Hi-Tech Hi-Touch Approach to Wearable Computing

Dr. Ron Dvir, Dr. Edna Pasher, Gal Sekely, Maya Levin

ron@futurecenter.co.il, gal@pasher.co.il, edna@pasher.co.il , maya@pasher.co.il

Abstract

The term Hi-Tech Hi Touch was coined by John Naisbitt in the early 80's. Since then his concept about the conscious integration of technology into our lives became even more relevant. After the general approach of Hi-Tech Hi-Touch is presented, the rational for applying it specifically to wearable computing is discussed. It is suggested that careful consideration of the human, social and organisational factors in the design of a wearable computing system will enhance its effectiveness. By doing so, both the "soft" and the "hard" outcomes will be improved. Then, we analyze the notion of "Wearable computing systems" and extend it to include many additional aspects beyond the hardware and software components. We argue that the designer needs to handle not only the physical and digital aspect– but also the complete eco-system which include intangible elements such as organisational culture, the time space, and the interpersonal dimension. In addition, a definition of wearable computing typology is provided – with three classes of interactions: Human-Machine, Human-Human and Community based. Once the wearable computing eco-system is presented, we specify the human, social and organisational factors which are involved in it. The paper is concluded with five practical suggestions to designers of wearable computing systems on how to address the hi-tech hi-touch challenge.

1. Introduction

Hi-Tech Hi-Touch approach

Wearable computers bring a new level of digitization into every day life. Unlike a laptop or a PDA, a wearable computer follows us around, and merges into our style of living and everyday interactions. Thus, it demands a paradigm shift in the perspectives on reality and human interactions, creating new concepts like "Mediated reality" and "Augmented reality" (Panuganty, 2000). John Nesbitt introduced the concept of Hi-Tech Hi-Touch – signifying the co-evolution of technology and human culture. According to Nesbitt, we are currently in a state of imbalance where technology has accelerated rapidly but social change has not kept the pace,

> *"High Tech is about shortening time, pushing everything towards real-time. High Touch is about taking time. High Tech is about the demand on the individual to produce more in less time. High Touch is about process, about allowing time for discovery" (Nasbitt, 1988).*

Nesbitt claims that while technology has accelerated rapidly, social change has not kept the pace, and as a result there is an increasing gap between technological and social change. This gap is manifested in a search for meaning, a desire for deeper relationships, a sense of community and a tendency towards spirituality. One of the key success factors of both a technology and an organization, is in restoring the balance of Hi-tech and Hi-Touch, by designing the technology and the work environment in a way that meet the human needs of personal growth and social relations. (Nadbitt, 1999)

? You already wrote this at the top of the page! Augmented reality is augmenting the real world with additional information and by doing so enhancing the users experience of that reality. Mediated reality refers to encapsulating the users' senses by processing information

from the outside world and filtering it for the user. One of the main challenges of Wear-IT is to design the new reality of the users in a way that will address both the Hi-Tech and Hi-Touch needs of the users, in a combined and seamless way.

The rational – why bother?

Why should Wear-IT consortium allocate special attention to the social and human aspects of wearable computing?

Dryer et al (1999) as well as other researchers suggest the following logic:

1. The design of the system's constructs can impact the human & social factors involved with wearable computing. The next section provides a holistic definition of the **socio-technical system** and its constructs. Section Y provides a detailed description of those factors.
2. Those factors, in turn, impact the outcomes of the system.
3. Therefore, in order to maximize the overall system outcomes and achieve the desired results, the system designers must address the design issues, which impact human and social factors.

According to IBM strategist Alan Marwick, "Above all, it has become clear that the culture within an organization had to change. While the underlying technology of finding and distributing knowledge is necessary, it is not in itself sufficient."[3] Overall these trends suggest that the success of emerging information technology will depend on how the technology affects human social behaviors (Dryer et al 1999).

We use the term "social computing" to refer to the interplay between persons' social behaviors and their interactions with computing technologies. Social computing involves both science and technology. As a domain of science, we seek to describe the relationships among social behaviors and machines so that we can **reduce our uncertainty** about how humans and machines will interact. As a domain of technology, we seek to apply social and behavioral science to the design of information technology systems that **enable efficient collaboration and support natural social behaviors**. (Dryer et al 1999).

