Developing a participatory approach to the design of work equipment

Assimilating lessons from workers' experience

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European Trade Union Technical Bureau for Health and Safety

TUTB

SALTSA

Foreword

This publication brings to an end the partnership research project we set up in 2001 with the Swedish SALTSA Programme. It had three main aims:

- Firstly, to bring the practices of trade union participation in standardization into the public arena; two reports on the situation in Sweden and Germany have been posted on the TUTB website.
- Secondly, to analyse where the globalization of technical standards might lead us, and particularly what effects might flow from the agreement between CEN and ISO on European standards, especially those mandated under European directives. The findings of that analysis were published at the end of 2002 as *Globalizing technical standards. Impact and challenges for occupational health and safety.*
- Thirdly, as reported in this book, to promote and focus on participatory approaches to equipment design. It shows what lessons not just standards bodies, but also the European public authorities responsible for framing design rules and policing the market of the work equipment, can learn from it.

These practices were garnered in a multi-stage process which produced thirty-eight case studies from seven EU countries, two-thirds of them previously unpublished. Thanks are due to everyone who helped identify and describe these case studies and allowed the information to be published.

Above all, it provides a showcase for the extensive but unseen knowledge base that final users possess on the processes and equipment that they work with. Knowledge that can be leveraged both in and outside the workplace to improve technical standards. The mine of information gathered from users is a basis not just for devising technical solutions, but also putting them to work.

Workers and trade unions must be actively involved in systematically collecting information at the workplace, and in transferring and giving legitimacy to their knowledge in arenas outside the workplace.

What this project shows is that there is an urgent need to put in place European-level information resources that incorporate data from final users, as well as procedures so that CEN technical committees, especially when operating under the Vienna Agreements with the ISO, can initiate their own information collection so as to be certain, for instance, that risk assessments stand up in practice.

Marc Sapir,
Director of the TUTB

Executive summary

The TUTB and SALTSA (the Joint Programme for Working Life Research in a European Perspective in Sweden) have carried out a review of current practices, trends and perspectives to integrate users' experiences in the standardisation process. There were a number of factors driving this work. Firstly it was recognised that standardisation of machinery, equipment, processes and products often affects working conditions and is therefore of great importance to employees. Secondly, as a voluntary instrument, standardisation has a growing importance regarding the implementation of health and safety regulation and also as a potential forum for dialogue between users and designers of technology.

As part of the project, the TUTB and SALTSA have commissioned a review of how European and international standards can influence the health and safety of workers in the European Community. The findings from this review have been published as *Globalizing technical standards – Impact and challenges for occupational health and safety* (Koukoulaki & Boy, 2003). This current report presents the case studies that have been collected by a number of national authors, in order to review the opportunities for participation of end users in the design or redesign of equipment. The participatory approaches used in the cases studied have been reviewed, their impact on the standardisation process considered and lessons learnt for consideration in future participatory projects have been identified. Within this report the term "end user" has been defined as those who are using the equipment for their work or who spend their working day in the particular workplace that has been described in the case study.

The first step in the programme of work was to establish criteria for the collection of data in case studies. The TUTB appointed a number of national authors across the European Union and a semi-structured questionnaire format was proposed which would provide a consistent framework for the data collection.

The format of the semi-structured questionnaire was developed following a review of the literature on participatory ergonomics and participatory design and was based on the initial framework for participatory ergonomics developed by Haines and Wilson in 1998.

The data from the national reports were presented first at a workshop held in Brussels in June 2002. A wide variety of delegates attended the workshop and the forum provided an opportunity to discuss the reports, the reported success factors for the use of participation and how user information can be incorporated into the standards process.

This consolidated report has sought to bring together the different cultural perspectives on participation and to demonstrate through individual case studies how particular factors of participatory projects have influenced the success or posed difficulties for the project. The report considers the possible interpretations of participation and notes that the use of participatory approaches is not limited to the work of ergonomists. Whilst all the cases indicate that participation was seen to be beneficial, the report also considers some of the barriers to participation that have been reported. In total thirty-eight participatory design cases have been collected from seven countries, of which twenty-four cases fell under the scope of the Machinery Directive and the Personal Protective Equipment Directive (63%). The remainder of the cases concerned work equipment or related devices that are not under the scope of the above directives. The national reports cover a wide variety of work equipment, from simple hand held tools to large machinery used in the printing industry, as well as several reports of developments in personal protective equipment.

Sixteen of the case studies concerned changes to an existing equipment design (42%), fifteen reported on new equipment and design innovation (39%), three cases involved changes to the work environment (8%) and four the design of new production methods including equipment (11%). It is noted that even in the cases of new design the majority involved the evaluation of previous equipment.

Irrespective of the trigger factor for the cases, a variety of improvements were made concerning ergonomics, safety and other health hazards. For example, in the cases where ergonomics was the

trigger, indirect improvements to safety have also often been achieved (e.g. by increasing the visibility in a truck or improving the visual tasks in a control room, safety hazards have been reduced). Similarly for cases where safety and an increased level of accidents was the trigger, not only were safety improvements made but also ergonomics ones that increased the acceptance of a product (this was particularly so for the cases involving changes to personal protective equipment).

For all the cases, the involvement of end users was reported to have brought concrete improvements to the existing design of the equipment. These improvements concerned the ergonomics of seats, cabins and controls, introduction of handling mechanisms attached to machinery, new tool handles, machine guards, reduction of noise, new safety devices, ergonomic properties and the protective function of PPE.

The review of the cases identified a number of factors which are important for the success of a participatory approach and these have been categorised under the following headings :

- Appropriate organisational climate
- Appropriate organisational attributes
- Commitment at all levels of the organisation's management
- Resources (time, money, people)

It is evident from the work carried out during this project that the participation of end users should be regarded as vital in the design of work equipment and workplaces (both for quality of content and also acceptance of solutions) and that such projects have a potentially important role to play in the standardisation process. It is also apparent, however, that there are many questions about how participation is used and how the outcomes of participatory projects can be evaluated. We do not want to know merely that user participation in equipment design, workplace design and even in standards production appears to have been successful; we need to know how and why it was successful, and what aspects of the process were the most important in order that these may be repeated in the future. Moreover we need to address this not just at the micro level of the particular case or study, but also more structurally at industry, trade union, societal and international levels. The report presents a number of areas for further enquiry to address these issues.

Finally a draft of the report was presented at a conference jointly hosted by the TUTB and SALTSA in Brussels in June 2003. The conference provided a forum for further debate as to how end-user information may be incorporated into the standards process in order to enhance the health and safety at work of users of machinery and personal protective equipment. A number of recommendations were proposed and work is ongoing within the TUTB, SALTSA and other organisations to consider how these may be further developed.

Acknowledgements
The authors are grateful for the contributions of the national authors, Roland Kadefors, National Institute for Working Life (Sweden), Alain Garrigou, Université de Bordeaux 1 (France), Eero Korhonen, Finnish Institute of Occupational Health (Finland) and Robin Bronkhorst, TNO Arbeid (Netherlands), as well as Marc Sapir and Stefano Boy at the TUTB, Ingvar Holmer, Lund Technical University (SALTSA), all the contributors to the collection of case studies and all the participants at the Brussels Workshop in June 2002.

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Section 1
Introduction

1.1. TUTB-SALTSA project

The TUTB in collaboration with SALTSA (the Joint Programme for Working Life Research in a European Perspective in Sweden) has undertaken a review of current practices, trends and perspectives to integrate users' experiences in the standardisation process. There were a number of factors driving this area of work. Firstly it was recognised that standardisation of machinery, equipment, processes and products often affects working conditions and is therefore of great importance to employees. Secondly, as a voluntary instrument, standardisation has a growing importance regarding the implementation of health and safety regulation and also as a potential forum for dialogue between users and designers of technology.

The project consisted of three main steps. The first two steps included a review of the role of trade unions in the European standardisation process - available on the TUTB web site (www.etuc.org/tutb/uk/technical-standards.html) - and an assessment of the impact that the globalisation of markets and standards has had on the health and safety of workers. The findings from step two are reported in the publication *Globalizing technical standards. Impact and challenges for occupational health and safety*, TUTB-SALTSA, 2002. The third step was a programme of research to collect case studies that concern the use of participation by end users in the development or design of their work equipment. The work of this third step is reported here.

1.2. Aims of the research programme

The following aims for the research programme were identified:

1. To justify the need to apply participatory methods when designing equipment and demonstrate the added value of incorporating end users' experiences from the workplace.
2. To suggest ways and systematic models to collect end

users' data from different sources across Europe.

3. To suggest changes in the formal procedures, either via current legislation or the standardisation process, to provide opportunities for end-user data to be incorporated into future standards.
4. To review the reported methods of participatory ergonomics projects within Europe so as to develop the level of understanding of participatory ergonomics approaches and consider whether a European guidance document might be needed.

Prof. John Wilson and the IOE - Institute for Occupational Ergonomics - were asked to assist the TUTB and SALTSA in carrying out this research programme. At the outset of the project it was noted that the fulfilment of the aims outlined above was very dependent upon the number and content of the case studies that would be collected by the national authors.

1.3. Definition of terms

The focus of the research programme has been the collection of case studies where 'end users' have been able to participate in the design or development of their workplace or work equipment. In this report a number of different 'users' will be referred to. The term 'end user' is defined as those who are using the equipment for their work or who spend their working day in the particular workplace that has been described. Other users may be 'users of the standards', such as manufacturers of equipment, and 'user companies' which are companies purchasing equipment that will be provided for end users.

1.4. Methodology

The methodology of the project is related to the field of 'action research'. It is acknowledged that there is considerable debate within the research world as to how action research may be defined and how beneficial such an approach may be. However, one of the definitions of action research suggested by Raporort in 1970 (cited in Robson, 1993) may be used to describe the approach taken in this study. Raporort suggests that action research "is concerned both with action (solving problems in real situations) and research (trying to further the goals of science)".

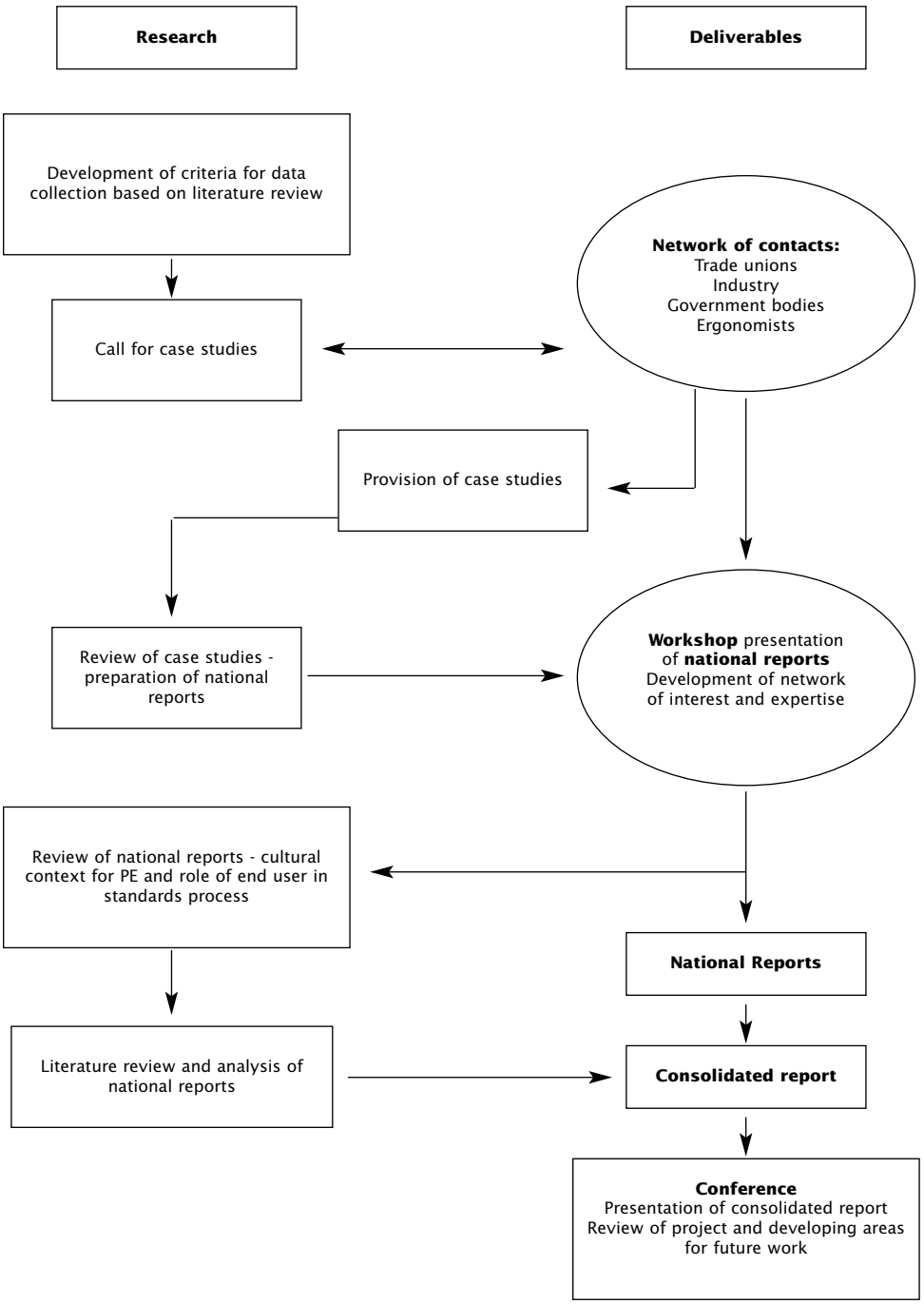


Figure 1: **Programme of work (IOE)**

In this project, information from case studies about the participation of end users in the design of equipment and the workplace has been sought. The purpose of their participation was to improve the design of the equipment and achieve benefits for the health and safety of end users. The use of participatory methods is of interest to a number of different groups and the evaluation of these case studies will further inform our understanding of the methods utilised, the focus of the approach and the outcomes that have been achieved. Therefore the 'action' part of the programme took place prior to the project: the data on how problems were solved within real world situations were reported in the case studies. The research element of the programme has been to reapply the knowledge gained from the real life experiences reported in the case studies into the development and review of standards and the field of participatory ergonomics. The methodology used in this project will be discussed in more detail in the following section, however an outline of the programme of work is presented in Figure 1. The work is divided into research stages and the deliverables that have resulted from the work.

Section 2
Project methodology

The aim of the research project was to collect case studies where there has been end-user involvement in the design of machinery and where there had been an integration of this end-user knowledge into the standardisation process.

At the outset, it was acknowledged by the researchers that there was little evidence of such case studies being reported in scientific journals and that a wider call for cases of end-user involvement in other areas, such as workplace design, would be beneficial.

2.1. Collection of case studies

The first step of the programme of work was to establish criteria for the data collection in case studies. The TUTB appointed a number of national authors across the European Union and a semi-structured questionnaire format was proposed which would provide a consistent framework for the data collection. The format of the semi-structured questionnaire was developed following a review of the literature on participatory ergonomics and participatory design, and was based on the initial framework for participatory ergonomics developed by Haines and Wilson in 1998.

The questions provided to each national author are shown in Table 1 below and concerned information about the project, the process and the results.

By the beginning of 2002 national authors had been appointed for the UK, France and Finland. TNO (Netherlands) was able to provide two case studies for the project. By June 2002 a national author for Sweden was appointed and soon after contacts with Bau-BG led to the provision of a number of case studies from Germany.

Table 1: **Questions provided to national authors**
The project
What is the organisation, type sector, size etc.? What triggered off the intervention? What was the initial purpose of the participatory process? Was this a one off activity or a structured system of work?
The process
Briefly describe the machine, work environment involved What was the number of participants, their jobs / roles? What was the level of influence, team / department / company? Describe the participatory method, was there a facilitator involved? What actually happened - did things go according to plan? At what stage in the design cycle were people involved? Were did the activity take place?
The results
What design problems were identified by end users? What improvements were made? Any opportunities to further evaluate the proposed changes? Were there any general H & S improvements after changes? Any wider implications for the organisation? General case study evaluation – was this a beneficial process or not?

At the beginning of 2002, the researchers, the national authors and the TUTB sent out a call for collaboration with the project, in particular for the provision of case studies using established and developing networks with trade unions, industry contacts, government bodies, standards organisations, research institutes and the ergonomics community.

As anticipated, this stage was lengthy and required considerable effort to gather together relevant information from such a wide variety of contacts.

2.2. Workshop

A workshop was organised by the TUTB in June 2002 at which the national authors were asked to present their work to date, to an audience of interested parties invited by the TUTB. The delegates at the workshop represented a number of different viewpoints; there were:

- trade union representatives who were able to present national and international strategies as well as representing 'end users';
- experts involved in standards development;
- persons who have been involved in design projects;
- ergonomists, both researchers and practitioners.

Although representatives from employers and equipment manufacturers had been invited none were able to attend, and so their views were represented as much as possible through the researchers who had worked with them.

At the workshop the national reports were presented and there were opportunities to discuss the findings. The national reports enabled a considerable body of information to be collated, reported and discussed. Whilst some case studies had been previously available in the ergonomics literature, many others have not been available in this way.

For the purposes of this project, the focus for the collection of case studies was on equipment, particularly that covered by the Machinery (98/37/EC) and Personal Protective Equipment (89/686/EEC) Directives. However, many of the case studies that have been collected are drawn from participation in workplace design projects. Such case studies are useful as they provide opportunities to learn from experiences of participation in the workplace, which can inform and direct the future work of this project. It is important to note that the case studies collected to date are generally reactive in nature, responding to problems identified, rather than being of a more proactive nature where end users can have an influence early in the design cycle. The design of equipment is also usually undertaken by a different organisation to the one employing the end users.

At the workshop a number of issues were discussed. In particular the questions as to what were considered to be success factors for the use of participation and how user information can be incorporated into the standards process were central to the work of the project.

2.2.1. Success factors for participation

It was noted that there are difficulties in discussing such a question because there are many levels of participation; it may be participation within an organisation, a country or internationally. However some general issues were identified.

A factor for successful participation that was noted in many of the case studies was the need for a champion who would

ensure the level of commitment from relevant departments or personnel. The level of commitment should be seen as an ongoing factor as the level may vary during the life cycle of the project. The ergonomist or project facilitator has to be willing to adopt different levels of intervention in order to match this.

Where possible, manufacturers should be involved in participatory design projects from the beginning. This was important to reassure participants that the new product would actually be produced and not stay on the designer's drawing board.

Other success factors suggested were:

- a sense of urgency to improve, which is linked to what the reason for the project was (WHY);
- the actors in the context should be clearly identified and it may be necessary to provide extra incentives to some actors in order to get them to participate! (WHO);
- the structures for the process should also be established and a clear, step-wise approach to improvement is useful (HOW).

Whilst a sense of urgency can be helpful it was also noted that this can tend to mean that the work is reactive, addressing an existing problem. The challenge is to find ways to bring this sense of urgency into the development of new designs in order to eliminate or reduce hazards in use.

It was suggested that there might be three levels at which end users may be enabled to participate in design, only one of which is directly linked to the standards process:

- contribution of worker knowledge into standards for design – direct;
- worker involvement in participatory design in the development of equipment – indirect, where a 'mediator' takes information into the standards process;
- trade union representatives and/or workers promoting the use of participation in the workplace. The workers (end users) and local trade union representatives rely on others to take their concerns to the appropriate forums.

A level of knowledge is required to enable end users to participate effectively within the workplace and there are questions as to how this training is to be supplied. Some may see it as the responsibility of trade union organisations, but some companies

appreciate the value of participation and are developing such an approach within their management structure. This leads to a further question as to what level of knowledge may be required, which will depend upon the level of participation. It was noted that there is a tendency in many cultures and organisations to rely on experts, but there are not enough experts to go around. In Sweden there is a reliance on health and safety representatives within the company. It was suggested that these should be the people to pick up the problems, note the details in a brief report and take this to the company safety committee. This approach is also being developed in many large organisations outside Sweden; for instance this structure was found within the automotive component manufacturers referred to in the UK author's report.

A factor which may encourage companies to use a participatory approach is good previous experience. In Finland it is reported that companies may be keen to have involvement of a research institute because they can point to good experiences in the past. Also large companies often have management systems based around the principles of continuous improvement and are keen to benefit from external advice. There is more difficulty however in research groups getting involved with small and medium-sized enterprises (SMEs). They need incentives to be encouraged to adopt this approach, as they are often too preoccupied with survival to become involved in initiatives such as participatory design.

A further factor for success is the need to keep it simple when dealing with large numbers of people. The UK GMB union noted from their involvement in several projects that appropriate groups should be targeted who are able to disseminate information, with emphasis on those who can actually bring about change. Reports of such work may then be used as examples, or even benchmarks, but there will be a need to separate out the process from the content to make the information relevant to different sectors.

From the national reports and discussion at the workshop it was concluded that there appears to be a considerable body of evidence that end-user involvement is beneficial in the design of the workplace and in principle of equipment also. The difficulty however is often in sharing this information outside the actual organisation or body. The possibility of offering incen-

tives to organisations to share such information was considered. There needs to be a process that can bring such information into the public domain and also allow for some evaluation in order to generalise the lessons that may be learnt.

2.2.2. End-user information for the standards process

A formal involvement of safety representatives in standards development was suggested, although the nature of this will vary according to the level of discussion and decision making that is required. For example, input to the discussions which shape the top level, framework directives, will be different from that required for setting very specific standards.

The shortcomings in existing standards, in particular EN 1050 on risk assessment for machinery safety, were noted. It was suggested that in such an 'umbrella' standard there should be concrete obligations on manufacturers to collect end-user data (in the clause on information sources) before designing a machine. Also in the current revision of the Machinery Directive itself, relevant provisions should be put in place to strengthen the obligations in the standards. It was proposed that it would not be enough just to open up ways for end-user data to be collected. It was essential also to follow through with the means for the application of data. Should such procedures be put in place, however, it was acknowledged that these would require systematic models to collect end-user information from workplaces.

An extension of the worker representatives' rights (provided in the Framework Directive) was suggested to also include involvement in standard setting. This would facilitate the involvement of workers in standardisation work and support the collection of appropriate end-user data. Such legislative provision could be introduced in the new ergonomics legislation that the Commission has announced as a future initiative.

It was acknowledged that the level of input from trade union organisations into the standards process would vary depending on the resources available to the unions and the culture of the member country. Again a framework to help collect end-user information was suggested.

Whilst some workshop participants were in favour of classifying data in the form of databases, preferably posted on the Internet, to share information on problems or other interesting data concerning work equipment across Europe, others noted that there would be problems with such a system. Firstly, databases are only as good as the information that is put into them and the workshop noted the difficulty that the national authors had had in collecting the case studies to date. Secondly the need to manage and update the database is a practical issue that would require resourcing. The validation of data that may be entered on the database was also questioned and some form of data quality assurance procedures would be necessary.

In summary there were a number of approaches that could be taken to improve the end-user information being considered in the standardisation process, and these are noted below. However, it was acknowledged that many of these required high level action within the European Commission to bring them about.

- Include end-user perspectives on research that is undertaken to support the standardisation process
- Make it compulsory for manufacturers to comply with existing standards on collecting end-user data
- Introduce relevant provisions into the Machinery Directive
- Monitor applicability and continuity of end-user data collection systems
- Careful dissemination of such data ensuring their validation
- Introduce new legislative provisions to enlarge the role of workers' representatives in the standardisation process

2.3. Consolidated report

This consolidated report is a further deliverable from the project. In the preparation of the report, a literature review using a variety of search terms such as participatory ergonomics, participatory design and standards was undertaken; interpretations of this review have informed the wider discussion in this report. The workshop also contributed to an understanding of the context of participation in the different EU member countries. The consolidated report also draws on the national reports, which were finalised after the workshop event in June

2002. Some of the authors were able to add further case studies, which has broadened the scope of the experience highlighted by these case studies. Summaries of all the case studies collected by the national authors are provided in an Appendix to this report. The full text of the national reports can be viewed on-line at http://www.etuc.org/tutb/uk/technical-standards.html.

2.4. Conference

The final outcome of this particular research project was the presentation of the consolidated report at a conference held in Brussels in June 2003. This was the starting point for further discussion among the delegates as to the way forward to better promote and support end-user involvement in the standardisation process. Outcomes of the conference are to be published in a special issue of the *TUTB Newsletter:* The safety of work equipment. User-oriented strategies for improving technical standards.

Section 3
Participation in the workplace

3.1. What is meant by participation

The growing interest in participation, particularly in the field of ergonomics, has generated a number of definitions. The different definitions reflect the various levels at which participation may be used, the different contexts in which it may be used and the variety of participants within the group. The difficulty in defining participation is not solely a problem for ergonomists. Other domains such as occupational health and safety and human resource management have promoted a participatory approach and also discuss the meaning and extent of employee participation. An earlier review of participatory ergonomics methods noted that in the domain of organisational management, participation was considered to be a 'fuzzy concep' (Cotton cited in Haines & Wilson, 1998, p. 3). In the French national report, Garrigou (2002) comments that "perhaps as participation is a rich and complex process linked with philosophical ideas such as democracy in the workplace, it is a fuzzy concept". A definition of employee participation was proposed by Buhl (1997) as "participation in all forms of (formal or informal) decision-making processes, where actors are negotiating factory practice". A review of participatory ergonomics in 1998 by Haines and Wilson (1998, p. 5) provided as a working definition:

"The involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals".

A review of literature published since that date reveals few other definitions of participation or debate on its meaning. Instead the focus of the literature has been to report and review methods and approaches that have been used. Therefore the meaning of the term ‘participatory ergonomics’ in this report will be that proposed by Haines and Wilson (1998).

3.2. Why use participation

There is a substantial body of opinion in the ergonomics and related literature suggesting that the participation of end users in the design of work equipment and workplaces will lead to better design, as these solutions are developed using the expertise and practical experience of the end users (St Vincent *et al.*, 1997; De Looze *et al.*, 2000). At the workshop it was noted that there is a need to clarify what is meant by better design; depending upon the product, the context or the participants this can mean different things. For example, a better design may mean one that is safer, healthier to use, more usable, better at the task for which it is required, more acceptable to use, more obvious as to what is should be used for or may be used by more people.

As well as a 'better' solution, the second main advantage of participatory processes is said to be the greater acceptability of these solutions for the stakeholders (Van der Molen *et al.*, 1997; De Jong & Vink, 2000). The reasoning is that if people (or their peers) have been involved in generating a solution or a change then they are likely to be more committed to making the change work, to be less resistant to change and to be more satisfied as a result. If all this is so, and given that in addition we expect a better designed solution, more fit for purpose, then the implementation of change should be more effective and of higher quality.

Other benefits from the use of participatory ergonomics in workplace design have been improved industrial relationships (Lanoie & Tavenas, 1996), improved productivity (Brown, 1994; De Looze *et al.*, 2000) and a reduction in the reporting of accidents and musculoskeletal discomfort due to work activities (Kuorinka *et al.*, 1997; Nygaard *et al.*, 1997).

Whilst ergonomists in particular have promoted a participatory approach in design and implementation of change, the use of a participatory approach and the various methods which support this are shared with many other professions. A controversial example is the use of quality teams as part of an organisational approach to Total Quality Management.

There is increasing pressure from health and safety legislation for employers to consult with workers about matters that affect their health and safety. In the UK, the guidance notes that are

provided for the Health and Safety (Consultation with Employees) Regulations 1996, define consultation as "listening to their views and taking account of what they say before any decision is taken" (HSE, 1996). Such an approach therefore may utilise participatory methods as well.

A review of the literature may lead the reader to conclude that a participatory approach within the workplace is generally beneficial. Most reports are positive in their assessment of the use of participation, sometimes being prone to exaggeration, for example "employee participation in an ergonomics intervention is always effective" (Maciel, 1998). There is, actually, often a lack of quality evaluation in reports of such projects, although a number of studies do provide information about problems encountered in the work and some make recommendations for future projects (Vink, 1997; Kardborn, 1998; Mathiesen & Hvenegaard, 2001; De Jong & Vink, 2002). Although it is acknowledged that it is difficult to publish cases where participation has been found to be problematic or may even have adverse effects for the participants and the organisation can be difficult (especially in scientific journals), we would have expected to find more. Reasons for this may be that increasing numbers of companies use a participatory style of management but little planning and support may be given to the process of participation or to its evaluation. Also, it appears that industry is focused on short term needs to achieve production targets and does not often reflect on methods that have failed in order to learn lessons for the future, to inform the development of the use of participation in the workplace.

Other problems noted in the literature concerning the use of participatory ergonomics were end users experiencing difficulties contributing if the future work equipment or workplace design was very different from that of which they currently had experience (Hasle *et al.*, 1997; Strain, 1997) and changes in the nature of the organisation or key personnel during the life of the project (Hasle *et al.*, 1997).

In this project, the opportunity to collect case studies from a number of EU member countries has allowed the review of case material which has previously been unreported. Some of the case studies provide information about projects where the use of participation has not achieved all the intended outcomes (Case Numbers 34 and 36).

3.3. Support for Participatory Ergonomics Programmes

At the workshop, key factors for successful participation were considered. Whilst some factors will be more important in certain examples and in some cultural contexts than others, there was general agreement on the factors which are given in Table 2 below.

Table 2: **Key factors for the success of participatory projects**

Commitment
A champion to support and or facilitate the process
A sense of urgency - reason why
Clear definition of actors and their role - who will be involved
Structures to support the process - how will the participation be managed
Appropriate levels of knowledge for all participants
Previous good experience
Trade union involvement
Involve end users in all stages of equipment design
Preferably involve manufacturers from the beginning of the process
Keep the project simple - well defined and well targeted
Keep the client's needs in focus

These supported the findings from the literature review. Kuorinka *et al.* (1997) noted the need for management support and for key individuals to support the process of participation. Where such input from management was lacking, a negative influence on the results was found. In a review of a long-term project in Denmark to reduce monotonous and repetitive work, Nygaard *et al.* (1997) noted that external consultants working with companies to achieve this aim depended upon "one or more fiery souls who committed themselves and the company to the project".

3.4. Use of participation

Within the literature and the case studies reported by the national authors it can be seen that the participation of end users in a project can be for a number of different reasons. They may be involved early in the design phase of a product or a system but more commonly have been involved in identifying problems with existing products or systems, suggesting solutions to problems and evaluating possible solutions. End users may be involved for one, some or all of these reasons in any one project or programme.

Garrigou (2002) has suggested a model of involvement which refers to a downward approach (this corresponds to end-user involvement in the design process), a bottom-up approach (which corresponds to end-user involvement in problem identification and solution generation) and an approach through simulation (such an approach will assist in solution evaluation). This is shown in Figure 2. Strain (1997) however has suggested that participation might be considered in terms of whether it is used in the design *for* work (how a work system will operate) or in the design *of* work (how a work task will be performed).

