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Human Factors Tools for Work System Design – What is out there?

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This paper introduces the second edition of the 'Human Factors Tool Inventory', summarising available tools, equipment and methods that can support the consideration of human factors in the design and operation of work systems. While many tools are available for the analysis of existing work systems, fewer exist for strategic planners, system designers, or those seeking cost analysis information to understand ergonomic implications of design decisions on a broader scale. Dissemination of the inventory is intended to raise awareness of the availability of different tools amongst practicing ergonomists and engineers with the long-term aim of increasing the application of ergonomics in work system design. The creation of this inventory is an ongoing effort. The next phase of this project will include interviews in Canada and Sweden aimed at understanding how ergonomists and engineers use such tools to support their everyday work processes.

Keywords: human factors methods, ergonomics evaluation, design, assessment tools

INTRODUCTION

While many evaluation tools, methods and interventions have been developed in the last 20 years the problem of work-related disorders persists. This paper introduces a new research agenda in Canada to understand and improve the application of human factors (HF) tools in the design and development of Canadian workplaces. We ask: What HF tools are available? Which are being used? How are they being used? And how might tools be modified or developed to better support application of HF in work system design? The aim of the current paper is to present the results of the first stage of the investigation - the creation of an inventory of available HF tools that might support consideration of HF in work system design. In this project we take a broad definition of tools to include methods, approaches, or even equipment that might be used in work-system design processes.

This paper introduces the updated inventory to the Canadian audience and presents the latest findings from this search. The first edition contained over 80 tools (Neumann and group, 2006) and the inventory is being continuously updated. The intent is to create a 'catalogue shopping' experience to assist designers in identifying potentially useful tools to suit current needs or perhaps to expand their consideration of how they might support HF application in their organisations by adopting new tools.

METHODS

We are engaged in an ongoing effort to assemble a comprehensive inventory of tools that can support the consideration of HF in the design and development of work systems. This search includes tools identified from literature searches, web searches, from ergonomics and HF textbooks, and from tools identified by readers of the 'inventory' (the target user group).

Providing structure to the list of tools was assisted by the application of a theoretical framework. This has been adopted from previous work (Neumann et al., 2002; Neumann, 2004) and is illustrated in Figure 1. This model describes a simplified workplace design process that begins with corporate strategies chosen by senior managers and proceeds through product (or service) design and production system design resulting in a production system that is run by system operators. Decisions made during each of these developmental stages can influence ergonomic conditions when the work system becomes operational (Neumann and Winkel, 2005). Outputs of the system as a whole will be the products that are

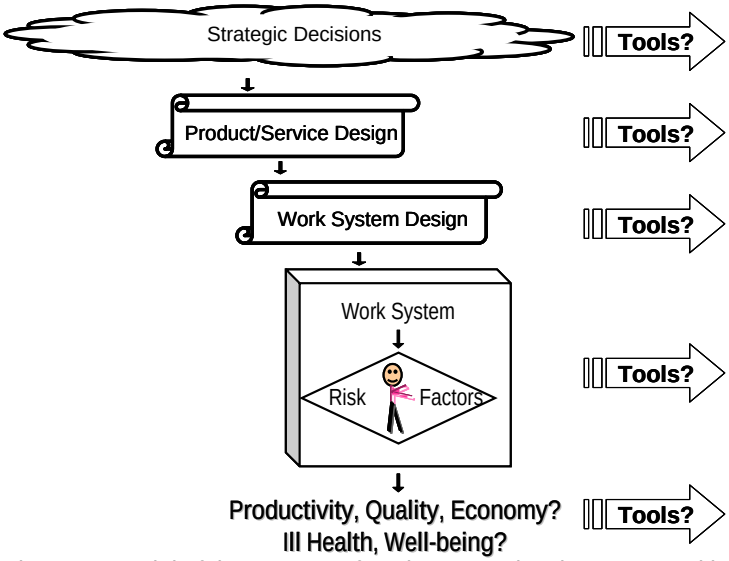

Figure 1: Model of the process of work system development used in industrial and service sectors. The model was used to help structure the tool inventory according to where in the process tools might be applied.

produced at a certain volume, cost, and quality level. If the system has design problems leading to risk factors, then these outputs may also include work-related ill health such as musculoskeletal disorders. Risk factors may also imply poor system performance. This description, although not comprehensive or fully detailed, was used to help structure the tool inventory and to identify related tools, based on their stage of development. Further grouping of tools was also conducted based on the nature of the tools themselves. Questionnaires and checklists, for example, were grouped separately as they are generally applied quite differently. The emphasis in this ongoing process is to find groupings that make sense to the target audience – rather than seeking some 'absolute' categorisation scheme for all tools. While it is possible for some tools, such as digital human models, to be used at different stages of the design process these have been placed into one category based upon usual usage for that tool.

