

A user-centred approach to system development and design should in all situations be preferred. The main reasons for this are two:

- End users are experts on their work and therefore the only ones that can describe it.
- End users are the ones that are most suitable for testing and evaluating prototypes and systems that are developed for them.

But, on the other hand, user participation in a development project is never, in itself, a guarantee for a usable system. Abundant evidence of this is furnished by the large number of computer systems with severe usability problems that exist in working life today and the vast number of projects that have failed before becoming a working system.

1.2 ISO 13407 Human-centred Design

A successful user-centred development process should be based on a fairly well defined, and controlled, iterative system development model. This is one of the key principles behind fully integrating a user-centred approach into an existing development framework. One possible way of doing user-centred design is to use the international standard ISO 13407 “Human-centred design process for interactive systems” [International Organisation for Standardisation, 1999]. ISO 13407 is an approach to human-centred software- and hardware development that identifies four basic principles:

- active involvement of users and a clear understanding of user and task requirements,
- an appropriate allocation of functions between users and technology,
- the iteration of design solutions, and
- multidisciplinary design.

Human-centred design according to ISO 13407 involves: 1) Understanding and specifying the context of use, 2) Specifying user and organisational requirements, 3) Producing design solutions, and 4) Evaluating designs against requirements, to determine how to further pursue the development (c.f. figure 1).

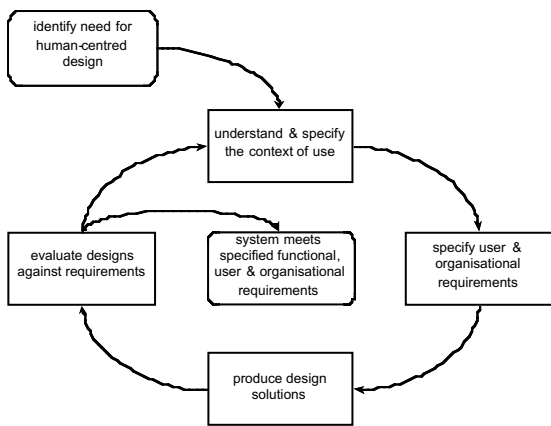


Figure 1: The ISO 13407 principle for a “Human-centred design process for interactive systems”.

However, our experiences from several different development domains shows us that even such a simple model is easy to misinterpret and to misuse. It is inevitably so that user-centred design is a

difficult approach to take in and make your property in a way that makes continuous iterations a natural and obvious approach in all your work. For this reason we have focused our research on overcoming the obstacles of learning developing organisations to improve their user-centred design approach.

2 Reengineering the systems development process for UCD

Reengineering system development work is a technique for understanding the current system development model within an organisation and to introduce new procedures and practices in the development work. Most organisations have a commonly agreed upon system development model, but it is very seldom that this model gives a correct image of the ways in which system development work is performed. The system development model can be a good way of introducing somebody to the general principles controlling the development work, but to be able to really understand the methodology that the organisation actually deploys one need to see it from within. This is true both if the system development model is unique and specific to the organisation and if the organisation is using a well-known commercial development model such as the Rational Unified Process (RUP) [Kruchten, 1998] or Dynamic Systems Development Method (DSDM) [Stapleton, 1995]. To be useful for a particular organisation, such a commercial development model must be customised to the organisation’s specific needs. Therefore, the model is in itself not a good description of the way the organisation and its individuals performs development. Nor can the participants in the development work describe how they actually work. These procedures have become tacit.