The following figure presents this logic.

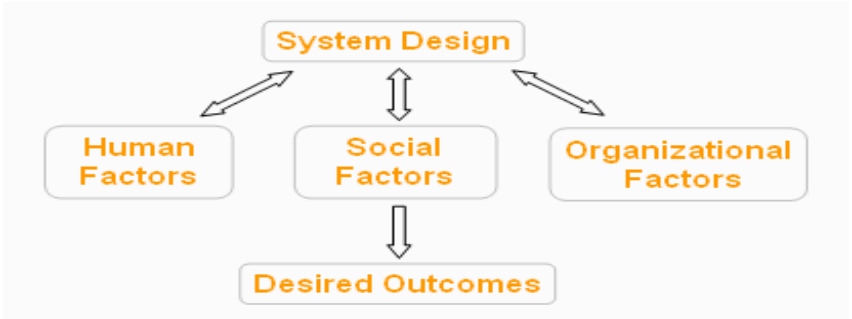


Figure 1: The design loop

System's Outcomes

The wearable computing in introduced to an organisation in order to achieve certain outcomes. The explicit identification of these outcomes will help the organisation in better designing the system in general, and its human and social aspects, in particular.

The following list of examples is divided into two categories: tangible and "hard" outcomes, and intangible and "soft" outcomes. However, the exact set of the desired outcomes is specific to each organisation.

However, we should not reduce the exploration of social factors in the above direct design-economic outcomes relationships. Viseu (Viseu b) states, "*despite the major changes wearable computers are bound to introduce in social and cognitive dynamics, and how these will shape the development of the technology itself, little has been written about this issue. Human and sociological issues are often reduced to issues of productivity, i.e., "Do the workers like it? Does it affect the quality and quantity of their work? Can the effects be measured?*".

"Hard" outcomes

- **Productivity** – output per resources (e.g. units tested by an employee per day)
- **Time to Market** – time to completed product, response time.
- **Quality –** measured by percentage of defects, for example.
- **Profitability –** the bottom line.

"Soft" and intangible outcomes

- **Employee Satisfaction** with their specific job, tasks or the organisation they work for.
- **Employee Loyalty and turnover –** does the system support the company efforts to retain its employees?
- **Corporate Image** -how is it perceived by its clients or other stockholders such as investors.
- **Employees quality of life –** and impact on their life beyond work

Note: the outcomes are interrelated. For example, higher employee satisfaction can lead to improved productivity.

2. The wearable computing system – a holistic definition

As was already suggested in the previews section, Wearable computing is not only the wearable device itself. Rather, it is a complex system introduced into a complex environment.

The figure bellow outlines the constructs of this system.

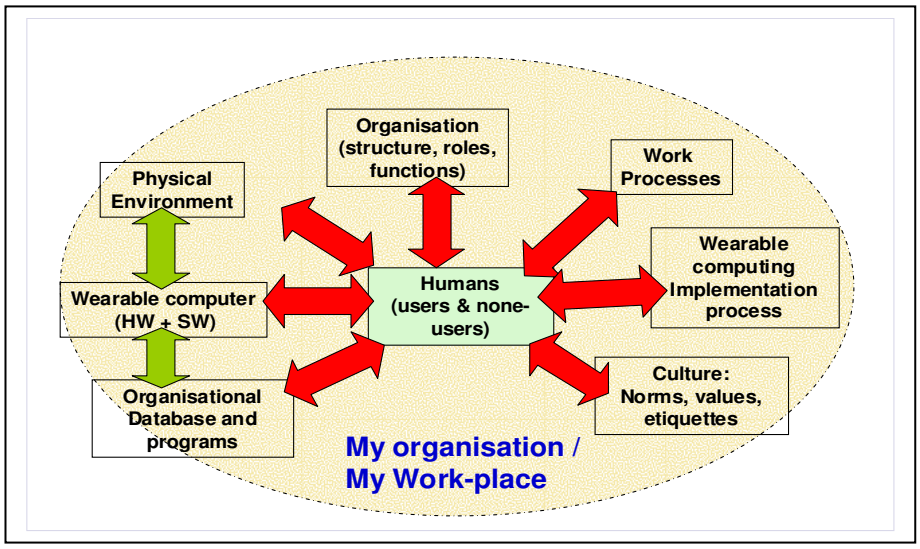


Figure 2: the wearable computing system

The system constructs

The system is composed of the following constructs. For simplicity, they are presented separately. However, in reality some of these constructs are interrelated and impact each other.

