Work 41 (2012) 5892-5898
DOI: 10.3233/WOR-2012-0985-5892
IOS Press

Case studies – ergonomics in projects

Ruud N. Pikaar Eur.Erg.
ErgoS Engineering & Ergonomics, P.O.Box 267, NL 7500 AG, Enschede, The Netherlands

Abstract. The aim of a series of sessions on Company Case Studies, is to learn from practical experiences, to give feed back to researchers on applicability of theories, methods and techniques, and last but not least, to market ergonomics. In order to learn from case material, reports need to be easy accessible and well structured. System ergonomics provides such a structure. Usually a project is not done twice, i.e. with and without ergonomics. Therefore, it is not possible to make comparisons and determine the impact of ergonomics directly. A different approach is needed. It has been suggested at the IEA2006 World Congress, to compile a database of published case studies, each case to be reported in a fixed report format and critically reviewed to enable generalizing the outcomes. This paper proposes such a format. At the IEA2012 World Congress 40 case studies have been accepted, representing applied ergonomics cases in manufacturing, process industries, aviation and logistic systems.

Keywords: System ergonomics, engineering project, marketing ergonomics, applied ergonomics

1. Marketing ergonomics

Ergonomics is described as fitting tasks, workplaces and interfaces, to the capacities, needs and limitations of human beings. The aim of ergonomics is to optimize safety, health, comfort, and efficiency for the human in the work system. The tools which are used and the production systems which are controlled, are numerous and varied. Due to a variety of tools and differences between users, favorable human-task matches will not arise as a matter of course. Hence, designing human-machine systems is a complex task [5], characterized by the need for an interdisciplinary approach.

A succinct definition of ergonomics is *user-centered design* or *user-centered engineering*, expressing a focus on the human being, at the same time emphasizing prevention by design. This definition also covers other frequently used words, such as human factors engineering (HFE), design for all, or participatory ergonomics. Here, ergonomics will be used as an overall term.

Unsafe, unhealthy, uncomfortable or inefficient work situations can be avoided by taking into account the limitations of human beings during design. Ergonomics contributes to the prevention of inconveniences and, to a considerable degree, improves system performance in terms of an increased productivity: good ergonomics is good economics [13]. Dul and Neumann [1,2] assume that most ergonomics research and consultancy deals with the well-being goal of ergonomics, i.e. occupational safety and health. In many countries this will be closely linked to legislation. Hence, companies may experience ergonomics as extrinsic and therefore will not spontaneously start ergonomic initiatives. Dul suggests to link ergonomics to business strategies and goals, such as:

- reduce costs and increase productivity;
- maximize the use of valuable, rare, and costly human resources;
- design products for (easy) manufacturing;
- integrate ergonomics into production engineering;
- corporate communication; i.e. ergonomically designed products and/or the company's corporate social responsibility.

After many years, working as a professional ergonomist, the author concludes that the value of ergonomics is beyond health and safety. Marketing ergonomics implies a focus on business performance and investment projects: the design, redesign, or extension of production systems. It is then by definition that ergonomists are not the only profession involved. Projects are run by teams of engineers, managers, and in some cases human factors engineers.

2. Applied ergonomics

Ergonomists, i.e. registered professionals, participating in projects need to know something about medical sciences, biomechanics, cognitive sciences, behavioral sciences, and industrial design. He/she also needs a background in one or several engineering sciences. Because this combination is almost impossible to achieve, the professional ergonomist relies heavily on methodology, in particular for analyses, design and engineering, i.e. the process of systems design.

According to de Looze and Pikaar [4], there is a gap between HF science and HF practice. For example, scientists develop reliable but time consuming task analysis methods, while industry (the project owner) expects quick answers. Another example concerns task allocation and job design: do the ergonomists really have efficient techniques to predict work load and to design jobs? It appears we still are on the level of debating terminology (task versus function allocation).

The problem of acceptance by industry, and the issue of a gap between research and practice can be solved by showing achievements. Best practices have been developed in the field. Cost benefit balances are available. As a consequence there is a need to get access to case material, other than formal scientific publications, because in general, journals do not accept case studies.