The reengineering approach described in this paper has a structure that is very dependent upon the development tradition in which it is applied. It uses the organisations current development process to model system development work. It should normally be performed in modelling sessions with representatives of the different actors in the organisation’s system development projects. Participants could for example be the users of the system development process, e.g. end-user representatives, system developers, software engineers, Graphical User Interface (GUI) designers, project managers, staff responsible for the maintenance of the organisation’s methodological framework, and, above all researchers or experts in user-centred design. Having the actual users of the system development model specify the very model themselves is an efficient way of teaching the new practices, which receive confidence within the organisation. The following activities should be per-

formed, focusing on usability and user-centred design:

1. Analyse and describe the current development process with its advantages and shortcomings.
2. Specify the roles in the organisation and their specific competence, skills and experiences (especially when it comes to experts in GUI design or usability).
3. Define an organisation specific definition of a user-centred design process.
4. Specify the key issues that the organisation needs to focus the development work on in the future.
5. Identify additional or complementary methodological steps to facilitate user-centred design.
6. Identify which of the current methodological processes that does not meet its expectations in contributing to the solution. This is an essential step. Usually, adding more methodological steps to complex development processes often fails in meeting its expectations.
7. When applying the new “process”, be open to the need for more ad hoc solutions as the development goes on.

Note that a development model is not a static document but a dynamic description that typically is modified for every project that is performed.

2.1 Relation to commercial system development methodologies

Note that e.g. RUP always needs to be customised to fit each project. The approach we suggest does not contradict that, rather the approach helps in the process of customising RUP to user-centred design.

3 CASE: User-Centred Design at the Swedish National Tax Board

This part of the paper explains our experiences when defining and applying the approach of reengineering the systems development process for user-centred design at the Swedish National Tax Board. This is an organisation with approximately 13.000 end-users, 400 simultaneously running applications developed using most of the publicly available technologies. Its systems development is performed by an in-house development organisation.

Successful deployment of user-centred design requires management support for the approach. Luckily we had a mandate from the general manager of the organisation to pursue with the introduction of a user-centred design approach in the organisation. User-centred design had been written into the overall goals of IT development in the organisation.

3.1 Defining user-centred design

Producing an own definition of user-centred design increased the awareness and made the organisations requirements on the development process more concrete. The definition was based on general definitions [e.g. Gould et al., 1997; ISO 13407] including aspects specific for the domain in question.

User-centred design at the Swedish National Tax Board means applying the following principles:

- *Work controlled development.* Early focus on users and tasks. The designer must understand the users, their cognitive behaviour, attitudes and the characteristics of the work. Appropriate allocation of function between the user and the system is also important to prevent unnecessary control and pre-emption.
- *Active user participation* throughout the project, in analysis, design, development and evaluation. This requires a careful user selection process emphasising the skills of typical users, both:
 - Work domain experts (continuously through the development project)
 - Actual end-users (for evaluation of various design results)
- *Early prototyping* to evaluate and develop design solutions.
- *Continuous iteration* of design solutions. A cyclic process of design, evaluation and redesign should be repeated as often as possible. The evaluation process should mean empirical measurement in which experiments are performed with prototypes with which real users perform real tasks with the purpose of observing, monitoring and analysing the users' reactions and attitudes.
- *Multidisciplinary design teams.* Include a usability designer in the process.
- *Integrated design.* Continuous developments of the system, the work activity, on-line help, education, organisation, etc. in the development work.

It was especially important for the organisation to manifest the role of the users. The organisation had strong experiences in user participation but felt a strong need to focus more upon the role of the user.

3.2 Shortcomings and possible improvements of the current development process

The modelling sessions identified the following five major obstacles towards successful user-centred design in the organisation:

1. Problems understanding iterative design

Through several years of co-operation with the Swedish National Tax Board we have observed the

difficulties for the developers to really understand the concept of iterative design (c.f. figure 2).

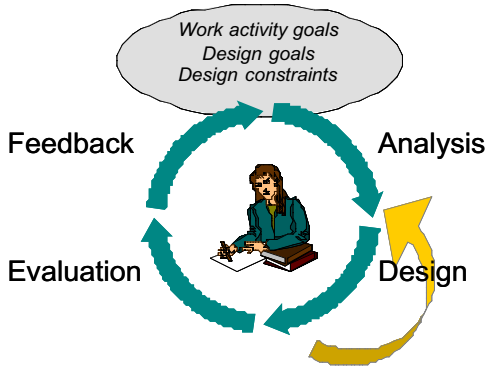


Figure 2: The cyclic process of analysis, design, evaluation and feedback that is so central to user-centred design.