The human: the center of the socio-technical system. Here we include both the users (wearers) and none-users interacting with the wearer.

The wearable computer: hardware (processor, input and output devices, battery, communication) and software.

Information System infrastructure: databases, programs and computerized communication channels through which the wearable computer exchanges data.

Work processes – the existing or new work processes conducted by employees using wearable computers.

Introduction process – the process for introducing and implementing the wearable computing in the organisation. This might include training, or internal promotion campaign, for example.

Culture: the aspects of the existing or desired organisational culture which are related to the introduction and operation of wearable computing. This might include values, norms, etiquettes.

Organisation: the organisational issues which might impact or be impacted by the introduction of wearable computing. This may include: enhanced job definitions, career paths, new functions, changes in the organisational structures.

Physical Environment: the environment in which the employee used the wearable computer. This includes the personal or common workspaces – either those at which the employee conducts her specific task or more general purpose spaces.

Beyond the workplace – an extended time/space view

What are the boundaries of the system? Is it limited to the physical boundaries of the workplace, to the work hours and to the work context alone?

Similar questions are dealt with in similar domains, such as lap tops and wor-owned mobile phones.

We suggest that wearable computers provided to the employee by the organisation might be used:

- Beyond normal work hours
- Beyond the physical borders of the organisation – e.g. at the employee home or at 'third places' -places which are not the workplace neither the home, such as cafe's, shopping moles, on the way to/from the workplace (Oldenburg, 1989).
- Beyond the organisational work context, i.e. for private or public purposes not related to the employee job.

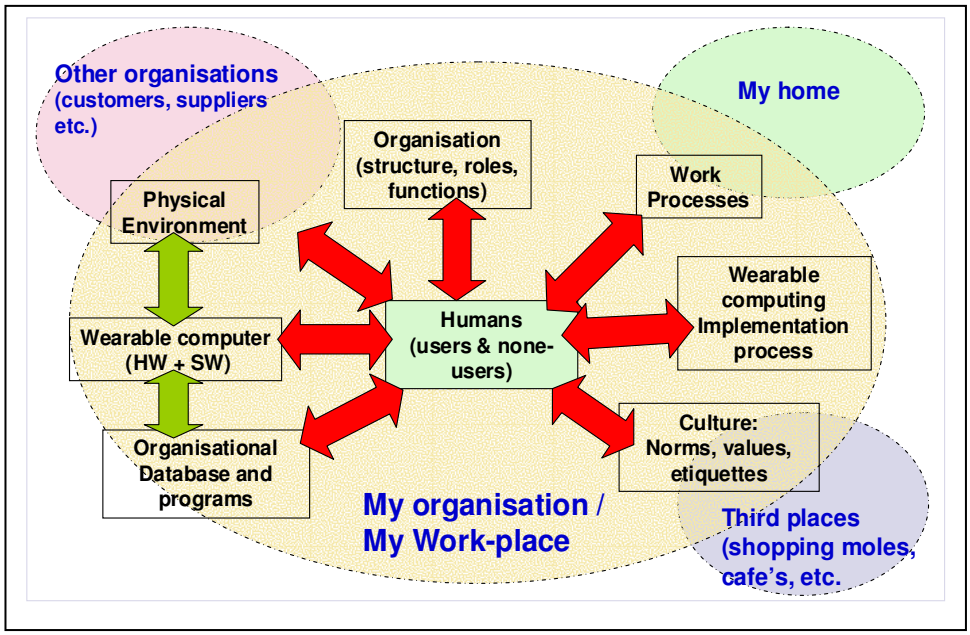


Figure 3: The System- with extended time/space dimension

The designers of the system need to take the question of time/space dimension into account and make decisions:

- ✓ Is the use restricted to the workplace and work context?
- ✓ How such restriction is enforced?
- ✓ Why? Perhaps the desired organisational outcomes will be better served if the device can be used beyond the work time/space narrow definition?
- ✓ In such case, the system would include also the home and 'third places' (see the figure above). What would be the implication of the system design (privacy and safety issues, for example).