3. Systems ergonomics

A systems ergonomics approach can be realized successfully in practice, provided ergonomists adapt to the company's strategy and standard engineering procedures. One of the first and well documented projects, using this approach has been the Exxon FLEXICOKER Consolidated Central Control Room project [8, 10]. The project scope included job design, local work organization design, and an extensive user participation program. The schematic of figure 1 has been a scientific product of this industrial project. It emphasizes the integration of technical and organizational design, as suggested by Singletons Ergonomics in System Design [12]. The ergonomic phases, problem definition, situation analysis and task allocation, could successfully be related to major industrial engineering phases, i.e. Design Basis, Design Specification, and Detailed Engineering and construction (Pikaar [6]).

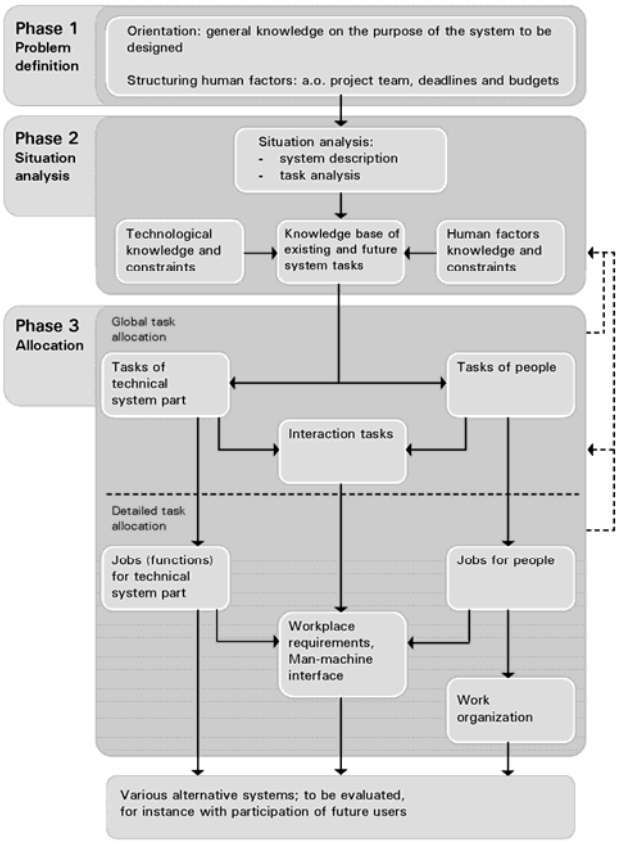

Figure 1. Systems ergonomics approach.

The systems ergonomics approach has been the basis for many successful projects. However, the presentation can be improved:

- Task allocation steps are difficult to substantiate because there is little guidance (theory) on this topic. Task allocation is difficult to explain to engineers and project managers. Usually, job design is not associated with ergonomics.
- In practice, one will experience a difficulty to explain why so much time has to spend on a task analysis of an existing situation, while working on a "new" project.
- Apparently, figure 1 stipulates that the largest part of the ergonomics work is done before the actual workplace design is even started. This is not in line with the general expectations.

Though the systems ergonomics approach didn't change over several decades, the presentation did. One could say that the marketing of the ergonomic contributions to projects has changed. In order to illustrate this, figure 2 shows a generalized overview

of project phases. Terminology may differ, depending on culture, country, and type of industry or organization. Figure 3 gives a recent overview of the presentation of ergonomic engineering steps. Some changes made to the original schematic of figure 1 are:

- The term *engineering* or *Human Factors Engineering* is now frequently used.
- The general project phases and the ergonomic *engineering* steps are presented in two parallel flows. Related to each project phase, a typical ergonomic input or activity (step) is specified. In case the ergonomic input starts several project phases later then indicated in the schematics, still every ergonomic engineering step has to be taken, preferably catching up with the main project phasing, as fast as possible.
- Phase 3 and 4, respectively Step 3 and 4, are a condensed version of the Allocation Phase; typical ergonomics terminology (such as *allocation*) to be avoided in real projects.
- In many cases, the ergonomics contribution ended before or after detailed design (now Phase 5/ step 5). This step has been expanded by guiding the realization steps construction, commissioning and evaluation.