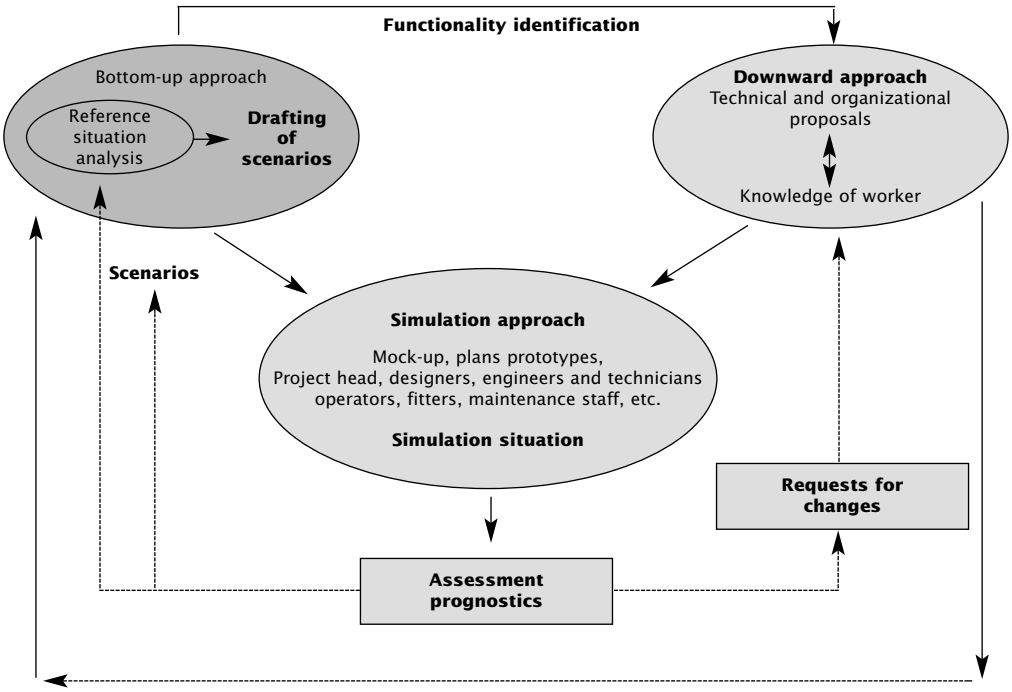


Figure 2: **General methodology in Participatory Ergonomics - Garrigou (2002)**

The majority of the case studies that have been collected and reported by the national authors have taken a bottom-up approach or an approach through simulation. Buhl (1997) comments that "employee participation focuses on collaboration and the need for new forms of *dialogue* and *learning processes*". There has therefore been considerable interest and debate within the field of ergonomics as to which methods best support this

dialogue and learning processes. In their review of participatory ergonomics, Haines and Wilson (1998) identified a considerable list of methods which have been used in participatory ergonomics projects. Some have been developed specifically for such projects such as Design Decision Groups, Activity Analysis and Cause and Effect Diagrams, while others have been borrowed from other areas of work, such as brainstorming techniques, focus groups, work study techniques and interviews.

There are differences in the reporting of methods used in participatory projects depending on the authors and the forum in which the report is published. In the ergonomics literature there is both description of the methods used and discussion as to their effectiveness in that particular scenario. In the case studies, however, particularly those that did not involve an external consultant or ergonomist in the team, they do not refer to the use of formal methods. The focus for such projects was problem resolution rather than developing and refining methods and tools. A further evaluation of the methods reported in the case studies will be provided later in the report in Section 6.

3.5. Evaluation of participatory projects

One major focus of this project has been to collect case studies that illustrate opportunities for end users to participate in the redesign of work equipment. As will be seen from a discussion later in the report, such case studies have been hard to find. The majority of the literature that considers the use of participatory methods concerns changes to workplace layout, the provision of new equipment or changes to the organisation of work. In the field of participatory design the focus of attention on end-user involvement in product design has been chiefly with human/computer interaction. Also the cases available predominately report on the methods used rather than providing a full evaluation of the outcomes of the process, identifying what actually changed. There can be a number of reasons for this. Often the ergonomist is an external consultant who may not have access to the organisation at a later date to follow up the progress of the project. In other cases, issues of commercial confidentiality may hinder the reporting of successes or failures in actual changes to equipment. Finally it may be that neither the agents of change nor the authors of any publication

consider the detail of the actual changes to be of interest to the academic community for which the articles and papers are generally written.

Table 3: **The Participatory Ergonomics Framework**

Dimension	**Categories**
Permanence	Ongoing Temporary
Involvement	Full direct participation Direct representative participation Delegated participation
Level of influence	Group of organisations Entire organisation Department Work group / team
Decision making	Group delegation Group consultation Individual consultation
Mix of participants	Operators Line management Senior management Internal specialist / technical staff Union External advisor Supplier / purchaser Cross-industry organisation
Requirement	Compulsory Voluntary
Focus	Physical design / specification of equipment / workplaces / work tasks Design of job teams or work organisation Formulation of policies or strategies
Brief	Problem identification Solution development Implementation of change Set-up / structure process Monitor / oversee process
Role of ergonomics specialist	Initiates and guides process Acts as expert Trains participants Available for consultation Not involved

Source: Haines *et al.*, 2002

If there is difficulty in evaluating individual case studies, then this is even more so between case studies, as often the situation, approach and methods used will be very different. In order to enable the development of guidance and advice for those considering the use of participatory ergonomics (PE) as

well as to provide a framework for cases to be reviewed, Haines *et al.* (2002) have developed "a conceptual framework for understanding PE". The framework comprises "nine different dimensions, each with two or more associated categories that define a feature of a PE initiative" (Haines *et al.*, 2002). The dimensions and categories of the Participatory Ergonomics Framework (PEF) are given in Table 3 above.

The PEF was used to assist in the comparison of the case studies presented by the UK author at the workshop, to consider where there were similarities or differences of approach. The earlier version of the PEF (Haines & Wilson, 1998) had also informed the development of the case study questionnaire (Table 1, p. 20). The PEF was then used to compare all the cases collected for the project and the findings from this will be discussed later in the report in Section 6.

Section 4
Standard setting

4.1. Overview of standards process

A standard has been defined as "a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results" (BSI, 2002). The nature of standards can vary considerably. They may be umbrella documents, which govern principles and define terminology. These are referred to as Class A standards and an example is EN 1050 *Safety of machinery - Principles for risk assessment.* Other standards may be concerned with a particular industry, Class B standards, an example of which is EN 1789 *Medical vehicles and their equipment - Road ambulances.* Finally they may be concerned with a particular product or service, Class C standards, for example EN 455-1 *Medical gloves for single use. Part 1: requirements and testing for freedom from holes.* The number classification system however does not give any guidance as to the level of the standard.

Standards also have different areas of influence, national, European or international. In all cases standards are developed by consensus. The views of interested parties are sought and taken into account. Whilst international standards have the widest sphere of influence it can also be difficult to reach international consensus.

Standards are developed by committees and working groups. At each level of standard setting (national, European and international) there will be a number of people employed by the standardisation organisation who will assist the work of the groups, but the majority of committee and group members act on a voluntary basis. Whilst it would be preferable to have one standard for a particular product it is often difficult to achieve this, due to the complex nature of some products, overlap with other standards and products and the diversity of the international market. Therefore finding information about product standards can be confusing and difficult.

A review of the history and progress of international standardisation discussed some of the difficulties of the process but also the benefits (Stewart, 2000). The author notes that while the committee structure and opportunities for public consultation mean that the process of standards development is slow and very formalised, such an approach helped to ensure that appropriate standards were developed, manufacturers were able to plan to meet the requirements and that the final standards are robust.

4.2. User involvement in standard setting

It is generally accepted that user involvement in the setting or revision of standards is important (Delleman *et al.*, 2000). However, there are considerable obstacles to this depending upon the type of user. Designers and manufacturers are users of standards and they are often represented in the committees and working groups both as experts in their field and as 'users'. Depending on the area being covered by the proposed standard and the extent to which it may influence their business activity, they may be more active or less involved. It is more difficult for end users of products or services to participate in the standardisation process due to lack of awareness that the work is being done and that they can contribute, as well as financial constraints. Most commonly, end users are represented by a trade union or consumer organisation, and such organisations have limitations on their time and resources to attend the numerous committee meetings each year[1].

1. Further information about health and safety standards and the role of trade unions in the European standardisation process can be found in:
- The safety of work equipment. User-oriented strategies for improving technical standards, Special issue of the *TUTB Newsletter* (to be published beginning of 2004).
- *Globalizing technical standards. Impact and challenges for occupational health and safety*, Theoni Koukoulaki and Stefano Boy, TUTB, 2002.
- TUTB web site: http://www.etuc.org/tutb.

Section 5
Overview of national reports

The TUTB and SALTSA sought case studies from European countries and in order to achieve this developed a network of contacts via trade union organisations and the ergonomics community. A number of national authors were appointed who worked on behalf of the project in co-ordinating the collection of case studies.

In the UK the national author contacted a wide variety of organisations and many people within the ergonomics community who have previously reported work using participatory methods. The majority of the case studies presented in the UK[2] report had not previously been published. In many of the projects an ergonomist had been involved, although this was usually as an external consultant rather than as an employee of the company. The case studies were mainly small-scale projects, although there were a few that had influence on large organisations or a group of organisations. In the UK, although government initiatives direct health and safety policy, there is little funding available through the government for research projects or support for smaller organisations to implement 'best practice'. The UK authors also contacted other ergonomists working within Europe whose work had not been reported by any of the other national authors. Further case studies, two from Portugal and two from the Netherlands, were provided for the project.

2. IOE: http://www.virart.nott.ac.uk/ioe/Overview.htm.

In Sweden, the application of participation in the workplace is well established and is supported by the government, the employer organisations and the trade unions. Therefore, whilst numerous examples could be found, the Swedish[3] national report concentrated on three case studies where there was participation from a wide variety of actors at many levels, from end users to manufacturers.

3. NIWL: http://www.arbetslivsinstitutet.se/en/.

The French author was able to draw upon a number of case studies that he had been involved with through his research

institution. The French[4] report developed the philosophy of participation, looking at different approaches as well as describing the difficulties in translating an expressed willingness on the part of organisations to use participatory methods into the implementation of such an approach.

4. Université de Bordeaux 1, IUT: http://www.iut.u-bordeaux1.fr/recherche.htm.

In Finland there is funding from the state to a national research institute whose main tasks are research, training of occupational health and safety professionals, provision of advisory services, and dissemination of information. The institute is able to provide services for state authorities free of charge. As with Sweden, the use of participation in the design and development of products is well established. The Finnish report was able to outline two case studies with which the FIOH[5] had been involved: one concerned a particular product, personal protective equipment for meat cutters, and the other proposed tools and methods to improve participation within an organisation to support productivity. The first case study provided details of the process of development and the findings from the work, whereas the second case study discussed the methods used to support end-user participation.

5. FIOH: http://www.occuphealth.fi/Internet/English/.

Two further case studies were reported by the Department of Ergonomics and Innovation of the Netherlands Organisation for Applied Scientific Research (TNO). TNO[6] is independent of the Dutch government but works closely with a number of government departments and acts as the principal laboratory and research institute for a number of ministries, in particular the Ministry of Defence. TNO also works for clients, and both of the case studies presented by TNO for this project are concerned with product evaluation and development on behalf of manufacturers. The methods used in the projects are described and the outcomes are discussed.

6. TNO: http://www.nia.tno.nl.

Finally, five case studies from Germany were reported to the TUTB by the Institution for Statutory Accident Insurance and Prevention in the building industry (Bau). These cases had all arisen following high levels of reporting of accidents or injuries associated with machinery or personal protective equipment. Bau was able to facilitate these projects in order to minimise future insurance claims.

The collection of the case studies took a considerable amount of time and effort on the part of the national authors. The

initial literature search had identified a number of projects that had used participatory ergonomics methods but many of these were from the USA or else they concerned the organisation of work rather than machinery design. It therefore took time to build networks of contacts throughout the European Union to identify appropriate case studies for the project. As discussed above it can be seen that within some countries the identification and selection of cases was less problematic than for others, as such work is organised by national research bodies.

The majority of the reports that involved clients required their permission and co-operation before they could be used in this study. Again this required time for contacts to be made, agreement from stakeholders to be sought and answers to be given.

In a number of the case studies there was no ergonomist involved and so alternative network links had to be explored. Many of these 'hidden' cases only came to our attention through contacts within trade union organisations or the inspection authorities.

Finally the majority of the case studies report a favourable outcome from the use of participatory methods. It is suggested that this may be due to the desire of organisations to avoid what is seen as 'negative publicity'.

Section 6
Review of case studies

In total thirty-eight participatory design cases have been collected from seven countries, of which twenty-four cases fell under the scope of the Machinery Directive and the Personal Protective Equipment Directive (63%). The remainder of the cases concerned work equipment or related devices that are not under the scope of the above directives. The national reports cover a wide variety of work equipment, from simple hand held tools to large machinery used in the printing industry, as well as several reports of developments in personal protective equipment.

Sixteen of the case studies concerned changes to an existing equipment design (42%), fifteen reported on new equipment and design innovation (39%), three cases involved changes to the work environment (8%) and four the design of new production methods including equipment (11%). It is noted that even in the cases of new design the majority involved the evaluation of previous equipment. Tables 4 to 8 below provide a basic outline of each case study that has been collected as part of this project.

The majority of the case studies were provided by research institutes or the ergonomics community who contacted companies for which they had undertaken work. Inspection authorities provided a few examples and affiliated institutes collaborated in the process of collecting and analysing the data (six cases - 16%)[7]. These cases involved the redesign of products that were responsible for accidents or where there was clear evidence of health problems. In one case the request for inspectors' involvement was made by trade unions for a new factory[8] development. Branch federations of trade unions were responsible in a number of cases for initiating the process of change or they participated in relevant projects (nine cases - 24%). When workers were involved, it was usually at a micro level of the enterprise, for example as worker representatives or as part of the Health and Safety Committee.

7. In the Swedish case studies, all three projects were funded by governmental funds. However the inspection authorities did not take part in the design process. Similarly the German case study on compression without noise was basically conducted with governmental funds, without inspectors actually being involved.

8. The Figaro printing industry case.

Table 4: **Details of case studies which concerned changes to an existing design**

Case No.	Type of company	Equipment	Participatory method(s)	Outcomes	Country of origin
1	Utility service provider	Biosolids tankers	Expert evaluation with end user input	Changes to layout of controls to improve working postures	UK
2	Utility service provider	Waste water effluent Autosampler	Expert evaluation with end user input	Changes to design of subsequent equipment	UK
3	Utility service provider	Water meter dials	Expert evaluation with end-user input	Changes to equipment design proposed and under development	UK
4	Clothing manufacturer	Sewing machine guard	Local task force with end-user input into trials and evaluation of designs	Changes to machine guarding and to relevant standard	UK
5	Emergency, rescue and healthcare equipment manufacturer	Ambulance carry chair and stretcher trolley	Focus groups of user companies and then field trials by end users	Changes to design	UK
6	Refuse incinerator plant	Crane driver seat and control unit	End users involved in design decision groups	Changes to workplace, seat and controls	UK
7	Automotive component manufacturer	New workplace layout design and improvements to individual workstations	End users involved in design process as part of a local task force	Changes to the workplace layout, lifting aids were developed and component suppliers modified the packing of their products	UK
8	Automotive seat manufacturer	Improvements to workstation design	End users involved in design process as part of a local task force	Changes to design, improve postures	Portugal
9	Automotive electronics	Improvements to workstation design to reduce risks of MSDs	End users involved in design process as part of a local task force	Layout redesign, new mechanisms for handling, improve postures	Portugal
10	SME manufacturers of wheel loaders	Wheel loader cabin	End users involved in evaluation of existing cabins	Proposed changes for improving the design	Netherlands
11	Mill industry	Flourmill (mill roll)	End users involved in accident analysis and evaluation of existing machine, involvement in producing improvements	Technical modifications to detect and prevent increase of temperature in the machine, further work will develop proposals for changes to the	France

				relevant standard (project in process)	
12	Supermarket chain	Redesign of checkout work equipment and layout	End users involved in design process as part of a local task force	Changes to checkout to improve comfort, reach requirements and overcome maintenance and cleaning activity problems	UK
13	Ambulance Trusts	Redesign of ambulance equipment and layout	Various strategies used, both formal and informal, to collect end-user input and allow evaluation of prototype designs	New vehicles have been designed with special lift mechanisms	UK
14	Institution for statutory accident insurance and prevention in the building industry	Concrete screed preparation machine	End users involved in describing the actual work procedures, during the design stage and in prototype testing	Changes in the design of the equipment - a switch was developed that automatically stopped the blades of the machine when the protective grid was removed. The improvements were also incorporated into the relevant standard	Germany
15	Institution for statutory accident insurance and prevention in the building industry	Protective gloves for the glazing trade	End users involved in the evaluation of various glove designs during a 6-month test period	The results of the evaluation were communicated to manufacturers for improving protective features of the gloves and ergonomics	Germany
16	Supermarket	Manual price markers	End users involved in the product evaluation at various stages: defining requirements, identifying areas for improvement and comparative testing	Comments sent to manufacturers concerning size, shape, weight, trigger etc.	Sweden

Table 5: **Details of case studies which concerned new equipment**

Case No.	Type of company	Equipment	Participatory method(s)	Outcomes	Country of origin
17	Postal collection and delivery service	Automated sorting system for A4 flat mail pieces	Workshops with a variety of end users involved throughout the procurement process	Changes to equipment design	UK
18	Transport service provider	Tram, the particular emphasis for this case study was on the cab design	End users were involved in design decisions and in mock-up evaluations	Iterative changes in the design process	Netherlands
19	Truck manufacturer	Off highway truck (seat and cabin evaluation before the mass production of the seat)	End users involved in field trials of the prototypes and two similar seat designs	Small improvements were made to the design of the seat based on the reports from the drivers. More changes were planned for the redesign cycle of the seat	Netherlands
20	Slaughterhouses	Personal protective clothing for meat-cutters	End users involved with the design team to report on complaints with older designs, evaluate the prototypes and develop the final design	Improved design in terms of physiological comfort and safety. New design applied in slaughterhouses	Finland
21	Finnish Army Special Forces	Combat clothing	End users involved to identify risk factors and hazards related to their current clothing and to test prototype designs	Improved design in terms of properties of the material used	Finland
22	A group of 6 hand tool manufacturers	Muscle operated hand tools	End users involved to identify problem tools, identify design requirements and evaluate prototypes	Tools which were considered to be more ergonomic in design were made available on the market	Sweden
23	Tool manufacturer	Hand tools for vineyards	End users involved in the testing of the developed prototypes	Better tools available on the market	Finland
24	Institution for statutory accident insurance and prevention in the building industry	Concrete compression machine	End users involved in evaluation of new machinery and able to make suggestions for further improvements	New techniques were developed and established for the new machinery that reduced noise emission	Germany
25	Institution for statutory accident insurance and	Protective clothing for abrasive blasting operations	End users involved throughout the design process	New products with improved protective functions,	Germany

	prevention in the building industry		(evaluation of old protective clothing, testing of new prototypes and input into the final discussions on improvements)	ventilation and ergonomics; the results were taken into account in the revision of the relevant standard	
26	Institution for statutory accident insurance and prevention in the building industry	Safety helmets	End users involved in definition of requirements, testing of new prototype	Improved product adapted to different needs of end users in different work situations, improved protective functions with improved materials	Germany

Table 6: **Details of case studies which concerned design innovation**

Case No.	Type of company	Equipment	Participatory method(s)	Outcomes	Country of origin
27	Health Care Trust	Plaster room chair	End users involved in design and evaluation of prototypes	New equipment developed, produced and successfully marketed which reduced reports of MSDs	UK
28	Health Care Trust	Equipment trolley	End users involved in design and evaluation of prototypes	New equipment developed which reduced reports of MSDs	UK
29	Airline support services	New product to load freight	End-user evaluation of mock-up with input into design development	Improvement in terms of comfort and reduction of MS strain	Netherlands
30	Domestic products manufacturer	New domestic product interfaces	End users involved in card sorting exercise and mock-ups	Methods allowed end users to participate in the design of new interfaces. It is not possible at this stage to say whether these will actually go into production	UK
31	Compressed gas manufacturer and supplier	Hand held tool for gas cylinder delivery	Initial end user evaluation of prototype and then field and laboratory trials by end users	End-user participation gave insight into the demands of the task and problems with the prototype tool were identified - further work was required	UK

Table 7: **Details of case studies which concerned changes to work environment**

Case No.	Type of company	Equipment	Participatory method(s)	Outcomes	Country of origin
32	Paper making industry	Paper making and finishing machines	End users involved in local task force initiatives to improve safety within the industry	Changes to safety culture and problems with design of machine features identified. Improved guarding in some areas of the machinery. Work is ongoing to influence the relevant standards	UK
33	KAMU national cross-sectoral project (30 companies)	Work environment, promote general co-operation and participation for increasing productivity	Workers were involved in KAMU teams to improve factors that support active participation and to encourage improvements to working conditions	Continuation of the project for several years, publication on improving industrial relations	Finland
34	A group of 8 powered tools manufacturers	Hand held powered tools	End users involved in local task force initiatives to identify needs for improvements in the design and selection of equipment	Development of a guide to end-user requirements for powered hand tools which was made available to tool manufacturers	Sweden

Table 8: **Details of case studies that concerned design of new production process (including work equipment)**

Case No.	Type of company	Equipment	Participatory method(s)	Outcomes	Country of origin
35	Manufacturing of asbestos-free fibre cement roof panels (design of a new factory)	The whole production process including work equipment	Expert evaluation with end-user input. End users were involved in work groups to identify problems in the future work system by visiting a company with a similar system. The ergonomist identified as a key need the provision of training; the H&S Committee supported this	Modification of access to the working devices, improved design of some items of equipment which led to improvements in the working postures of operators	France

36	Waste treatment (including asbestos)	Design of two production lines (Focus on crushing devices)	Expert evaluation with end-user input. The end users were involved in working groups to elaborate problematic scenarios in the future situation and identify future needs	Ergonomists have withdrawn from the project due to co-ordination problems. Scheduled simulations to specify design modifications were called off. Identification of necessary tools was possible and improvement of maintenance operations	France
37	Chemical industry	Processing chemical products (preparation, rolling up, moulding, stoving and finishing)	Steering committee and working groups. End users (H&S Committee) were involved in both structures to identify problems and suggest solutions for future situations	Improvements of work equipment and processes to facilitate the work for ageing people and people affected from back injuries (mechanisations, treatment of fumes at source, etc.)	France
38	Printing industry	Printing machinery	Steering committee and working groups. End users (H&S Committee) were involved in both structures to identify problems and suggest solutions in a future situation	Improvement of air-conditioning and cleaning systems, acoustic treatment of walls, cabin and work devices, introduction of lifts and trolleys for handling	France

6.1. Trigger factor

For a large proportion of the cases (22 cases - 58%), the factor that triggered the intervention was the need to reduce musculoskeletal disorders or make other types of ergonomics improvements. For the remainder of the cases the trigger factors were accidents, safety problems, other health problems or a combination of these. One case, which was an exception, was the KAMU project in Finland, for which the trigger factor was to increase productivity and improve work conditions. However, increasing the quality of the product or the effectiveness of the production method were included as additional initial goals in a few cases. Considering the trigger factors for the case studies it is notable that the majority were reactive, responding to problems that had been identified either through reports of mus-

culoskeletal discomfort or following accidents. For a much smaller number of cases the redesign of work equipment provided an opportunity to evaluate the existing design and seek to minimise problems with future equipment. Such cases may therefore be regarded as more proactive in nature.

6.2. The Participatory Ergonomics Framework (PEF)

To further review the case studies, the dimensions of the PEF (Haines *et al.*, 2002) have been used. There is little in the literature to provide a framework for the structured evaluation of participatory case studies other than the PEF. This may in part be due to the fact that participatory ergonomics is a relatively new field, with significant interest in the area developing over the past fifteen years. It is important to note that this framework is still being developed but this wide ranging collection of case studies provides an opportunity to use it, to consider how well it is able to categorise the projects and to identify areas which may require further development. One of the problems with the PEF is that the categorisation of a case study in each of the different factors may vary depending upon the perspective taken. In this project we have considered, in particular, the participation of end users. Therefore when considering the case studies collected for the project, the focus has been on the participation of end users within the participatory group. There may also be a number of different participatory groups working within an organisation, and it is suggested by the developers of the framework that each level of group be evaluated separately (Haines *et al.*, 2002). Again in this report we have considered the participatory group in which the end users are participating. The assessment and categorisation of the case studies in this report has been undertaken by the Institute for Occupational Ergonomics based upon the information available in the written reports received from the national authors. The time constraints on the project did not permit each original author, who had the most experience of the case, to be contacted and asked to submit their own evaluation of their projects. This is an area for further work that may be followed up at a later date. The tables report that thirty-eight cases were provided to TUTB-SALTSA for the project; however, the IOE did not have sufficient information on three of these to allow for a case study evaluation using the PEF. Therefore the total number of cases evaluated for this report is thirty-five.

The number of cases assigned to each category is shown in Table 9 below. It is important to note that some categories are exclusive – a case study can only be assigned to one level (for example permanence), whereas for others a number of different categories may be applicable (for example mix of participants). Each of the dimensions will be discussed in the following sections.

At the core of good participatory ergonomics practice is the need to address the context and requirements of the organisation in which the work is being undertaken. It is therefore difficult to be prescriptive about the approach that should be taken and how the various tools and methods should be used. However, participatory ergonomics does require consideration as to how, when, why and where the approach is to be used and what is to be done. The PEF therefore provides a framework of factors that need to be considered and agreed, defined etc. at the outset of a participatory project. Such consideration will ensure that attention is given to the process of participation as well as to the content of the work. A review of the factors and examples illustrating these from the case studies is presented here, to demonstrate how a participatory ergonomics approach may be used in a wide variety of settings.

Table 9: **Evaluation of case studies using the PEF**

Dimension	**Categories**								
Permanence	Ongoing (O) **10**					Temporary (T) **25**			
Involvement	Full direct participation (FDP) **9**			Direct representative participation (DRP) **22**			Delegated participation (DP) **4**		
Level of influence	Group of organisations (GO) **10**		Entire organisation (EO) **8**			Department (D) **10**		Work group / team (WG) **7**	
Decision making	Group delegation (GD) **5**			Group consultation (GC) **24**			Individual consultation (IC) **6**		
Mix of participants	Operators (O) **35**	Line management (LM) **14**	Senior management (SM) **9**	Internal specialist / technical staff (IS) **24**		Union (U) **9**	External adviser (EA) **27**	Supplier / purchaser (SP) **16**	Cross-industry organisation (CIO) **4**
Requirement to participate	Compulsory (C) **4**					Voluntary (V) **35**			
Topics addressed	Physical design / spec of equip., places, tasks (PD) **35**			Design of job teams or work org. (DJ) **2**			Formulation of policies or strategies (FP) **1**		
Brief	Problem identification (PI) **30**	Solution development (SD) **32**	Implementation of change (IC) **14**	Set-up/structure the process (SP) **0**	Monitor / oversee process (MP) **1**				
Role of ergonomics specialist	Initiates and guides process (IP) **9**	Acts as an expert (AE) **21**	Trains participants (TP) **21**	Available for consultation (AC) **3**	Not involved (NI) **12**				

Note : the numbers in bold are the numbers of case studies assigned to that category of each dimension.

6.2.1. Permanence

The majority of cases were temporary projects that were set up for the particular need identified. A small number were seen as part of an ongoing programme within the organisation. These tended to be either large-scale projects with many partners or those occurring within large organisations. Some projects start off as temporary but the approach is found by the organisation to be successful and so continues to be used after the initial focus of the project is completed. In many examples the ergonomist who has worked in the case study has been in the role of an external adviser. They therefore may use the methods and approaches consistently in their practice but this is the first time that it has been applied by the study group in this way.

Example: Case Number 14 - Germany

An example of a temporary project is that of improving the mortar screed preparation machinery. In this case the trigger factor was the high level of reporting of accidents with such machines. The mortar screed is mixed in a pressure vessel and then conveyed to the point of delivery via a transfer line using compressed air. The aggregates making up the mortar (mainly sand and cement) are added to the pressure vessel manually. The mixing shaft is turning while the aggregates are being added to the pressure vessel, as it would not be possible to start the shaft turning once the vessel was full. To comply with machinery safety regulations the machine is designed with a mesh grid, secured in place with screws.

The participatory group comprised representatives of the machine manufacturers, and construction workers. The review of the work activity with the construction workers identified that it was necessary after use to clean out the vessel and the blades using a water spray for which the grid has to be removed (Figure 3, below).

The need to use the tools to remove the grid was found by the operators to be impractical due to the frequency of the task during the day. Therefore the grid was generally removed and access to the machine remained open during the mixing operation. The main cause of accidents was operators reaching into the mixing vessel while the blades were still in operation. The participatory group proposed the use of a built-in switch to

Bau-Berufsgenossenschaft Rheinland und Westfalen

Figure 3: **Removable grid on concrete mixing machine**

stop the mixing shaft when the grid was removed from the top of the machine. This was developed by the manufacturers and is now a part of their design. The improvement has also been incorporated into the draft standard prEN 12001 *Conveying, spraying and distributing machines for concrete and mortar; safety requirements*. This states that "in the case of grid covers which are removed once a day or more often, it shall be ensured that the agitator or the screw elevator is forcibly stopped and is secured against restarting when the grid cover is open".

This case study demonstrates that end users were able to work with machinery manufacturers to develop a solution to a problem that met safety requirements but was also practical in the workplace. There has been good acceptance of the solution by end users and the information gained from the project has been incorporated into the drafting of an industry-specific standard.

Example: Case Number 5 - UK

An example of a permanent participatory group is the one coordinated by a manufacturer of emergency and rescue equipment. Ferno took over a medical equipment manufacturer that had developed a user group forum. Ferno decided to continue to support and host the forum, which meets twice a year. There was further impetus to continue the group with the formation of the Health Services Advisory Committee (HSAC) to investigate the problems associated with musculoskeletal disorders in

the ambulance services. Unison, a trade union which represents many ambulance staff has reported that 74% of all front-line staff who leave the ambulance service retire early on grounds of ill health. Therefore efforts to reduce the manual handling load placed on ambulance staff as they undertake their duties were to be encouraged.

The user group is open to all those working within the ambulance sectors at a managerial level. The forum provides an opportunity for a peer group to meet and discuss issues as well as to review developments in equipment. Equipment developed by the manufacturer is tested in the 'field' by end users, and their comments and evaluations are reported to the manufacturers via the user group forum.

In this case study a cross-organisation partnership of equipment manufacturers, authorities, user companies and end users has been able to achieve improved design of products that are practical but also meet health and safety requirements.

6.2.2. Involvement

The dimension of involvement considers whether people participate directly or indirectly, through a representative who may be elected or selected. The category of direct representative participation is included to recognise that there are many situations where someone is selected to participate as they represent a stakeholder group. They do so, however, largely through their own experience rather than formally representing the views of the stakeholder group.

Most of the cases used direct representative participation. The method by which the person(s) were chosen to participate was not always made clear in the case study reports. In some cases it is known to have been opportunistic (where someone was available at the time) rather than by selection. The Framework does not allocate different categories for how people were chosen to participate and indeed it may be very problematic to do so. This factor may however be important as it may influence the attitudes of the people who participate. A small number of cases involved full direct participation, where all relevant participants are involved. These tended to be very small-scale projects or where workplace teams form the participatory group.

A smaller number of studies used delegated participation, where representatives understand that they need to use not only their own experience but that of colleagues who may be working in different environments. In some of these cases it was the trade union representative who fulfilled this role.

Example: Case Number 27 - UK

A case study in which there was full direct participation is the development of a chair for a hospital plaster room. The problem of accidents and injuries due to manual handling incidents within the health care sector is well reported. In order to address this problem many health care trusts in the UK are appointing manual handling advisors. There are however often conflicts to be resolved between patient care needs and 'best handling practice'. There are also problems identified by the risk assessment process for which there is no immediate solution. The following case study involved a small team of plaster room technicians who worked with the manual handling adviser of the Ipswich Hospital NHS Trust and a manufacturer of medical equipment. The plaster room technicians identified a task during their manual handling training for which a solution was not immediately available. The task was the application of an above elbow plaster (one that extends from above the elbow down to the wrist, possibly extending into the hand). The task required two members of staff, one to apply the plaster and one to support the patient's arm. The plaster takes approximately fifteen minutes to complete. The patient was usually seated on a standard plastic chair, which required the plaster technicians to adopt very stooped postures.