Developers regarded iterative design to be merely the making of a phone call to a user that they knew, to get some specific information. It was necessary to identify some minimum requirements for iterative design. Therefore, each iteration must contain:

- a proper analysis of the user’s requirements and the context of use,
- a prototype design phase, and
- a documented evaluation of the usability of the prototype that must result in suggestions for modifications in the following prototype design.

2. Guidelines for “using” users

The Swedish National Tax Board has an impressive tradition of involving users in their development work. But which users they involve, where, when and how in the process was decided without any defined regulations. Several problems of this nature have been observed. For example, extensively user involvement in inappropriate phases could result in less effect in the phases where the development would benefit the most of their active participation. The user representatives faced the risk of becoming alienated from their ordinary work. With their increasing experience in user participation they more or less became professional project workers. The solution to this problem was to define process guidelines to be used by the project manager when planning the user participation, in the project. The guidelines are important to:

- specify where, when and how the users should participate in the development process,
- stress the importance of approaching the user’s in their own work environment,
- use a familiar concept terminology for the users,

- identify appropriate phases for participation and describe their characteristics, e.g. for analysis, design, evaluation, and construction.

It contained guidelines on user feedback, i.e.

- Collect and document all the user comments.
- Address all user comments and make decisions:
 - to change in accordance with the comment.
 - not to make the change (especially in this case it is important to inform the users of the outcome of the decision and the reason for the decision).
- Report the decision back to the users.

Finally the organisation needed guidelines on user selection, e.g. based on:

- Randomised sample or stratified sample (e.g. by maximising user differences).
- Users that are flexible and prone to change, with a high degree of social competence.
- Representativeness, i.e. whether they represent a particular group of users.
- Participation needs to be voluntary. Channels for anonymous user feedback must be provided.
- Users should be in majority in the project, or at least not solo.

It is important to distinguish between users and domain experts (not really users any more but experts at the work task at hand, e.g. staff representing the jurisdiction behind a work task). Users participating in a project lose their sense of acting as representatives already after a couple of weeks full time development project work.

3. Earlier prototyping

The user interface design process was extensively in need of modification. Issues relating to usability or to the design of the user interface were typically brought up very late in the development project. Proportionally the user interface received far too little attention in relation to its proportion of the program code. Several previously made decisions had limited the design space, having severe effects on the potential for creating usable interfaces.

The suggestion was to focus more on work with prototypes (low-level mock-ups) very early in the project. The early prototypes should be possible to use to capture basic usability requirements.

Based on the organisation’s tradition of user participation, the prototyping process was suggested to be a collaborative process, in which the user interface designers could work intimately with the potential users of the system. Such a collaborative prototyping session could typically consist of:

- Specification of a few typical usage scenarios, representing the most frequent operations performed.
- User interface design in parallel design teams using low-level mock-up tools.
- Bringing the different teams together to refine the design suggestions.

Note that these collaborative prototyping sessions does not need to be especially time consuming; rather several iterations of the above could be made in half a day.

Finally the issue of contextual prototyping was brought up. Based on the observation that several of the developers never had actually seen the work setting, (nor did they show any interest in visiting it), we suggested to move and distribute the development team members in the user organisation for the developers to be able to meet the users directly. Through this several misconceptions could be solved undramatically and informally. Distributing the development team should not have any significant negative effects due to their relatively big maturity when it comes to communicating and co-operating on a distance.

4. The role of the usability designer

The term design, with the purpose of describing the development of the user interface is often misinterpreted for design as the label for the entire development process, which inevitably makes all system developers user interface designers. This is neither good nor correct since only a small part of all the decisions that are made during the development are directly related to the design of the user interface. Design of the user interface requires special knowledge and competence, not just common sense. We strongly argue that experts in the field should perform the design of the user interface. The professions that could be shouldering the role of caring for the usability and designing the user interface we call the *usability designer (U-designer)* (c.f. Figure 3).

