

# DESIGNING FOR USABILITY: HUMAN FACTORS IN A LARGE SOFTWARE DEVELOPMENT ORGANIZATION

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In his insightful book on how to design for usability, *The Psychology of Everyday Things*, Norman [4] makes the following observation about the computer/software industry:

## ABSTRACT

Bellcore has recently initiated a concerted program to introduce user-centered design practices into its software development cycle. We have found that the challenges include organizational, management, and technical issues. In this paper, we describe some of our experience and conclusions to date that might generalize to other organizations of a similar size. Three key ingredients for the success we have achieved to date are: top management's recognition that usability is a quality issue, company-wide coordination of human factors resources, and the opportunity to demonstrate the value of user-centered design in the context of some key projects.

## INTRODUCTION

We have recently observed a growing commitment to the concept of user-centered design within the software industry. User-centered design [4,5] is a philosophy that bases the design of systems on the needs and characteristics of the intended users, with an emphasis on producing products that are both useful and usable. While few would argue against the need for useful and usable software systems, in reality, designing for usability has not been the historical focus of system design within our particular business, operations support systems<sup>1</sup> for the telecommunications industry, nor within the software industry at large. We have recently begun to devote substantial attention to changing our software development process to better promote the design of systems for usability. In this paper we explore some of the organizational and management issues affecting the incorporation of user-centered design into one particular (but fairly typical) large software development organization.

## HUMAN FACTORS AND SOFTWARE SYSTEMS

<sup>1</sup> Operations systems are used by operating company employees for a variety of tasks, including facilities planning, equipment testing and maintenance, and inventory control. The systems produced by Bellcore range from small to very large, and run on a variety of mainframe, minicomputer, and microcomputer platforms.

"Now turn to the computer, an area where all the major difficulties of design can be found in profusion. In this realm the user is seldom considered. There is nothing particularly special about the computer; it is a machine, a human artifact, just like the other sorts of things we have looked at, and it poses few problems that we haven't encountered already. But designers of computer systems seem particularly oblivious to the needs of users, particularly susceptible to all the pitfalls of design. The professional design community is seldom called in to help with computer products. Instead design is left in the hands of engineers and programmers, people who usually have no experience, no expertise, in designing for people."<sup>2</sup>

And, quoting a representative of the telecommunications business, he observes:

"People, generally engineers or managers, tend to feel that they are humans, therefore they can design something for other human beings just as well as a trained expert. It's really interesting to watch engineers and computer scientists go about designing a product. They argue and argue about how to do things, generally with a sincere desire to do the right thing for the user. But when it comes to assessing the tradeoffs between the user interface and internal resources in a product, they almost always tend to simplify their own lives. They will have to do the work; they try to make the internal machine architecture as simple as possible. Internal design elegance sometimes maps to user interface elegance, but not always. Design teams really need vocal advocates for the people who will ultimately use the interface."<sup>3</sup>

Historically there has been some human factors involvement in the design of our software systems, but we have not routinely had, as part of our design/development teams, vocal advocates for the people who will ultimately use the systems we develop. Nor have we had a process in place to systematically ensure an end-to-end user-centered design process. Part of the reason for this has to do with the nature of the systems we developed to automate (or at least mechanize) telecommunications operations support activities.

<sup>2</sup> Norman [4], p. 177.

<sup>3</sup> Mike King, as quoted in Norman [4], p. 156.

Our early software systems, begun in the 1960s, were developed to automate back office functions -- putting records on-line for functions such as billing and inventory management. Users, generally clerical workers, keyed in data from paper forms for batch processing. Human factors efforts centered on the ergonomics of the work position; the computer system itself provided little support for the users in doing their task. User assistance was provided through documentation and training - again often the province of human factors personnel. Later systems, begun in the 1970s, focused on front office functions, providing on-line data entry and data access for employees who handled certain customer contacts, such as service ordering, directory assistance, and trouble reports. In these systems, some effort went into designing screen layouts, but again most human factors efforts went into developing the documentation and training for the users.