A small team comprising the plaster room technicians and representatives from a local supplier of hospital equipment met to develop ideas to solve the postural problems the technicians experience. An alternative design of chair was considered to be a possible way of reducing the musculoskeletal strain to which the technicians were exposed. The manufacturer discussed the task requirements with the plaster technicians and then developed a prototype. The plaster room technicians then used the prototype for a period of a month. The manual handling adviser facilitated the evaluation, which also involved the patients who are equally users of the chair. The chair has a high degree of adjustability in terms of seat height and angle, and the tables can also be adjusted with respect to height and angle. A number of

recommendations for further improvement were made as a result of the product trial and these were included in the final design. The chair has been found to improve the comfort of both the plaster technicians and patients, and has since been marketed and sold throughout the UK (Figure 4, below).

This case study provides an example where a partnership of equipment manufacturers and end users has led to a design innovation, which has extended in its influence beyond the local area. An outcome of this work has been the development and successful launch of a new product.

IOE

Figure 4: **New design of plaster room chair**

Example: Case Number 19 - Netherlands

A case study which provides a good example of delegated participation is the design of an Off Highway Truck (OHT) cab, which TNO were asked to assist with. The particular focus of the project was the evaluation of a new prototype seat, however other aspects of the cab layout were to be considered. TNO selected a sample population to represent the workforce in terms of gender (15-20% of drivers are female) and of these a majority of the sample were from the high and low percentile ranges for stature and body weight (2, 5-25th and 75-97th) as these were considered to be critical for certain tasks and measurements. A smaller proportion of the sample was from the average range of percentiles for these dimensions. In this case study therefore delegated participation was used but the representatives were selected for particular reasons, such as gender and anthropometry. This approach may also

be used in the category of direct representative participation.

Although the prototype seat was rated the best overall there were a number of factors identified by the sample population for further improvement. Due to the stage of development of the design, some of these could be addressed but many modifications had to wait until the next redesign cycle. The study found a number of discrepancies where practice differed from that anticipated by the developers of the standards relevant to OHTs. For example an increasing number of drivers are female but the data in the standard (ISO 3411, amendment 1, 1989) was based on male populations. The revised standard published in 1999 now provides data which has been derived by combining national data to represent the worldwide operator population, but no further information about the source of the data is available (EN ISO 3411: 1999). The case study involved evaluation of the seat and tasks undertaken by the operators in a workplace setting. Such an assessment was able to provide a lot of useful information about the equipment and the tasks. The authors of the case study concluded that the applicable guidelines and standards might be improved by using a participatory methodology.

This case study combines a traditional ergonomics evaluation with an insight into real work practice experienced by end users. From such an approach very valuable information has been gained, which will enhance the future development of the product and improve the comfort as well as safety of the end users.

6.2.3. Level of influence

This is a factor which may vary for each case study depending upon the point at which the categorisation is done. At the start of the project it may be used to determine the responsibilities and operation of the participatory group and to manage expectations about what may be achieved. Later in the project it may reflect the extent of the project outcomes. In this report the assessment was made upon the extent of influence of the participatory group during the project.

It is not always clear from the reports of the case studies just how much influence the participatory group had, and categorising the case studies was therefore not always straightfor-

ward. At the simplest level there are projects which involve only a particular work team. Examples are the review of the hand held tool developed to carry compressed gas cylinders (Case Number 31), the hospital equipment trolley (Case Number 28) and the crane control room (Case Number 6). However, a number of studies which have been categorised as influencing only a work group may in fact be more influential but the evidence for this was not clear. For example the plaster room chair (Case Number 27): it was reported that this item is now marketed throughout the UK, which suggests that the work of the group has had a wider sphere of influence. The figures given in Table 9 (see p. 49) therefore reflect an understanding of the project at a certain point in time and may change following discussions with the case study providers and if a different perspective is taken. A significant number of cases (18 - 51%) were considered to have been able to influence either an entire organisation (8 - 23%) or a group of organisations (10 - 28%). These tended to be larger projects, particularly those where there were a number of parties involved, some being external to the organisation.

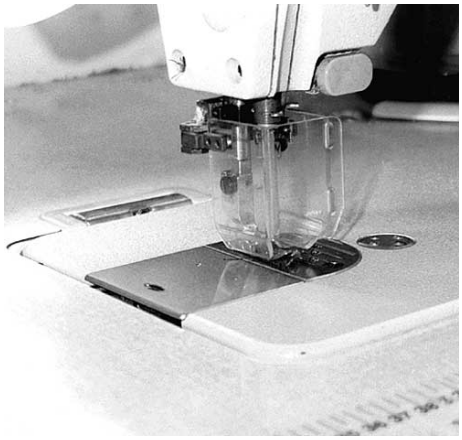
Example: Case Number 4 - UK

An example of a case study that was able to influence a group of organisations started with the partnership of a manufacturing company and a trade union organisation. In 1996 the clothing manufacturer, William Baird, reviewed the costs associated with compensation claims for needle-in-finger injuries during sewing operations. They identified that this was a considerable problem for them and in partnership with the GMB union began an initiative to prevent such accidents occurring. The main focus of the initiative was to develop an improved design of guard for the sewing machines. The traditional wire guards on sewing machines leave a gap, which an operator's finger can get into. As the needle moves downwards this can puncture the skin (requiring first aid treatment) or at worst the needle can become embedded in the bone (requiring surgery to remove it).

A local task force comprising two trade union safety representatives, an engineer, a supervisor and user representatives was established at one factory owned by the company that had a high number of needle-in-finger injuries. The task force was responsible for idea generation and the development of proto-

types. There was a need for new designs of guards to consider task requirements: the guard needed to be efficient for sewing, provide good visual access to the needle during sewing operations but also be easy to access for threading. End users at the site were involved in the evaluation of design prototypes. It took six months to find a design that was both safe and efficient. Following the initial design of a prototype, end users were involved in the evaluation of new designs and able to make suggestions for their improvements. Several later prototypes were developed to meet all the necessary requirements and various types of sewing machines. Other manufacturers with different machines have since modified the guard design to suit their own particular needs.

The new guard design (Figure 5, below) has almost eliminated needle accidents while the machine is in operation. There was a gradual introduction of the guard to all sites once necessary modifications to allow the guard to work on all machines had been made. Within the organisation, the project was found to be a success in terms of communication and co-operation.



GMB

Figure 5: **New design of sewing machine needle guard**

The inclusion of end users ensured that the guard not only protected them but also would be used by them. Finally, later on, changes were made to the relevant European standard EN ISO 10821, which now requires that guards encapsulate the needle. In the past bent wire guards had been considered acceptable but this is no longer the case.

This case study demonstrates the strength of the partnership of a trade union with a manufacturer in bringing about improvements to the design of equipment. In this example 'better design' of the needle guard has led to a reduction in accidents whilst at the same time not interfering with production requirements.

6.2.4. Decision making

Decision making was assessed to be predominately at the level of group consultation in the case studies. This was often because the case study information did not clarify who was involved and at what level decisions could be made. The end user may participate in a group with people of varying managerial levels; however, it was not clear in many cases where the power to make decisions rested. Whilst a degree of group delegation may be indicated, it is difficult to determine whether the decisions are made by individuals or based on the group's recommendations. Examples of 'true' group delegation are few although one example is presented below.

A few studies have used individual consultation; these tended to be those where particular methods were used such as interviews or questionnaires. Case Number 4, described above, used individual consultation.

Example: Case Number 6 - UK

One example where end users were given delegated responsibility is that of the design of the crane control room. The control room is part of a refuse incineration station which burns more than 120,000 tonnes of refuse each year to create superheated steam. The steam is piped to another facility, which contains coal-fired boilers and electricity generating turbines. The steam is then used to drive the turbines and produce electricity for the National Grid system capable of providing power sufficient for over 2000 private dwellings. Two large overhead cranes move refuse around to clear the entry chutes where refuse is delivered and to feed the supply chutes to the incinerators. The cranes are operated by drivers in the control room on the sixth floor of the building along one of its sides. In 1991, an ergonomics assessment of the control room was requested by the trade union health and safety officer, following complaints from operators. A formal ergonomics assessment of the

workplace was undertaken by an ergonomist, which identified a number of issues requiring intervention. In the redesign of the control room, however, as there were so many problems, there was a need to prioritise the interventions due to limited financial resources. A participatory approach was proposed by the ergonomist, as the drivers were sceptical that the assessment would achieve anything and they also could provide useful insight as to the more urgent areas to address. Such an approach was agreed by the site managers and the operators were involved in the prioritisation of work. They were also allocated a certain budget within the financial constraints that they had authority to use. The end users reviewed the workplace assessment with the ergonomists and identified the seat (Figure 6, below) and the controls as being the areas that required the most immediate attention.

The operators took part in design decision groups with the ergonomist as a facilitator to consider alternative seating and control designs. Initially sketches of possible designs were made and then mock-ups were built for further evaluation. The operators also had the opportunity to visit other similar sites to view possible equipment. New seats (Figure 7, below) and control consoles were selected following the design decision group work. However, problems with the suppliers meant that replacing the control units did not happen as planned and 'in-house' solutions were found. These were less desirable in the opinion of the ergonomist but were well liked by the end users. The ergonomist would have preferred a single control unit (to allow use by either hand) with movements to mimic the control of the crane. However, the facilitator withdrew quite early on in the process and this led to some weakness in solution ownership and implementation of changes. It was reported in a later follow-up visit by the ergonomist that the participatory approach had gained the interest and increased the confidence of the operators. Further improvements in the workplace had also taken place after the project had formally ended as additional finances had become available.

This case study demonstrates that participatory methods can be suitable for people who have little design experience. It was also noted that the limited input of the facilitator had an impact on the progress of the project as other members of the group were not clear as to who had responsibility for managing the process. However, although it was a small-scale project

with limited resources, the process was considered to have been beneficial for the confidence of the operators and the acceptance of the solutions implemented.

IOE

Figure 6: **The old seat**

IOE

Figure 7: **The new seat**

6.2.5. Mix of participants

The number of different groups of people (managers, safety advisers etc.) participating in each case study varied between two and seven. A summary of the cases according to the num-

ber of groups involved is given in Table 10 (below). From this it can be seen that the majority of case studies (22 cases - 63%) had 3 or 4 different groups of people participating in the project. In these case studies, because of the focus of the project, all of the cases had end users represented in the participatory group. The larger, more multidisciplinary groups tended to be the larger-scale projects and/or those that influenced a group of organisations.

Table 10: **Number of different groups involved in case studies**

	Number of different groups involved					
	2	3	4	5	6	7
Number of case studies	4	9	13	4	4	1

Example: Case Number 22 - Sweden

An example of a case study in which there was a large number of participating groups is the hand tool project. In Sweden there was a growing awareness among occupational health and safety professionals that poor hand tools were a significant risk factor for the development of musculoskeletal disorders within manufacturing industries. Whilst individual companies recognised some of the problems they had little influence over the tool manufacturers. One manufacturer in particular, Volvo, was keen to improve hand tool design, and when the Swedish Working Life Foundation (SWLF) was created they saw the possibility of gaining financial and research support for their project. A project proposal was developed which brought together six major manufacturing corporations. The first stage was to identify the most frequent problem tools and then to work with tool manufacturers to design ergonomic products to replace them. The proposal received funding from the SWLF and was able to begin. The project design is given in Figure 8 (below).

As part of the project four different groups were formed. These were:

- The tool manufacturers
- The tool dealers
- The end users
- Researchers

Each group had a particular aim(s) in supporting the project,

and the findings from their work were reported to the steering group which made the information available to other groups as appropriate. Due to the time and financial constraints on the project, the focus of the work was agreed by all groups to be non-powered hand tools.

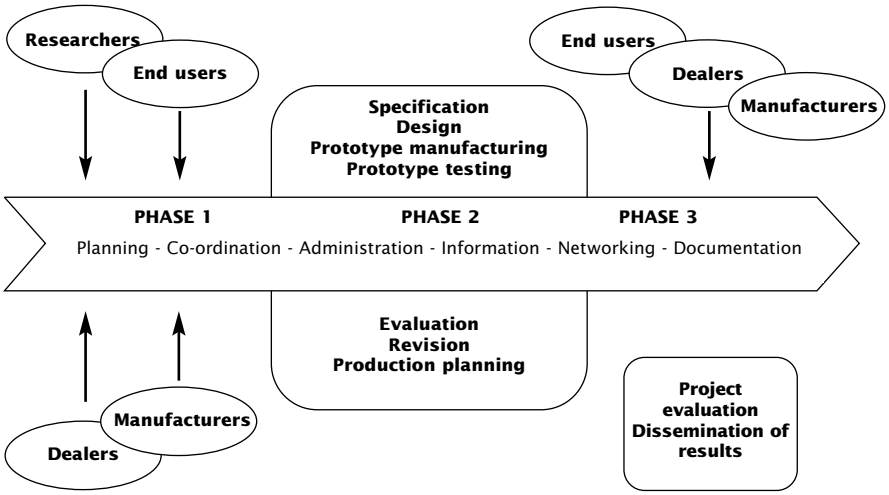


Figure 8: **The Swedish hand tool project**
Adapted from the final report of the project steering group to the Swedish Working Life Foundation (Kardborn, 1995).

The Swedish national report contains information concerning a subsequent project, which looked at powered hand tools. Having undertaken a survey of hand tools with end users, a number of tools were identified for further development. The information provided by the researchers on hand tool design was made available to the manufacturers, as part of a specification dossier for that tool. Prototypes of new designs were tested by a number of experienced end users. A review of the project found that six of the project tools had been made available on the market and four were still at the prototype stage. A high degree of user satisfaction was reported for the new tools and those at the prototype stage, compared with the traditional tools. The participatory approach was found to be useful as it brought together a number of important stakeholders and drew attention to the problem of poor hand tool design. The project also developed a number of useful tools for the testing and evaluation of hand tools.

The external funding available from the SWLF provided an opportunity for user companies to work together with a number of tool manufacturers. The research group established for the project also supported the process, making generic and specific information available to all manufacturers. There were some difficulties experienced in the project with respect to commercial confidentiality and intellectual property rights. However, many benefits were reported, including the provision of valuable information from end users for the design process.

6.2.6. Requirement to participate

In all the case studies the involvement of end users in the participatory process was assessed to be voluntary. However, in some examples there was considered to be a 'compulsory edge'. In one example this was with respect to the organisation and for three case studies it was concerning the participation of the end users.

In the UK approximately 100 paper mills were involved in the PABIAC initiative as a response to serious health and safety concerns within the industry and as a means to introduce improved health and safety measures within the industry (Case Number 32). Therefore it would be difficult for a paper mill not to be a part of the project.

In some industries that use local ergonomics groups, the employee who reports a concern with the workstation etc. will be expected to be involved in the participatory group that is established.

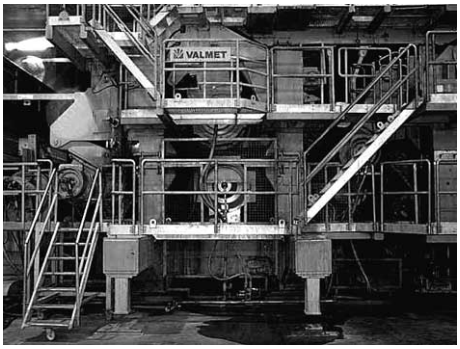
6.2.7. Topics addressed

All of the case studies addressed physical design issues, but a small number indicated that they were also able to effect changes to the work tasks that people undertook. Only one project had the opportunity to influence the policies of organisations and this was the PABIAC initiative within the UK paper mills [Case Number 32). In this project each mill had to agree and implement its own health and safety plan. It is anticipated that in line with health and safety legislation this would have been done in consultation with employees. The end users

were therefore able to influence policy at a local level. It is not clear whether representatives of end users other than the trade union representatives were part of the PABIAC group which would influence policy making at a higher level. The other case studies which eventually led to changes in standards may however also be considered to have influenced policies at a national or international level, but it is not clear that end users were directly involved in this process of change.

Example: Case Number 32 - UK

In 1996 the main trade union representatives on the Paper and Board Industry Advisory Committee (PABIAC) expressed concern over the high rate of fatal and major injuries suffered by their members. The rate of such events was equal to or in excess of that of the construction industry. The initial response of PABIAC was to sponsor fundamental research to investigate the variable accident rates within the industry. The research considered three factors: technological risk, safety management systems and safety culture. Analysis of the data identified that safety culture was the factor of most influence. An initiative to improve safety culture throughout the industry was therefore developed. One hundred paper mills in the UK were involved in this initiative. Each mill was required to develop and implement its own health and safety action plan. The degree of commitment at all levels in the organisation was increased along with the provision of appropriate health and safety training. This initiative required an improved system for workforce participation in the development and implementation of the health and safety action plan. As part of the process, information about the design of paper mill machinery was collected from end users. A number of improvements to the design of paper making machinery were identified during the PABIAC initiative. One example of these improvements is the provision of guards in the wire and dryer sections of the paper making process. A guidance document was provided for the industry, entitled *Making Paper Safely*, which outlined improvements required to existing machines. The findings from this work have since been taken into the committees dealing with the relevant standard - BS EN 1034 *Safety of machinery - Safety requirements for the design and construction of paper-making and finishing machines* (2000).



GPMU

Figure 9: **Paper mill machinery**

As a result of this initiative the number of accidents has fallen over the three-year period of the initiative; the major and fatal accident rate decreased by 26.6% (against a background of increases in production and reductions in employee numbers due to difficult economic circumstances). A further benefit was that the machinery standard was also improved. The PABIAC initiative is ongoing, and further health and safety improvements are anticipated.

Although the primary focus of the initiative was to improve safety culture within the industry, problems with machinery design have been identified, solutions have been tested and as a consequence changes to the relevant industry standard have been proposed.

6.2.8. Brief

The majority of the case studies were targeted at either problem identification or solution development. Few continued to oversee the implementation of change or monitor the progress of the proposed changes. However, this was a difficult category to assign in the same way that decision making was. Many of the case studies did not clearly indicate how involved the participatory group was in the implementation of change. Only one project indicated that it was able to implement change and then had the opportunity to review and monitor the process (the example from the Royal Mail).

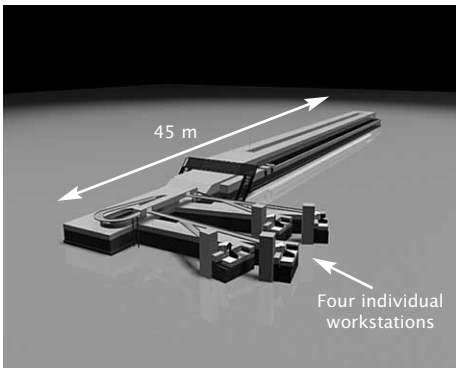
Example: Case Number 17 - UK

The Royal Mail is a public limited company wholly owned by the UK Government, with annual sales in excess of £8 billion UK sterling and more than 220,000 employees. It owns the brands of Royal Mail, Post Office and Parcelforce Worldwide, which provide distribution services in the UK and internationally. The organisation's networks can collect, process and deliver 82 million items to 27 million addresses each day. As part of the ongoing programme of service development a new automated system for sorting A4 flat mail pieces was being purchased.

A working group with a wide representation of stakeholders, from shop floor operators to plant and operational managers as well as the equipment manufacturers, utilised a risk assessment process, facilitated by a senior ergonomist from the organisation. A series of workshops was held. The initial workshop took place at the manufacturer's site so that the equipment could be physically inspected. A number of electrical safety concerns and physical injury risks due to insufficient guarding or interlocks were identified. Therefore a number of changes to the design were agreed with the manufacturer prior to the completion of the design of the equipment, and other modifications have also been made once the equipment has been installed. Further workshops took place at the Royal Mail Technology centre and then at the premises to which the machine had been deployed. Other potential problems were identified by the group, which related to repetitive work and manual handling activities.

As part of the workshops further actions were identified to address these problems, and responsibility for completing actions was assigned to group members. The outcomes of their work were then evaluated at review meetings and new risk control measures and assigned actions were agreed.

A senior ergonomist from the organisation was the facilitator for the group workshops. Recommendations were also made addressing issues such as operator training and the level of human resource required to support the operation of the equipment.



Royal Mail

Figure 10: **Mail sorting equipment as a VR model**

The participatory process was found to be of great benefit on a number of different levels. The process helped to keep the risk identification and control process objective and realistic, supporting both health and safety issues as well as operational requirements. People found the process increased their level of understanding of the implications of introducing the new machinery. The process also improved industrial relations both within the organisation and with the equipment manufacturers. As the project is still ongoing, full evaluation is not possible. However, the process has achieved several of the original objectives, which were to provide a safe working environment, ensure the equipment is safe and fit for purpose, provide an audit trail for relevant authorities and identify key user interface issues.

In this case study a multidisciplinary team was able to take a very proactive approach to the management of health, safety and production risks that may have been introduced with the purchase of new machinery. Such an approach has supported the efficient implementation of new equipment and fostered good industrial relations.

6.2.9. Role of ergonomics specialist

It was not always easy to determine the appropriate category for the role of the ergonomics specialist from the written reports. It appeared that they may have acted in more than one role in many of the case studies: for example, if acting as a facilitator of a group, were they also able to offer an opinion as an expert either at the time or at a later date? The category 'initiates and guides process' was particularly ambiguous as it was

not clear whether this referred to the motivation for the intervention or the participatory approach once the intervention had started. In the evaluation of these case studies it was taken to mean that they guided the participatory process. However, information as to why such an approach was used is also lacking. It may be helpful to know whether a participatory approach was recommended purely because it was compatible with the company culture or whether the ergonomist selected such an approach for specific reasons.

In a third of the case studies there did not appear to be an ergonomist involved. This reflects the discussion on participation in Section 3.2 where it was noted that participatory methods are not solely the domain of the ergonomist. Where an ergonomics specialist was involved, they were predominately assessed to have acted as an expert.

Example: Case Number 35 - France

In the following case study the ergonomist undertook a number of different roles. The work was with a manufacturer of cement roof panels, the production of which was originally based on asbestos. However, health and safety legislation had been introduced which meant that the use of asbestos would be banned from 1 January 1997. The company therefore planned to build a new factory to produce an asbestos-free product. The ergonomist was asked to assist with the project quite late on in the design process, so many design decisions had been made and could not be altered. The ergonomist was asked by the company to assist with the training of the company's employees to help them adapt to the new work methods. The ergonomist planned a training and action programme against a background of strained industrial relationships. They also considered that a training programme may be the only way in which they could indirectly influence the design of equipment going into the factory.

In order to plan future work a review of past activities was undertaken. However, the old work site had been demolished and so workers were asked to reconstruct their tasks. The workers had difficulty verbalising the skills and knowledge concerning their tasks. But a respected foreman began to act out his work and talk through his actions, which encouraged the other workers to do the same. The ergonomist acted as

facilitator for this.

The second stage of the programme was to review a video of the processes undertaken in a factory using similar equipment and processes to that which was being planned for the new factory.

Following these two stages a number of workers were able to visit the factory seen in the video and undertake a more thorough assessment of the equipment and processes. The ergonomist was able to provide ergonomics expertise and advice on design issues at this stage. The workers also collected video data, which was used to report back to those workers who had not been able to go on the visit.

Based upon the findings from these earlier stages of work, a number of concerns with the process and equipment planned for the factory were identified. These were discussed with the designers and production managers of the company. A number of improvements to the equipment and tasks were possible, which eliminated or reduced some of the risks for accidents and injuries identified from the workplace visit.

The ergonomics assistance in this project was requested at a late stage in the project development. This created a number of difficulties, as many of the design decisions had already been made. The ergonomist used a training approach to assist end users to take ownership of the new work arrangements. The training included a review of old work practices, assessment of a reference factory and planning for the new work arrangements. The approach used helped to make available the skill and knowledge of the operators that had previously not been verbalised. However, delays in the building of the new factory (not due to the participatory approach) meant that the company lost its share of the market to its competitors and the factory was subsequently closed.

6.3. Participatory methods used in the case studies

Out of the total number of cases, the vast majority concerned one-off activities and not a systematic collection of user data for machinery design. Ten cases had a structured system to collect data from the end users, or else the participatory system that was established remained for future purposes. Of these ten

examples, the majority had an internal structured system, meaning that it was the practice of the enterprise to involve workers and collect data before purchasing or improving work equipment. This information was rarely diffused to other enterprises or manufacturers. In a review of the cases from product manufacturers, only one (Case Number 5) had the established practice of organising forums for users and collecting data from workplaces when amending its products.

The majority of the case studies did not report the use of formal methods of participation. Fifteen cases did comment on a more formal structure for the use of participatory methods: these were essentially the ones that were reported by researchers or Institutes that have been applying formalised participatory methods as a work practice.

The most commonly reported type of participatory approach was evaluation by experts (usually the ergonomist or safety expert or in some cases a combination of professionals) with the input of end users and other health and safety practitioners. In a significant proportion (approximately 50%) the end users were active members of the design group, able to suggest improvements throughout the design process. For the remaining 50% of the cases, the end users collaborated at one or two of the following stages: problem identification at the beginning of the design process, solution generation during the 'actual work' analysis, in the evaluation of solutions or with prototype testing.

Example: Case Number 12 - UK

An example of where end users were involved throughout the design stages of their workplace is that of a checkout design for a leading UK supermarket - Sainsbury's. The checkout is a key feature of most food retailers and Sainsbury's is no exception. In 1999, the HSE published a report 'Musculoskeletal Disorders in Supermarket Cashiers' which summarised the results of a widespread survey of cashiers and an ergonomics evaluation of current checkout designs. The survey of cashiers found high levels of reporting of musculoskeletal discomfort in the previous twelve months. The design of the checkout and the nature of the work were suggested to be related to the reporting of musculoskeletal symptoms, and recommendations for workplace design were given. Against this background Sainsbury's invited ergonomists from the Robens Centre for Health Ergonomics to

assist them in the redesign of their checkouts. A participatory approach was taken, and in the early stages of the design of the workplace the checkout carcass was drawn with the checkout operator area left completely blank.

The checkout, Checkout 2000, was to be installed in all new large supermarkets and to be retrofitted into the existing larger stores according to a strict time schedule. The work of a checkout operator involves highly repetitive handling of goods, often with significant time pressures imposed by customer demands. The checkout operator is also seen as crucial in establishing and maintaining good customer relations. For many customers this is their only point of contact with the organisation, and staff well-being is recognised as being important to enhance this interaction.

Representatives of the checkout operators were selected from three stores. They included experienced and novice members of the workforce. Females and males were included. Representatives of each part of the engineering process were also part of the team, as were representatives of the organisation's health and safety team, customer relations department and an external ergonomist. An external ergonomist acted as facilitator in the early stages. As the project progressed and following some guidelines, other facilitators from the engineering project team were able to also adopt this role.

Regular meetings were held with end users. The response by end users included comments such as they 'loved' the idea of only having bits of wood to look at and not a finished checkout to 'comment on'. They felt this really showed that they could have some influence on the design. Mock-ups were built after each session and then commented on and tested through simulations at each subsequent meeting. Many changes were required. These were always agreed by all those present. This iterative process was used throughout. Final testing was carried out at a trial store over a period of a few weeks. Minor modifications were made.

It was noticeable that members of the team who were not checkout operators came to increasingly respect the views of those who actually used the equipment, as the project developed. Whilst the focus of the participation was the checkout operators, some evaluation of customers' requirements (also end users) was undertaken. Much of the early work took place

at a 'concept building' belonging to the organisation. This was important as it was away from the shop floor and not located at the company's headquarters either. It was a neutral location that encouraged each contributor to think in an open way and for all ideas to be received equally. As the project developed the participatory process was moved to the checkout manufacturer's offices and the final meetings were held at the store where the in-store trials were being run.

Sainsbury's Supermarkets plc.

Figure 11: **New design of checkout**

The first focus group showed there to be some 50 significant problems identified with the existing design. These related to both customer and staff problems. The richness of this information enabled most of the problems to be identified very quickly. These were then classified as to how easily the problem could be overcome, if possible, in the new design. The types of problems reported for staff included comfort, reach requirements, postural demands (especially the need to twist), cleaning and maintenance difficulties, snagging of clothing on protuberances, inefficient operation and feelings of insecurity.

As a result of the participatory design approach an ergonomically designed work space was developed, including: the provision of sit or stand option, acceptable reach requirements, task analysis leading to improved location of peripherals and technological devices (e.g. scanner, scales, displays), improved customer interface, tested and improved scanner, better chair, a full footrest and a secure 'back to back' checkout design. Many improvements were also made for the customer, notably with regard to packing and ease of communication with checkout operators. In addition, the checkout operators were co-owners of the new design, so feelings of comfort and well-

being increased. The installation of the new checkout is still ongoing. Benefits in terms of reduced reporting of MSDs are anticipated. The design was significantly better than could have been achieved by the design team without the input from end users, and the additional cost of the participatory approach was insignificant.

6.4. Outcomes

The structure of the PEF does not propose a category for outcomes, in particular categorising the measure of success or failure. This aspect of evaluating participatory projects is fraught with difficulties and gives rise to much discussion. Often no measurable outcomes are clearly defined at the outset of a project, against which the progress of the work can be evaluated. In other situations the impact of confounding factors can be significant and prevent reliable conclusions being drawn from the work.

Against this background it was proposed to undertake some evaluation of the outcomes of the case studies collected for this project. The focus for the collection of case studies was on changes to international standards, changes to machinery or equipment design, changes to personal protective equipment and improvements for employee health and safety. The latter often involved improvements to the layout of the workplace. The case studies have been reviewed by the IOE and TUTB; outcomes of the projects have been proposed on the basis of the reports, and these are summarised in Tables 4 to 8 (see pp. 41-46).

Independent of the trigger factor for the cases, a variety of improvements were made concerning ergonomics, safety and other health hazards. For example, in the cases where ergonomics was the trigger, often indirect improvements to safety have also been achieved (e.g. by increasing the visibility in a truck or improving the visual tasks in a control room, safety hazards have been reduced). Similarly for cases where safety and an increased level of accidents was the trigger, not only were safety improvements made but also ergonomics ones, thus increasing the acceptance of a product (this was particularly so for the cases involving changes to personal protective equipment).

In **all** the cases, the involvement of end users was reported to have brought concrete improvements to the existing design of the equipment. These improvements concerned the ergonomics of seats, cabins and controls, introduction of handling mechanisms attached to machinery, new tool handles, machine guards, reduction of noise, new safety devices, ergonomic properties and the protective function of PPE etc.

The outcomes from the case studies have been summarised in the following table. The total number of outcomes in the table is greater than the total number of cases as some have had more than one outcome; for example in Case Number 32, changes were made to the guarding of machinery, changes in an international standard and changes to safety culture within each organisation and the industry.

Table 11: **Summary of outcomes from the case studies**

Outcome	**Number of cases**
Changes to equipment and/or workplace	26
Changes to machine guarding	4
Changes to personal protective equipment	5
Changes leading to new product development	4
Changes to international standards	5 (+1)
Changes to safety culture	1

From Table 11 it can be seen that, of the total number of cases, five cases, with a potential of a sixth in the near future, have influenced the standardisation process (13%) and introduced improvements into the relevant technical standards. These cases are as follows:

- The sewing machine needle guard (Case Number 4)
- The concrete mixer guard (Case Number 14)
- Improvement of PPC for slaughterhouse workers (Case Number 20)
- Improvement of efficient PPE for abrasive blasting operations (Case Number 25)
- The paper mill safety initiative (Case Number 32)
- The flour mill project (Case Number 11) - possible changes in progress

A few of the cases (about 10%) found some inconsistencies with existing standards but they did not proceed further in their improvement.