4. Ergonomics engineering steps

4.1. Step 1. Feasibility

The feasibility step typically includes a review of project owners' human factors assumptions. There may be assumptions regarding work load, level of automation, capabilities of operators, and so on. For the HFE it is important to be aware of such assumptions, and if needed, give feed-back on a general level. For example one could temper a too optimistic view on the number of operators needed.

4.2. Step 2. Problem definition

This step starts with a general description of the project and the purpose of the system to be designed. The outline of the design steps have to be negotiated with project management, including design constraints.

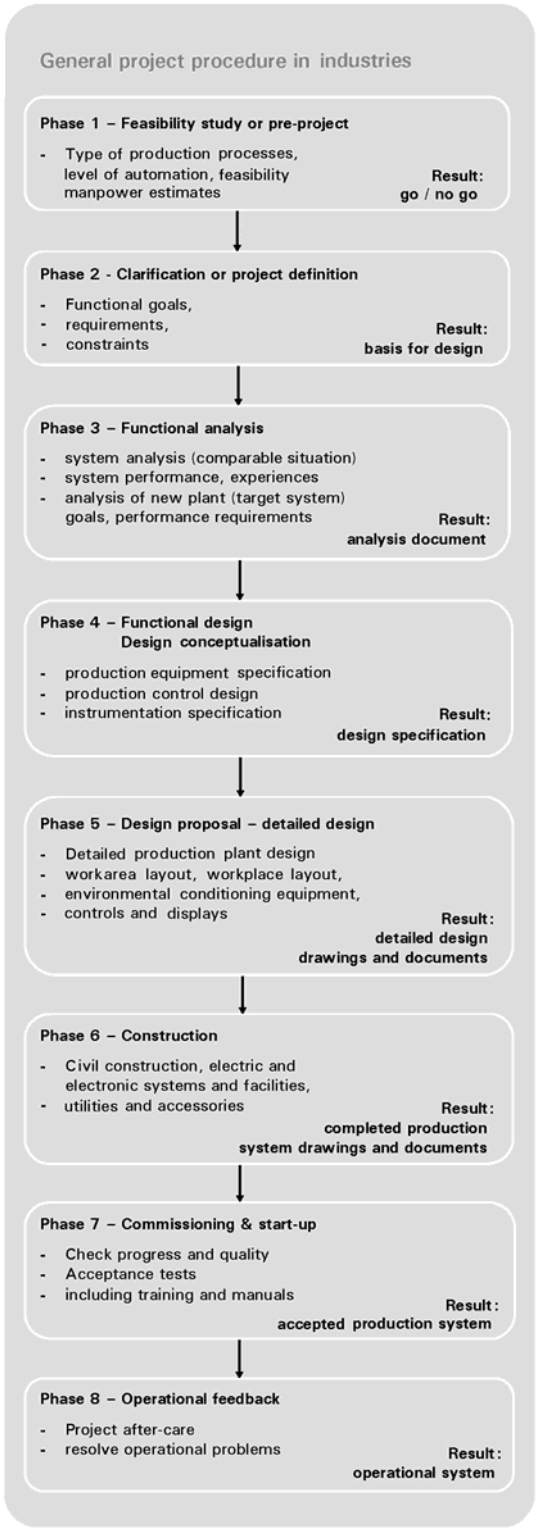

Figure 2. Generalized project phases.