Table 1: Summary of tools found for each category in sequence of the development process.

Tool Category / Developmental Process	**# Tools**	**(%)**
1) STRATEGIC DECISIONS	2	2%
2) PRODUCT DESIGN - Usability	7	
- Other	8	11%
3) WORK SYSTEM DESIGN - Flow Simulation	12	
- Simple Digital Human Models	3	
- Complex Digital Human Models	12	
- Design Checklists and Other Tools	3	23%
4) WORK SYSTEM		
Operator Physical Risk - Checklists	23	
- Questionnaires	3	
- Hardware Tools & Instruments	9	
- Software Tools	13	
Operator Psychosocial / Stress Risk - Checklists	1	
- Questionnaires	7	
Operator Mental Workload	2	
Other System Characteristics	7	50%
5) SYSTEM OUTPUTS		
Health Status & Wellbeing - Fatigue, Motivation, Satisfaction	9	
- Pain & Disability	4	
- Economic Performance	2	
- Quality Assessment	1	12%
6) OTHER - Return to Work Tools	3	2%

RESULTS

131 Tools have been entered into the inventory at the time of writing with over 100 tools awaiting classification. The categories identified in the inventory process are outlined in Table 1. The first five levels are based on the development model presented in Figure 1. These include: strategic decision making, product design, work system design, work system evaluation, and system outputs. Processes such as 'return to work' were not captured by the model and are listed as 'Other'. Level 4 – 'work system evaluation' had the largest number of tools identified (50%). Tools in this category were sub-classified based on the type of risk factor, physical vs. psychosocial; and, secondarily, by the nature of the tool itself; checklist or questionnaire for example. Other levels also required sub-categories based on a pragmatic approach to creating coherent clusters of tools and methods. Level 1 – 'strategic decision making' appeared to have the least number of ergonomics related tools.

A considerable number of commercial software programs aimed at ergonomic evaluation and education were identified and the volume of products poses an organisational challenge to the inventory. These tools often contained within them a number of assessment approaches available in the open literature such as RULA or the NIOSH equation. We present this list separately as these are mostly applications of established methods and are difficult to find information on without buying or trying the software.

DISCUSSION

With so many different 'HF' tools available, an ongoing challenge for this inventory was to create a framework to help a reader identify appropriate tools. The large number of tools creates difficulty in a single person understanding all the tools, and classification errors can result. We have attempted a structure for the tool inventory that is consistent with the phases of industrial development where the tools might be applied. This supports the aim of fostering the consideration of HF throughout the development of the work system. We also attempt to provide some practical tips for those trying to select and apply new methods in their work – some examples of this are listed in Text Box 1. The next major phase of tool gathering will focus on engineering tools that are currently being used for work system design. The intent here again is to create potential for integrating HF by encouraging consideration of both types of tools (ergonomics and engineering) simultaneously in order to help close the gap between traditional engineering design and ergonomics The project will continue to gather tools over the next two years.

- **Use the right tool for the job.** Just because you have a hammer in your hand doesn't mean your problem is a nail.
- **Every tool has a 'blind spot'.** No tool is perfect.
- **It's the skill of the carpenter not just the sharpness of the saw that counts.** Consider how best to apply a tool to suit your specific needs.
- **Think outside of the box.** Many tools can be used in a variety of ways.
- **This list is incomplete.** Be on the lookout for new tools – just because it's not listed here doesn't mean it doesn't exist or that it won't be useful for you - submit new tools to this list!

Text Box 1: Examples of advice included in the inventory.