A number of cases made an *a posteriori* evaluation of the impact on health and safety issues (reduction of complaints, accidents etc.) and on equipment design; the evaluations were found to have brought about a number of benefits.

In considering the outcomes there is often a question as to how successful a project was. In considering this issue a further question is then raised: 'success from whose perspective?'. Whilst the organisation may not report significant improvements, the people involved in the participatory project may report subjective findings about new skills gained, feelings of involvement and improved job satisfaction. An example of this is Case Number 35. The company responded late to changes in the manufacture of its product (cement roof panels that prior to January 1997 contained asbestos fibre). A participatory approach was used by the ergonomist who also became involved late on in the design process of a new factory. The employees gained new skills from the approach, visiting other sites, developing solutions to problems, working as a team. However, the original delay meant that the company lost its share of the market and subsequently closed. The following section will consider the success factors for the use of a participatory approach that have been identified from the projects and how these may be used to provide appropriate guidance for those considering using a participatory ergonomics approach. However, they do not necessarily guarantee success for the company, as this is dependent upon a multitude of other factors.

Section 7
Lessons from case studies

Beneficial outcomes from the individual case studies have already been highlighted in Tables 4 to 8 (see pp. 41-46) and summarised in the categories presented in Table 11 (see p. 74). In the following discussion we generalise to consider what factors support the use of a participatory ergonomics approach within an organisation.

Two key questions which can help establish whether a participatory approach is appropriate for a particular project or programme are:

1. **What** is the purpose of the project? and
2. **Why** would a participatory approach be used?

In the case studies reported in this project the driving force was often a need identified within an organisation such as to reduce musculoskeletal sickness absence, or because a new production process is being introduced. Occasionally the driving force came from outside the organisation, such as the PABIAC initiative in the UK and the work led by the Institution for Statutory Accident Insurance and Prevention in the building industry in Germany.

The reasons why a participatory approach might be used tended to be either that the approach was consistent with the attributes and philosophy of the organisation or because it was the preferred method of an ergonomics or other specialist working with the organisation. Such projects can work well if there is commitment to the approach from the decision makers within an organisation, and can even work well with limited commitment as long as the project is tailored to the situation and works within the constraints. The following discussion considers the key factors for success in more detail; examples will also illustrate how the projects have had to work within constraints.

7.1. Key factors for success

The key factors for success that were identified and discussed at the workshop held in Brussels in June 2002 have been presented earlier in the report (Table 2, p. 30) but are repeated here for ease of comparison with the other information:

- Commitment
- A champion to support and/or facilitate the process
- A sense of urgency - reason why
- Clear definition of actors and their role - who will be involved
- Structures to support the process - how will the participation be managed
- Appropriate levels of knowledge for all participants
- Previous good experience
- Trade union involvement
- Involve end users in all stages of equipment design
- Preferably involve manufacturers from the beginning of the process
- Keep the project simple - well defined and well targeted
- Keep the client's needs in focus

In a review of participatory ergonomics methods, Haines and Wilson (1998) also identified a number of requirements for the success of a participatory ergonomics approach. These were:

- Appropriate organisational climate
- Appropriate organisational attributes
- Commitment at all levels of the organisation's management
- Resources (time, people, money)

In addition, a review of the case studies presented in Tables 4 to 8 suggests the following success factors:

- Involvement of a 'champion'
- Multidisciplinary groups or partnerships, such as a trade union working closely with a manufacturer
- An existing structured system of work within the company which supports a participatory approach being used
- Sufficient resources to support the process
- Support from top level management

Common themes can be found across these three sets and the headings suggested by Haines and Wilson (1998) provide a structure to collate the proposed factors.

7.1.1. Appropriate organisational climate

There are a number of factors that may be important within an organisation, which will support the use of a participatory approach. Those identified from the workshop and the case studies in the national reports are summarised below:

- Degree of urgency
- Previous good experience
- Trade union involvement
- Good industrial relations
- Top level management support

In Case Number 11 (France), an accident during a routine maintenance operation, that seriously wounded three people at a flour mill, was the trigger for a participatory project, described in the French national report. An investigation into the accident found that the procedure for the operation had complied with health and safety regulations and that the equipment was not faulty. A review of the operation was undertaken by a multidisciplinary team, including end users and representatives from statutory authorities. The input from the end users enabled the team to fully understand the conditions in which the accident occurred and then to develop solutions to improve the system and maintenance procedure. The French Labour Ministry has supported the work and ongoing research is being undertaken to address specific problems identified by the project team. As appropriate such improvements will be taken forward to the relevant standards committees.

Good industrial relationships can be dependent upon many factors: these are both intrinsic and extrinsic to the organisation and it is not possible to consider such a large topic in this report. However, it is suggested that where there are good industrial relations within an organisation this will encourage the involvement of company personnel in multidisciplinary groups. Such involvement has been seen in many case studies to have had a significant bearing on the success of participatory projects. Such multi-disciplinary groups allow a variety of stakeholders and decision makers to come together to problem-solve and implement change. Examples already given in the report are as follows:

- Case Number 4 - the sewing machine guard, which was supported by both the clothing manufacturer and the GMB trade union
- Case Number 11 - the review of an accident in a French flour mill

- Case Number 14 - the improvement of the screed preparation machine guarding
- Case Number 17 - the design review and implementation of mail sorting equipment by the Royal Mail
- Case Number 22 - the Swedish hand tool project
- Case Number 32 - the safety initiative within UK paper mills
- Case Number 35 - the introduction of new processes and equipment into a French roof panel manufacturer

The need for support from top management is not always fully realised at the start of the project, but where this is obtained it can greatly support the participatory approach. This level of support can be linked with good previous experience, as resources may be easier to obtain for a tried and tested approach than one which is unknown. An example described earlier in the report is Case Number 12, the redesign of the supermarket checkout. A participatory approach had been used previously for other aspects of a design review; senior managers were willing to adopt this approach for the redesign of the checkout project and in so doing made resources available for the process.

7.1.2. Appropriate organisational attributes

The organisational attributes are closely linked to organisational climate, as one will influence the other. Indeed there may be discussion as to whether the factors have been appropriately allocated within these headings. With this in mind, the factors identified from the workshop and the case studies which concern the attributes of an organisation are:

- Structured systems of work which support participation
- Appropriate levels of knowledge for all participants
- Involvement in multidisciplinary groups

In some case studies reported by this project the use of a participatory approach was part of a structured system: this tended to be the large organisations where the approach was established centrally and transferred out into all company sites. Case Numbers 7, 8 and 9 were all collected from automotive component manufacturers where such a system has been introduced, either from their parent company or as part of supply chain management by their customer.

The case studies did not specifically mention training of personnel except for Case Number 35, the introduction of new processes and equipment into a French roof panel manufacturer, which took the form of a training and action programme. It is suggested however that in many of the case studies there would be an element of training, either given to the participatory group delegates as part of the project or for personnel who are part of structured groups and fulfil particular roles in their organisations.

Good industrial relationships and involvement in multidisciplinary groups has been considered in the previous section. This is a particular example of which factor comes first. It is suggested that some organisations may become involved in a multidisciplinary group in response to a national or sectoral initiative but through this involvement find an improvement in industrial relations. Certainly the use of participatory approaches in an organisation can be a stimulus to improved industrial relations if managed well. An example of this is Case Number 6, the redesign of the crane control room, although it is on a small scale. One of the outcomes of this project was improved communication and relationships between the operators and their manager. On a larger scale, improved industrial relations were also noted as a result of the participatory approach used in the design review and implementation of mail sorting equipment by the Royal Mail, Case Number 17.

7.1.3. Commitment at all levels of the organisation's management

One of the requirements suggested by Haines and Wilson (1998) is commitment at all levels of the organisation's management, particularly top level management. Other key factors are suggested here:

- A champion to support and or facilitate the process
- Keep the project simple - well defined and well targeted

The need for a 'champion' to support an ergonomics programme, particularly where participatory methods are being used, was discussed at the workshop in June 2002 and was also identified from a review of the case studies. The two factors, commitment at all levels and the need for a champion, are closely linked. It may not be possible - at the start of an ergonomics programme - to achieve support from all levels of management,

but with a champion in place an increasing level of influence on management may be gained. The level of support can also be influenced by the purpose of the ergonomics participatory programme and how importantly this purpose is perceived by people within an organisation.

In Case Number 15, the Institution for Statutory Insurance and Prevention in the Building Trade in part of Germany undertook a participatory project in order to reduce the number of accidents reported by operators working in the glazing trade. There were two aspects of the project: one was to better inform operators of the need to use appropriate protective gloves, and the second was to improve glove design for such tasks. The champion in this example was the Insurance Group who saw the need from the high levels of claims but was also in a position to influence both the glaziers' professional groups and manufacturers of protective gloves. They undertook a large trial of protective gloves and asked end users to complete evaluation forms. They also sent out information to glove manufacturers concerning the required suitability and comfort of the gloves. The user information was collected and reported back to the manufacturers, who were able to review and modify their glove designs accordingly. Early evaluation of the new gloves indicates a higher acceptance of the design by end users, and it is anticipated that this will lead to a reduction in the reporting of accidents.

A further example of the importance of a champion is that of Case Number 1, the tanker design review undertaken by a water utility company in the UK. The company asked an external ergonomics specialist to assist it in a programme to reduce work-related musculoskeletal accidents and injuries reported by employees. A review of archive data indicated that tanker drivers were a group reporting high levels of absence due to musculoskeletal disorders. A review of their tasks and equipment was undertaken by the ergonomics specialist.

A team of company personnel was also trained in workplace ergonomics principles and practice to continue the work of assessing tasks from an ergonomics perspective. One of the team was the Transport Manager of the company, whose interest in the field of ergonomics has developed over the time of the ergonomics programme within the company; with the support of the ergonomics specialist a wide variety of company

vehicles has also been reviewed and ergonomics factors have been built into the procurement process. The transport manager has become an ergonomics champion within the organisation and is using their new skills within their area of influence. Without the interest and enthusiasm of this person many of the improvements would not have been possible.

IOE

Figure 12: **Example of company tanker**

7.1.4. Resources (time, money, people)

An argument which may be used against the use of participatory approaches is that they require many resources in terms of time, money and input from people. A review of the literature does not provide a clear cost/benefit argument for or against the use of participation, but it is important to recognise that controlled studies in this area of work are very difficult to establish. A number of authors evaluate the benefits of a particular programme, and the benefits may be measured in terms of reduced musculoskeletal accidents/injury/absence or reduced compensation claims. Such a project is therefore a field study rather than a controlled experiment and the results may be affected by a number of confounding factors. Therefore the benefits gained from using a participatory approach rather than other methods is difficult to demonstrate. However, some of the case studies have reported favourable outcomes to support the use of participatory methods in terms of acceptance and implementation of solutions into a workplace, for example:

- Case Number 13 - the redesign of ambulances and their equipment layout
- Case Number 20 - the redesign of personal protective clothing

for slaughterhouse workers
- Case Number 25 - the redesign of protective clothing for abrasive blasting operations

At the workshop a number of factors concerning resources were identified in the case studies as being of importance for the success of a participatory project:
- Sufficient level of resourcing
- Clear definition of actors and their role - who will be involved
- Involve end users in all stages of equipment design
- Preferably involve manufacturers from the beginning of the process
- Keep the client's needs in focus

The following two examples illustrate how the level of resources in terms of time, money or people can influence the outcomes of a project.

Case Number 34, which took place in Sweden, was established to reduce the number of musculoskeletal disorders that operators using powered hand tools were reporting. As discussed in Section 5, the culture in Sweden supports the use of participatory methods and a follow-on study from the hand tool project described in Section 6.2.5, which involved a number of different stakeholders, was established. There were however considerable time constraints on the project, so the participatory approach had to be tailored and well managed to gather the information and utilise it within the required time scale. The project had a number of components to it. The first of these was to identify problem tools and develop prototypes of alternative designs. End users were asked via a questionnaire to identify problem powered tools. Tool manufacturers were then asked to develop tool prototypes based on the findings from the questionnaire and guidance provided by the research group. Prototype tools were made available for end-user evaluation as appropriate.

Another aspect of the project was to document technical and organisational solutions and develop reference workplaces in industry. A benchmarking exercise allowed over 120 examples of 'best practice' in facilitating work with powered hand tools to be identified and documented in a published report. Within one of the end-user companies participating in the project a 'powered hand tool centre' was established. The purpose of

this was to bridge the gap between end users and those responsible for the procurement of hand tools. The centre provided a range of tools for end users to evaluate whilst also allowing technicians to ensure that the tools met technical requirements. Finally a further six demonstration workplaces were established in participating companies to show how 'best practice' had been implemented.

A further aspect was to make available information to end users and purchasers of hand tools regarding important ergonomic features to look for and consider. A training kit was developed to support this, which consisted of equipment to measure hand size and strength and also equipment for testing various types of tools. A tool evaluation checklist was also made available.

National Institute for Working Life West

Figure 13: **The training kit developed for increasing awareness of the importance of hand ergonomics in end users**
A number of hand tools are contained in the box. On the table: measurement devices for hand anthropometrics, hand force, tool torque, and an instruction manual.

An evaluation of the project found that a number of prototype tools were developed, the ‘powered tool centre’ was established and the six reference workplaces made available. The educational resources were also developed and made available to relevant industries. However the timescale of the project meant that the dissemination of information was curtailed, and in the evaluation it was found that many people did not know anything about the project and the resources available. The project would have benefited from additional resources to enable the communication of the results to a wider audience.

Case Number 20 shows how resource support from the Finnish government through the Finnish Institute for Occupational Health (FIOH) enabled a comprehensive participatory ergonomics research programme to be undertaken to develop improved personal protective clothing (PPC) for slaughterhouse workers. Such a comprehensive programme may not have been possible without this support, in particular the use of a number of physiological research tools and a thermal mannequin. A multidisciplinary team worked on the project, which included occupational hygienists, work and clothing physiologists, ergonomists, designers, manufacturers and end users. The level of accidents and occupational disease reported by workers in this field of work was one of the highest in Finland.

The project started with a risk assessment of the tasks of workers in slaughterhouses, a review of the literature on current guidance, interviews with a number of end users to understand their requirements and evaluations of the working conditions and work demands.

From this initial review a number of problems with existing PPC were identified, in particular due to the conditions of the working environment. Requirements for alternative designs of clothing were drawn up and prototype sets of clothing were developed. These were tested 'in the field' by end users and some physiological data measurements were collected as well as the end user evaluations. Furthermore, detailed physiological trials were also undertaken which collected a wide range of data to aid the design process.

On the basis of these tests, further sets of prototype clothing were developed and tested by end users for a period of three months. At the end of the trial it was reported that the end users found the new systems warmer and more protective against dirt and moisture than the previous clothing. The maintenance of the new clothing was also acceptable and did not reduce its protective element. A final commercial design of PPC was then made available throughout Finland and is now commonly used in many slaughterhouses. The findings of the project were used directly in the CEN standards development for protective gloves and aprons for slaughterhouse workers.

Many of the case studies provided little detail about the specific method that was used, so discussion and examples from the

cases about how roles were defined within the participatory groups, how the groups were led and decisions were made, is not fully possible. Case Number 17, the design review and implementation of mail sorting equipment by the Royal Mail does however indicate that responsibilities were assigned to individual team members for specific actions and that these were reviewed at subsequent meetings. Also in Case Number 22, four groups of stakeholders were defined and each group had a particular function to support the project. The findings from their work was then reported to the steering group and made available to other groups as appropriate.

One case study which illustrates the importance of involving manufacturers early in the project is Case Number 29. This case concerned the design of a new system to assist in the loading and unloading of freight from aircraft. From the report it would seem that the need to increase the speed with which freight can be handled, but also to reduce the number of manual handling injuries reported by operators, was identified by the ground services operators. Ergonomists from TNO, a Dutch research institute, were asked to assist in the design of a new system. End users were involved in laboratory tests and evaluation of mock-ups of alternative designs, and an improved design was developed. However, at the time that the case study was reported the system was not available commercially as the manufacturer had not agreed to put it into production. It was suggested that earlier involvement of the manufacturers in the project might have reduced this delay.

7.2. Summary of lessons learnt from the cases

Reviewing all the different success factors it is hard to single out the one which is the most important. It is suggested that this will depend upon the scale of a project and the context in which the project takes place. However, the focus of this project has been instances where end users have been part of a participatory approach that has led to improvements in machinery design and/or international standards. From this perspective it would appear from the case studies that the key factor for success is the partnerships of a number of different stakeholders. In particular, the partnerships of trade unions working together with manufacturers and research groups have been able to influence the standards process and introduce changes to relevant technical stan-

dards. Other multidisciplinary groups were also successful in influencing the design of products.

It is demonstrated in the case studies that end users have considerable tacit knowledge of the processes and equipment with which they interact. Some of the case studies used methods which allowed this useful information to be more formally recognised and used within the participatory process. The richness of information gathered from end users supports good design solutions and their implementation. A variety of methods can be used and different strategies can be appropriate at different stages.

Section 8
Discussion of the PEF

The Participatory Ergonomics Framework (PEF), see Section 6.2, can help with trying to classify the variety of participatory projects but there are still some categories which are hard to define – such as decision making and brief. Some of the difficulties with the categories are noted in the practical use of the Framework reported by Haines *et al.* (2002). Key issues appear to be the need to clarify at what point in time the classification takes place (at the outset or later in the life cycle of the project) and from whose or what perspective (whether the evaluation is being taken as in this report from the end-user perspective, or perhaps from that of the senior manager). The nature of participatory projects appears to be that they evolve during their life cycle, often having to change and adapt to external factors. Therefore the PEF may be used to review the participatory project at a number of different points in its history. It would also seem that some of the terms require further clarification.

A further category in the factor 'mix of participants' is also proposed, namely that of designer / manufacturer. It was found during the review of the case studies for this report that the term supplier / manufacturer may not fully represent all the stakeholder issues and that the additional group designer / manufacturer may be beneficial.

The PEF does not consider the methods which the participatory groups may have used, but as the case studies have shown, there is often little reporting of the methods or else the approach did not use formal methods.

A further consideration is that the PEF does not provide the dimension of ‘outcome’ by which the effect of the project may be evaluated and categorised. Again such a category would be a challenge. Many of the cases found in this research project have been undertaken by external consultants and they may not be involved with the project long enough to undertake any review of the changes implemented. Also some of the project

aims can be very general, for example to reduce musculoskeletal injuries, but the baseline data are weak so that pre- and post-project reviews are not reliable evidence of the outcomes of the project. As some of the case studies indicated, other factors may also influence the success of the project, such as management changes, interest of manufacturers and adverse changes in the economic climate.

Section 9
Summary of the case studies

The research project reported here has collected details of thirty-eight case studies that used a participatory approach to the design of work equipment or workplace. The cases have been drawn from seven European countries (UK, France, Germany, Sweden, Netherlands, Finland and Portugal). A review of the literature was undertaken and the use of participatory methods was also reported in use in Denmark (Nygaard *et al.*, 1997) and Greece (Nathanael & Marmaras, 2000). However, the lack of reports of participatory ergonomics cases from other European countries is not evidence of a lack of such work taking place there. A considerable proportion of the thirty-eight cases found (approximately 26 cases - 68%) did not appear to have been published in the ergonomics literature or other scientific journals, but were found through contacts within the fields of occupational health, safety and ergonomics. It is suggested, then, that participatory methods may be used by a number of different professional groups in a number of different countries, but are frequently not reported in the scientific journals.

Of the thirty-eight cases, twenty-four were relevant to the Machinery and Personal Protective Equipment Directives. The cases covered by the Machinery Directive ranged from simple hand held tools to large printing machinery. A number of cases reported in the literature concerning workplace design were focused on the participatory approach used and on the effects on the musculoskeletal health of subjects, rather than describing changes to equipment or the workplace and evaluating the impact of the project in terms of equipment or workplace design. The difficulties experienced when collecting the case studies have already been discussed earlier in the report in Section 5.

Reports of changes to standards as a result of the case studies was much harder to find generally or in the case studies reported by national authors. Those case studies able to make a difference to standards were those that involved a large number

of different participants (authorities, organisations, trade unions, researchers etc.). In such cases, some of the participants were also existing members of standards committees or had links with representatives on such committees. Following a brief review of the standards process and subsequent discussions with those who have been involved in standards committees, it is apparent that the standards process is complex and confusing. The ability of researchers and or organisations to influence the standards process therefore depends upon an initial awareness and understanding of the process, resources in terms of time and finance to attend committees and the ability to gain support from other committee members to support any proposals. These factors can present considerable hurdles to individuals and organisations, and may indicate why so few cases were found where the outcome of participatory projects has influenced new or existing standards.

As for the cases that were able to influence the standards process, it appears that this came as an additional element of the project, once the outcomes of the project became clear, rather than as an initial aim. However, the project aims of improving safety and reducing accidents and injuries indicated that the existing standards, if they were being met by the existing machinery or personal protective clothing, were limited and that further improvements were necessary.

Section 10
Future research

It is evident from the work carried out during this project that the participation of end users should be regarded as vital in the design of work equipment and workplaces (both for quality of content and also acceptance of solutions) and that such projects have a potentially important role to play in the standardisation process. It is also apparent, however, that there are many questions about how participation is used and how the outcomes of participatory projects can be evaluated. We do not want to know just that user participation in equipment design, workplace design and even in standards production appears to have been successful; we need to know how and why it was successful, and what aspects of the process were the most important in order that these could be repeated in the future. Moreover we need to address this not just at the micro level of the particular case or study, but also more structurally at industry, trade union, societal and international levels.

The work carried out to produce the report, and particularly the contact with participation experts and clients across Europe as well as the workshop held in June 2002, has enabled a number of potential research projects to be identified. These are outlined below.

10.1. Potential research projects - process of participation

- A deep examination of the cultural influences – national, organisational, industrial, historical etc. – on the readiness for participatory processes and on the success of their outcomes.

- A study of a number of different cases, both set up for the purpose of the research and also tracking those which were running anyway, to examine the real gains to be made. The efficiency of the process, the quality of the solution (set against what might have been achieved by consultants or universities in structured quasi-experiments) and the degree of acceptance

of the solution in the real organisation should all be examined.

- The development of guidelines for the use of participatory approaches and consideration of how to promote their use with trade union officials and support staff. Also to train such people in the application of participatory approaches in the workplace.

- Resources to continue to build and develop the network of people who use participatory approaches within their area of work. This will allow the ongoing collection of case studies where such approaches have been used and the development of appropriate guidance to organisations that may wish to use a participatory approach either as a one-off project to address a particular need or to implement it as an attitude or philosophy.

10.2. Potential research projects - methods used for participation

- A study of the participatory session processes to examine what methods are used and whether some appear to be of more value than others. The nature of participatory projects is such that the methods need to be appropriate for the context of the work, and some methods may be easier to adapt than others. It is suggested that whilst this may be undertaken via structured experimentation in somewhat artificial settings the more appropriate route would be by observation of a number of participatory exercises. Amongst the questions to be answered could be the relative value of homogenous versus heterogeneous groups, how initial ideas propagate throughout the sessions, whether there is an optimum number and length of sessions, what types of sessions might be run (in terms of being structured or not and with visual aids or not). There should also be investigations of the deeper content of participatory sessions and whether there are balanced contributions from everyone.

- With the continuing improvements in advanced visualisation technologies, particularly various forms of virtual reality and virtual environments, a study of the use of such tools to support participatory design is suggested. The Institute for Occupational Ergonomics is developing such a proposal as part of the 6th Framework Programme in a consortium currently involving the University of Lund and TNO. Further

partners are being sought for the proposal and the TUTB has been provided with details of the project for its consideration.

- A study to consider the effectiveness of participation when carried out by distributed or virtual groups. This in general will probably not be as successful as co-located groups but may be better than having no participation, and should be examined. Possible tools are web-based forums, collaborative virtual environments or a variety of virtual team information and communication technologies.

- The development, and study of the use, of personal digital assistants and other wearable or mobile technologies to gather use data and user opinions about existing equipment and personal protective devices.

10.3. Potential research projects - process of standardisation

- A structured study of the production of standards with and without participatory processes being involved, perhaps comparing this across three or more European countries.

- A review of the requirement to collect and utilise end-user data as part of the ongoing process of updates to standards for equipment and machinery. There would need to be a link to the work above to provide guidance for those involved in standards production as to how and when this information should be incorporated.

- A review of the format of standards to review whether the end user is able to understand and interpret the information they contain.

- Undertake pilot studies to include end-user perspectives on research undertaken to support the standardisation process and report on the effectiveness of such an approach.

- Consider the introduction of new legislative provisions to enlarge the role of workers representatives in the standardisation process.

Section 11
Conclusions

With reference to the original aims of this project, as presented in Section 1.2 of this report, the following conclusions can be drawn.

The case studies collected by the national authors support the use of participatory ergonomics methods with end-user involvement to better inform the design of work equipment and workplaces. Although various difficulties were reported in a number of case studies when applying participatory methods within organisations that are continually changing or evolving, these did not outweigh the reported benefits in terms of implementation, productivity, and employee health.

The difficulties in reporting case studies and collecting them for publication, as experienced by the national authors, indicate that there is not a simple system available to report such evidence. The cultural differences observed, often in the methods of financing projects (government or private funding), also determined the availability of results in the public domain. The ergonomics and related scientific literature provides a forum for reporting such case studies but many projects are undertaken within commercial organisations which are reluctant or unable to allow the time for such work to be written up and reported within scientific journals. This project has however developed a network of personnel who are interested in the field of participatory ergonomics and/or standards, who may be called upon to participate in future studies or programmes of work. It is appreciated, however, that the network is far from complete and that further extension is required to ensure that it remains up to date and a useful resource. This implies a need for ownership of the network database and resourcing to maintain and develop it. Such issues are not within the remit of this programme.

The workshop, organised within this project in June 2002, identified a number of ways in which end-user information

may be introduced into the standards process. The case studies and the literature review identified a number of cases whereby end-user information had been taken through into the standards process but, as acknowledged at the workshop, this required the commitment of key actors such as trade unions or regulatory authorities. In order to encourage the collection and use of end-user information in the standards process, changes were suggested which required a high level of discussion and action and therefore are beyond the scope of this project. Such issues need to be discussed further.

The Participatory Ergonomics Framework (Haines *et al.*, 2002) was used to evaluate the case studies collected by the national authors. It is appreciated that there are still areas for further development of the Participatory Ergonomics Framework (PEF) and a need for clarification of the categories into which participatory case studies may be allocated. However, the field of participatory ergonomics is broad, varied and therefore difficult to summarise easily. The PEF provides a starting point for the future examination and evaluation of projects using a participatory approach. It also identifies a number of factors which will require attention, should a participatory approach be considered. Although the use of participatory ergonomics methods has been reported for several decades, the application in different cultures and environments has been varied. The provision of guidance for participatory projects is a difficult area to develop; as with most guidance there is a need to balance the provision of generic and specific information. There will be a requirement to produce generic guidance that enables the information to be useful in many different cultures and industries but may not appear to be relevant to a person's area of work. Alternatively, information that is very specific for a particular culture or industry can lead to difficulties for people from other sectors in relating this to their own experience.

Finally a number of areas for future research have been identified which address the process of participation, as well as the methods used in participatory approaches and in the process of standardisation.

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Appendix
Case studies

Contributors

The case studies presented here have been collected from a number of contacts and organisations who have given of their time to make the quality and depth of the report possible. The authors of the report are very grateful for their participation and interest in the project and would like to acknowledge the following individuals and companies, listed in alphabetical order of surname or company name, for all their help.

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Sally Williams - Health and Safety Executive

Case No. 1, 2 and 3 - UK

Biosolids tankers – Waste water effluent. Autosampler – Water meter dials

IOE

Figure 1: **Example of a biosolids tanker**

IOE

Figure 2: **Urban waste water sampler units**

IOE

Figure 3: **Example of a water meter *in situ***

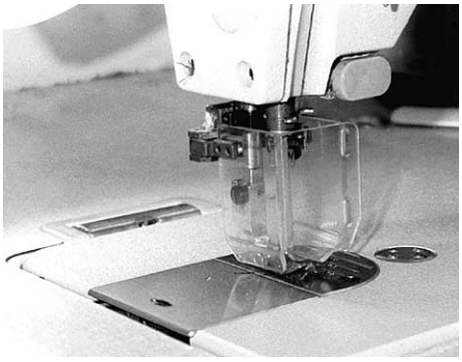
Organisation, type sector, size etc.	Utility service (water and wastewater) company with an operational workforce of 2500 employees, working in departments providing specific services to customers both internal and external.
What triggered off the intervention?	1. Reports of musculoskeletal discomfort due to work activities and sickness absence of employees. 2. Procurement of new equipment presented an opportunity to review the current designs and consider how risk factors for the development of MSDs may be reduced.
What was the initial purpose of the participatory process?	To review the use of equipment by end users and collect their comments as well as to undertake an expert evaluation. The review of existing designs allowed problems with the usability for operators to be identified. The expert evaluation considered how the equipment compared to ergonomics design guidelines.
Was this a one off activity or a structured system of work?	This was a structured system of work as part of the implementation of an ergonomics management programme within the organisation. However the participatory approach was in some departments initially a one-off event. The approach however has since

	been utilised by some departments, without the involvement of the ergonomist, when considering other workplace issues.
Description of machine, work environment involved	1. Biosolids tankers - various sizes of tanker, with pumps to load and unload biosolids. The biosolids are transported from unattended stations to large treatment works for conversion into recycled products for agriculture. The task requires the use of various items of equipment which are stored on the tanker. 2. Waste water autosamplers - these are left at a site for a period of 24 hours to collect samples which are then taken for analysis at a laboratory. Such sample collections are required of the company by the regulatory body (OFWAT) which monitors the level of service provision to customers and sets quality standards for the industry. The unit is just over a metre in height and weighs 25kg when ready for use. The unit is designed to be carried in two halves. The sampling points are at waste water treatment sites and the actual sampling point is not always easily accessible by road / path and can be up several flights of stairs. 3. Water meters - the water meter design complies with the relevant standards BS 5728 and ISO 4064. However in the UK the meters are usually placed below ground level, the depth can vary between 20 and 70cm, to protect the water supply from extreme cold weather conditions. The meters are often located in public footpaths and other awkward environments. To read the meter the operator often has to kneel and stoop to bring their face close to floor level in order to be able to read the digits on the dial.
Number of participants, their jobs and roles	In each case initially the ergonomist reviewed the equipment with an operator, observing their tasks 'in the field' to understand the constraints faced by operators from their working environment. Following the expert evaluation a report was prepared for the appropriate manager. A small group then met representing end users, managers and the ergonomist to discuss the findings from the design review. On subsequent occasions representatives from the equipment manufacturers were also present so that design changes could be discussed with them directly.
Level of influence, team / department / company	1. At department level influencing the selection of new vehicles as well as the review of existing vehicles. Work with the manufacturer has also helped inform their design process. 2. Again within department influencing selection of new equipment but also influencing the equipment manufacturer who has incorporated suggested changes into the future design of their product. 3. Within the department but also influencing manufacturers of the product and manufacturers of associated products.
Description of participatory method	Initial expert evaluation combined with product design review by end users. This identified areas where there were mis-matches between the equipment design and end-user capabilities. Subsequently meetings with manufacturers, end users and experts were arranged to discuss various methods to solve problems that had been identified.
What actually happened?	For each case more than one assessment was undertaken by the ergonomist, to consider different models of tanker / equipment and also the effect of different areas of work on the task, use of equipment etc.