Today the products we are developing are much more complex. Many of them support employees and customers performing complex cognitive tasks such as network design, engineering, and management. User expectations about the usefulness and usability of computing systems have changed in this decade, driven both by their experience with software available on personal computers, and the general trend to consumerism [2]. As a company, we believe that, in order for our products to be successful in the increasing competitive telecommunications marketplace, our products must meet these elevated expectations. We also believe that this can be accomplished only by adopting the user-centered design model.<sup>4</sup>

#### HOW TO MAKE IT HAPPEN: ORGANIZATIONAL ISSUES

Adopting the user-centered design model means changing the way we do business, but that change must begin within the context of our ongoing development process and organizational structure.

##### Centralized vs. decentralized human factors

Human factors activities at Bellcore are currently completely decentralized - small groups, or even individuals, working within project organizations. In a recent paper Riley and Schwartz [6] described the history of human factors work at Bell Laboratories (through 1983) and Bellcore (following the AT&T divestiture in 1984). The current decentralized structure evolved (or perhaps devolved) from earlier centralized organizations supporting customer-related and employee-related products. Riley and Schwartz addressed the question of whether the increasing decentralization of human factors activities at Bellcore was leading to the strengthening of human factors work or to its eventual extinction.

<sup>4</sup> It is interesting to note that while user-centered design of software systems is in general a recent trend, the insight is hardly new. Nearly two decades ago James Martin [3] wrote:

"During its first two decades, the data processing industry ... has paid little attention to effective [hu]man-machine dialogue ... Where they have been used at all, terminals and their languages have often been an adjunct to the computer and its languages. Systems have been designed from the inside, out.

Increasingly in the next decade, the [hu]man must become the prime focus of system design ... To be effective, systems will have to be designed from the outside, in. The terminal or console operator, instead of being a peripheral consideration, will become the tail that wags the whole dog."

The advantages of a decentralized structure are considerable, and come from the effectiveness of the human factors efforts when fully integrated into project teams. Human factors people are not brought in as consultants too late in the design/development process to make a difference, as was often the case when they resided in centralized organizations. Riley and Schwartz asserted that the breadth and effectiveness of individual contributions of human factors professionals, as well as their personal sense of value and accomplishment, could often be attributed to a decentralized organizational structure. In this structure human factors people often do work in addition to human factors, which can enhance their opportunities for career development in a company dominated by computer science and engineering disciplines. A frequent career path that we have observed is for human factor specialists to move into systems engineering roles on their projects, or, less frequently, development positions. Historically, the opportunities for promotion have been enhanced by such moves.

Riley and Schwartz also observed significant disadvantages to the decentralized organizational structure, however, especially as related to sustaining human factors as a discipline within the company. With individuals dispersed throughout project organizations there is very little opportunity for broad, longer-range work that spans multiple projects. Recruiting and retaining new human factors people is difficult. There are few mentors and role models for new people when they are not in human factors organizations. There is little or no opportunity for career development within human factors as a discipline. With the pressures to meet product delivery schedules and other demands of project organizations, there is very little human factors *culture* - something that was quite strong before the dispersion of human factors people into project organizations. Sharing ideas and experiences is difficult; synergy is lost.

The dilemma, Riley and Schwartz concluded, is that decentralized human factors is needed for the work to be most effective, but centralized organizations are needed to sustain the professional discipline. There is no simple answer to the question of how to organize human factors efforts in an organization such as Bellcore. The management of human factors activities requires constant attention to organizational factors in order to maintain a dynamic balance between the day-to-day effectiveness of individuals and the long-term maintenance of the discipline.