The lack of tools available at the earliest, strategic, planning stages (2% of tools) was not surprising to us. While strategic choices have been linked to ergonomics considerations (Dul and Neumann, 2005) interviews with ergonomists in the UK suggest they are focussing mostly on workstation design issues (Whysall et al., 2004) where we found 50% of tools. We see the lack of tools to support such planning as inhibiting the inclusion of HF in the management decision making process. The possibility of adapting available strategy analysis tools to HF practice will be explored as the inventory is expanded. Some tools, such as discrete event simulation are rarely used for HF analyses although these also have potential to include both physical (Kazmierczak et al., 2007) and psychsocial (Neumann and Medbo, Submitted) factors. The adaptation of existing engineering tools to include ergonomics aspects has also been demonstrated for standard motion time systems such as MTM-type tools (Laring et al., 2002). The inclusion of time aspects in the planning of the work system is a crucial aspect for both productivity and HF concerns (Wells et al., 2007) and such tools hold good promise for integrating HF into work system development at each stage.

Many tools, such as digital human models, were seen to be potentially usable at different stages of development. The difficulty of maintaining a simple set of categories for this growing inventory of 'human factors' tools is leading us to consider a web-based database

approach in which tools are characterised on a number of factors rather than just one. This web application approach would then allow users to identify tools by searching on different characteristics such as 'work system design stage' or 'low back' or 'computer software', reducing the problems associated with errors in categorisation required for a linear document. A web based application allows a yet more complicated structure to support a better organization of the tools inventory. The development of a web-based application might include the creation of a broad range of keywords, terms and categories allowing users to focus on their particular needs – rather than rely on the editorial clustering decisions currently required for static document versions. An appropriate interface would need to be designed allowing simple search functions, while also making users aware of tools and methods they were perhaps not aware of. The web application could also encourage sharing of experiences possibly in a WIKI format or structured as 'user reviews' as is done on some commercial retail websites. A web-based database would also simplify updates and expansions as these could be incorporated on a continuous basis without requiring the periodic generation of new 'inventory' editions. A possible drawback of this approach is the move to a pull-media: users must ask for a specific subset of tools. This may reduce the possibility of serendipitously discovering new tools that might suit them, but that hadn't been previously considered – one of the possible benefits of browsing that is available with a paper 'catalogue' approach.

As the tool inventory, or database, expands to include engineering tools for work system design, the tools may be expected to contain less human factors content. This will also change the appropriateness of the name of the inventory. Future inventories will focus more on 'Tools for Work System Design' and will include both explicitly 'ergonomic' tools as well as more general planning tools such as Quality Function Deployment or Computer Aided Drafting (CAD) tools that have potential for ergonomic content but are often not used in this way. Other aspects that might be included would be listings of available standards for ergonomic aspects of engineering design such as those highlighted by Dul et al. (2004).

The tool inventory presented here provides a background for an investigation of tools and approaches actually used by professional ergonomists today. The interviews for this project are currently underway and results will be submitted to next year's ACE conference. Interviews will then be conducted with professional engineers in order to explore any possible gaps that may exist between the daily work of engineers and ergonomists in both Canada and Sweden. It is also intended that these interviews be conducted with professionals in Sweden, a country with a long tradition of workplace ergonomics, allowing comparisons of different cultures of practice. Surveys conducted in Denmark have suggested that engineers see lack of tools as a barrier to applying HF principles in their design work (Broberg, 1997). Dissemination of this inventory to the engineering community may help dispel the impression that no HF tools are available. Knowledge gained from these interviews may also help guide the development of 1) new and improved tools and approaches suited to users' needs; and 2) improved application of available tools in industry by both professional engineers and ergonomists. These in depth interviews will extend our knowledge of professional practice beyond the survey data currently available on tool use frequency amongst professional ergonomists' in the US (Dempsey et al., 2005).

CONCLUSIONS

Conclusions based on preliminary results from the inventory creation process suggest that, while many tools exist for evaluating existing operational systems, there are fewer tools available for evaluating HF in early design stages and even less to support strategic decision

making. Most tools seem to focus on biomechanical aspects of risk with only a few questionnaires addressing psychosocial factors. There are a large number of general systems analysis tools that are not specifically designed for MSD risk evaluation but that might support these considerations along with other system priorities.