	The level of influence AWS had with each manufacturer depended on the relationship between them and whether AWS was a major client with the manufacturer.
At what stage in design cycle were people involved?	Each case study concerned the review of an existing design but where there was an opportunity to influence future models when replacement tankers / equipment were being considered. Where possible prototypes of equipment were made available for end users to trial.
Where did the activity take place?	Assessments were undertaken out 'in the field'. Subsequent meetings with manufacturers took place : 1. At the manufacturers' premises 2. & 3. At the utility company premises
Design problems identified by end users	1. Inappropriate location of controls / equipment requiring awkward reaches, working postures etc. High levels of force required at awkward working heights. 2. Equipment has to be carried but the design of handles provided on the equipment did not facilitate this. 3. Problems with access and visual access to the meter dial face in order to read the meter.
What improvements were made?	1. Changes to existing models, wherever possible, concerning the location of controls to improve reach distances. Establishing regular servicing of equipment to minimise force requirements and providing a system for end user information to be fed back into the design process for subsequent models. 2. Changes to handle design agreed with manufacturers, and end users proposed an aid to eliminate some need to carry the equipment. The manufacturers were interested in developing such an aid and this is being tested at the moment. Also a reduction in the weight of the battery was recommended and has been implemented. 3. The manufacturer is reviewing whether a lens, which magnifies the meter dial, can be used and they are also considering the provision of a tool to assist the task of meter reading.
Any opportunities to further evaluate the proposed changes?	1. Design of tanker equipment reviewed as an ongoing process now with end user requirements in mind as well as operational requirements. End users feed comments back to managers as appropriate regarding vehicle design issues. 2. The lighter weight batteries are reliable in the field and have proved beneficial in reducing the manual handling load on the end users. The aid to improve transportation of the unit has been developed and is currently under review. Early results suggest that the aid is usable and robust. 3. This case study is at the early stages of problem solving but further evaluation by end users is anticipated.
General H & S improvements after changes?	The ergonomics intervention is part of a wider strategy to improve health and safety of employees. The strategy includes early referral to occupational health advice, physiotherapy and a programme of rehabilitation to enable employees to return to work. Reductions in long term sickness absence have been seen.
Any wider implications for the organisation?	An increased awareness in many departments within the organisation of need to take an ergonomic approach has been achieved. End users are encouraged to be part of the problem solving process. The department responsible for the procurement of equipment and services is now aware of the need to consider ergonomics issues in their selection process.

General case study evaluation	The implementation of the ergonomics management programme is ongoing. Reorganisation within the industry has hampered some progress and continues to give rise to problems with project evaluations due to changes and confounding factors.

Case No. 4 - UK
Sewing machine guard



GMB

Figure 4: **New design of sewing needle guard**

Organisation, type sector, size etc.	Clothing manufacturer making branded products for women and a trade union organisation, the GMB.
What triggered off the intervention?	A review of the costs of compensation claims which identified considerable cost and loss of working time due to needle-in-finger injuries during sewing operations for the company.
What was the initial purpose of the participatory process?	To plan an initiative to prevent this type of injury. The redesign of the existing guard was the focus for this initiative. It was recognised that the new guard design had to be practical, with respect to production demands, as well as effective.
Was this a one off activity or a structured system of work?	A one off activity.
Description of machine, work environment involved	Sewing machine - in particular improvements to the design of the needle guard. The traditional wire guards on sewing machines leave a gap which an operator's finger can get into. As the needle moves downwards this can puncture the skin (requiring first aid treatment) or at worst the needle can become embedded in the bone (requiring surgery to remove it).
Number of participants, their jobs / roles	A local task force comprising: 2 trade union safety representatives, an engineer, a supervisor and user representatives was established at one factory owned by the company that had a high number of

	needle-in-finger injuries.
Level of influence, team / department / company	Initially they influenced the type of guard used at their manufacturing site. With further development, the new design was then introduced at all sites owned by the company. With support of a local engineering company the design was then modified to be suitable for a wide range of sewing machines and became available throughout the industry. William Baird challenged the existing guarding standard which had been in place since approximately 1918. Eventually with the support of the GMB changes to the European standard (EN ISO 10821) for sewing machines were introduced.
Description of participatory method, was there a facilitator involved?	A team leader was appointed within the group to manage the project.
What actually happened - did things go according to plan?	End users were involved in the evaluation of design prototypes. It took 6 months to find a design that was both safe and efficient.
At what stage in design cycle were people involved?	Following the initial design of a prototype, end users were involved in the evaluation of new designs and able to make suggestions for their improvements.
Where did the activity take place?	At one manufacturing site owned by the company.
Design problems identified by end users	There was a need for the guard to be efficient for sewing, provide good visual access to the needle during sewing operations but also be easy to access for threading.
What improvements were made?	Several later prototypes were developed to meet all the necessary requirements and various types of sewing machines.
Any opportunities to further evaluate the proposed changes?	Other manufacturers with different machines have modified the guard design to suit their own particular needs.
General H & S improvements after changes?	The new guard design almost eliminated needle accidents while the machine was in operation.
Any wider implications for the organisation?	There was a gradual introduction of the guard to all sites once necessary modifications to allow the guard to work on all machines had been made. Within the organisation the project was found to be a success for communication and co-operation. The inclusion of end users ensured that the guard not only protected them but would be used by them. Also later on, changes were made to the relevant European standard EN ISO 10821, which now requires that guards encapsulate the needle. In the past bent wire guards had been considered acceptable but this is no longer the case.
General case study evaluation. Beneficial process or not?	The initiative was considered to be a success as there was a reduction in needle accidents particularly while machine was in operation. The work also led to the incorporation of new design criteria developed as part of the initiative into a revised European standard.

Case No. 5 - UK
Ambulance carry chair and stretcher trolley

Ferno

Figure 5: **The Falcon stretcher trolley**

Ferno

Figure 6: **The Sirocco carry chair**

Organisation, type sector, size etc.	Emergency, rescue and healthcare equipment manufacturer - market leader within the UK
What triggered off the intervention?	The take over of a medical equipment manufacturer that had developed a user group forum. The new organisation has continued to support and host the user group forum. Meetings are arranged twice a year. The work of the HSAC has also provided further impetus for the group.
What was the initial purpose of the participatory process?	To provide a forum for end users to meet, comment on current designs of equipment and review new prototypes. This has benefited both the end users and the organisation.
Was this a one off activity or a	This has been an established system for many years. The company also attends the annual trade exhibitions and gains considerable

structured system of work?	feedback from end users' representatives at such an event.
Description of machine, work environment involved	Two items of equipment that have been reviewed and developed with end user involvement are lift assisted stretcher trolleys and carry chairs.
Number of participants, their jobs / roles	All health and safety managers of UK ambulance trusts are invited to attend the user group meetings. Numbers attending vary between 20 and 30 people.
Level of influence, team / department / company	At the group meetings end user issues with equipment design are considered and where possible designed into new equipment developments. Information from the manufacturer on EU standards development etc. is taken back to the ambulance trusts.
Description of participatory method, was there a facilitator involved?	The manufacturer acts as host and facilitator.
What actually happened - did things go according to plan?	The original plan for the user group was for the 'users' to lead the planning and running of the group. Due to work demands and ongoing changes in the organisation of the health care sector, this has not happened. The lead contact from the equipment manufacturer has therefore taken a more direct role in the organisation and planning of the group meetings.
At what stage in design cycle were people involved?	From idea generation to review of prototypes as well as evaluation of current designs.
Where did the activity take place?	At the headquarters of the manufacturer.
Design problems identified by end users	Both manufacturer and end users were aware of the high rates of manual handling injuries reported by ambulance personnel, which have been associated with the use of these items of equipment. A particular concern is the handling of the equipment and pateint in and out of the vehicle and within the patient's home. New designs of equipment were sought to eliminate or reduce the risks of manual handling injuries and accidents.
What improvements were made?	Mechanical and hydraulic technologies have been utilised to reduce the physical force required of ambulance staff when using the equipment. End user reviews of design prototypes have further improved the design.
Any opportunities to further evaluate the proposed changes?	Working prototypes are then made available for field trials and end users complete standardised evaluation forms. Information from these forms is analysed by the manufacturer and acted upon as appropriate.
General H & S improvements after changes?	The new equipment became available for ambulance crews during mid 2000. A reduction in the level of manual handling accidents and injuries associated with such equipment has already become evident.
Any wider implications for the organisation?	Feedback from end users via the group forum informs the future equipment development plans for the manufacturer. The manufacturer is involved with European standards committees as

	appropriate. There are a number of different requirements covered by standards and changes to some concerned with crash safety have had an impact on operability.
General case study evaluation. Beneficial process or not?	Both end users and the manufacturers find the forum and the process beneficial.

Case No. 6 - UK
Crane driver seat and control unit

IOE

Figure 7: **Old design of seat and placement of controls**

IOE

Figure 8: **New design of chair and placement of controls**

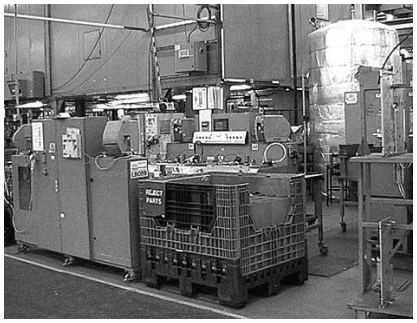
Organisation, type sector, size etc.	Refuse Incinerator plant, in the early 1990s this was part of the public sector but is now owned by a multinational company.
What triggered off the intervention?	Input from trade union health and safety officer following reports of discomfort from the operators.

What was the initial purpose of the participatory process?	Improve workplace conditions with limited resources.
Was this a one off activity or a structured system of work?	One off initially but end user participation continued for some time after the project.
Description of machine, work environment involved	Control room for silo cranes used to move refuse. The cranes were moved by the operator controlling two joysticks with spring-loaded deadman's handles which required constant pressure to use. The system is operational 24 hours a day, 7 days a week.
Number of participants, their jobs / roles	All five end users, trade union representative, the local site manager and an ergonomist from the University of Nottingham.
Level of influence, team / department / company	The end users were able to influence the design of their control room, including prioritisation of action and how to allocate available resources.
Description of participatory method, was there a facilitator involved?	End users were involved in design decision groups with the ergonomist as a facilitator. Initially sketches of possible designs were made and then mock-ups were built for further evaluation. End users also had the opportunity to visit other similar sites to view possible equipment.
What actually happened - did things go according to plan?	New seats and control consoles were selected following the design decision group work. However problems with the suppliers meant that replacing the control units did not happen as planned and 'in-house' solutions were made. These were less than desirable in the opinion of the 'expert' but were well liked by the end users. The ergonomist would have preferred a single control unit (to allow use by either hand) with movements to mimic the control of the crane. However the facilitator withdrew quite early on in the process and this led to some weakness in solution ownership and implementation of changes.
At what stage in design cycle were people involved?	'Expert' assessment initially and then end users were involved in the problem solving process.
Where did the activity take place?	Both at the site and in a laboratory of the University of Nottingham.
Design problems identified by end users	Problems with the design of the seat and controls, the working environment, particularly the impact on the visual components of the task were identified.
What improvements were made?	Alternative seat designs and modifications to the control console design, changes to the lighting levels and working environment were trialed.
Any opportunities to further evaluate the proposed changes?	Ongoing evaluation has been undertaken by the end users throughout the process although this was an informal rather than a formal process. The ergonomist undertook a follow up visit to review the changes that had been implemented.
General H & S improvements after changes?	There was a reduction in the reporting of work related musculoskeletal discomfort.

Any wider implications for the organisation?	The investigation has led to an ongoing process of involving end users in the process of solving workplace problems.
General case study evaluation. Beneficial process or not?	Improvements in workplace conditions for users were achieved although some changes were less than desirable. The interest and confidence of end users improved and the participatory process continued to allow further improvements to the workplace.

Case No. 7 - UK

New workplace layout design and improvements to individual workstations



IOE

Figure 9: **Intercooler assembly cell**

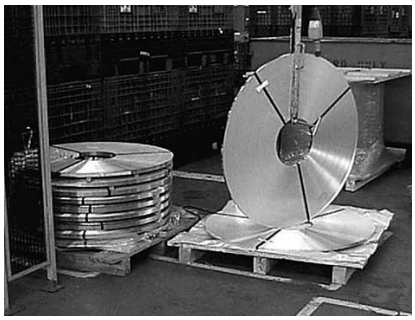


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Figure 10: **Lifting coils of radiator fin cover material**

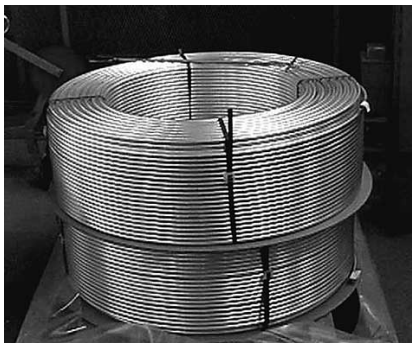

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Figure 11a: **Steel tubing as delivered by supplier**

IOE

Figure 11b: **Aid designed to lift steel tuning coils**

IOE

Figure 12: **Shot blasting machine**

Organisation, type sector, size etc.	An automotive component manufacturer which is part of a multinational organisation. The examples are from one site employing approximately 500 people.
What triggered off the intervention?	Reports of safety / ergonomics problems may be made to the Safety Engineer, Occupational Health staff or raised at weekly production meetings.
What was the initial purpose of the participatory process?	To reduce injuries and absence due to workplace problems and to support implementation of control measures.
Was this a one off activity or a structured system of work?	Part of a structured approach. The organisation was previously part of a multinational automotive manufacturing corporation which had established systems for reporting workplace concerns and a structured approach to their investigating and implementation of changes. The component manufacturing company is now separate from the parent organisation but is continuing with the structured approach.
Description of machine, work environment involved	1. Intercooler assembly cell. 2. Coil lifting tasks – a) fin cover material; b) steel tubing. 3. Shot blasting machine – to clean flux from radiator/condenser core frames.
Number of participants, their jobs / roles	For each project a small team of people is formed comprising representatives from the operators, the trade union, safety department, engineering department and occupational health. For example 1, all operators from the cell were involved in the team.
Level of influence, team / department / company	Each project team has responsibility for identifying and implementing solutions to the problems identified in that work area in partnership with the end users. The information gained from the project can be input into a company wide database for other sites to view.
Description of participatory method, was there a facilitator involved?	Team set up during ergonomics committee meetings. A committee member is assigned responsibility for project.
What actually happened - did	1. All operators in the cell were asked to assist in the redesign of their work area to improve the process flow and the layout to

things go according to plan?	reduce awkward working postures. Operators were encouraged to draw out possible plans; Lego was also used to construct 3D models. A consensus plan was reached and implemented. The cell layout worked well and no reports of MSDs were reported. 2. End users identified the problem, the project team negotiated with the suppliers to improve the method of product delivery to the site. In one case this was achieved with the support of the supplier. In the other case improvement to the method of supply was not possible so an 'in-house' solution was developed with reviews of initial prototypes undertaken by the end users. 3. End users worked with engineers and the maintenance departments to develop a solution to the problem by modifying the equipment.
At what stage in design cycle were people involved?	Usually in problem identification and then review of solutions or design prototypes.
Where did the activity take place?	On site.
Design problems identified by end users	1. Layout of equipment originally required awkward postures. 2. Awkward handling of loads, the method of supply did not facilitate the use of lifting aids. 3. The original design required heavy manual handling activities.
What improvements were made?	1. Changes to the workplace layout were made to improve the process and working postures required of operators. 2. a) The suppliers place pieces of wood between the coils so that the operator can insert the lift aid without any manual handling of the coil. b) An aid to lift the coil was developed to provide a means by which the main lift aid can be inserted. This was developed with help from a local company with review of the prototype by the operators – further improvements were made following this review. 3. An additional 'arm' was built onto the machine so that the manual handling activity could be eliminated.
Any opportunities to further evaluate the proposed changes?	The company is continuing to develop its structured approach to implementing ergonomics throughout the organisation. The project team has responsibility for taking solutions back to the end users before and after implementing changes. An evaluation of the work is completed and any further work undertaken before the project is signed off.
General H & S improvements after changes?	This work is part of a programme to raise awareness of health and safety issues within the company, to manage risks and support the well being of the individuals and the organisation.
Any wider implications for the organisation?	The new company is reviewing the systems inherited from their parent organisation and considering the best approach to enable the sharing of lessons learnt and best practice across all their sites.
General case study evaluation. Beneficial process or not?	Whilst there are difficulties in achieving consensus on solutions to problems, the value of involving end users in the problem solving process is recognised. Such an approach facilitates the development of effective solutions and their implementation.

Case No. 8 - Portugal
Improvements to workstation design

Organisation, type sector, size etc.	Components for automotive industry - seat covers.
What triggered off the intervention?	It usually arises either from complaints from the operators or according to an observation by the ergonomist involved.
What was the initial purpose of the participatory process?	According to the type of tasks performed – in particular concerning the associated repetitiveness of the task – intervention is intended at ensuring an adequate and comfortable working posture, as well as reducing or eliminating unnecessary or extreme muscle efforts. Participation plays a crucial role in the development of auxiliary assistance tools or systems as well as in the analysis of the possibility of replacing the current task by some other activity that is less demanding.
Was this a one off activity or a structured system of work?	A structured system of work.
Description of machine, work environment involved	The company is structured in three main sections: 1. Storage – load handling 2. Cut section – load handling 3. Sewing activities – short cycle time, need of awkward postures.
Number of participants, their jobs / roles	This is variable – it may involve only the ergonomist and the range of operators directly involved (for example when dealing with the need for changing the postures adopted). However there are also examples of situations where several operators and personnel from different departments (production, engineering, maintenance, health and safety, etc.) are involved.
Level of influence, team / department / company	Depending on the project the following are involved: production supervisors; engineers, maintenance technicians; Health and Safety officers, ergonomist. The influence of the project can also vary from affecting only a small group to more widespread within the section / company etc.
Description of participatory method, was there a facilitator involved?	A facilitator is usually involved, and who takes this role varies according to the project phase and the improvement goals defined as the objective of the participatory process.
What actually happened - did things go according to plan?	Yes – although there is often the need for adjustments.
At what stage in design cycle were people involved?	Normally operators are involved from the design stage – regarding the collection of data and information about the workplace and the task. These data are subsequently analysed by the ergonomist who defines a set of actions aimed at improving the workplace. This is then presented to other company levels in order to formally establish and implement a plan of action towards improvement.
Where did the activity take place?	Sewing department.

Design problems identified by end users	Example: Some of the materials that need to be sewn are plastics which vary in size but which are often 1000mm long. These were initially fed to the workplace from tubes placed vertically at the side of the sewing machine. This original layout required extreme postures from the operators both at arm, upper arm and shoulder levels.
What improvements were made?	The position of the tubes with the materials was changed. Those plastics which are longer were placed underneath the working bench in such way that the operators no longer have to pull them completely – in other words, the operator only has to pull the end of the plastic material which is then placed underneath the clamp shoe and which is fed smoothly as the operator pulls it – requiring no awkward postures or relevant pulling strength. Smaller plastics are placed on an articulated support device located on the working bench or on a side-table.
Any opportunities to further evaluate the proposed changes?	Yes – these may arise either from the operator's opinions regarding the changes introduced or from a detailed ergonomic analysis into the movements required for task performance (before and after the introduction of changes to the workplace). Regarding this example results obtained show that not only the number of movements required for task performance was reduced but also the respective amplitude.

Case No. 9 - Portugal

Improvements to workstation design to reduce risks of MSDs

Organisation, type sector, size etc.	Multinational company making electric and electronic equipment for the automotive industry. Employing circa 2000 operators.
What triggered off the intervention?	Ergonomic analysis of workplaces, feed-back from operators, feed-back from medical department.
What was the initial purpose of the participatory process?	• Definition of the sequence and frequency for rotation among different workplaces with the production line in order to reduce the problems associated with the repetitiveness of movements. • Adaptation of workplaces in order to reduce the postural requirements at shoulder level caused by the need to use to different conveyors (at different heights). • Reduction or elimination of handling movements with the implementation of mechanical/pneumatic assistance.
Was this a one off activity or a structured system of work?	The company has defined and implemented a formal procedure for ergonomics interventions – this defines the different stages; which actions need to be taken, the timing for implementation of changes and a clear definition of the personnel responsible.
Description of machine, work environment involved	Assembly line – packaging work and short cycle time. Workplace of the quality control section – with specific visual and postural requirements. Assembly workplace – with highly demanding requirements at wrist and hand levels due to the characteristics of the product handled.

Number of participants, their jobs / roles	Each team comprises: operator (1), ergonomist (1), occupational physician (1), process engineer (1), safety engineer (1).
Level of influence, team / department / company	These teams described above are responsible for any alterations which are required at the ergonomics level. Participants come from different departments – manufacturing, design, work relations, health and safety department.
Description of participatory method, was there a facilitator involved?	The identification of the problem is done by the ergonomist on the basis of the information gathered through the ergonomic analysis, from the feed-back from operators involved, and from the health department. The ergonomist acts as the facilitator of the complete process. Ideas and suggestions for changes are developed with the participation of all the team members. The person responsible for implementing the changes into the line or workplace is the process engineer. The re-assessment process is ensured by the ergonomist.
What actually happened - did things go according to plan?	Completed and evaluated. Completed after 4 stages of re-evaluation and adaptation. Completed and implemented into other workplaces with similar requirements.
At what stage in design cycle were people involved?	Operators are involved from the early stage of problem identification.
Where did the activity take place?	At the manufacturing site.
Design problems identified by end users	During the re-assessment stage, operators are always involved. Their contributions and suggestions are always registered and analysed in order to consider them for the definition of subsequent alterations.
What improvements were made?	Implementation of a rotation scheme. Layout re-design – a single conveyor placed at optimal sight height. A rotational mechanism for product handling.
Any opportunities to further evaluate the proposed changes?	Further alterations and changes regarding the examples presented are mainly related to the implementation of similar structures and systems in similarly demanding workplaces. At the present stage it seems that there is little room for further applications of the specific recommendations defined from the examples presented.
General H & S improvements after changes?	All implementations required minor adjustments but this improved the job design and working postures for operators.
Any wider implications for the organisation?	For all the examples described there was a slight decrease in production and/or quality levels which occurred only during the implementation stage and which was due to the adaptation of the operators involved and the need for a re-definition of old working strategies and procedures.
General case study evaluation. Beneficial process or not?	For all examples presented there was a reduction in the incidence of upper limb disorders, an improvement in operator's satisfaction and an overall improvement on product quality levels.

Case No. 10 - Netherlands
Wheel loader cabin


TNO


TNO


TNO

Figure 13: **Examples of earth-moving machinery produced by the 3 companies involved**

Organisation, type sector, size etc.	Three private small and medium sized enterprises (SMEs) manufacturing earth-moving machinery.
What triggered off the intervention?	An ergonomics assessment was requested to assist the companies improve the comfort level and ergonomics factors of their machines to improve their competitiveness in the vehicle market.
What was the initial purpose of the participatory process?	To gain understanding of ergonomics issues and problems experienced by end users operating the machines.
Was this a one off activity or a structured system of work?	A one off activity for the three companies but a structured system of work for the researchers involved.
Description of machine, work environment involved	The machines reviewed in the project were small and large wheel loaders and medium sized excavators.

Number of participants, their jobs / roles	46 operators from two of the companies were sent a postal questionnaire and then 10 respondents were visited at their place of work. A further 12 operators from the third company were also interviewed at their place of work.
Level of influence, team / department / company	The work of the project was able to influence the redesign of the cab by the manufacturing companies, although some concerns could not be addressed immediately.
Description of participatory method, was there a facilitator involved?	The researchers conducted semi structured interviews with the operators, who were seen individually. The 12 operators at one company were also observed using the machinery. There were some difficulties accessing operators and due to safety issues it was not possible to sit in the cab and observe the operator while they were working.
What actually happened - did things go according to plan?	The manufacturers supplied the researchers with details of companies using their products but there were some difficulties gaining access to operators due to the time away from work that was required.
At what stage in design cycle were people involved?	End users were involved in evaluation of the existing design. Participation of end users in the redesign phase was limited but it was anticipated that they would be asked to evaluate the proposed new design.
Where did the activity take place?	At the machine operators' sites. The postal questionnaires sent out may have been completed by operators at home rather than at work.
Design problems identified by end users	A number of problems were identified which were summarised as follows: • Noise - problems with low level but annoying noise when the engine was running idle. This was considered to be often considerable periods of time while operators are waiting for permission to carry out their tasks. • Outside improved view around the cab was requested to avoid awkward postures. • Ease of cleaning - the cabs often were seen as the operators' living area and they therefore wished to be able to keep them clean more easily. • Ease of maintenance - a number of items were identified to make the maintenance tasks on the vehicle easier. • Feedback - on some machines improved feedback on the position of the shovel was requested.
What improvements were made?	Some of the problems could not be addressed in this project as they required a complete review of the design of the machine cab. However alterations to the design of the joystick, arm support, and noise level in the cab were possible.
Any opportunities to further evaluate the proposed changes?	At the time of writing the improved machines are under construction and so further evaluation by end users has not been possible.
General H & S improvements after changes?	Health and safety improvements are anticipated due to improved comfort and working postures.
Any wider implications for the	The improvements suggested by the experts and end users were not all covered by the machinery standard as they were concerned

organisation?	with comfort rather than safety. There was some discussion that the standards and guidelines were restrictive rather than encouraging the manufacturer to go beyond the baseline requirements.
General case study evaluation. Beneficial process or not?	The end user information differed from some of the problems identified during the expert evaluation; however the opinions of the end users were considered to be very important and of benefit to the project.

Case No. 11 - France
Flourmill (mill roll)

A. Garrigou

Figure 14: **View of the distribution roll (1) and of the protective slats (2) in front of the grinding cylinders which cannot be seen in this photo**

Organisation, type sector, size etc.	One production site which is part of a French milling group. The site referred to in this case study has 160 employees.
What triggered off the intervention?	An accident occurred during a routine maintenance operation which injured three people.
What was the initial purpose of the participatory process?	The health and safety investigation of the accident found that the required procedures had been followed and the equipment was not faulty. Therefore a further investigation using the knowledge of the end users was agreed in order to review the current process and if possible identify ways to prevent such an accident occurring again.
Was this a one off activity or a structured system of work?	This was a one off activity which took place following the accident.
Description of machine, work environment involved	The machine (section of it shown in Figure 14) is one of many identical machines which are required for a milling plant. In this factory, 20 of these machines are set out in series to turn wheat grains into flour. The variable feature of these machines is the surface of the cylinders, the surfaces are smoother towards the end of the line.

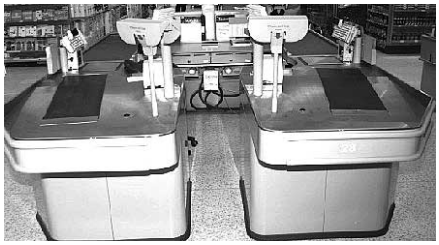
	There are four cylinders per machine powered by two motors. The space between the cylinders is set by an operator using a hand tool. The cylinders are protected by curved iron plates and the gap between them is protected by a slat to prevent entrapment injuries.
Number of participants, their jobs / roles	The project team involved the managing director of the plant, the group technical manager, the head of the milling installation, the head of maintenance, the group head of Health and Safety, the Quality manager and four members of the Health and Safety Committee. Prevention staff from the work Inspectorate and from CRAM Essonne were also involved.
Level of influence, team / department / company	At inquiry level and to work out the cause-tree, the personnel representatives of the Health and Safety Committee, the operators and the supervisors of the plant co-operated to find out facts. The stages of the analysis were presented at two extraordinary Health and Safety Committee meetings, in October and December 2001, then regularly at each ordinary meeting.
Description of participatory method, was there a facilitator involved?	The participatory approach relied on interviews, exchanges of reports and attending meetings. The experts were encouraged to observe production and maintenance activities of the operators. No specific methodology was set up. The operators were also to be involved in evaluation of design solutions as their experience of the work would be valuable.
What actually happened - did things go according to plan?	The participation of Health and Safety Committee members in the work group allowed a precise description of the accident conditions. This information was reported through the cause-tree analysis. Based on this analysis, improvement solutions were collectively envisaged.
At what stage in design cycle were people involved?	In problem identification, solution generation and solution evaluation.
Where did the activity take place?	At the plant.
Design problems identified by end users	The outcomes of the design evaluations were not known at the time of reporting the case study but a control system to monitor the variations in temperature of the cylinders is being explored.
What improvements were made?	At the time of writing the report for the case study the outcomes of the work were not yet available - work is ongoing.
Any opportunities to further evaluate the proposed changes?	In the future when design solutions are implemented.
General H & S improvements after changes?	Different analyses have emphasised the need to work on the design of a temperature checking device, in order to avoid future similar accidents.
Any wider implications for the organisation?	The analysis of the accident led to the integration of the Safety, Quality and Maintenance approaches. It also highlighted the fact that when the accident occurred, under-staffing problems existed, particularly as far as line conductors and maintenance operators were concerned. The approach also contributed to the setting up of an identification process, piloted by the Labour Ministry, to find

	out any fault as regards safety standards.
General case study evaluation. Beneficial process or not?	Today, research is still being done to find a technical solution to the permanent monitoring of the cylinder temperature. The review of the accident also identified issues of training and staffing which previously had not been recognised.

Case No. 12 - UK
Redesign of checkout work equipment and layout

Sainsbury's Supermarkets plc.

Figure 15a: **Design of checkout, side view**



Sainsbury's Supermarkets plc.