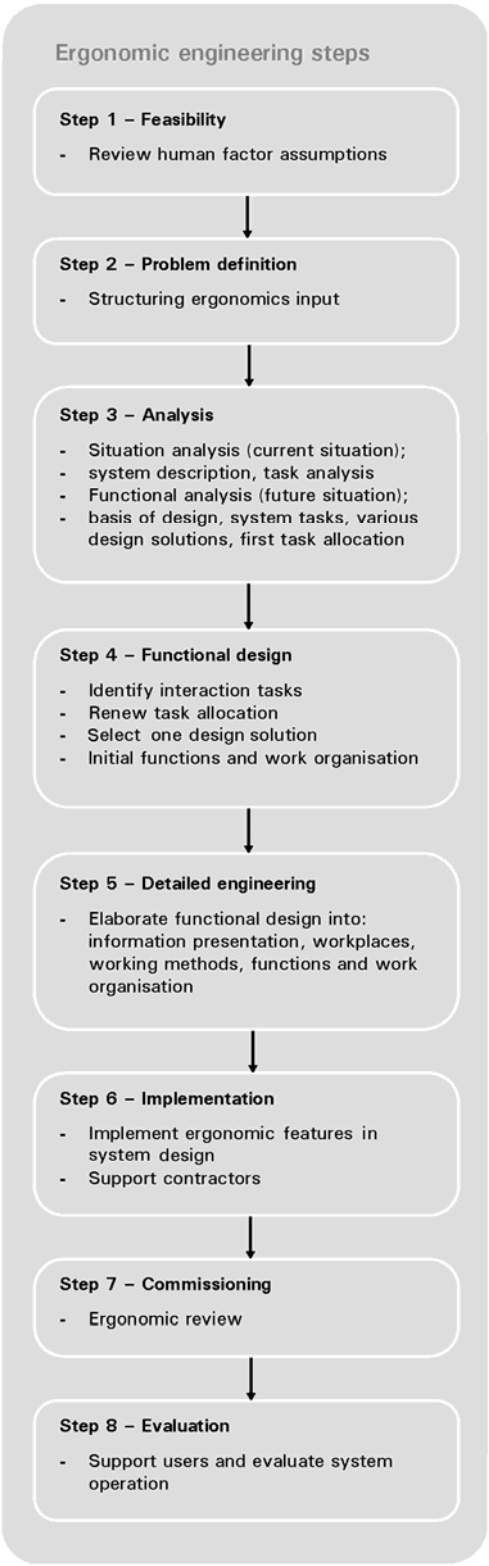

Figure 3. Human Factors Engineering Steps.

4.3. Step 3. Situation analysis

The aim of the situation analysis is to gain insight in existing and future tasks. A situation analysis includes activities such as:

- collect formal documents, specifying the existing system;
- analyze the existing situation by observations and interviews about work tasks, problems the users experience, and wishes they might have for the new situation;
- gather relevant knowledge on the new system (the system to be designed).

Ergonomists have many tools available for an analysis, as can be found in textbooks on methodology. A careful selection has to be made. Within a project, there is only a need for detailed knowledge on tasks and topics relevant to the project. For example, there is no need assess manual lifting situations in a logistics department, if a project concerns full mechanization of packaging.

4.4. Step 4. Functional design specification

In theory, the functional design specification is about the allocation of system tasks. An allocation procedure includes a discussion on the level of automation, job requirements, and the design of a local work organization. Following, a program of functional design requirements has to be drafted, including amongst others:

- the allocation of tasks to workplaces;
- the lay out of a system;
- shape and size of workstations (including equipment);
- environmental requirements (noise reduction, lighting levels).

4.5. Step 5. Detailed design/engineering

On the basis of a set of functional design requirements, various design solutions can be developed. Choices have to be made, which implies weighing all aspects involved, including ergonomics. Basic decisions regarding the detailed engineering may be based on 3D-drawings, mock-up evaluations, or prototyping.

4.6. Step 6. Implementation

During the construction phase the production system is being build. Typically, this will start with the production of workshop drawings and building-site drawings. For example, from an ergonomic point of view assistance in making workshop drawings for dedicated furniture, may be required. An example to illustrate the relevance of a HFE contribution can be found in dedicated operator consoles. During the earlier steps, a 3 meter wide console may have been developed with two supporting legs, one on either side. The workshop engineer decides that an additional leg will be needed and locates this leg exactly in the middle of the console. This happens to be the central work position of the operator, thus reducing his leg room. This type of "errors" can be avoided, if the HFE reviews the construction drawings.

4.7. Step 7. Commissioning

Once the system is finished, formal hand over (commissioning) of a working (and tested) system to the project owner will be organized. Typically, an ergonomist could be involved in the review of all workplace and interaction oriented parts of a system.

4.8. Step 8. Evaluation

Ideally, an evaluation of the running system, for example resulting in operational feed-back on design, engineering and management of the project should be organized. This is not common procedure in industry, The project owner does not hire the ergonomists after the project, to do an evaluation study.