Indeed, wearable computer empower the users by extending the time/space/social setting dimensions – information is available to the user anytime, any place with any partner involved (Marti, 2002).

The design space

Each of the system constructs can be designed or at least impacted by the designers of the wearable computing system. The following figure shows few examples of "things" that can be designed, in order to enhance the performance of the system.

However, there are choices to be made: which constructs should be dealt extensively, which can be addressed "lightly" and which can be neglected.

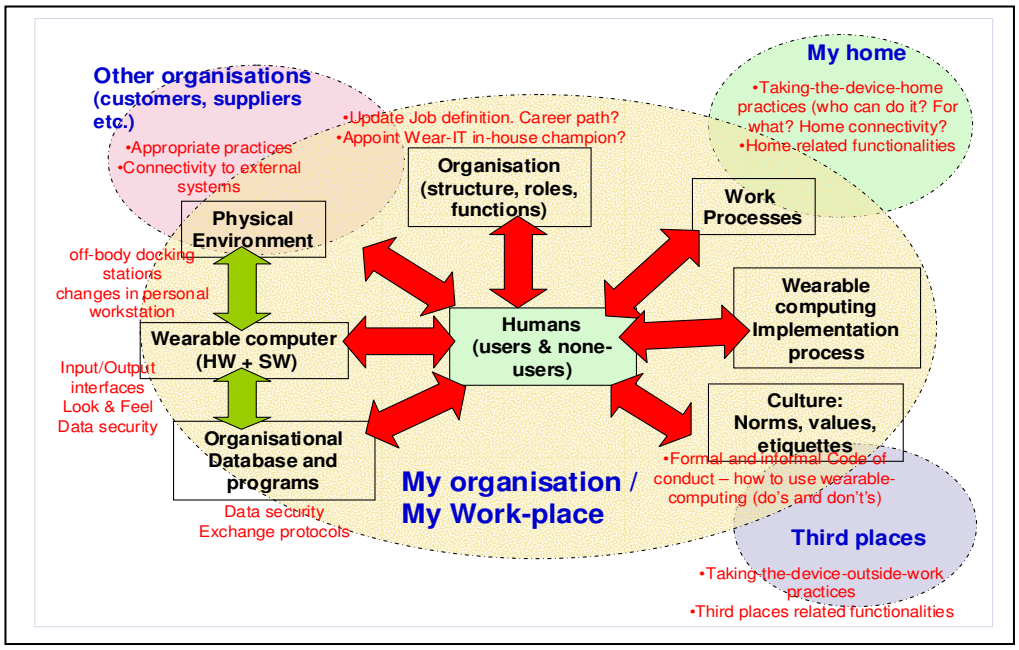


Figure 3: the design space

3. Typology of Interactions

Sine a wearable device is "always-on" meaning we carry it for the most part of the day, and it is constantly turned-on, it has the power to influence our day to day interactions, and to transform the way we experience reality. As a result, in order to ensure the success of the wearable device, we should analyze the different of interactions types that people are engaged in and to try to identify the impact of wearable computers on the **user's experience**

Type 1: Human-Machine

Human -Machine

The individual employee interact with his computer, or with other computers using his wearable device.

Example: a Doctor searching a database.

Several issues regarding the quality of interaction are

involved:

- Does is employee feels empowered, or controlled by the device?
- Is the device convenient to wear and use?

Type 2: Human-Human

There are several sub-categories of this interaction type: Co-located users, Remote users, Co-located User-none user, Encountering

Co-located Users

Two employees at the same physical location wear wearable computers, and uses them to:

- collaborate on a shared task
- To execute their own individual tasks.