##### Software development at Bellcore - status and challenges

The software development organization at Bellcore consists of about 2500 people (with hundreds more in associated organizations responsible for generating system requirements). There are more than 40 large development projects and many smaller ones. Projects come in all shapes, sizes, and stages of maturity. There are small numbers of human factors people scattered throughout this organization. Human factors activities historically have been mostly screen design and documentation and training development. Activities central to the concept of user-centered design, especially interface prototyping and early usability testing, have not been done on a routine basis.

Recently, based on a realization of the value of user-centered design and its close association with product quality, Bellcore's top management made a commitment to the goal

of following a user-centered approach in the design and development of all products and services.

Our challenge was twofold: first, we needed to broaden the concept of human factors work beyond screen design, documentation, and training, to one of designing for usability. Second, we needed to start the user-centered design process in a context where the necessary organizational structures and staff did not exist. The earlier analysis by Riley and Schwartz pointed out these needs, but did not address a plan for meeting them. The next sections of this paper are a report on some of the steps we have taken in the past year to get the process in motion, and some of our plans for the future for ensuring its success.

### SUMMONING THE RESOURCES

The first issue in a fully decentralized human factors environment is the question of who is responsible for making sure that human factors work is done. In the best case, commitment to a user-centered design process would simply be part of the organization's value system, and no special effort would be necessary to sustain it. Where centralized human factors organizations exist, the managers of those organizations are the natural champions for human factors work, and have an organizational imperative to sustain the work. In our decentralized structure, no one was uniformly carrying out this responsibility.

Riley and Schwartz were concerned that Bellcore had lost its human factors community. Earlier attempts to reform this community, such as grass roots efforts to create an inter-organizational human factors committee, failed. Now we have a bigger task. Not only do we wish to create a sense of community and sharing of ideas, but we are also trying to increase significantly the scope of the human factors efforts and change the way we do business. Why do we think we will be any more successful this time around? The major difference, and, we believe, key to changing the organization, is top management support and attention, with accountability and regular reporting of plans and progress.

### Human factors coordination

One year ago, at the direction of top management, a company-wide *Human Factors Coordinating Committee* was formed. Members of this committee, who represent each of the five technical areas of Bellcore, are technical managers with backgrounds in human factors. The committee was instructed to propose and initiate activities to improve communication among human factors people, establish a professional community within the company, provide a general resource and referral mechanism for human factors expertise, ensure that state-of-the-art methods are being applied, and assess the needs for shared laboratory and other facilities.

The current organizational structure was taken as a given, the intention being to establish mechanisms that will allow us to have the benefits of project-oriented (decentralized) human factors, while minimizing the disadvantages described earlier.

### A user-centered design champion

In addition, the committee has a higher-level management sponsor, whose job is to champion the cause of revitalizing human factors, and communicating between the committee

and the top management of the corporation. In our case, it has been important that the champion be at a high enough level of the company to have easy access to the top officers, and yet be available and willing to work with the coordinating committee on a regular basis. It is also important that the champion was *already* a believer in the value of human factors (in the broad sense of the term) and had a considerable track record of managing such work.

### IMPLEMENTING A USER-CENTERED DESIGN PROCESS

User-centered design requires substantial attention to user needs and task analysis prior to requirements definition. It requires testing of product functionality and usability with real users - early and often. To design effective user interfaces, prototyping and iterative design methods are most effective. Usability objectives and usability test plans must be developed and documented (see Whiteside, et. al.[7]). In most cases, usability testing should begin in the early phases of a project using prototypes in both laboratory and field settings. Product testing for usability must continue throughout the product development lifecycle. Without question, this kind of effort takes resources - staff, time, testing facilities, etc. Adopting these methods requires the cooperation and commitment of the manager who controls project resources, and that is also the person responsible for the delivery of the product - on time and within budget. Thus, ultimately, if we wish to change the way we do business, we must educate the middle managers that user-centered design methods will enable them to deliver better products and will not have a negative effect on budget and schedule.