5. Case studies

Pikaar reported 12 ergonomics projects [in 6, 7 and 9]. For all these projects the system ergonomics process steps as presented above, were used to structure the reports. Summarizing, the following items have been included in each case study report. The same approach and listing can also be found in the case book *Enhancing Industrial Performance* by Kragt [3].

- Overall project scope
  - type of industry or organization
  - short description of the project (example: building a waste incineration plant)
  - investment in the overall project
  - realization period
  - general overview of project organization (management, engineering contractors, consultants)
- Structuring HFE in the project
  - position and responsibility of HFE within the project organization
  - hours by HFE and/or made under full responsibility of HFE
  - % of the project investment influenced directly by ergonomics
  - type and extent of user participation
- Ergonomic topics; main topics elaborated within the project.
  - has the main emphasis been on: job design, workplace design, interaction design? For this item a list of topics could be prescribed; example of items: job, workplace, interaction, manual handling, graphics, anthropometrics.
  - number of different jobs involved
  - number of different workplaces involved?
  - procedural: role of other disciplines (architect, engineering), responsibilities, management of user input, and so on.
- Project phases - Ergonomic engineering steps
  - project phases that included ergonomics (refer to figure 2)
  - ergonomic engineering steps (1 – 8) carried out (refer to figure 3), and to what extent.
  - techniques applied for each of the ergonomic engineering steps.
- Lessons learnt
  - projects' motive to hire HFE
  - did HFE live up to the expectations
  - typical results, i.e. a summary of expected and unexpected outcomes of the HFE contribution to the project
  - cost/benefit: has it been worthwhile to include ergonomics.
  - lessons learnt on the level of the project.
  - lessons learnt regarding ergonomic methods and techniques.

On a general level, the following conclusions from the reported case studies, stand out clearly.

- Once a project manager has had the pleasure of working with a HFE, he will do so in every new project. After several years, management usually does not remember the results, but "the design process": ergonomics had tools to tackle human factors issues effectively.

- The cases show that professional ergonomics is not about an additional effort or higher project costs, probably on the contrary.
- Stick to the system ergonomics approach including a thorough situation analysis, because it works well and is understood by the engineering community. If the project owner is not convinced of the use of an analysis, you may consider doing the analysis for your own risk, because it will pay out later, anyhow.
- The ergonomics community should compile an overview of cases and examples indicating the benefits of a HFE involvement. The same may be suggested regarding user participation.
- Job load assessment, task allocation/job design, and work organization design is considered human factors/ergonomics. In this area useful and validated design tools are missing and could be developed by the ergonomics community.

6. Company case studies

At the IEA2012 Congress, the idea has been launched to include special sessions on case studies, i.e. sessions on applied ergonomics projects. A total of 59 abstracts has been submitted. After review 40 papers met the criteria to be accepted as a company case study. The criteria included: a systems ergonomics approach, an actual human factors intervention and/or design contribution, and feed back on results of the project as well as the methods used. Approximately half of the contributions came from South American countries. Typically, these contributions emphasize the systematic analysis of work tasks and work situations and usually carefully suggest some workplace or organizational improvements. Probably, employers or companies are not yet ready to accept on a large scale the human factors interventions. However, the number of well structured and high quality workplace analyses is encouraging.

There are 15 contributions from Europe, USA and other western countries, amongst others related to manufacturing, aviation, automotive and health care. Several other cases concern heavy (steel) industry, for example in India. These contributions usually include: 1) HF interventions on a project basis, and 2) tools to manage and effectuate systematic human factors programs in (very) large companies. Whether, these HF programs really are successful on a project base, remains yet unclear. Nevertheless, several high quality case studies could be included in the IEA2012 Congress proceedings (refer to the References section).

7. Discussion

Shorrock and Chung [11] argue in the Ergonomist, there is a gap between HF scientific research and practitioners. It can also be noted that the number of published case studies is limited. Journals do not easily accept case study papers. Case studies may be (written) below the journals' scientific standard, and/or human factors professionals do not spend much time writing about their work and results. However, there is a need to publish about the application of theory, principles, data and methods to design.