Example: two doctors at a doctors round.

Several issues regarding the quality of interaction are involved:

- Can the employees maintain a personal relationship when they interact through their wearable computers? For example, can and is eye contact established between them?
- What is the quality of conversation between them?

Co-located User-None User

While one employee uses a mobile computer, he interacts with another person who does not wear a computer.

Example: a Doctor examining a client.

Several issues regarding the quality of interaction are involved:

*Would this situation put the user in a superior position, as he has better access to information ("knowledge is power")?

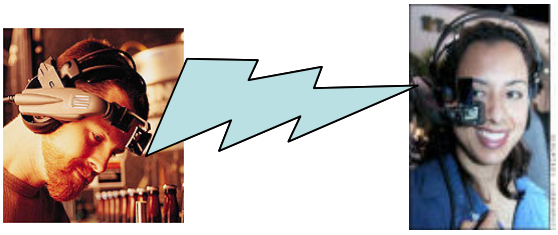
*How can they share knowledge?

*does the device intrude face to face conversation between the two?

*Can they really collaborate in executing a shared task?

Remote Users

Two employees which are physically remote uses wearable computers to interact.



Example: a Doctor consults with a specialist in another hospital, during an operation.

Several issues regarding the quality of interaction are involved:

- how to avoid lose-of-privacy concerns (medical records privacy, in the above case)
- How to enhance the personal characteristics of the interaction in order ot make it richer?

Impromptu Encountering

Two employees or an employee and an external person meet without preplanning. Social encounters play an important part in our social life and are vital for collaboration at the workplace. An encounter with another person, whether we know the person or not, is a chance for striking up a conversation and for exchanging information. It has been argued that in today's world individuals are suffering from a lack of authentic psychological encounters or "**human moments**". For example, Internet use of as little as 4 hours per week can result in higher level of depression and loneliness. Face to face interactions, on the other hand, have an immediate effect on hormones levels and have the potential of reducing feelings of stress and fear and increasing feeling of trust, bonding and well being. (Korteum et al)

Impromptu encountering and collaboration can occur in the absence of any enabling hardware other then what the collaborators commonly carry with them and thus is possible at any time and in any environment. Impromptu encountering and collaboration is:

Opportunistic: it allows people to take advantage and make use of an opportunity that present itself

Spontaneous: it requires no prior planning or preparation on behalf of the human

Proximity based: collaboration is made possible by physical proximity of two or more individuals

Transient: interactions are short-lived, seldom lasting more than a few minutes or even seconds (but can lead to longer face to face or virtual interactions).(Korteum et al).

Example: a doctor meets another doctor at the hospital cafeteria which she didn't meet before.

Several issues regarding the quality of interaction are involved. For example:

- how can wearable computing enhance the chances that such encountering will happen, and lead to work relations and exchange of professional knowledge
- how to avoid the intrusiveness and distracting effects of wearable computers, which might inhibit meaningful encountering.

Type 3: Community

wearable communities are social networks based on augmented face-to-face encounters. They might be co-located or distributed in different locations. They might belong to the same professional disciplines, or come form different domains. However, they identify themselves as members of a community.

Wearable Community as a group of wearable users who cooperate for their mutual benefit. In such a community, wearable computers act as personal agents on behalf of and in the interest of their 'owners'. These agents are goal-directed and will perform a broad array of tasks for the user, ranging from personal scheduling to task planning. (*Kortuem et al, 1999)*

"The idea of Wearable Communities is based on the belief that non-monetary exchange of value is the essence of community. My goal is to use technology to enhance the spirit of cooperation. What community sites do in Cyberspace, Wearable Communities do in real life. The crowds who surround us every day constitute a huge waste of social capital. If you live in a city for instance, there are many who pass within a few yards of you each day who could give you a ride home, buy an item you're trying to sell, or consider you as dating material. Dynamic networking makes it possible to tap those resources through a momentary alliance among transient interest groups, (*Kortuem et al 1999)*

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Wearable Communities use mobile and wearable computing technology to assist people in the exchange of information during face-to-face social interactions in the real world: when people meet on the way to the office, in the elevator, or at the grocery store. (Schneider et al)