### To change practice, start with the top and the bottom of the management ladder

Our committee's strategy is to initiate change in practice and change in middle manager attitudes by working from both ends toward the middle. That is, we are working to generate enthusiasm among the small cadre of existing working-level human factors people, and we are simultaneously working to educate top management, and elicit from them a mandate for change. To date we have had success on both counts, and the committee's champion has taken strong ownership of this issue and continues to keep it visible at high levels.

One valuable tool in this education process has been the use of testimonials from managers who are involved with the production of software similar to ours. Fred Chang of Pacific Bell, for example states that,

"It has been our experience that if you start early in the software development cycle, usability tests can actually save on software development costs. If conducted properly, the results from the tests will accurately reflect what would have happened had you released the software without the testing. Detecting and fixing the problems early and often prior to final release is certainly better and more cost effective than waiting for the end users to find the problems and then complain about them." [1]

### Identify a few target projects as demonstrations

In order to cope with the need to begin with a small pool of resources, we have decided to identify a few key projects on which to focus attention and implement the user-centered

design methods. We judge that focusing on a few projects is likely to have more impact than spreading resources across a larger number, thus diluting the effect. Again we have tried to exploit the current top management commitment by having them identify the projects to be targeted and tracked.

Management's agreement to follow the new process on a project presupposes commitment of dedicated staff, time, and facilities. The key activities tracked early in the project that reflect that commitment are to identify and (if necessary) train staff, to identify and prepare testing facilities, to document usability objectives and test plans, and to establish key milestones in the project plan to address usability (task analysis, user interface prototypes, usability objectives, usability test plans). By establishing key milestones we hope to avoid the common belief that "We do it already, (but we don't devote staff time, resources, schedule, etc.)."

We believe that designing for usability will lead to products of higher quality. The long term success of user-centered design will depend on the economics associated with it. An important aspect of the target project approach is to produce measurable demonstrations of the value of user-centered design. In order to change the beliefs of the managers who are on the line to deliver their products on schedule and within budget these demonstrations must be convincing. There are a number of possible dimensions on which quantitative measures of success can be obtained, and part of the process with target projects is to obtain such measures. Although the measures (metrics) of effectiveness vary somewhat from product to product, a typical list might include the following.

- Reduced user training costs,
- Increased user effectiveness and satisfaction,
- Reduced product support costs (e.g., fewer modification requests from the field on the user interface and on system functionality, reduced hotline support), and
- Software engineering and requirements gains (e.g., tested, re-usable user interface designs, re-usable user interface software tools, increased stability, verified correctness).

#### Ongoing Committee activities

In parallel with initiating the target projects, the coordinating committee has started to address some of the issues that span organizations, including, among others,

- An organizational policy for incorporating user-centered design practices as part of the organization's quality and software development policy,
- Appropriate training for human factors people,
- Examples of good practices (e.g., for prototyping and usability testing), and
- A coordinated recruiting program.

In addition, the committee sponsors community-building activities to enhance communications, including a human factors newsletter, regular seminars, and user-centered design symposia.

#### Managing expectations

Although our efforts have only recently begun, we are

optimistic, based on results achieved to date, that with top management attention and a targeted approach that we will achieve success that will cause a change in the way we design and develop systems. We also believe that the user advocates on projects, to be successful, need to be part of the project organization - part of the team. We hope that the activities of our cross-organizational committee, and the active participation of a management champion will allow us to have many of the advantages of both the decentralized and centralized organizational structures.

Going forward, our greatest challenges will be first, to demonstrate measurable success on key target projects, and second to convince management to give the process time to work - not to expect dramatic results in too short a time.

#### SUMMARY

The issue of system usability is increasingly recognized as an important component of overall quality, defined as user satisfaction. The challenges in instituting a user-centered design program in a large software development organization are both organizational and technical. In this paper, we have described the results of the early stages of Bellcore's experience in instituting such a program. Those results include the successful formation of a company-wide human factors coordinating committee, a description of its functions and mandate, its communications with company management, and tactical plans for demonstrating the value of user-centered design in the context of key projects.

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