It is suggested that the ergonomics community establishes a database of systematically reviewed cases, indicating costs and benefits of a HF involvement in projects. The best advertisement is delivering a good project, making the end users and the project owner happy with the results. The IEA2012 sessions on Company Case Studies represent a step forward in convincing management of organizations to include ergonomics/human factors in design and engineering projects.

Case presentations should be structured by system ergonomics process steps. An important feature of a published case study should be, that the project or system has actually been build and is in operation. Another important feature of a published case, should be a feed-back of practitioner to HF scientist regarding the applicability of theories and methods.

Considering that professional ergonomists have to report projects to fulfill the requirements for registration, case material may be easily available. Also looking at web-sites of (major) HFE firms, indeed case material is available, however not in a structured way. Finally assuming that HFE professionals and consultancy firms can only afford to spend a limited amount of time on publishing case studies, a database requirement will be, that case reports should be easy to enter and highly structured. Hence, what the ergonomics community needs, will be a virtual location to compile a database, amongst others to be usable for marketing purposes. In the authors view, the IEA could host a Wikipedia-like system to compile data on case studies. Some strict rules should be developed regarding the format of case reports, as well as for moderating the system.

Finally, the author encourages the IEA triennial congress organizers to develop the concept of Company Case Sessions at the congress further.

Acknowledgement

The author thanks all his colleagues at ErgoS Engineering and Ergonomics for their contributions to this paper. Also, the author thanks the IEA2012 Congress organizers for facilitating the Company Case Sessions, thus including 40 valuable case studies in the Triennial World Congress of the International Ergonomics Association.

References

This paper is largely based on Chapter 3 of *Meeting Diversity in Ergonomics* [5], adding recent experiences applying systems ergonomics in industrial and governmental projects. This, and several other related papers may be downloaded at www.ergos.nl.

The author, i.e. moderator of the Company Case Studies, may be contacted for an edited compilation of case studies (at contact@ergos.nl).

[1] Dul, J., W.P. Neumann (2007), The strategic business value of ergonomics. In: R.N. Pikaar, A.E.P. Koningsveld, & P.J.M. Settels (eds.), Meeting diversity in Ergonomics, (Elsevier, Amsterdam), 17-27.

[2] Dul, J., W.P. Neumann (2009), Ergonomics contributions to company strategies, Applied Ergonomics 40, 745-752.

[3] Kragt, H. (editor) (1992), Enhancing Industrial Performance: experiences of integrating the human factor, Taylor & Francis.

[4] Looze, M. de, Pikaar R.N. (2006); Meeting diversity in ergonomics; Applied Ergonomics 37, 389-390.

[5] Pikaar, R.N. et.al. (1998); Ergonomics in Process Control Rooms, Part 1: Engineering Guideline; WIB International Instrument Users' Association, The Hague.

[6] Pikaar, R.N. (2007), New challenges: Ergonomics in Engineering Projects. In: R.N. Pikaar, A.E.P. Koningsveld, & P.J.M. Settels (eds.), Meeting Diversity in Ergonomics, (Elsevier, Amsterdam), 29-64.

[7] Pikaar, R.N. (2008); Ergonomics in Engineering Projects – how to achieve a booming business; In: L. Sznelwar, F. Mascia and U. Montedo (eds.), Human Factors in Organizational Design and Management – IX.

[8] Pikaar, R.N., Lenior, T.M.J., Rijnsdorp, J.E. (1990), Implementation of Ergonomics in design practice: outline of an approach and some discussion points, Ergonomics, 33 (5), 583-600.

[9] Pikaar, R.N., F.Th.M. Asselbergs (2011); Systems Engineering – Innovation in airport baggage handling; In: M. Göbel (ed.), Human factors in organizational design and management – X.

[10] Rijnsdorp, J.E. (1991); Integrated Process Control and Automation, Elsevier, Amsterdam.

[11] Shorrock, S., A. Chung (2010); Mind the gap: research and practice in human factors and ergonomics; IEHF Annual Conference; published in the Ergonomist of February, March and April 2010.

[12] Singleton, W.T. (1967), Ergonomics in Systems Design, Ergonomics, 10, p. 541.

[13] Vink P. et.al.; Positive outcomes of participatory ergonomics in terms of greater comfort and higher productivity, Applied Ergonomics 37 (2006), 537-546.