> *"Ad-hoc and personal-area networks will make it possible for devices belonging to different individuals to communicate during face-to-face encounters, thus enabling new forms of spontaneous social interactions between people who are co-located and organized in an unforeseeable way. We argue that these developments will eventually lead to the emergence of new social networks of like-minded individuals who use their wearable devices to communicate, share information, play games, and coordinate their activities. We call such social networks enabled by wearable computing devices Wearable Communities."* (Rheingold, 2002)

> *"We believe that fully embodied "human moments" are essential for community building. While Virtual Communities on the Internet have led to a separation of physical place and social space, our work is an attempt to reunite the two. At first approximation, we define a Wearable Community as a social network created by or maintained through the use of wearable computing devices. A collection of wearable computer users becomes a Wearable Community when enough people use their wearable computers to form webs of personal relationships".* (Rheingold, 2002)

Example: a group of doctors meeting at a conference, all wearing computers.

Several issues regarding the quality of interaction are involved. For example:

- how can wearable computing enhance the knowledge exchange between the members of the community and deepen their relationships.
- how to avoid the intrusiveness and distracting effects of wearable computers, which might reduce the chance of a meaningful interactions.

4. Human, social and organisational factors

This section presents in details a set of factors which should be addressed by the players involved in the system design, in order to maximize desired system outcomes. This group includes the designers of the device and SW, the designers of the extended socio-technical system e.g. planners of work processes, the experts leading the implementation process, and of course the users (or at least representatives of the users).

The set includes three types of factors:

- *Human:* related to the individual user.
- *Social:* related to the relationships between two individuals
- *Organizational:* related to the relationships of the individual with the organisation in which he operates.

The factors are presented in the following figure according to the interaction type(s) they are most related to. Note: This is a crude categorization – most are relevant to all interaction types.

Prioritize and Balance!

In an ideal world, all the social-human factors would be fully addressed and comprehensive solutions would be designed. However, there are constraints: designer resources, time to market and system cost.

The factors intertwined - changing one effects to others (Starner 1999). Moreover, some factors are conflicting, i.e. enhancing the system performance related to one factor might decrease the performance related to another factor.

For instance, a wearable computer equipped with GPS (Georephical Position System) can be of great help if an individual is injured and needs help, but it can also be the perfect tool for an employer to find out if the workers are spending too much time in the donut shop! The answer lies on a complex balance between comfort, security and ownership of personal data (Viseu b).

Thus, there is a need to take design decisions based on prioritization and balancing of conflicting factors.

Sometimes **the problem can become part of the solution**. For example If the wearer controls information contained in it, then he/she can decide when, where and why to disclose it. In this case, the computer initially thought of risking the user privacy become a tool to protect it.