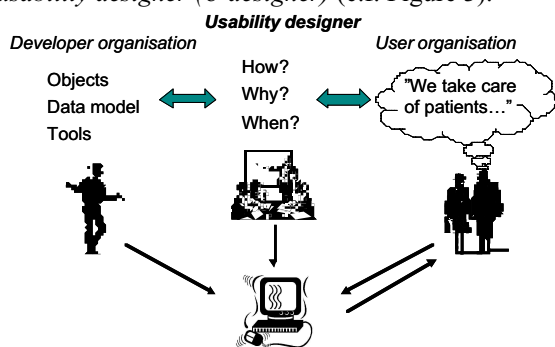


Figure 3: The usability designer to support the user-centered design.

The U-designer is in charge of and handles the usability-related activities. The U-designer needs knowledge and competence within several different areas such as psychology, behavioural sciences, layout, typography, system science, computer science, and development tools. All of these areas are important parts of human-computer interaction (HCI). HCI can in a structured and scientific way try to provide methods and tools for being able to develop usable systems. The U-designer must have basic knowledge on methodology and deeper knowledge and understanding of HCI. The role becomes kind of a link between the users of a system and the system developers.

5. Integrated design

The problems achieving a well functioning user-centered development methodology are due to facts outside of the actual system development project. It has been known for several decades [Leavitt, 1958] that changing the information technology support cannot be made without an effect on the organisation, the work activity, the human being and his/her competence. In fact, they all influence one another so that an attempt to change either of them inevitably will result in needs to change the others. It is important to be aware of these changes in advance, to be able to meet them with appropriate actions.

If the information technology development could be regarded as a motor in this development process we believe that a lot could be gained. Working with all four areas simultaneously is a formidable task, which few systems development projects have had the ability, time and knowledge to carry out successfully. We believe, however, that user-centred design, together with, for instance, management commitment, user commitment and objectives, and well-defined goals, are all important contributors to the success of such an undertaking.

3.3 Modelling user-centred process activities

Modelling the specific activities of the user-centred system development process, and especially focusing upon the user interface design process, can be used to efficiently justify a user-centred development process within the development organisation. We decided to model the development process using the current techniques that were well known for the participants at the Swedish National Tax Board. We modelled the current development processes and based on the results of this we established the future processes in close co-operation with the user representatives. The following people participated in these modelling sessions; two representatives of skilled domain experts (professional user representatives), one skilled development project manager from the organi-

sation, one senior modelling leader from the organisation, one usability analyst from the organisation and two usability designers who were also academic researchers. The work was performed in eight full-day meetings with a considerable amount of reporting and documentation work in relation to and after these modelling sessions. The development methods used were the organisations' own methods that were adapted to the specific conditions of this specific work item. This work was complemented with observation-interviews of the user interface developers within the organisation.

The current status of the development process proved to be a very waterfall-like development method with clearly defined steps in the development specifying the object model (data model), business processes and after this was done engineering the user interface (rather than designing it). The future model (see Figure 4) only describes the user interface design process although we observed the need to focus more on the steps taking place before this process, such as the development of the new work situations and the new business processes.

3.4 Problems in current development processes

The very common technique of *use cases* and *use case modelling* [Jacobsson I., Booch G., Rumbaugh J., 1999] can from the outside be regarded as the ultimate solution to be able to have a high degree of user participation and develop usable systems. However, this has proven not to be the case. We have found several problems in the use of use cases as a technique or description (and as a methodology

— use case modelling) in conjunction with a user-centred approach. The problem areas can briefly be divided into the following:

- *Modelling seminars:* the modelling seminars as forum for gathering information in a well-structured and formal way have big drawbacks. Users feel uncomfortable away from their work context and have to learn and communicate through an abstract modelling language and notation.
- *User participation and selection of users:* representative users are often not participants in the seminars. Instead the participants tend to be selected experts of the target domain, who already have a lot of presumptions of the forth-coming system.
- *User-centred activities (methods):* use case modelling seminars are used as the only source for understanding the users and their work tasks. Other more user-centred activities such as user analysis and task analysis are seldom performed.
- *Iterations: analysis, design, redesign, evaluation:* once you have decided on a use case model, it is too complex and complicated to change. The description of the model becomes a burden itself. Normally the possibilities of iterating the use case models are limited.
- *A shift of focus:* the focus for the use case seminars and the models are often the notation in itself. Once you start to describe the tasks in the domain with a formal notation, you shift focus from investigation to drawing.