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HF Tools Research Agenda

Aims: - Integration of HF in work-system design
- Examine the engineering-ergo gap'

1. What 'HF' Tools are out there?
2. Which tools are being used?
   1. By Ergonomists
   2. By Engineers
3. How might tools be used or improved to help designers consider HF

-> International Cooperation Canada - Sweden

Introducing 'Tool Inventory v2'

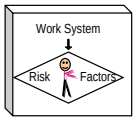
- 2006: 1st edition:
  - 80+ Tools (& methods)
  - Focus on MSD Evaluation
- 2007: 2nd edition:
  - More 'HF tools' (inc. usability, cognitive)
  - Broader scope (still biased to MSD prevention)
- 2008: 3rd ed?
  - Include Engineering Tools & Methods

Methods

Multiple Search approaches:
- Known to contributors
- Emerging from Lit review
- Text Books
- Web searches
- Suggestions from user base

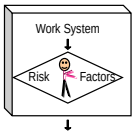
Categorisation based on theoretical frame

Results – Current Counts = 138



Tools? **71, 51%**

Results

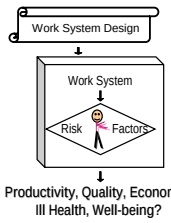


Tools? **71, 51%**

OUTPUTS — Productivity, Quality, Economy? Ill Health, Well-being?

Tools? **20, 14%**

Results – Current Counts

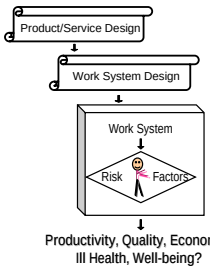


Tools? **25, 18%**

Tools? **71, 51%**

Tools? **20, 14%**

Results – Current Counts



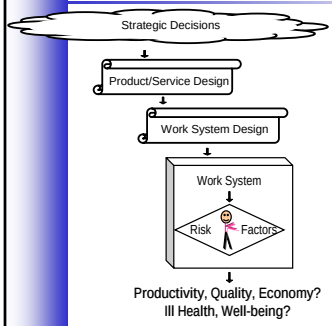
Tools? **20, 14%**

Tools? **25, 18%**

Tools? **71, 51%**

Tools? **20, 14%**

Results – Current Counts



Tools? **2, 1%**

Tools? **20, 14%**

Tools? **25, 18%**

Tools? **71, 51%**

Tools? **20, 14%**

RESULTS – Summary Table

Tool Category Breakdown		# Tools	(%)	Composition by Category
STRATEGIC DECISION MAKING		2	1%	1%
PRODUCT DESIGN	Usability	10	7%	
	Other	10	7%	14%
WORK SYSTEM DESIGN	Flow Simulation	6	4%	
	Digital Human Models	12	9%	
	Other Design Tools	8	6%	18%
WORK SYSTEM EVALUATION	Operator Physical Risk	51	37%	
	Operator Psychosocial / Stress Risk	9	6%	
	Operator Mental Workload	3	2%	
	Other System Characteristics	9	7%	51%
SYSTEM OUTPUTS	Health Status & Wellbeing	15	11%	
	Economic Performance	2	1%	12%
OTHER	Return to Work Tools + Miscellaneous Tools	3	2%	2%
TOTAL				138

Discussion

- Most tools focus on exisitng workstations
  - Primarily physical workload checklists
  - Some psychosocial questionnaires
- System Design tools are primarily DHMs with a few new innovations
- Strategic tools are largely missing (at least any with a human focus)

Discussion

- Many tools remain to be added (100+)
  - Mostly software products
- Creates an organisational Challenge
  - Error – categorisation, missrepresentation
- Tool identification is ongoing
- Problem: Depth vs. Breadth
- Only gets worse when Engineering tools are added!
- User needs?

Future?

- Web-Database solution?
  - Characterise not categorise
  - Serves broader needs
  - Wiki interface? - community resource
  - Quality Control?
  - Lose 'browsability' of print media?
  - Pull media: Only find what you search for!

Conclusions

- Many tools exist
  - Are they being used? (interviews ongoing)
- Tools emphasise biomech over psychosoc.
- Less tools support strategic and design processes
  - Integrating Ergo into design is inhibited
- Lack of tools may still be a barrier for 'Safety by design' initiatives

NEXT?

- Extend Inventory to Engineering Tols
- Interview Ergonomists in CDN
  - PLEASE VOLUNTEER!!!
- Interview Engineers in CDN & SE
- Identify improvement opportunities

THANK YOU

- Copies available here at the conference or from **www.ryerson.ca/hfe**
- YOUR INPUT IS WELCOME!

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