Figure 15b: **Design of checkout, rear view**

Organisation, type sector, size etc.	A leading UK supermarket chain, employing up to 70,000 check-out operators
What triggered off the intervention?	Concern over the health and safety of checkout operators (especially musculoskeletal disorders of the back, neck and upper limbs). There was also a business need to develop a new family of checkouts.
What was the initial purpose of the participatory process?	To design a new checkout. The checkout carcass was drawn with the checkout operator area left completely blank. A participative approach was to be used to develop, test and agree the final design - Checkout 2000.
Was this a one off activity or a structured system of work?	A series of earlier modifications to existing checkouts and a selection of individual new technological components had also used a participatory approach. This project was the first to consider the complete design.
Description of machine, work environment involved	The checkout was to be installed in all new large supermarkets and to be retrofitted into the existing larger stores according to a strict time schedule. The work of a checkout operator involves highly repetitive handling of goods, often with significant time pressures imposed by customer demands. The checkout operator is also seen as crucial in establishing and maintaining good customer relations. For many customers this is their only point of contact with the organisation, and staff well-being is recognised as being important to enhance this interaction.
Number of	Representatives of the checkout operators were selected from

participants, their jobs / roles	three stores. They included experienced and novice members of the workforce. Females and males were included. Representatives of each part of the engineering process were also part of the team, as were representatives of the organisation's health and safety team, customer relations department and an external ergonomist.
Level of influence, team / department / company	The previous participative studies had illustrated the benefits of taking a participatory approach. The Checkout 2000 team were therefore mandated with a clear brief by the operational board to develop the new checkout to ensure the best possible operator environment, within specified cost and time constraints.
Description of participatory method, was there a facilitator involved?	• An external ergonomist acted as facilitator in the early stages. As the project progressed and following some guidelines, other facilitators from the engineering project team were able to also adopt this role. • Regular meeting were held with end users. The response by end users included comments that they "loved" the idea of only having bits of wood to look at and not a finished checkout to "comment on". They felt this really showed they could have some influence on the design. • Mock-ups were built after each session and then commented on and tested through simulations at each subsequent meeting. Many changes were required. These were always agreed by all those present. This iterative process was used throughout. Final testing was carried out at a trial store over a period of a few weeks. Minor modifications were made. • It was noticeable that members of the team who were not checkout operators came to increasingly respect the views of those who actually used the equipment, as the project developed. Whilst the focus of the participation was the checkout operators, some evaluation of customers' requirements (also end users) was undertaken.
What actually happened - did things go according to plan?	The project ran according to plan and to budget. The post implementation report highlighted the role the checkout operators had played in the design and their preference for the new design, particularly for its space, layout of and design of equipment, choice of standing or sitting working posture and comfort. Customers also showed high satisfaction with the new design.
At what stage in design cycle were people involved?	From the drawing board to implementation.
Where did the activity take place?	Much of the early work took place at the "concept building" belonging to the organisation. This was important as it was away from the shop floor and not located at the company's headquarters either. It was a "neutral" location that encouraged each contributor to think in an open way and for all ideas to be received equally. As the project developed the participatory process was moved to the checkout manufacturer's offices and the final meetings were held at the store where the in-store trials were being run.
Design problems identified by end users	The first focus group showed there to be some 50 significant problems identified with the existing design. These related to both customer and staff problems. The richness of this information enabled most of the problems to be identified very quickly. These were then classified as to how easily the problem could be over-

	come, if possible, in the new design. The type of problems reported for staff included comfort, reach requirements, postural demands (especially the need to twist), cleaning and maintenance difficulties, snagging of clothing on protuberances, inefficient operation, and feelings of insecurity.
What improvements were made?	As a result of the participatory design approach an ergonomically designed work space including: the provision of sit or stand option, acceptable reach requirements, task analysis leading to improved location of peripherals and technological devices (e.g. scanner, scales, displays), improved customer interface, tested and improved scanner, better chair, a full footrest and a secure "back to back" checkout design. Many improvements were also made for the customer, notably with regard to packing and ease of communication with checkout operators. In addition, the checkout operators were co-owners of the new design.
Any opportunities to further evaluate the proposed changes?	The post-implementation follow-up was reported. Some minor modifications were required and will be addressed in subsequent checkouts to be installed.
General H & S improvements after changes?	Feelings of comfort and well-being increased, the installation of the new checkout is still ongoing. Benefits in terms of reduced reporting of MSDs are anticipated.
Any wider implications for the organisation?	The checkout operators were co-owners of the new design. The design was significantly better than could have been achieved by the design team without their input. The additional cost was insignificant.
General case study evaluation. Beneficial process or not?	The process was adjudged successful by all parties and in the post-implementation follow-up. Some minor modifications were required.

Case No. 13 - UK

Redesign of ambulance equipment and layout

Westcountry Ambulance Trust

Figure 16: **Example of a Westcountry Ambulance NHS Trust ambulance**

East Anglian Ambulance Trust

Figure 17: **East Anglian Ambulance NHS Trust ambulance showing new lift system**

Organisation, type sector, size etc.	Three ambulance trusts: 1. The Westcountry Ambulance NHS Trust - this provides a service to the counties of Cornwall, Devon and Somerset covering an area of 15,540 sq. km. For the year 1999/2000, it was estimated that the Trust provides a service to 2 million permanent residents and over 18 million visitors to the region. 2. The East Anglian Ambulance NHS Trust - this provides a service to Cambridgeshire, Norfolk and Suffolk. They have 35 operational stations (and 10 response posts) within an operational area of 5000 sq. miles. 3. East Midlands Ambulance Service NHS Trust - This provides a service to Derbyshire, Leicestershire, Nottinghamshire and Rutland. They have 38 operational locations covering an area of 2788 sq. miles.
What triggered off the intervention?	All were undertaking a replacement programme of their vehicles over a period of several years. There was also a concern within all ambulance service providers about the level of injury reported by ambulance personnel, and the design of the current vehicles was considered to be a contributory factor. The HSE had also visited a number of Ambulance Trusts, and notices to improve aspects of the work, particularly related to manual handling tasks of staff, had been issued following some of these visits which gave a greater emphasis to addressing some of these issues.
What was the initial purpose of the participatory process?	1. & 3. To collect end user comments about the design of their current vehicles, both good and bad points, to help identify important design issues which should be considered in new vehicle procurement. 2. There was a genuine recognition that vehicle design and equipment selection required a 'whole' rather than fragmented system approach.
Was this a one off activity or a structured system of work?	1. & 3. Essentially this was a one-off activity with the focus on ambulance design but the importance of consultation with staff groups is increasingly being valued and implemented. 2. This was a structured ongoing approach to capture representative contributions to vehicle, equipment and uniform procurement issues.
Description of machine, work environment involved	Each Trust reviewed the design of their existing ambulance, which is defined in EN 1789 (1999), as "vehicle or craft crewed by a minimum of two appropriately trained staff for the provision of care and transport of at least one stretchered patient". The ambulance therefore has within its treatment area attendant and patient seats, a stretcher trolley, medical equipment and supplies, medication and medical gases on supply. In addition the Trust took the opportunity to introduce design features not specifically set out in the EN 1789 requirements to improve the operators' working environment. The areas of improvement not directly referred to in the CEN standard were the tail lift (although this is covered by LOLER), the hydraulic trolley cot and the external compartments for equipment such as medical gases.
Number of participants, their jobs / roles	1. Two Unison Trade Union health and safety representatives, a large number of end users, vehicle fleet managers, maintenance providers, contracts managers, finance personnel. 2. The Trust has formed an Operations Procurement Group (OPG) to consider all vehicle, equipment and uniform procurement issues. This comprises at least 24 staff from a variety of

	departments and end user area groups. 3. Ergonomist, Assistant Director of Corporate Affairs, Risk Manager and Fleet Manager and end user representatives.
Level of influence, team / department / company	1. & 3. Able to influence the design of vehicles used within their Trust. Some members of these groups are also involved in a national forum considering ambulance design. 2. The OPG has significant influence and an active role in shaping vehicle specification and equipment selection. Two members of the OPG have also been able to contribute to the national forum, which is seeking to develop a single vehicle specification for the UK.
Description of participatory method, was there a facilitator involved?	1. The Unison Trade Union representatives spoke with end users, collected their comments and opinions and fed these back to the Vehicle and Equipment Group for the Trust. 2. End user feedback is elicited via five working groups. Staff questionnaires were also used to capture a braoder range of end user views. Re-evaluation of all new specifications via the working groups is sought. The working groups report back into the OPG. 3. Four month ergonomic project which included task analysis, observations, interviews, empirical measurement (to benchmark anthropometric dimensions) and postural analysis. End user information was collected during the interviews and observations.
What actually happened - did things go according to plan?	1. The informal approach to collecting end user information was found to be useful and effective. 2. Generally yes although it is a challenge to combine the competing requirements of budget planning, vehicle build programme (for example lead times), meeting requirements set by the relevant standard and access to staff for working group meetings within a busy operational climate. 3. Project still on-going, but progress to date is excellent.
At what stage in design cycle were people involved?	1. Review of the existing design and ongoing evaluation of new models as they come into service. 2. The process is ongoing, being cyclical and iterative in nature to pick up relevant design themes. 3. A range of staff members have been involved at various stages, including the design of the project, data collection and review of interim findings.
Where did the activity take place?	1. Discussions with end users were held 'out in the field'. Meetings of the Vehicle and Equipment group took place at the Trust Headquarters building. 2. User input was obtained 'out in the field' at planned, facilitated working group meetings and by visits to suppliers/manufacturers to view the build process at different stages. 3. Project took place at the Ambulance Stations and on the vehicles during routine and emergency calls for A&E ambulances with over 10 shifts observed.
Design problems identified by end users	Need to lift stretcher trolleys in and out of the vehicle, some designs had high kerb heights which required a high step access. High load heights were a major issue and excessive use of the carry chair was noted. The physical load on the end user when taking the weight of the trolley and patient when loading into / taking out of the vehicle. The repetitive raising and lowering of the trolley stretcher and accessing equipment from inside the patient

	carrying area during a range of tasks were also identified as problematic.
What improvements were made?	New vehicles have been designed to include a tail lift mechanism or a ramp to eliminate the need to lift stretcher trolleys in and out of the vehicle. Certain makes of vehicle are preferred by some Trusts as they offer lower kerb heights at the outset. Improved patient transfer equipment as described above also eliminates the need to manually lift or lower the patient trolley. The internal layout of the vehicle has also considered the variety of tasks undertaken in the vehicle, and although the Trusts have settled for different designs the decisions have been based on end user requirements, with consideration for health and safety issues, best ergonomics practice within the constraints of the vehicle and compliance with relevant international standards.
Any opportunities to further evaluate the proposed changes?	The vehicle replacement programmes will take a number of years and so each new design can be further reviewed and the design improved accordingly.
General H & S improvements after changes?	Combined with improvements to other items of equipment that the ambulance staff use, it is anticipated that the number of manual handling injuries reported should decrease. It is also anticipated that end users will have longer career opportunities, not shortened by ill health or physical injury.
Any wider implications for the organisation?	The broader implications involve demonstrable and meaningful user involvement to improve working conditions for end users and patient experiences. Improved clinical practice resulting from the facilitation of tasks due to ergonomic design of work place layout.
General case study evaluation. Beneficial process or not?	The process of participation of end users in the design review has: • enabled identification of issues that concern end users; • supported the acceptance of the new designs, which often also lead to changes in work practice; • led to the development of solutions to problems that take into account operational requirements.

Case No. 14 - Germany

Concrete screed preparation machine

Bau-Berufsgenossenschaft Rheinland und Westfalen

Figure 18: **Removable grid on concrete mixing machine**

Organisation, type sector, size etc.	Württembergische Bau-Berufsgenossenschaft (institution for statutory accident insurance and prevention in the building trade in Württemberg), approx. 20 000 companies with 230 000 insured persons, Prevention department.
What triggered off the intervention?	Frequent accidents with screed preparation machines, because workers reached into the running agitator for cleaning.
What was the initial purpose of the participatory process?	To develop an automatic stopping device for the mixing blades in a screed preparation machine that stops the blades as soon as the protective grid is removed. It was proposed to involve workers in the development of a device that prevents the user getting his hand caught in the mixing blades to ensure the acceptance of the machinery and safe working techniques.
Was this a one off activity or a structured system of work?	A one-off activity.
Description of machine, work environment involved	Screed preparation machines: Screed is mixed in a pressure vessel and then conveyed through a delivery line filled with compressed air to the place where it is needed. The main aggregates, sand and cement, are filled – manually – into a round charging hole on top of the pressure vessel. When feeding the vessel, the mixing shaft has to turn, because it is not possible to start the mixing shaft with the vessel completely filled. The round charging hole has to be secured by a grid with a maximum mesh width of 70 mm and a minimum distance of 120 mm to the danger zone – i.e. the rotating mixing blades – preventing people from getting their hands caught in the mixing blades. After work or during prolonged interruptions of work, it is necessary to open the grid, spray out the vessel and mechanically clean the mixing blades. Initially, in accordance with the directive on machinery safety, the grid had to be tightly fixed by screws, so that it could only be opened by means of tools. Even though a safe solution, it was not acceptable for the users, since it is not practical to use tools to open the grid when this could be necessary several times per day. Therefore the users tended to leave the grid open so that they could clean the vessel without using special tools.
Number of participants, their jobs / roles	The design departments of the companies Brinkmann and Putzmeister, some entrepreneurs and construction workers.
Level of influence, team / department / company	The design departments of the manufacturing companies and the working teams in the user companies.
Description of participatory method, was there a facilitator involved?	Discussions with employees, as it was agreed that a practical solution was necessary in order to make sure that the safety measures were accepted and applied. There were opportunities for consultation with representatives of the users and of the manufacturers.
What actually happened - did things go according to plan?	Yes, end user participation was possible on different occasions during meetings manufacturer / user, Berufsgenossenschaft / user, Berufsgenossenschaft / manufacturer.
At what stage in design cycle were people involved?	At the design stage and during prototype testing.

Where did the activity take place?	On construction sites, in companies and at the manufacturers' plants.
Design problems identified by end users	When discussing the working procedures with the workers, it became clear that the cleaning procedure often had to be executed several times per day. The fixed screws solution was therefore neither acceptable nor practical.
What improvements were made?	Built-in switches stop the mixer at the very moment when the grid is opened and will ensure the mixer does not restart when the grid is open.
Any opportunities to further evaluate the proposed changes?	By monitoring construction sites and how such accidents happen.
General H & S improvements after changes?	Reduced accident risk.
Any wider implications for the organisation?	The solution is reflected in prEN 12001 *Conveying, spraying and distributing machines for concrete and mortar; safety requirements* which states that in the case of grid covers which are opened once a day or more often, it shall be ensured that the agitator or the screw elevator conveyor is forcibly stopped and is secured against restarting when the grid cover is opened.
General case study evaluation. Beneficial process or not?	The solutions developed by the manufacturers have met with the acceptance of the users and are not considered to hinder them in their work.

Case No. 15 - Germany
Protective gloves for the glazing trade

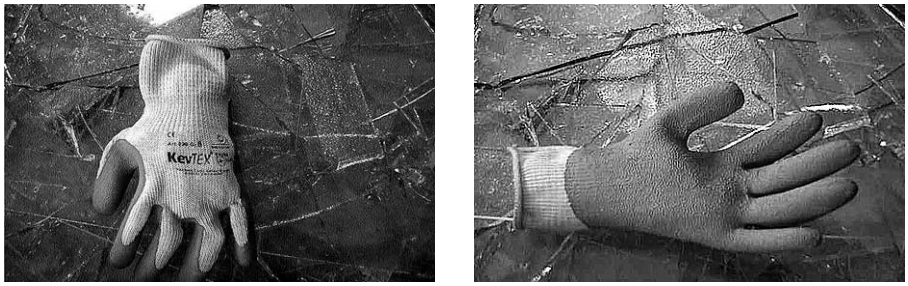


Figure 19: **The test glove, glove back, glove inner surface**

Bau-Berufsgenossenschaft Rheinland und Westfalen

Organisation, type sector, size etc.	Bau-Berufsgenossenschaft Rheinland und Westfalen (institution for statutory insurance and prevention in the building trade in the Rhineland and in Westphalia), approx. 65 000 companies with 439 000 insured persons - Prevention department.
What triggered off the intervention?	An initiative of the 'Jungglaserverband NRW' (federation of young glaziers in North-Rhine Westphalia).

What was the initial purpose of the participatory process?	Promote the widespread use of protective gloves against cutting for use in the glazing trade; Limit the use of materials unfit for hand protection (such as rubber gloves) and thus prevent accidents; Improve glove characteristics: develop better ergonomic features that will help increase the acceptance of such gloves by the workers.
Was this a one off activity or a structured system of work?	A one-off activity.
Description of machine, work environment involved	Protective gloves against cutting for use in the glazing trade. For the project, an inventory was drawn up of protective gloves available on the market that are claimed to provide protection suitable for work in the glazing trade. The protective gloves were tested in practical work; the workers were asked to evaluate the protective gloves. Manufacturers were informed about the statements relating to the suitability and comfort the gloves provide. The test persons were effectively motivated to wear protective gloves.
Number of participants, their jobs / roles	Organisation: FA PSA (expert committee for PPE) and the 'Jungglaserverband'. Participants: 30 people from 3 companies, including entrepreneurs.
Level of influence, team / department / company	Company, department.
Description of participatory method, was there a facilitator involved?	Samples of protective gloves against cutting as available on the market were distributed to the workers of three different companies. The gloves were used by the workers in their normal work over a period of six months. On different occasions, the workers evaluated the protective gloves they used by way of filling in questionnaires. Additionally, at the end of the six months, every worker was questioned in an interview about the protective gloves and his / her experience in the wearer test itself.
What actually happened - did things go according to plan?	From the beginning to the end of the project, there were different occasions for the users to express their opinions in questionnaires and personal meetings. The statements gave information on the practical use of the protective gloves in the specific activities of glaziers, and reflected suggestions and ideas for the improvement of the gloves (in terms of comfort and efficiency) that was considered necessary before a widespread use of such gloves in the trade seemed likely.
At what stage in design cycle were people involved?	The users were involved in the selection phase. During the wearer tests, they were asked on different occasions to provide an interim statement about the gloves under test. After testing the gloves for six months, they were interviewed to give a final evaluation on the gloves and the wearer test itself. There were improved models and these were able to be integrated into future designs.
Where did the activity take place?	In the companies.

Design problems identified by end users	The users gave reports on any problems they encountered when using the gloves (in terms of ergonomic aspects as well as protective features). The manufacturers received this information from the users, supported by the samples, when gloves that had proved unsuitable were sent back to them.
What improvements were made?	Being informed by the users about the performance of the protective gloves in working practice, the manufacturers have been put in a position to improve the ergonomic as well as the protective features of the gloves in order to be able to provide specific protective gloves against cutting for use in the glazing trade. With more suitable products on the market, they will be able to expand this market segment, as the users become aware of the benefits of wearing protective gloves, so that the acceptance among the users can be improved.
Any opportunities to further evaluate the proposed changes?	
General H & S improvements after changes?	A higher acceptance of the protective gloves reduces the risk of accidents.
Any wider implications for the organisation?	
General case study evaluation. Beneficial process or not?	

Case No. 16 – Sweden
Manual price markers

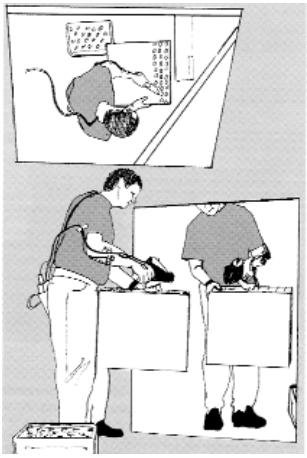
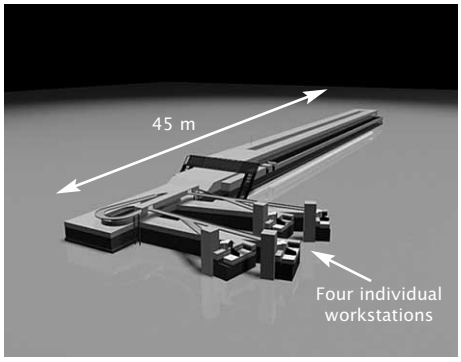

Designkonsulterna

Figure 20: **Laboratory experiment of price marking**

Organisation, type sector, size etc.	Retail stores, supermarkets.
What triggered off the intervention?	An awareness of ergonomic problems experienced by end users.
What was the initial purpose of the participatory process?	To elucidate the problems with existing equipment and thereby to influence buyers and manufacturers of price-markers.
Was this a one off activity or a structured system of work?	This was a one off project, but there were continued efforts carried out by the user organisations, for instance by approaching international manufacturers.
Description of machine, work environment involved	Manually operated, muscle powered price-markers.
Number of participants, their jobs /roles	About 40 participants in different stores.
Level of influence, team / department / company	End users, managers, occupational health personnel.
Description of participatory method	Participation included use of consumer technology methods, e.g. group sessions for articulation of user demands according to the Quality Function Deployment (QFD) methodology.
What actually happened?	User demands were collected, and a methodology for comparative testing was developed and implemented. Information material comparing four different brands of price-markers was developed.
At what stage in design cycle were people involved?	In the formulation of demands, in testing and evaluation.
Where did the activity take place?	In the shops and in a hand tool laboratory.
Design problems identified by end users	The work is repetitious, which makes ergonomic design critical. Price-markers are sometimes heavy and poorly balanced, and may require high finger force in operating the actuator.
What improvements were made?	Some tools were found to be ergonomically better than others, and this information was circulated very widely to end users for consideration. Manufacturers were alert to the testing results.
Any opportunities to further evaluate the proposed changes?	Not really. Traditional price marking is getting less common (but other types of marking is on the increase).
General H & S improvements after changes?	No follow-up study has been carried out to evaluate the results.
Any wider implications for the organisation?	The project may have boosted the development to mark price on shelves rather than on products.

General case study evaluation. Beneficial process or not?	The project was a well designed, customer driven development where the potential of comparative testing was highlighted. It may be possible to apply this type of evaluation to production equipment on a much wider scale, engaging test houses specialised in ergonomic evaluation of products.

Case No. 17 - UK
Automated sorting system for A4 flat mail pieces



Royal Mail

Figure 21: **Virtual model of the machine**

Organisation, type sector, size etc	Postal collection and delivery service, public sector employee, large national organisation.
What triggered off the intervention?	New technology was being purchased and implemented.
What was the initial purpose of the participatory process?	To provide a safe working environment and a comprehensive audit trail for relevant authorities.
Was this a one off activity or a structured system of work?	The process has evolved over a number of projects and continues to be used in novel ways in other projects.
Description of machine, work environment involved	An automated sorting system for A4 'flat' mail pieces. Operators load mail into the process at the workstations identified in Figure 21 above. There are also operators who 'patrol' the machine undertaking various tasks to support the process.
Number of participants, their jobs / roles	A sub group of approximately 16, representing the equipment manufacturer, unions (including 'end users'), maintenance providers, unit managers, operations managers and health & safety personnel including an ergonomist.
Level of influence, team / department / company	Able to influence the implementation of the project within the organisation.

Description of participatory method	A series of workshops were held. The initial workshop allowed group members to review the equipment, identify problems and prioritise risks identified using a risk matrix. There was an opportunity for the identification of risk control measures and then responsibility for the actions was agreed. Subsequent workshops reviewed progress, evaluated actions from earlier stage(s), set new risk control measures and assigned actions. A senior ergonomist from the organisation was the facilitator for the group workshops.
What actually happened?	The process outlined above was followed through. This has provided a clear audit trail of risk identification and how control was established.
At what stage in design cycle were people involved?	A proof of concept approach was taken which involved the development of one machine to enable the assessment of: • Supplier capability including technical solution and safety equipment. • Operational capability including ability to use the equipment effectively, productively and with safe systems of work.
Where did the activity take place?	The first workshop took place at the manufacturer's site so that the equipment could be physically inspected. Other workshops took place at the premises to which the machine had been deployed.
Design problems identified by end users	A number of electrical safety concerns and physical injury risks due to insufficient guarding or interlocks. Other potential problems related to repetitive work and manual handling activities.
What improvements were made?	A number of changes to the design were agreed with the manufacturer prior to the completion of the design of the equipment. Other actions were taken subsequently as part of the review workshops and concerned not only the machine design but also organisational issues such as training, numbers of operators and task rotation.
Any opportunities to further evaluate the proposed changes?	The project is ongoing. The equipment has been installed but is not fully commissioned. It is therefore not yet operating at its full potential. Work to implement some of the actions is still ongoing. Initial reports from operators though are very positive about the machine and the process of employee involvement in its development.
General H & S improvements after changes?	Implementation of the equipment eliminated a number of manual handling and work related upper limb disorder (WRULD) risks. Comparison with an unmodified piece of equipment is not possible as this is a new piece of equipment and this organisation is one of the first to purchase it. However no health and safety concerns have been raised as it is being gradually commissioned for use.
Any wider implications for the organisation?	The process was found to be of great benefit on a number of different levels. The process helped to keep the risk identification and control process objective and realistic, supporting both health and safety issues as well as operational requirements. People found the process increased their level of understanding of the implications of introducing the new machinery. The process also improved 'industrial' relations both within the organisation and with the equipment manufacturers.
General case study evaluation	As the project is still ongoing, full evaluation is not possible. However the process has achieved several of the original objectives, which were to provide a safe working environment,

	ensure the equipment is safe and fit for purpose, provide an audit trail for relevant authorities, identify key user interface issues. Although not fully operational, the machine has been in regular use since October 2001. To date there have been no accidents or reported injuries.

Case No. 18 - Netherlands

Tram, the particular emphasis for this case study was on the cab design

TNO

Figure 22: **Mock-up of the cab design**

Organisation, type sector, size etc.	Public transport enterprise.
What triggered off the intervention?	Change in tram 'stock' to meet increased demand for passenger capacity.
What was the initial purpose of the participatory process?	Need to consider ergonomics and safety issues for tram drivers.
Was this a one off activity or a structured system of work?	A structured system of work.
Description of machine, work environment involved	Case study particularly concerns the design of the cab for the driver.
Number of participants, their jobs / roles	Design engineers, ergonomists from TNO, 6-8 experienced tram drivers and staff of the transport enterprise.
Level of influence, team / department / company	The process was able to influence the current design of tram but experience gained from this will inform further designs.

Description of participatory method, was there a facilitator involved?	Stepwise approach, the facilitator was the ergonomist who worked with the design engineerstaff and end users.
What actually happened - did things go according to plan?	Yes
At what stage in design cycle were people involved?	After expert evaluation of the initial designs, changes were made and then mock-ups built. End users evaluated and modified the design of the mock-ups and dynamically tested the new seats in an old design of tram.
Where did the activity take place?	At the tram manufacturer's premises and then out 'in the field' while testing the new seats in an old tram.
Design problems identified by end users	In the initial phase, problems with the driver's lines of sight were found due to the dashboard design. During the mock-up phase it was found that space for knees was also limited by the shape and size of the dashboard and that an arm rest was required.
What improvements were made?	Height adjustable pedals were provided to allow drivers to adjust their seat position but also maintain good lines of sight. The shape of the dashboard was further improved, an arm rest was provided and further improvements to the layout and type of controls and displays were made.
Any opportunities to further evaluate the proposed changes?	A further end user evaluation of the proposed design was undertaken.
General H & S improvements after changes?	Too early to evaluate.
Any wider implications for the organisation?	The study confirms the benefit of using end users in the design evaluation stage.
General case study evaluation. Beneficial process or not?	Evaluation of the process found it to be beneficial.

Case No. 19 - Netherlands

Off highway truck (seat and cabin evaluation before the mass production of the seat)

Organisation, type sector, size etc.	Two large companies; one a manufacturer of Off Highway Trucks (OHTs), the other a buyer and user of OHTs.
What triggered off the intervention?	The manufacturer had developed a new seat for the driver and required an evaluation of the prototype to assist in the decision as to whether it should be produced or not.

What was the initial purpose of the participatory process?	Operators of OHTs consider the seat to be the most crucial item in the cabin and therefore it was important to involve them in an assessment of the seat.
Was this a one off activity or a structured system of work?	This was a one off activity for the companies although the approach is used by the researchers in much of their work.
Description of machine, work environment involved	OHTs are used to transport soil / rocks, etc. in large quantities in open pit mines or at huge road building sites. The operators drive the OHT usually from the location where the soil / rocks are loaded to a place where the load is dumped. Afterwards they return back again. The OHT application was uphill and downhill driving. In mines this occurs every transport cycle; the largest proportion of time is uphill. In some mines shifts can last for 12 hours due to a 2-shift organisation. The operators are obliged to wear a safety-helmet and safety-belt during driving. The evaluation setting was a mine in a hot climate. The cabins are air-conditioned; so climate in the cabin is largely controlled. The seat and its configuration within existing cabin layout was under review.
Number of participants, their jobs / roles	From the operations department of the mining company 15 experienced drivers (12 males and 3 females) operated the vehicles during a 12 hour test. For efficiency reasons a majority was selected from both a high and low percentile (2.5-25th and 75-97.5th) category in the distribution of population anthropometrics for stature and body weight. A minority was selected from the average categories. Personal from the safety department at this company oversaw the full process to monitor the safe work procedures for those participants that were not familiar with all relevant safety aspects and rules during OHT operations. Repair and service personnel were standing by and were very helpful to solve problems with seats or trucks which occurred during the test. Two researchers from TNO, with expertise in physical load, comfort and ergonomics and one researcher from the OHT manufacturer performed the systematic part of the seat usa-bility test with participative observations and interviews during organised driving sessions. In addition two engineers from the manufacturer's product development department joined the project. Their major roles were: vibration measurement and observations about mechanical driver seat interaction effects. Their secondary aim was to learn from this type of methodological and participatory approach.
Level of influence, team / department / company	Within the manufacturing organisation's design and development departments.
Description of participatory method, was there a facilitator involved?	A method of relative comparison was chosen; two other seats were tested as well. People are relatively good in comparing, moreover every seat has its particular good or bad properties to learn from for a final or future design. Each driver drove a session of about four hours on each seat, twelve hours in total.
What actually happened - did things go according	The entire protocol was tested in a pilot phase and needed only brief improvements. The five rating scales were kept visible for the operator during driving. Many questions could be answered with

to plan?	a yes or no, enough time was available for specific comments from the drivers.
At what stage in design cycle were people involved?	The prototype testing took place during the final phase of the design process.
Where did the activity take place?	At a mine operated by the user company.
Design problems identified by end users	The fit of the upper back and head rest, especially the longitudinal curvature, is not optimal - causing unsupported or pressure areas during driving. For small operators wearing a safety helmet the head rest should be easily removable. The back of their helmets contacts the cushion when trying to lean. The lumbar support adjustment range should be larger (more swell and retraction). Large waist sized drivers want a quite flat lumbar area. Negative rake is wanted by some and needed for the shortest operators to reach the pedals comfortably without adverse effects for the seat reference point and thus for the viewing angles towards outside. Sliding off the seat is a limited problem due to the large amount of time spent in uphill driving. The armrest was not well fixed and not sufficiently forward adjustable. It should not interfere with the control console as well. The seat and especially the backrest micro climate should be further improved.
What improvements were made?	Only a small number of the problems identified by the end users could be redesigned in the short time left before final introduction. The more drastic suggestions for further im-provement unfortunately had to be postponed until the next redesign cycle.
Any opportunities to further evaluate the proposed changes?	To prove the quality of the proposed changes another prototype needs to be built and to be evaluated again.
General H & S improvements after changes?	On the basis of physical discomfort rated at the end of the four hour sessions, it is expected that the new seat, which was evaluated best of the three seats, decreases fatigue levels of the drivers during twelve hour shifts. Less fatigue is also relevant for a safe operation of the vehicles.
Any wider implications for the organisation?	Ergonomic standards and tools used by the design engineers are often not very adequate for the wide range of applications and user populations of the products developed. It is one of the results of this study as well. This participative study on location revealed the specific driver populations and the driving conditions in this mining application of OHTs. The divergences from ergonomic standards observed in practice should be taken into account more in applied ergonomics during the design process; e.g. products should be suitable for larger percentile ranges. More variability in standard products or through additional options offer possibilities. Internationalisation and globalisation encourage 'designing for more'.
General case study evaluation. Beneficial process or not?	User / worker participation studies under practical working conditions are important and reveal a lot of worthwhile results. Experienced users are great experts in their tasks and have a lot of knowledge about the variation in conditions that might occur during working days, shifts and seasons. Results may contribute to practical evidence that should be added to the currently used ergonomic standards or should even replace them before the

	design process itself starts. Recommendations going beyond the usually used guidelines and standards is also one of the results in this case study. In other words we can conclude that applied guidelines can be improved by using a participatory methodology.