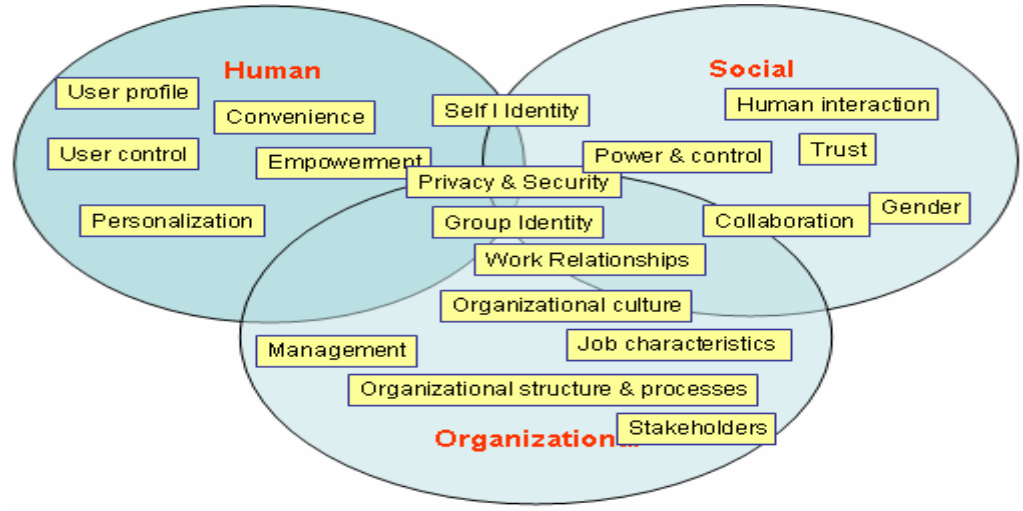

Figure 4: Human, social and organisational factors

Overview of the human, social & organisational factors

Empowerment	To equip the user with new capabilities or to enhance existing ones. Increasing and augmenting the wearer's social, professional, personal strength.
Privacy & Security	Right of individuals to control the collection and use of personal information about themselves. Safeguarding of information from unauthorized users
User profile	The fit between the system and the characteristics of the user (sophisticated? IT literate? Etc.)
Personalization	The capability of the user to modify the device to his personal preferences and treat it as a personal device.
Convenience	Being suitable to the user's comfort, purposes, or needs
User Control	The degree to which the wearer can control and modify the properties and operation of the wearable computer.
Safety	The condition of being safe: freedom from danger, hurt, injury, hazard.
Self Identity	The self-concept (self identity) is the mental notion a user has about it physical, psychological and social attributes as well as its attitudes, beliefs and ideas. The self-identity consists of the self-image and self-esteem. (e.g. how do I look with the device? A geek? A small part of a machine?)
Human interaction	The characteristics of interaction between the wearer and another individual, (user or none-user).
Collaboration	The act of working jointly
Trust	The trait of trusting; of believing in the honesty and reliability of others when engaging in interaction involving exchange of information through wearable computing.
Gender issues	the properties that distinguish men and women, and the implications of these properties on the design and use of wearable computing
Power & Control	The features of the socio-technical wearable computing system which enables

	the organisation or a person to control the actions of the individual wearer.
Group identity	How does the collective use of wearable computers by several/most members of a group impacts its identity.
Work relationships	The characteristics of the connection between people working in the same context, ad the implications of wearable computing over their relationships.
Organisational culture	Culture encompasses the values, beliefs, attitudes, norms and behavior of an organisation. Culture is how things get done in organisations. A norm is an expected pattern of behavior in a given situation.
Stakeholders	How does the introduction of wearable computing impact all people and group of people which might be involved directly and indirectly? Are their needs taken into account? (e.g. clients, suppliers, union, family etc.)
Job Characteristics	How does the use of the wearable computing impact the job characteristics and definition
Management	How does the introduction of the wearable computing (by an employee and/or manager) impact their relationships.
Organizational structure & Processes	The impact of wearable computers on the structure or the work processes within the organization.

Table 1– Human and Social factors

A detailed analysis of the above factors is beyond the scope of this paper. However, the reader is invited to read a detailed description of each factor in www.wearit.com/ucd.htm

5. Conclusions – an advice to designers of wearable computing systems

How can designers of wearable computing systems address to challenge of the Hi-Tech Hi-Touch approach?

We suggest the following process which is based on the logic presented in this paper:

- **Acknowledge** the challenges of Hi-Tech Hi-Touch, and the links between the intangible factors of the system and the results and benefits it will deliver to all its stake holders.
- **Define** the borders of the specific wearable computing system – draw the map of the complete ecosystem involved. The map presented in this paper is not comprehensive, and different wearable computing system might work in different eco systems.
- **Identify** the human, social and organisational factors which might impact the specific wearable computing ecosystem.
- **Prioritize** these factors – analyze their potential (negative and positive) contribution to the specific system outcomes. Focus
- **Address** each factor – but focus mostly on the high priority ones. When designing each of the system components (e.g. hardware, software, operating procedures, usage policies etc) analyze how the factors can be addressed. This should be done in the micro level and holistic system level.

How can the design team implement the above process?

A User Centered Approach, which involves in the design process in intensive and interactive interaction with all stakeholders, is proposed.

The Waer-IT project (2004-2007) is following this logic – it adopted a User Centered Approach as its "guiding compass' and follows the above process.

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