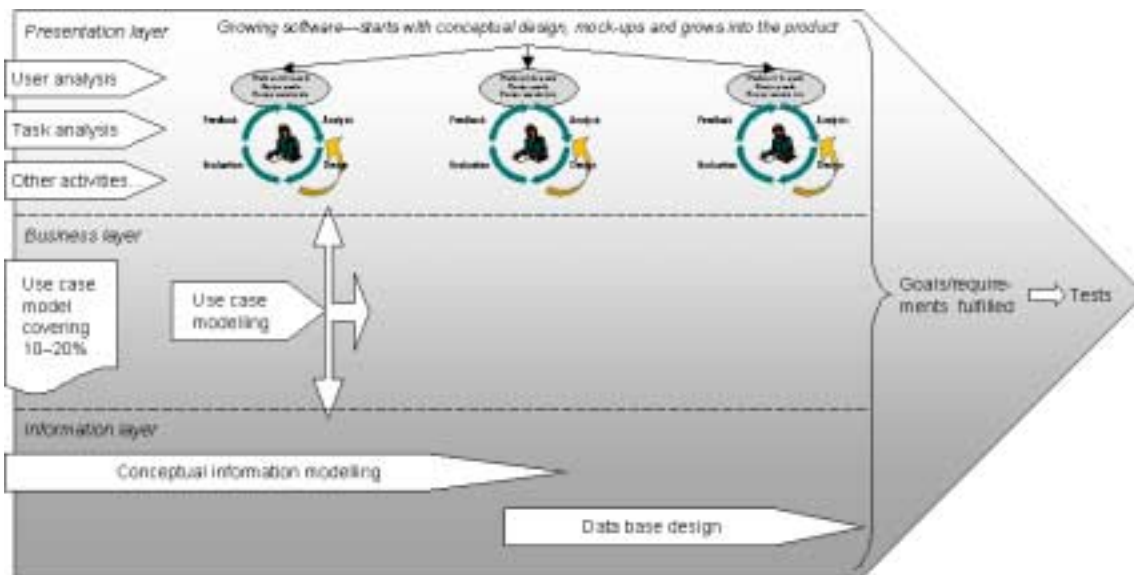


Figure 4: The results of the modelling of the user-centred design processes for user interface design as they turned out in our case at the Swedish National Tax Board.

- *Project roles*: real end-users are not recognised as the valuable source of information that they are.

Based on these drawbacks we can conclude that there is a need to define additional methods or techniques to complement the use case modelling process. Such methods can include, but is not limited to, users/task analysis, scenario specification, techniques for prototyping or parallel design. When the organisation has defined their view on user-centred design and specified their adapted framework for user-centred design there is a good reason to, however controversial, question the necessity to perform use case modelling at all.

3.5 System development and business processes

Traditional system development methodologies make a clear distinction between the development of the business processes (in RUP this is the business modelling) and the system development process (c.f. Figure 5).

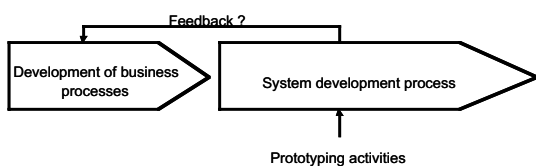


Figure 5: Relation between the system development and the development of business processes in real life.

To be able to start system development work you need a clear expression of the business goals and a description of the business processes. Usually usability related activities are first introduced in the system development project. And, even then, the system development project may run for quite some time before issues relating to the user interface are regarded.

In the system development process the business processes are mainly regarded as frozen specifications that may not be modified. Even if the organisation has a high usability maturity level and accepts the notion of *iterative* design, it is very common that the business processes needs to be modified as the development work gets into aspects that are more concrete for the users, such as prototypes. It is therefore very important to have an open door towards modifying the business processes because of factors occurring during early prototyping phases (c.f. Figure 5). The development project must clearly recognise the business processes as dynamic in this phase.