Case No. 20 – Finland

Personal protective clothing for meat-cutters

FIOSH

Figure 23: **Work activities of meat-cutters**

Organisation, type sector, size etc.	The Finnish Institute of Occupational Health (FIOH) undertook a comprehensive study covering the meat cutting industry funded by the Finnish Work Environment Fund. The manufacturers of clothing, safety shoes and gloves participated in the study. The trial of clothing designs was undertaken in one company which had approximately 100 employees.
What triggered off the intervention?	The high levels of occupational accidents, injuries and diseases in this sector of industry. The aim was to study possibilities to reduce the amount of accidents and diseases by developing work methods, personal protective equipment and the work environment. The aim of the project was also to design a functional clothing system for meat-cutters, paying special attention to the metabolic requirements of the work and the thermal and general working conditions in slaughterhouses as well as the norms and legislation. The temperatures of the work environment and the meat were lowered according to the EU regulations.
What was the initial purpose of the participatory process?	To study possibilities to reduce this level of occupational injury / ill health and to design functional personal protective clothing (PPC). The participatory approach was chosen to motivate workers in the industry to use protective clothing and gloves by being part of the design and development of such clothing.
Was this a one off activity or a structured system of work?	A one-off study within the industry but the process has since been repeated by FIOH for further projects.
Description of machine, work	All aspects of the slaughterhouse work were studied: work environment, ventilation systems, tools and machines, work methods,

environment involved	material flows, physiological and other characteristics of the workers, clothing, gloves, shoes etc.
Number of participants, their jobs / roles	A survey of accident statistics, occupational diseases, absenteeism etc. was undertaken in all companies within the meat cutting industry. The field studies took place within one company that had approximately 100 employees.
Level of influence, team / department / company	The aim of the project was to influence the whole sector of industry. The research team had continuous contacts and discussions with the workers, with the line managers, employer representatives and representatives of the trade union and employer association.
Description of participatory method, was there a facilitator involved?	The end users participated actively especially in the first specification phase, testing of the prototypes and in the specification of the final designs. The decisions were made on the basis of the findings during the study and discussions with the workers. The research team consisted of representatives of the slaughterhouse and of occupational hygienists, medical doctors, accident researchers, ergonomists, clothing designers, textile engineers and representatives of industrial laundries.
What actually happened - did things go according to plan?	From the report things seemed to go according to plan. New protective clothing design was developed. More comfortable gloves were developed. Recommendations for the design of footwear were given.
At what stage in design cycle were people involved?	The workers had direct involvement throughout the process. The end users continuously had the possibility to participate in design discussions.
Where did the activity take place?	All the discussions were conducted at the workplace. The physiological testing was made at the workplace and in the laboratory of FIOH.
Design problems identified by end users	Cold was a common problem in slaughterhouses. Cold cutting rooms caused thermal discomfort and cold stress and strain among slaughterhouse workers. Radiant asymmetry, cold draughts, elevated air humidity and low floor temperatures were also common complaints. The lack of sufficient thermal insulation of the extremities was a particular problem. According to the questionnaire, the most common complaints were: local cooling of neck and shoulders, ankles, wrists and lower back. The body fluids of the slaughtered animals wetted the clothing, decreasing their thermal insulation and causing extra discomfort. Particularly the stomach, hands and wrists were perceived to be uncomfortably wet and cold.
What improvements were made?	On the basis of the pilot study, clothing requirements were set for the new PPC system and three different prototype sets of clothing were designed by students of the Helsinki University of Industrial Arts. A few workers used these prototypes for 3-4 weeks on the job. At the same time, the materials were tested and the thermal insulation values of the clothing ensembles were measured on a thermal mannequin.
Any opportunities to further evaluate the proposed changes?	Further modification was based on the feedback received from the workers and on the results of material tests. Two further sets of clothing were designed and used by some meat-cutters on the job during physiological wear trials. All the workers wore the similar

	long-sleeved and long-legged underwear made of 50 / 50% cotton / polyester in the trials with the prototype PPC. Comparative measurements were made using the traditional PPC system. The accident rate and amount of absenteeism will be evaluated later.
General H & S improvements after changes?	Prototype wear trials consisted of continuous registration of typical work physiological parameters: heart rate, body core and skin temperatures at different body sites. The skin temperatures, especially those of the shoulders, lower back and chest, were several degrees higher with the new PPC system than with the traditional PPC, with about the same thermal insulation. However, in the traditional clothing the insulation was unevenly distributed over the body. The workers found the new PPC system warmer and more protective against dirt and moisture than their traditionally used PPC system. On the basis of the results of the workplace survey, many other improvements in working conditions were made like changes in the ventilation systems, flow of materials etc.
Any wider implications for the organisation?	The final commercial PPC system, also accepted for common use in many slaughterhouses in Finland, consisted of three garments made of polyester (65%) / cotton (35%) blend: an overall with braces, a work coat and an apron. In the design stage, special attention was paid to protecting the parts exposed to cold and moisture and to make the collar and the sleeves functional. Thus the new PPC system can also be worn in other tasks in the food industry, e.g. in dairies and packing departments, with even colder environments but physically lighter activity. The study has led to better acceptance of using protective gloves and to a reduction of injuries.
General case study evaluation. Beneficial process or not?	This study-based systematic design project indicated that the chances of succeeding in designing and developing a functional PPC system, especially for extreme or multi-risk work, requires intensive multidisciplinary teamwork with continuous feedback from end users. The results were used directly in the CEN standardisation of the protective gloves and aprons for slaughterhouse workers. The leader of the team acted as chairman of CEN TC 162 WG5, which made the existing product and testing standards for those devices. The chairman also invited some workers to participate in meetings of this working group.

Case No. 21 - Finland
Combat clothing

Organisation, type sector, size etc.	Finnish Army Special Forces.
What triggered off the intervention?	Request to design more comfortable clothing for military use against foul weather conditions (-15 to +10°C, water, snow etc.).
What was the initial purpose of the participatory process?	

Was this a one off activity or a structured system of work?	One off for the Special Forces but a structured approach for the research institute involved.
Description of machine, work environment involved	Combat clothing for special forces personnel.
Number of participants, their jobs / roles	117 servicemen and 24 trainers and contract soldiers.
Level of influence, team / department / company	
Description of participatory method, was there a facilitator involved?	
What actually happened - did things go according to plan?	
At what stage in design cycle were people involved?	A questionnaire was sent out to collect information on end users' requirements for their combat clothing. End users also took part in trials of prototype designs of clothing.
Where did the activity take place?	
Design problems identified by end users	
What improvements were made?	
Any opportunities to further evaluate the proposed changes?	
General H & S improvements after changes?	
Any wider implications for the organisation?	
General case study evaluation. Beneficial process or not?	

Case No. 22 -Sweden
Muscle operated hand tools

Organisation, type sector, size etc.	Six major manufacturing companies (cars, trucks, electrical equipment, etc.), and a number of hand tool manufacturers.
What triggered off the intervention?	An awareness that hand tools represent a major health problem in industry, and also that funds had been made available.
What was the initial purpose of the participatory process?	To make tool manufacturers aware of the real needs of the end users and that better tools could be made available on the market.
Was this a one off activity or a structured system of work?	The project aimed at development of new tools, and at an increased awareness of ergonomic aspects in tool design. After the project new products with better properties were made available. The project was one off but the results were long-lasting.
Description of machine, work environment involved	Automotive assembly, appliance assembly, electronic circuit board assembly, plate-work etc. Project tools included: engineer's hammer, knife, crimping tool, ratchet, hex key, wire brush, plate shears, cable stripper, band cutter, spanner.
Number of participants, their jobs / roles	It was estimated that about 2,000 employees in the user companies participated in the project.
Level of influence, team / department / company	The project aimed at influencing tool manufacturing companies and tool dealers, but also to increase awareness in user companies at all levels: end users, supervisors, technical personnel, occupational health specialists, purchasers, managers.
Description of participatory method, was there a facilitator involved?	Problem tools were identified by the end users in group meetings in the participating companies. User demands on the project tools were collected in a participatory process, Quality Function Deployment (QFD). End users participated in prototype evaluation.
What actually happened - did things go according to plan?	About 400 report forms identifying problem tools were collected from user companies. Ten tools that had multiple nominations were prioritised. A specification document was developed for each tool, containing technical demands, ergonomic demands, and demands in user terms. For each tool a task force was set up, consisting of a representative of the unions, the employers, a tool manufacturer, and a designer. Functional prototypes were developed and tested against the specifications. Out of the ten prototype tools, seven have hit the market. There was a marketing drive throughout the project.
At what stage in design cycle were people involved?	End users participated from the very beginning (problem identification) and throughout the project.
Where did the activity take place?	Problem identification, collection of user demands: shop floor. Design work and prototyping: tool manufacturing companies and design firms. Ergonomic comparative evaluation: research laboratory. Field testing: shop floor.
Design problems	Typically excessive force demands, high accident risk, tool not

identified by end users	adapted to hand size, handle surface too edgy and/or having poor friction properties, generally poor quality, not adapted to the work, tools ugly and unattractive.
What improvements were made?	A series of new prototype tools with better ergonomic properties were designed and made available to end users (not only in the participating companies).
Any opportunities to further evaluate the proposed changes?	A special test facility "the hand tool laboratory" was made available, and it was intended that this facility would serve future similar projects. However, due to economic problems, this lab was closed some time after the end of the project.
General H & S improvements after changes?	The new improved tools have been successful commercially which means that they have entered into widespread use. However, no specific follow-up studies with respect to health and safety patterns have been carried out.
Any wider implications for the organisation?	Following the apparent success of the present project, a second project was launched (Swedish case study 2). Tool manufacturers as well as dealers were made aware that ergonomics might be a selling point.
General case study evaluation. Beneficial process or not?	This project was well designed and resulted in significant improvements for thousands of end users. The project showed clearly the power of many end users and user companies uniting, and that there are ways to influence manufacturers and make them aware of the real needs of users representing a substantial market for the products. A European effort of this nature could be envisaged.

Case No. 23 - Finland

Hand tools for vineyards

Organisation, type sector, size etc.	The Eurohandtool project was carried out by two Universities and five companies in Finland and Germany.
What triggered off the intervention?	Non-powered hand tools constitute an important element of work and production systems. The use of poorly designed hand tools in work has led to a serious increase in occupational disorders. These problems cause great human suffering and economic losses Europe-wide. Poorly designed hand tools also cause unnecessary workload and decreases in productivity. There is a growing awareness in industry in this respect. In North America and Scandinavia, ergonomics in tool design has become one of the major selling points. This implies growing dynamic markets for improved standard tools, and for new categories of specialised tools.
What was the initial purpose of the participatory process?	The main objectives of this project are to improve the effectiveness, ergonomic quality and application areas of non-powered hand tools, and to improve the productivity of work done using them.
Was this a one off activity or a structured system of work?	

Description of machine, work environment involved	A completely new generation of hand tools used in wine harvesting and grapevine tending will be developed.
Number of participants, their jobs / roles	
Level of influence, team / department / company	
Description of participatory method, was there a facilitator involved?	
What actually happened - did things go according to plan?	
At what stage in design cycle were people involved?	
Where did the activity take place?	
Design problems identified by end users	
What improvements were made?	
Any opportunities to further evaluate the proposed changes?	
General H & S improvements after changes?	
Any wider implications for the organisation?	
General case study evaluation. Beneficial process or not?	

Case No. 24 - Germany
Concrete compression machine

Organisation, type sector, size etc.	Württembergische Bau-Berufsgenossenschaft (Institution for statutory accident insurance and prevention in the building trade in Württemberg), approx. 20,000 companies with 230,000 insured persons. The work was undertaken by the Prevention Department.
What triggered off the intervention?	The Federal Ministry for Research and Technology supported some research between 1975 and 1985 in order to reduce the risks of hearing damage and restrict the high incidence of deafness due to noise. The resulting improvements in the machinery were not fully sufficient, as the noise reduction was low and the costs for new equipment high. In order to help develop solutions that resulted in efficient noise reduction on site, the ARGE Bau (working group combining members of all the Bau-Berufsgenossenschaften) took the initiative to promote the introduction of new machinery and support the further development of techniques used in concrete compaction.
What was the initial purpose of the participatory process?	Improve the acceptance of new techniques and further develop new technology to efficiently reduce the noise emission of concrete compacting machinery, taking account of the workplace conditions as experienced by the workers.
Was this a one off activity or a structured system of work?	A one-off project.
Description of machine, work environment involved	Noiseless technique of concrete compaction with electrically driven shaking machines.
Number of participants, their jobs / roles	Four plants for pre-cast concrete with 30 – 100 members of staff were involved in the project. The machinery was installed and used, and reports were established that reflected the experience of the workers when using the machinery, taking account of problems and including suggestions for further improvement. The persons involved at each plant included the management, the safety experts or engineers and the workers at the shaking machines.
Level of influence, team / department / company	The management as well as the persons responsible for occupational health and safety.
Description of participatory method, was there a facilitator involved?	Installation of new machinery in four plants; this was supported by allowances that were granted to the participating companies / plants by their Bau-Berufsgenossenschaft. In return, the companies were obliged to draw up reports on their experiences with the new machinery (positive and negative comments based on practical work with the machinery). Allowances were also provided for member companies to compensate the additional cost for the new machinery.
What actually happened - did things go according to plan?	
At what stage in	Users were involved in the selection and evaluation of the machinery.

design cycle were people involved?	
Where did the activity take place?	In plants manufacturing pre-cast concrete.
Design problems identified by end users	The companies produced reports on their positive and negative experiences with the new machinery, based on the information given by the people who worked with the machines. These related e.g. to the use of additional equipment that could negate the noise-reducing effects, the comparison of different types of techniques (hydraulic and electric drives; different types of tilting mechanisms / tables etc.).
What improvements were made?	New techniques were developed and established that efficiently reduced the noise emission from the machines. At the same time, the direct participation of staff members led to a higher level of acceptance of the new technique.
Any opportunities to further evaluate the proposed changes?	Measurements of the noise level in companies.
General H & S improvements after changes?	Concrete compaction techniques that exclude the risk of hearing damage. In addition, the new machinery improves the quality of the concrete and the energy consumption in the production process is reduced.
Any wider implications for the organisation?	The acceptability of the new technology contributes to a better use of noise-reduced machinery. The limit values defined in the regulations by the Berufsgenossenschaften (Lärmschutzarbeitsblatt LSA 04-602, October 1999) reflect the lower values that could not be reached with the old technology.
General case study evaluation Beneficial process or not?	Further evaluations confirm the good results obtained at the beginning. More machinery is used, with the aim of reducing noise emission and protecting the neighbourhood against noise.

Case No. 25 - Germany
Protective clothing for abrasive blasting operations

Organisation, type sector, size etc.	Bau-Berufsgenossenschaft Rheinland und Westfalen (institution for statutory insurance and prevention in the building trade in the Rhineland and in Westphalia), approx. 65 000 companies with 439 000 insured persons - Prevention department.
What triggered off the intervention?	Frequent, in some cases even fatal, accidents due to insufficient protection of the operators in abrasive blasting operations (injuries of the extremities and lead poisoning due to insufficient respiratory protection).
What was the initial purpose of the participatory	Development of protective clothing for abrasive blasting operations, taking account of respiratory protection, on the basis of the

process?	users' work experience (postures, work organisation, specific risks encountered).
Was this a one off activity or a structured system of work?	Temporary activity. In a second step a round table forum was established to discuss improvements made so far, further observations and remaining problems.
Description of machine, work environment involved	Protective suit for abrasive blasting operations. Users were asked about existing problems in the application of the existing protective equipment (ergonomic aspects, combination problems) as experienced in their daily work; the findings were discussed with federations / user organisations and manufacturers to consider organisational aspects; the information was discussed with manufacturers, who set out to design new protective clothing. Prototypes of this protective clothing were tested at workplace level. Any remaining problems are still discussed during round table discussions.
Number of participants, their jobs / roles	A total of approx. 40 persons was involved, including entrepreneurs as well as staff members; At organisational level and for additional assessments, different types of organisations and federations were consulted such as: the BVK (the federal association for the prevention of corrosion), the state institute for occupational health and safety (STAFA), Bau-Berufsgenossenschaft Rheinland und Westfalen, manufacturers, retailers, FA "PSA" (expert committee for PPE in the BG system).
Level of influence, team / department / company	Manufacturer; company; team.
Description of participatory method, was there a facilitator involved?	Gathering of information on problems at work as encountered by the users of protective clothing for abrasive blasting. Consultation with user organisations and manufacturers in order to propose design improvements. Production of prototypes of an improved model. Field tests to gain experience with the function of the prototypes. Follow-up on further developments.
What actually happened - did things go according to plan?	From the report it would seem that all went according to plan.
At what stage in design cycle were people involved?	Right from the start of development: the users were asked about their experience with conventional protective clothing and their wishes for improved protection and comfort. During prototype testing they were able to assess the new equipment at work and were encouraged to make suggestions on possibilities of further improving the design.
Where did the activity take place?	On construction sites and in companies.
Design problems identified by end users	Problems were described and presented by the users when in the beginning they were asked to comment on insufficient ergonomic characteristics and protective features with regard to the existing protective clothing. The aspects taken account of related to protective functions as well as the ventilation of the clothing and postures when working. In prototype testing, remaining problems with the newly designed protective clothing were described. New developments concerning abrasive blasting operations – new

	procedures and the use of different hazardous substances – created the necessity to further discuss problems in round table discussions.
What improvements were made?	Design of a new type of clothing that meets the requirements defined by the users. Higher acceptance of the clothing at the workplace because the users see that their needs have been taken into account.
Any opportunities to further evaluate the proposed changes?	Field tests of the prototype designs allowed users to report their findings which were then taken into account for subsequent designs. Consideration of reports on work experience is taken into account in Round Table discussions on the results and further developments.
General H & S improvements after changes?	Improved hygiene and ergonomics.
Any wider implications for the organisation?	The requirements defined for the protective clothing are reflected in an accident prevention regulation (BGV D 26). The results of the project and the Round Table discussions have also been taken into account in the revision of EN ISO 14877.
General case study evaluation. Beneficial process or not?	During the Round Table discussions, the need to adapt the protective clothing to the latest developments in working techniques and requirements in relation to the handling of hazardous materials was established. New developments have already started.

Case No. 26 - Germany
Safety helmets

Bau-Berufsgenossenschaft Rheinland und Westfalen

Figure 24: **Example of new design helmet**

Organisation, type sector, size etc.	Bau-Berufsgenossenschaft Rheinland und Westfalen (institution for statutory insurance and prevention in the building trade in the Rhineland and in Westphalia), approx. 65 000 companies with 439 000 insured persons. The work was undertaken by the Prevention Department.

What triggered off the intervention?	The experience that there seems to be a low degree of willingness among workers to wear industrial safety helmets. Head injuries are frequent and generate high costs for the institutions for statutory accident insurance and prevention in the building trade. This situation led to the research project promoted by the German federation of institutions for statutory accident insurance and prevention (HVBG).
What was the initial purpose of the participatory process?	Optimisation of industrial safety helmets, in order to achieve a better acceptance among the work force. Improvement of the comfort and design of industrial safety helmets according to the users' wishes should help improve their acceptance and thus contribute to a decrease in the accident figures.
Was this a one off activity or a structured system of work?	A one-off research project.
Description of machine, work environment involved	Safety helmets with different protective functions and wear characteristics.
Number of participants, their jobs / roles	The project was organised and supported by: the German expert committee 'PPE' (FA 'PSA') and its working group for head protection (AK 'Kopfschutz'), the Occupational Health Service (AMD) of Bau-BG Rheinland und Westfalen, the Institute for Machinery (Institut für Maschinenwesen) and the Institute for research and testing of the German Berufsgenossenschaften (BIA), an industrial design company (IMB) and a helmet manufacturer. For information on the improvements required to ensure a better acceptance of industrial safety helmets and for testing of the prototype helmet, different companies and their staff were involved for questioning and prototype testing.
Level of influence, team / department / company	The company as a whole.
Description of participatory method, was there a facilitator involved?	Questionnaires, field tests (prototype testing), proposals for improvement, discussions about remaining problems. There was not a facilitator involved. The participation took place at four levels: 1. Entrepreneurs, project engineers 2. Safety advisors in the companies 3. Foremen 4. Skilled and unskilled workers
What actually happened - did things go according to plan?	
At what stage in design cycle were people involved?	The users participated right from the start in order to define the existing problems, as well as later in the test phase (prototype testing). A considerable number of users from different backgrounds were questioned at the start of the project (definition of requirements) and in field tests with prototypes: 25 companies of different size ranges (up to 10 staff members, 10-100 staff members and > 100) all over Germany, as well as subcontractors of the Deutsche Bahn AG.

Where did the activity take place?	On construction sites and in companies.
Design problems identified by end users	Low level of acceptance of PPE because of insufficient ergonomic design characteristics, not enough confidence in the usefulness of the helmet and therefore no real identification with the PPE.
What improvements were made?	Development of an industrial safety helmet based on a modular approach which can be adapted to the different needs encountered in different working situations and shows improved comfort and thus meets with a higher level of acceptance.
Any opportunities to further evaluate the proposed changes?	Field testing of prototypes: the new product, which has been developed on the basis of the results of the questionnaires answered by entrepreneurs, project engineers, safety advisors in the companies, foremen, skilled and unskilled workers, had been given to the workers for further evaluation.
General H & S improvements after changes?	Higher level of acceptance of the helmets by the workers. The helmet design was taken as a basis of further studies on optimising the protective functions of helmets through the use of improved materials.
Any wider implications for the organisation?	
General case study evaluation. Beneficial process or not?	The feedback concerning comfort and acceptance was positive. Unfortunately, the studies mentioned above were not further encouraged by the manufacturer participating in the study for commercial and financial reasons, so that, for the time being, any further development along the lines of the modular helmet has had to be postponed.

Case No. 27 - UK
Plaster room chair


IOE


IOE

Figure 25: **Plaster room chair (from front and side)**

Organisation, type sector, size etc.	Health Service NHS Trust.
What triggered off the intervention?	Poor workplace design for certain tasks and reports by staff of musculoskeletal discomfort. Problems with certain tasks were identified by staff during their manual handling training. The tasks were reviewed by the manual handling adviser but there was no appropriate equipment currently available to eliminate or reduce these problems. A particular concern was the task of applying above elbow plasters. This requires two members of staff, one to support the patient's arm and the other to apply the plaster. The plaster takes approximately 15 minutes to complete. Both members of staff are required to maintain static awkward postures for the duration of the task and these are risk factors for the development of musculoskeletal discomfort.
What was the initial purpose of the participatory process?	To develop solutions to improve the working postures of the plaster technicians.
Was this a one off activity or a structured system of work?	One off activity for this department but the approach has since been used by the manual handling adviser to solve other workplace problems.
Description of machine, work environment involved	Chair for plaster room to be used when patients require a plaster on their arm.
Number of participants, their jobs / roles	2 plaster room technicians, designers and reps from the equipment manufacturers (Mediplinth). The manufacturers supply other products to the hospital and are also based in the same area.
Level of influence, team / department / company	Within the plaster room of the hospital initially but the product design is now being sold nationally and has been adapted for other health care tasks (phlebotomy).
Description of participatory method, was there a facilitator involved?	The manufacturer discussed the task requirements with the plaster technicians and then developed a prototype. The plaster room technicians then used the prototype for a period of a month. The manual handling adviser facilitated the evaluation which also involved the patients, who are equally users of the chair.
What actually happened - did things go according to plan?	Useful information was collected from the end user evaluation which led to an improved product design.
At what stage in design cycle were people involved?	Initial ideas from the end users were suggested to the manufacturers. End users were then able to evaluate the design prototype.
Where did the activity take place?	At the Hospital.
Design problems identified by end users	The width of the chair was reduced to allow easier access for the technician supporting the patient's arm. A table was provided for both sides of the chair to eliminate the need to keep changing this from side to side. The ability to recline the seat, raise the leg supports and remove the arm rests was included in the final design. Such adjustments supported the care and handling of patients who become unwell while in the plaster room.

What improvements were made?	The manufacturers addressed the suggestions made by the end users and these were included in the final design.
Any opportunities to further evaluate the proposed changes?	The relationship with the manufacturer allows ongoing evaluation as appropriate.
General H & S improvements after changes?	Improved working posture for plaster room technicians.
Any wider implications for the organisation?	Improved working conditions for the staff, improved working posture for staff and also increased comfort for the patient.
General case study evaluation. Beneficial process or not?	Overall a beneficial process and outcome. The product continues to be well used, well liked and has improved the working posture and therefore enhanced the comfort, health and safety of end users.

Case No. 28 - UK
Equipment trolley

IOE

Figure 26: **Equipment trolley**

Organisation, type sector, size etc.	Health Service NHS Trust.
What triggered off the intervention?	Specialist equipment for the wards and hospital departments is stored at one depot within the hospital. The hospital departments cover a large physical area. There are two members of staff who are responsible for delivering equipment to the wards and departments as requested. The specialist equipment comprises slings, hoists, mattresses etc. which can be heavy and awkward in shape. The transportation of such equipment was undertaken by a member of staff using a wheelchair! The use of a pedometer proved that staff were walking a minimum of 1 mile per hour. The average day was anything between 8-10 hours. The amount of walking across the vast site was causing both members of staff discomfort to

	knees, ankles and feet and therefore a motorised vehicle was proposed.
What was the initial purpose of the participatory process?	To provide a suitable and safe means of transporting expensive specialist equipment throughout the Trust and to reduce the risk of injury to the staff.
Was this a one off activity or a structured system of work?	A one off activity.
Description of machine, work environment involved	Bradshaw Electric Vehicle Model SC-59 shown in Figure 26 above.
Number of participants, their jobs / roles	The two equipment co-ordinators, the manual handling adviser and the company Area Sales Representative.
Level of influence, team / department / company	The specialist equipment department of the hospital.
Description of participatory method, was there a facilitator involved?	The area sales representative discussed the task requirements with the equipment co-ordinators and reviewed the environment in which the trolley would be used. The manufacturer developed a prototype and the equipment co-ordinators were able to evaluate the prototype. The manual handling adviser facilitated the evaluation.
What actually happened - did things go according to plan?	The first vehicle was too large. It was unable to turn in the corridor and only just fitted in the lift. A second prototype was then provided for user evaluation.
At what stage in design cycle were people involved?	The initial design came from the Company, NHS trust staff suggested improvements to the design.
Where did the activity take place?	At the Hospital.
Design problems identified by end users	The staff suggested changes to the height of the steering wheel to improve posture and comfort. The ignition key and gear lever were too low and alternative placement of these was suggested to improve access for the user. The height of the back rest was altered to provide better support and padding was provided for comfort. The shape of the front of the trolley was changed from an arrow head to a square front to improve the load holding capacity. The sides of the trolley can be released and dropped down to improve access to the loads and the handling of these items.
What improvements were made?	The above problems and suggestions made by the users were incorporated into the final design of the trolley.
Any opportunities to further evaluate the proposed changes?	The Company is based in Ipswich, close to the hospital, which allows periodic review; currently this is four visits per annum.
General H & S improvements after changes?	The staff are less tired after a full day's work. Their injury rate has decreased and neither has complained of musculoskeletal discomfort since the purchase of the vehicle.

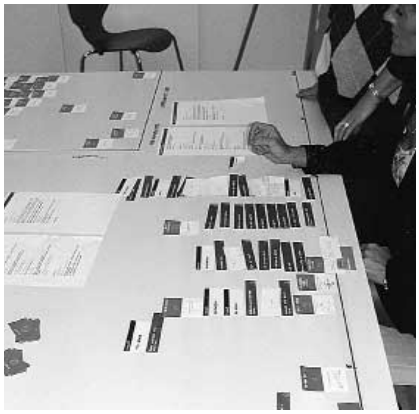
Any wider implications for the organisation?	Improved working conditions for 2 members of staff. Safety of expensive equipment. Improved efficiency of the delivery service and reductions in the time taken to supply essential equipment to wards and departments.
General case study evaluation. Beneficial process or not?	Overall a beneficial process and outcome with improvements to both the service being provided and the health and safety of staff.

Case No. 29 - Netherlands
New product to load freight

Organisation, type sector, size etc.	Airline
What triggered off the intervention?	High incidence of musculoskeletal health problems.
What was the initial purpose of the participatory process?	Faster loading / unloading of the aircraft was required as well as a reduction in musculoskeletal injuries.
Was this a one off activity or a structured system of work?	A one off activity.
Description of machine, work environment involved	Light-weight retractable luggage transport system.
Number of participants, their jobs / roles	Management of the ground services operations, design engineers, ergonomists from TNO and 12 experienced freight handlers.
Level of influence, team / department / company	Initially for specific product but new design is being patented and will then be available to a wider market.
Description of participatory method, was there a facilitator involved?	Laboratory testing of design mock-up (physiological measurements). End user evaluation of mock-up also taken into consideration to improve the design (subjective evaluation).
What actually happened - did things go according to plan?	Yes, except for the latest stage.
At what stage in design cycle were people involved?	End users involved once an initial design mock-up had been agreed by 'experts'.
Where did the activity take place?	Laboratory setting at a research organisation.

Design problems identified by end users	In the initial phase the work was reported by the freight handlers to be very heavy. In the mock-up evaluation they reported improvements in their level of comfort while undertaking the tasks.
What improvements were made?	In the initial phase a design team developed a prototype which provided some mechanical assistance to the movement of freight into the aircraft which had previously all been done manually in awkward working postures. Following the evaluation no further improvements were identified.
Any opportunities to further evaluate the proposed changes?	This has not yet been possible as the manufacturer is not making the system at the present time.
General H & S improvements after changes?	Improved physical load for freight operators; improved working postures and reduced physiological strain.
Any wider implications for the organisation?	Yes, probably in future projects the manufacturer should be involved at an earlier stage.
General case study evaluation. Beneficial process or not?	This was a useful process, however the product is not available yet.

Case No. 30 - UK
New domestic product interfaces



J. Bonner

Figure 27: **Card sorting exercise**

Figure 28a: **Undertaking a task** J. Bonner

Figure 28b: **Reviewing the 'design' while completing the task**

Organisation, type sector, size etc.	International manufacturing organisation producing domestic products such as washing machines, cookers and refrigerators (referred to 'in the business' as brown and white goods and wet products).
What triggered off the intervention?	A researcher from Huddersfield University was developing design tools for interface designers and worked in partnership with the manufacturer to trial and develop the tools for this particular design environment.
What was the initial purpose of the participatory process?	The researcher planned to evaluate the usefulness of the design tools which required the involvement of potential end users. The organisation however had a different aim, which was to develop innovative interfaces for their products.
Was this a one off activity or a structured system of work?	The approach was being used by the researcher in other similar projects but the participatory process so early in the design cycle was new to the manufacturing organisation.
Description of machine, work environment involved	The products concerned new or novel consumer- based interactive interfaces which may be applied to existing domestic products.
Number of participants, their jobs / roles	A group of approximately 20 end users who worked for the organisation at product assembly sites met with the product design team (6 designers in total). The researcher provided the designers with the design tools, trained them in their possible use and then observed the process, only intervening when asked for advice by the designers.
Level of influence, team / department / company	The decisions made by the end user groups were able to influence the outcomes of the design department involved with the project. The outcome of the project had implications for the wider organisation as there were design departments located in our companies but implementing the findings from this project this would require approval from higher levels of management responsibility to proceed.
Description of participatory method, was there a facilitator involved?	The end users and designers met on three occasions for about half a day on each occasion. The first workshop used a card sorting activity (Figure 27). This provided a focus for both the designers and participants to discuss and articulate their future needs. The

	cards had words associated with the process or function of the product which the participants were asked to select and arrange as they felt they were relevant. New cards could be created if the desired statement or description was not available. 'Open' statements provided an opportunity for participants to discuss what may be meant and helped to identify underlying reasons for choices which otherwise may have remained hidden. On another occasion the participants undertook an activity relevant to the product. They were able to build and develop the product interface prototype out of paper as they 'acted' out the activity (Figures 28a and 28b).
What actually happened - did things go according to plan?	Initially the designers found the process difficult but with time and guidance from the researcher became confident in using the tools with the end users. The end users were very positive about the tools and the process from the beginning. The role play exercise, where end users carried out a task, helped to place the interaction problems identified in the card sorting exercise into a relevant context. The design tools assisted in this process and the designers found the exercise provided a wealth of useful information.
At what stage in design cycle were people involved?	At the very early stages of design development.
Where did the activity take place?	At one of the manufacturing organisation's industrial design departments.
Design problems identified by end users	As the participation was so early on in the design cycle, end users were involved in developing potential design solutions and identifying future user requirements. There were some difficulties on occasions for end users to consider alternatives to what they currently knew and had experience of.
What improvements were made?	During the role play activity the end users were able to create and develop the user interface in partnership with the designers, although sometimes one group led the process more than the other. It is too early to say at this point whether the outcomes from this process will be incorporated into future design decisions as there are many other factors which will influence the development of such products.
Any opportunities to further evaluate the proposed changes?	End users were consulted on design issues during the process and were able to discuss changes and possible suggestions with the designers.
General H & S improvements after changes?	It is too early to evaluate whether the new designs will have any influence on health and safety issues for end users.
Any wider implications for the organisation?	Whilst the information collected using the design tools and the participation of end users was considered to be very valuable, the designers found difficulties in reporting and presenting this knowledge in their 'traditional' ways. The researcher was not able to continue to work with the organisation after the project to assist them in developing appropriate reporting systems and methods. It appears that the approach has not been used subsequently by the organisation, as a number of the design team have left the organisation and so the body of knowledge gained from the project went with them.
General case study evaluation.	Despite some of the difficulties the design tools and participatory approach were considered to be of considerable benefit to the

Beneficial process or not?	designers. They had not previously discussed design solutions with end users at such an early stage in the design cycle. One designer commented that he had learnt more in the short period of the project than in the many years he had been working within the design team. In particular the involvement of end users had made the designers aware of the complexity of issues that end users faced when using interactive interfaces which may require complex solutions. To a lesser extent they also became aware of the variety of usability requirements that may need to be met.

Case No. 31 - UK
Hand held tool for gas cylinder delivery

Robens Institute for Health Ergonomics

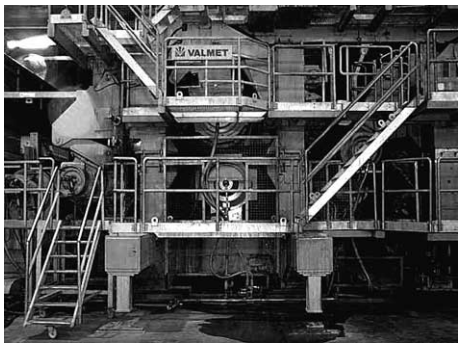
Figure 29: **Use of the HHIT to carry gas cylinders**

Organisation, type sector, size etc.	Compressed gas industry – large multinational organisation producing and delivering cylinders of compressed gas to industry and the healthcare and service sectors.
What triggered off the intervention?	Within the industry there was a very high level of reporting of musculoskeletal discomfort by operators, particularly related to the delivery of gas cylinders.
What was the initial purpose of the participatory process?	To design and evaluate a hand-handle interface tool (HHIT) to reduce the strain of manually delivering the cylinders.
Was this a one off activity or a structured system of work?	One-off activity.
Description of machine, work environment involved	Gas cylinders do not have a handle designed into them. Operators use the top rim of the cylinder, which is open in design to enable the operators to grip, roll, lift or drag the cylinder. In some cases

	a trolley can be used to transport the cylinder but the operator still has to lift this from the delivery vehicle onto the trolley. An operator suggested the design of a manual handling aid, called the HHIT.
Number of participants, their jobs / roles	Initially a small group of operators, line managers and engineers met to evaluate the tool. An ergonomist, not involved in the prototype design, conducted an evaluation on 21 end users.
Level of influence, team / department / company	At a local level and within the UK sector of the organisation.
Description of participatory method, was there a facilitator involved?	Initially end users participated in a small group forum to review a prototype design of a tool. The ergonomist designed a formal evaluation study, which involved field trials and laboratory studies. For the field trials operators reported their experience through user diaries, discomfort questionnaires, comparative questionnaires and semi-structured interviews. In the laboratory posture analysis and force measurements were undertaken.
What actually happened - did things go according to plan?	One subject was withdrawn from the study as they considered using the HHIT to be a hazard.
At what stage in design cycle were people involved?	End users had developed the HHIT and were then part of the formal evaluation study.
Where did the activity take place?	Both out 'in the field' and in a laboratory setting.
Design problems identified by end users	The use of the HHIT made the positioning of the cylinder difficult in some circumstances, such as stacking between other cylinders, due to interference of the ring around the cylinder. The design of the handle and the resultant angle that the cylinder was carried at made access in some confined corridors and doorways more difficult than when not using the tool.
What improvements were made?	Analysis of the field and laboratory data indicated that there were few benefits from using the HHIT compared with the normal method. The end user involvement in the problem solving process had given valuable insight into the constraints and demands of the task. However the lack of expert ergonomics involvement in the early stages led to the development of a tool with limited benefits. The benefits of the participatory process were realised and it was used for other company projects, in particular a redesign of a cylinder trolley and the development of better work practice training for operators.
Any opportunities to further evaluate the proposed changes?	User feedback, lost time data and delivery efficiency data.
General H & S improvements after changes?	The formal evaluation of the tool enabled its strengths and weaknesses to be identified. The tool was considered by some operators to be useful in certain situations but was also a potential problem in others. The use of the tool in the latter situations was therefore prevented. The evaluation of the tool led to greater awareness of problems and solutions within the business. As a result, work system changes were made.

Any wider implications for the organisation?	The use of the process has been utilised since for other projects.
General case study evaluation. Beneficial process or not?	The experience suggests that whilst end users can provide a valuable problem solving resource, wider issues of work organisation and job design need to be considered as part of the problem solving process rather than reliance on a tool to achieve a reduction in physical strain. The participatory process however was beneficial and has been used successfully for other projects within the UK sector of the organisation.

Case No. 32 - UK
Paper making and finishing machines



GPMU

Figure 30: **Example of paper making machine**

Organisation, type sector, size etc.	Paper making industry employing approximately 17 - 19,000 people.
What triggered off the intervention?	Review of health and safety performance in the industry.
What was the initial purpose of the participatory process?	Need to reduce the numbers of people killed or injured in the industry.
Was this a one off activity or a structured system of work?	Began as a one off activity but the programme of work is continuing as a structured activity for each mill.
Description of machine, work environment involved	Paper making machinery - process involves the bonding of cellulose fibres with water which then has to be pressed and dried before it is finished, which can involve glazing, sheeting or wrapping etc.
Number of participants, their jobs / roles	All 100 paper mills within the UK, trade unions, the trade association and the Health and Safety Executive (HSE).

Level of influence, team / department / company	From Chief Executive Officer (CE0) to plant operators within the mills and representatives from the other organisations.
Description of participatory method, was there a facilitator involved?	Initiative developed by the Paper and Board Industry Advisory Committee (PABIAC) which comprises representatives from the paper industry employers, trade unions, and the HSE. This initiative was communicated to all paper mills via meetings, conferences and visits to each mill.
What actually happened - did things go according to plan?	The initiative has been well received but the level of accidents and injuries has not reached the target set at the outset of the programme (50% reduction). Some demotivation of poorer mills was noted; they felt that whatever they did had little effect on their record.
At what stage in design cycle were people involved?	Once PABIAC had agreed the approach the initial target were the CEOs of companies. The initiative required each mill to set an Action Plan and this required participation of end users, both in its development and implementation.
Where did the activity take place?	Within each paper mill and at a variety of external locations for both national and local meetings arranged through the initiative.
Design problems identified by end users	Although this was not the primary focus of the initiative, problems with design concerning guards, interlocks and entrapment points were noted.
What improvements were made?	Each mill developed its own health and safety action plan. The level of commitment at all levels in the organisation was increased along with the provision of appropriate health and safety training. As part of this initiative an improved system for workforce participation has also developed.
Any opportunities to further evaluate the proposed changes?	The effects of the initiative have been evaluated and recommendations made to develop the programme in the next phase of implementation.
General H & S improvements after changes?	Accidents have reduced; over the three year period of the initiative the major and fatal accident rate decreased by 26.6% against a background of increases in production and reductions in employee numbers due to difficult economic circumstances.
Any wider implications for the organisation?	A number of improvements to the design of paper making machinery were identifed during the PABIAC initiative. Examples of these improvements are the provision of guarding in the wire and dryer sections of the paper making process. A guidance document was provided for the industry entitled 'Making Paper Safely' which outlined improvements required to existing machines. The PABIAC group is taking the recommendations from the Making Paper Safely project, including the requirement to improve guarding, into the technical committees for the relevant industry standards such as prEN 1034 to ensure a 'level playing field' throughout Europe.
General case study evaluation. Beneficial process or not?	The reduction in fatalities within the industry is a huge benefit to the organisations and to the employees. An improved safety culture has also been developed as part of the initiative. The process may also be transferable into other industries.

Case No. 33 - Finland

Work environment, promote general co-operation and participation for increasing productivity

Organisation, type sector, size etc.	A variety of industries, 30 in number, both in the public and private sector, participated in the project, which was initiated by the Finnish Government working together with labour market organisations.
What triggered off the intervention?	To develop means and tools to improve productivity.
What was the initial purpose of the participatory process?	To improve working conditions and productivity by employee empowerment.
Was this a one off activity or a structured system of work?	Initially a one off project lasting a year but many companies have continued to use the approach.
Description of machine, work environment involved	A wide variety of manufacturing and service industries.
Number of participants, their jobs / roles	Each organisation established a KAMU team where employees, supervisors and managers were represented. In most companies the employee representatives were elected by the members of staff.
Level of influence, team / department / company	Varied for each organisation: for some the level of influence was their department; for others the wider organisation.
Description of participatory method, was there a facilitator involved?	Consultants from the Finnish Institute for Occupational Health assisted organisations in the start up of the KAMU teams and then acted in a supervisory role as required.
What actually happened - did things go according to plan?	In most cases the process seemed to advance without great difficulty.
At what stage in design cycle were people involved?	People were asked to identify problems that existed within their workplace and organisation and to help develop solutions.
Where did the activity take place?	At each company site.
Design problems identified by end users	Not possible to detail here.
What improvements were made?	Most of the participating companies succeeded well in initiating improvement processes.

Any opportunities to further evaluate the proposed changes?	Each KAMU team was asked to complete an Achievements list and a Productivity Matrix which recorded the progress and outcomes of their work.
General H & S improvements after changes?	Not fully clear but the process of employee participation was found to be beneficial.
Any wider implications for the organisation?	The positive experiences reported suggest that policymakers in other countries could utilise the model.
General case study evaluation. Beneficial process or not?	Yes

Case No. 34 - Sweden
Hand held powered tools

National Institute for Working Life West

Figure 31: **The training kit developed for increasing awareness of the importance of hand ergonomics in end users**
A number of hand tools are contained in the box. On the table: measurement devices for hand anthropometrics, hand force, tool torque, and an instruction manual.

Organisation, type sector, size etc.	Eight major manufacturing companies (cars, trucks, heavy machinery, electrical equipment, household appliances etc.).
What triggered off the intervention?	Experiences made in Case No. 22 that many of the problem tools identified were externally powered rather than muscle driven, and that a focused project would be necessary in order to address these particular problems. Also funds were made available.

What was the initial purpose of the participatory process?	To identify problem tools, to articulate demands in user terms, and to develop ways in concert with end users to reduce exposure to work with hand held powered tools.
Was this a one off activity or a structured system of work?	This project was one off: project time was less than a year due to administrative constraints, and there was little time to follow up on the achievements.
Description of machine, work environment involved	The project addressed in principle all work with powered hand tools in the user companies. Project tools included: battery powered screwdriver; stapler; pop riveter; cutting device for electronic assembly; angle grinder.
Number of participants, their jobs / roles	It is estimated that about 100 persons participated in the user companies, including end users, supervisors, technical personnel, occupational health specialists and managers.
Level of influence, team / department / company	The focus was on the entire organisation in the user companies.
Description of participatory method, was there a facilitator involved?	End users participated in the identification of problem tools, in the design processes, in the testing of prototypes, and in listing good solutions in a benchmarking effort. Diaries were used to map exposure to work with powered tools.
What actually happened - did things go according to plan?	The project incorporated a large number of efforts aimed at improving work with hand held powered tools through a combination of technical and organisational measures. Such efforts included development of five prototype tools, benchmarking of good solutions between companies, increasing end user influence on purchasing of tools, rehabilitation strategies aimed at personnel on sick leave because of exposure to work with powered tools, smart technical design of products to be manufactured, guidelines with respect to design of work with powered tools, and educational and marketing activities.
At what stage in design cycle were people involved?	In the problem identification stage, in the design process, in evaluation of prototypes, in information activities.
Where did the activity take place?	The major part of the project was carried out within the companies, on the shop floor.
Design problems identified by end users	Powered tools are heavy, sometimes have poor balance, are used repetitiously, cause shock and/or vibration, become cold or heated, are risky to use, are sometimes dirty, ugly and unattractive, may be poorly adapted for the work intended.
What improvements were made?	A large number of good technical and organisational solutions were circulated between user companies and adopted. Ergonomics awareness was improved, but the general impact was limited.
Any opportunities to further evaluate the proposed changes?	Due to the short project time, no follow-up activity was carried out.
General H & S	It has not been possible to trace health and safety improvements

improvements after changes?	back to this specific effort.
Any wider implications for the organisation?	Ergonomic awareness has increased, but the effect was limited, probably due to the shortness of time for supporting effective circulation of information within the user companies. Educational activities have influenced the way that occupational health specialists engage on the shop floor.
General case study evaluation. Beneficial process or not?	The project was successful in achieving all its operational goals, but failed to make a significant impact on the user companies, let alone Swedish industry at large. An effort was made to create a system for testing tools and providing them with ergonomic quality certificates that the end user and the purchaser could consider in the selection of tools. This system was supported by all partners including tool manufacturers, but failed at the end because of lack of economic commitment. Nevertheless, this effort points to a most interesting possibility to improve the ergonomic quality of powered hand tools.

Case No. 35 - France

The whole production process including work equipment

Organisation, type sector, size etc.	A construction materials manufacturing company with 200 employees; part of a group.
What triggered off the intervention?	The intervention was carried out in an industry whose production process was originally based on asbestos cement. Following a government announcement on 3 July 1996 that asbestos use in the building industry would be outlawed from 1 January 1997, however, the company decided to reconvert the old site within a year by designing and building a new factory to use an asbestos-free process. The project ran from February to September 1997.
What was the initial purpose of the participatory process?	Ergonomic expertise was enlisted late on in the project, because nearly 80% of the orders had been placed. The request came from the Human Resources Manager and Plant Manager, who had qualms about workers' problems in adapting to the new production systems, stemming from their different entrenched perceptions about the operators and their abilities.
Was this a one off activity or a structured system of work?	It was a structured system of work for the ergonomists involved but was a one off activity for the company.
Description of machine, work environment involved	The new factory was to manufacture asbestos-free fibre-cement roof panels from a composite of silica, sand, cement, water and colouring agents. The raw materials were blended in mixers and the resulting slurry preparation was homogenised in pug mill mixers and then transferred to the endless felt of a sheet-making machine. During the process, glass fibres were mixed into the slurry before shaping and cutting, then autoclaved. The panels were then cut to the desired dimensions.
Number of participants, their	The work groups (with foremen and operators) proposed by the ergonomists were part of a participatory framework, set up for the

jobs / roles	project. The Health and Safety Committee was involved in the ergonomics aspect: it validated the presentation of the ergonomics intervention. Furthermore the ergonomists presented to the HSC the intermediate results and the final results at the end of the ergonomics intervention.
Level of influence, team / department / company	The work group influenced the team and department level. Through the Health and Safety Committee, the ergonomists were able to have company-wide influence. The ergonomists played the role of link between the different decision-making levels.
Description of participatory method, was there a facilitator involved?	The proposed training/action was developed out of the diagnosis made by the ergonomists after the initial analyses at the reference site. The participatory method was based on a training/action plan developed by the ergonomists following an initial assessment of the reference site. The programme involved the preparation for (2 days) and visit (2 days) to the reference site by operators from the future factory. The findings were then analysed (1 day) and put into a format for submission to the designers. From the experience feedback, benchmarks were developed for design and modifications, and the operators produced a video to show the approach taken and the form of the future work activities to those operators who did not take part in the analyses.
What actually happened - did things go according to plan?	Due to all the information taken by the work groups, one day was added in order to formalise the outcomes.
At what stage in design cycle were people involved?	The users participated directly in the design discussions during critical reviews (about 5 times). The ergonomists' job was to continue the discussions with the designers after each critical review and activity analysis. The users and ergonomists were involved at the detail design stage, in fact quite late on in the design process.
Where did the activity take place?	At the company site and at the reference site.
Design problems identified by end users	This branch of industry uses different products (cement, sand, fibre-glass, colouring matter, silica, water) that are very sensitive to variations of temperature and humidity. Since these products are blended the consistency of the paste obtained will change quickly. In some cases, incidents, delays, etc., the paste will become a crust that will generate other incidents and bad quality products. Shop floor workers play an important role in looking after the modification of the paste consistency and in cleaning all the crusts in the machines. The workers' participation contributed to modifying the access to the devices in order to facilitate the monitoring and cleaning operation.
What improvements were made?	A number of changes were made to the design of the equipment and the work area. One example is improvements in the preparation of colouring materials. Others are a better handling system; a new type of fixation of the big-bag on the tank chimney; better tightness of the tank; a Ventura suction system at the junction of the tank chimney and the big-bag, in order to catch the powder of metallic oxides; the granulometry of the colouring matter changed to be bigger for facilitating the flow out, and a fold system for the big-bag.

Any opportunities to further evaluate the proposed changes?	The review was informed by an evaluation done by the ergonomists, occupational health doctor, plant manager and project manager nearly 5 months after the first production line came on-stream.
General H & S improvements after changes?	Many technical choices had already been made well before the ergonomists were enlisted and the work groups set up. Compared to the reference situation, the ergonomists' technical input focused mainly on equipment access (walkways, ladders, etc.), the conditions of plant supervision and cleaning. A major safety contribution was made as regards both dust exposure and handling postures at the unloading station for the big bags of colouring agents.
Any wider implications for the organisation?	Note: the factory was shut down by the group after two years. The explanation given by the company was that delays to all parts of the project allowed international competition to capture a large share of the roofing panel market. The firm was unable to make up lost ground as its products were at the higher end of the market.
General case study evaluation. Beneficial process or not?	Through the work group dynamics, the ergonomic intervention helped gain recognition for the operators' know-how and helped them project themselves into the future work situation. This was particularly important for the foremen who, like the operators, had until then been sidelined from the project. Also, the video showing given by the work groups to those operators who were not involved in the visit gave the foremen an opportunity to hold discussions on the future and get involved in equipment acceptance from the start. The training/action was also said to have had a cross-cutting effect in all areas of technical training provision.

Case No. 36 - France

Design of two production lines - (Focus on crushing devices)

Organisation, type sector, size etc.	The intervention took place in the waste incineration sector, in a small (approximately 40 workers) but technologically leading-edge firm.
What triggered off the intervention?	The intervention was initiated by a presentation of the ergonomics contribution to industrial design at a colloquium for different stakeholders (attended by the company manager), after which the manager asked the research group to join the project in order to improve the design of a new production line. One singular feature of the project was the presence of asbestos dust in the waste treated by the plant.
What was the initial purpose of the participatory process?	The request concerned the design and implementation of a new production line; two lines were already functioning. It mainly related to the upstream part of the process: materials reception, selection, and crushing activities.
Was this a one off activity or a structured system of work?	The system of work is a structured system for the research group but a one off activity for the company.
Description of machine, work environment involved	The plant can be divided into different areas: waste containers reception, selection (depending on the calorific properties, form and weight of the material), material crushing, very high

	temperature destruction of materials, new waste treatment (fumes, molten metals, etc.). The line has to treat a wide range of waste from asbestos removal sites, which may include stone screed, plaster or brick, parts of walls, ceilings, wood, doors, metals etc. The presence of asbestos dust means that workers have to wear a full-face mask and a suit during materials selection and crushing.
Number of participants, their jobs / roles	The group comprised 40 workers belonging to the logistic and administration service, maintenance service and operations service.
Level of influence, team / department / company	The level of influence was the industrial design team, production manager and teams of workers. The negotiation of the ergonomics intervention involved the general manager of the enterprise. Two meetings were organised in order to alert him of the difficulties encountered in the intervention.
Description of participatory method, was there a facilitator involved?	Four work groups were set up to produce prognoses of future activity, based on the designers' presentation of the characteristics of the future work site situations and the future activity scenarios devised by the ergonomists. The task for the workers was to validate the results of the ergonomists' analysis, formulate the operators' needs and discuss the designers' proposals. At the first stage of the project, the top management asked the ergonomists to produce a diagnosis. In that context, the ergonomists first acted as experts in analysing the existing situation (2 initial lines were being run). The ergonomists translated the diagnosis into a list of activity scenarios involving the incidents, incidental variables and the strategies used by the workers to address them.
What actually happened - did things go according to plan?	After these meetings, a full-scale simulation with workers from the working groups, the designers, the project manager and the subcontractors was to have been organised, but the designers got cold feet and cancelled the meeting at the last minute. Following that we identified the industrial engineers' fear of encountering the future workers. It was due to a very unstable design process, work hypothesis and concepts changing often.
At what stage in design cycle were people involved?	Four working groups were set up, each including a production foreman, two production workers, two maintenance staff, one logistics person, the safety officer and the ergonomists. Each working group was assigned one part of the process to deal with: reception, selection and crushing; work organisation; health and safety organisation and maintenance activities. Two preparation meetings were arranged for each group in order to set up with the workers future activity simulations based on blueprints, a cardboard mock-up (prepared by the ergonomists) and the list of future activity scenarios.
Where did the activity take place?	At the company site.
Design problems identified by end users	An engineer and an ergonomist visited a reference site. A real crushing device, similar to one of the machines proposed by the suppliers was analysed and filmed. Based on the debriefing work and on the video, the workers added comments concerning the loading of the crusher device. They also identified incidents that could occur when the crusher is full, or when it is jammed.
What improvements were made?	Due to the different problems raised by the ergonomists' analysis and the workers' comments, a crusher machine trial was planned

	at the plant. The project manager negotiated the rental of one machine with a supplier. One of the workers participated in this trial; he was in charge of selecting the tested materials to crush. After two hours of trial, one tooth of the crusher machine was broken by a piece of steel. That contributed to discussing the maintenance operations. After that trial, the industrial engineers decided to take into account different incidents with the crusher machine, such as the material jamming. They decided to integrate into the future workplace a grapnel crane in order to remove problematic materials.
Any opportunities to further evaluate the proposed changes?	Due to the difficulties of negotiating the implementation of truly participatory ergonomics within the work organisation and with the engineers, the ergonomists left the project at the requirements stage. Even though the industrial designers said that they would integrate the remarks and the scenarios made by the work groups and the ergonomists, we do not have any proof of that at the moment.
General H & S improvements after changes?	The project has encountered about one year of delay. The line is currently under construction. It is therefore too early to evaluate changes.
Any wider implications for the organisation?	As above
General case study evaluation. Beneficial process or not?	As above

Case No. 37 - France

Processing chemical products (preparation, rolling up, moulding, stoving and finishing)

Organisation, type sector, size etc.	The enterprise belongs to a large French group in the chemical industry. 200 workers are employed at the plant where the intervention was carried out.
What triggered off the intervention?	There were two reasons: • The industrial and economic need to develop its activities by increasing production and gaining new markets • The need to plan for its ageing workforce
What was the initial purpose of the participatory process?	Ergonomics input was sought for the redesign and improvement of the manufacturing process which was to be used in the production of a new product. Also advice was sought on how work stations may be adapted for a wide range of users, particularly those with some restrictions due to medical problems.
Was this a one off activity or a structured system of work?	This is not fully clear, it would appear that the application of ergonomics in the redesign was a one off activity at the start of the project from the company's perspective but was a structured approach for the specialists asked to assist with the programme.
Description of	The production process comprises the preparation, mixing,

machine, work environment involved	laminating, rolling, stoving and moulding and final finishing of the product. The case study focuses mainly on the rolling part of the process.
Number of participants, their jobs / roles	To give coherence to the two aspects of the project (existing sector and new equipment) and to facilitate solution generation, the ergonomists suggested a specific structure including a steering committee with decision-making power, a project group and ad-hoc operator sub groups. The steering committee was a large multidisciplinary group including the director of the enterprise, other senior managers, health and safety personnel and external agencies.
Level of influence, team / department / company	Decisions were made by the steering committee at the plant level. The director however was also able to report back to the parent group.
Description of participatory method, was there a facilitator involved?	An analysis of existing work stations and through simulation an analysis of future work stations was carried out. This allowed an assessment of risks to all workers and workers with restricted capabilities to be identified and prioritised. Video data was collected of operators performing tasks and these were then used to facilitate discussion within the ad-hoc operator groups and the project groups which enabled a number of old problems to be identified.
What actually happened - did things go according to plan?	The approach proposed by the ergonomist enabled all the 'actors' to contribute to the decision-making process where previously the technical requirements had dominated.
At what stage in design cycle were people involved?	Operators were involved in the analysis of existing work stations and the evaluation of future workplace designs.
Where did the activity take place?	At the company's site.
Design problems identified by end users	These concerned the manual handling aspects of the task, the problem of debris created by the process and awkward working postures.
What improvements were made?	A number of changes were made to the layout of the workplace and equipment, some elements of the task were automated to eliminate manual handling activities, in other instances handling aids were introduced and guarding or extraction systems were used to eliminate the problems from the debris.
Any opportunities to further evaluate the proposed changes?	An evaluation of all the modifications was planned but had not been completed at the time of reporting the case study.
General H & S improvements after changes?	The project gave a greater emphasis on health and safety matters in the workplace and allowed the health and safety committee to be more closely involved in the decision-making process. The members of the health and safety committee also gained from the experience. The simulation of future work stations enabled them to have a better understanding of what the future workplace would be like and to therefore propose appropriate modifications.
Any wider implications for the	The involvement of ergonomists and the use of participatory methods was new to the company but found to be of benefit,

organisation?	particularly at such an early stage in the project. More organisational flexibility and an improvement in the competencies of employees were reported.
General case study evaluation. Beneficial process or not?	All the participants in this project reported the benefits from such an approach and the company has since used the approach for further projects.

Case No. 38 - France

Printing machinery

Organisation, type sector, size etc.	The *Figaro* printing press plant which employs 200 workers.
What triggered off the intervention?	The company management of the *Figaro*, then *Le Monde*, asked Laboratoire d'Ergonomie du CNAM and ANACT to assist them with the modernisation of the production facilities. The request was initiated by the Parisian CGT printing trade union, and more particularly by the rotary printers category. It should be noted that these requests followed an ergonomics and epidemiological study, which highlighted problems of morbidity and mortality specific to the rotary printers category.
What was the initial purpose of the participatory process?	The initial purpose of the participatory process was to involve the trade union and the workers in the design process in order to enhance working conditions. The Health and Safety Committee played an important role in the project.
Was this a one off activity or a structured system of work?	The working production system was a structured system of work. The use of ergonomics in the design review was a one off activity for the company but a structured system of work for the research groups involved.
Description of machine, work environment involved	The project concerned the design of the entire new plant. The participatory ergonomics intervention looked into the delivery of paper rolls, the rotary devices, the newspaper dispatching, etc.
Number of participants, their jobs / roles	The participatory ergonomics project ran for two and a half years. More than 70 working group meetings were organised on different topics. Members of the Health and Safety Committee were present at each meeting.
Level of influence, team / department / company	The level of influence was the company.
Description of participatory method, was there a facilitator involved?	In this case study, the methodology proposed by the ergonomists, which was accepted by management and the staff representatives, involved the participation of the printing plant operators and representatives of the Health and Safety Committee in the ergonomic intervention. Two separate structures were set up: • A follow-up and evaluation of the intervention by the company management and staff representatives took place in a follow up group. • The approach to the future activity, the formulation of forecasts and the production of modification proposals took place in working groups which included operators from the

	different occupational categories concerned, the designers, the project managers and the ergonomists. After every five to six meetings of the working groups, the follow up group had the task of reviewing the work plans proposed by the working groups.
What actually happened - did things go according to plan?	After every five to six meetings of the working groups, the follow up group had the task of evaluating the pertinence of the different forecasts and modification requests established by the working groups. Depending on the case, the pertinence of the modification requests could be accepted quickly by the social partners (the company management then agreed to take the modifications into account) or could be subject to more difficult negotiations which, in turn, could be taken up by other bodies in the company. The follow up group meetings were an opportunity: to take stock and follow up the decisions made by management concerning the modification requests examined at previous follow up group meetings; to define the work timetable, the choice and scheduling of inspections of reference sites and to designate the different participants. One of the main difficulties of this project came from the relationships, often conflicting, between the Health and Safety Committee and the company management.
At what stage in design cycle were people involved?	As described above.
Where did the activity take place?	At the production facilities.
Design problems identified by end users	The work groups that met for each of the following areas saw fit to make many remarks, as well as numerous requests for changes. The areas covered by the project were the paper hall, the rotary printing-press workshop, the dispatching hall and the newspaper departure quay, as well as more cross-cutting issues such as acoustics, air conditioning and lighting.
What improvements were made?	Some of the forecasts elaborated among the groups have led to important modifications of the technical installations, or of the organisation of production: • an important re-organisation of the supply system for the paper rolls for the rotative presses; • an increase in the number of automatically guided trolleys; • a change in controls that direct the loading of the rolls onto the unwinding machine; • other changes were launched during 1992, for example the way paper rolls were delivered and the assessment of waste; • the installation of a lift, so as to limit the loads to be carried; • the designing of trolleys for the transport of paper rolls; • the installation of hot water taps and of technical sinks; • the transformation of foot bridges and of the access to the printing machines; • the installation of lighting systems within the printing machines area; • the acoustic treatment of the premises and machines led to many changes that make this plant a model in Europe, which attracts many visitors; • an in depth review of the air conditioning system of the rotative printer hall took place.
Any opportunities to	It seems that the intervention contributed to changes in two main

further evaluate the proposed changes?	respects: • The intervention facilitated many changes to the workplace, both the environment and equipment situation. Equally, many problems identified by the work groups, which were not taken into account by the designers, unfortunately proved to be right during the starting up of the installations. • There were also changes to the work practices of the different members of the groups and more particularly those of the Health and Safety Committee members. At the beginning of the intervention, the Health and Safety Committee's practices were often geared towards protests and claims within the work groups, which was their traditional way of functioning. But progressively they changed during the work sessions and turned to a more beneficial exploration of the future work situation.
General H & S improvements after changes?	As described in the improvements section above, a number of improvements were made to the working environment (noise control and level reduction, improved air conditioning system), the workplace layout and equipment.
Any wider implications for the organisation?	The use of simulation methods / mock-ups as part of the project enabled the work teams to anticipate questions on the organisation of the teams and the level and nature of communication between the enterprise and sub-contractors.
General case study evaluation. Beneficial process or not?	An assessment of the project identified that it had benefited the operators, increasing their skill levels. Also the trial period and the starting up process were shorter than those originally planned.

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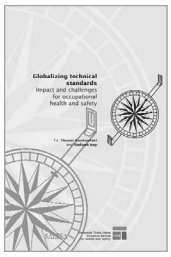

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