Otherwise one could start from the prototyping level, even before you have your requirements, and use creativity methods to brainstorm the user interface design on a very low level (c.f. Figure 6).

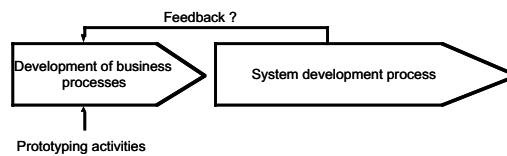


Figure 6: Prototyping during the business process development to earlier elicit requirements understandable for the user.

In this way you should have the possibility of enhancing the skills present at the development site. Still, this approach does not mean that you can live with frozen business processes at some stage.

At this point it is tempting to use prototyping as a main framework for the growth of the software product. We have the possibility of building on our early prototypes and adding functionality to the usability prototype. According to this approach there is no clear distinction between the development of the business processes and the system development process (c.f. Figure 7).

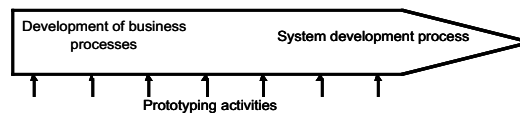


Figure 7: Early and continuous prototyping makes the software “grow”.

With this approach we anticipate the following advantages:

- Noticing severe misunderstandings in the business processes much earlier.
- Facilitating user participation already from the initial business processing by tools and terminology that is concrete and familiar to the users.
- Facilitating true iterative design as it is not based on frozen specifications.
- Producing results that are easy to evaluate early.
- Possibly speed up the development process.
- Prevent project breakdown.

4 Summary and conclusions

Shortly after we had finished modelling the future development process at the Swedish National Tax Board, the organisation decided to purchase the Rational Unified Process (RUP) as their new development framework. At that point several of our co-operation partners suspected that the work we had performed would have been wasted. The faith in commercial development packages is initially almost infinite. However, RUP quite quickly proved not to meet the expectations when it came to solving all the problems with the current development model. The shortcomings when it comes to the lacking

usability focus and lack of support for use centred design became obvious almost immediately. Therefore the organisation specific model for user-centred design that we had developed proved to provide substantial input for what needed to be customised or modified with RUP.

Reengineering the systems development process for user-centred design for a software development organisation does provide the requirements needed to be able to customise the development method for a more user-centred design approach. The approach also helps highlighting in what way the commercial development models fails in addressing usability issues and aspects relating to user-centred design. It also provided the development organisation with a tool to help them understand in what way user-centred design should be designed and what their current development models lacked.

This reengineering approach differs quite a lot from the methods provided by RUP for customising the development processes for the organisation at hand in that it is based on the organisations own procedures that are very familiar to them.

Finally, using this approach could potentially help the organisation to solve two very common problems that large in-house development organisations face, and that are not that often highlighted:

- **Adapting projects to the old environments.** System development strategies suffer from the fact that it is not possible to modify the entire computer system at the same time. Very often poor design solutions are blamed on the need to adapt to the current system and its limitations. By modelling the development process from a user-centred perspective and taking the entire business process and system development work into account, factors influencing the definition of development projects can be highlighted. Through this one can decide initially how to attack this problem.
- **Off-the-shelf products.** When adopting a user-centred approach it is very difficult to efficiently be able to customise commercial off-the-shelf products to the work processes that it is supposed to support. The tendency rather becomes that the work is adapted to the product, which very often results in usability problems when interacting with the product. Rather, a user-centred modelling approach could help setting the requirements on these products.

By applying this approach to other types of organisations, something that is planned for in the near future, we will be able to achieve the following:

- **Education.** We need to specify the education program on user-centred design for the partici-

pants in the modelling sessions. Here, it is important that a lot of this material is introduced as it is found appropriate during the modelling sessions. Every organisation is unique in its needs and in what processes they can learn to manage.

- **Documentation.** We need to define a framework for the documentation of the findings when using the approach.

5 Acknowledgements

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