Systems Ergonomics within a Systems Architecture Framework: Future Issues

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Abstract. The need to develop the key concepts of systems ergonomics is examined. The benefits of introducing architectural concepts into the high level set for systems ergonomics are presented in terms of an improved capability to address ergonomics issues of major systems. A brief review of the key concepts associated with systems ergonomics and systems architectures is carried out and a framework developed. This is exemplified with the architecture of a User's workstation. Issues for future consideration are presented.

Keywords: Systems architecture, ergonomics, future issues

1. Introduction

ISO 26800 (2011), describes the concept of a "man-machine system". It uses Figure 1 to represent the relationship between User(s), tasks and equipment within an environment.

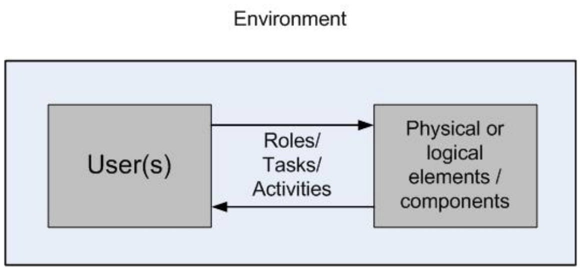

Figure 1: A User, equipment system as in ISO 26800

Figure 1 is useful as a high level summary of key concepts for "systems ergonomics" It summarises the elements which are related to meet a purpose. However, as the problems ergonomists address are changing so there is a need to investigate the scope of application for this principle in ergonomics. We need to be able to move our investigations and implementations from individuals/small teams within work systems to large scale applications. The applications might cover sets of Users/Occupational Groups and equipment/physical entities which include global networks of work systems.

This paper aims to examine some key concepts in systems ergonomics with the intention of showing how the subject might be developed for better application to large scale systems using concepts from systems architecture.

2. Key Concepts

2.1 Key concepts within systems ergonomics

A starting point is ISO 26800 which defines a set of key concepts (Tainsh 2013). These include:

(a) The elements of a system – people, equipment (which could also be a building or other element) which lead on to a concept of work system.
(b) The relationships between the elements.
(c) The concept of fit between elements.

2.2 Key concepts within systems architectures
The systems architectural approach has been designed to support work on large scale projects, and enable concepts such as "systems of systems" where multiple integrated systems work together. The concept of architecture is used to characterise a work system in various ways. One of the most important concepts is "Viewpoints" The Viewpoints not only describe a set of layers but also the views that may be taken of the information held with a layer. The higher layers within the architecture indicate "what" is to be achieved by the lower. This means that the characteristics of one layer can be mapped onto the characteristics of adjoining layers with known functions. The mapping relationship is referred to as a coherence function. Individual projects may tailor the views held within the layers that are appropriate for its purposes. These may include:

(a) The Contract/Requirement.
(b) The Business model.
(c) System Model.
(d) Technical model/User Model (The User's task performance contribution of systems ergonomic is covered within the Operational Viewpoint).
(e) Assessment.

This approach considers that complex layers need to be constructed so that there is:
(a) Coherence across items within the layer.
(b) Coherence between layers.

Coherence means that there is a logical relationship between viewpoints associated across layers, and there is a set of logical relationships within a layer. It does not specify what these relationships should be. It does exemplify them. Traceability of design solutions can be seen as a result of combining "coherence functions" so that the relationship between sets of layers of description can be understood. As a consequence of multiple mappings, objects at the lowest levels can be "traced" back to higher layers. Verification and validation are both inferred from examination of the design characteristics and the degree to which they can be traced back to the scenario and functional requirements successfully.

3. Possible developments for Systems Ergonomics within an Architectural Framework

3.1 Systems Views from Systems Architecture
The architectural approach for systems development is generic. Ergonomics can borrow these concepts and develop them. Hence we may consider: requirements, assessment techniques, including the concept of fit between elements, system elements, coherence between and across layers, system, technical and User descriptions, and functional relationships

3.2 Placing system ergonomics within an Architectural Framework including requirements and assessment
It is suggested that the consideration of architectural concepts leads to Figure 2. The inputs and outputs included:
(a) Inclusion of requirements statements for equipment functionality and scenario descriptions.
(b) Inclusion of overall business and system models.

(c) Inclusion of contribution and links between technical system models from contributing disciplines and systems ergonomics.
(d) System assessments to be derived from the characteristic of the "upper layers" and support development of statements on verification, validation and effectiveness, including their traceability.

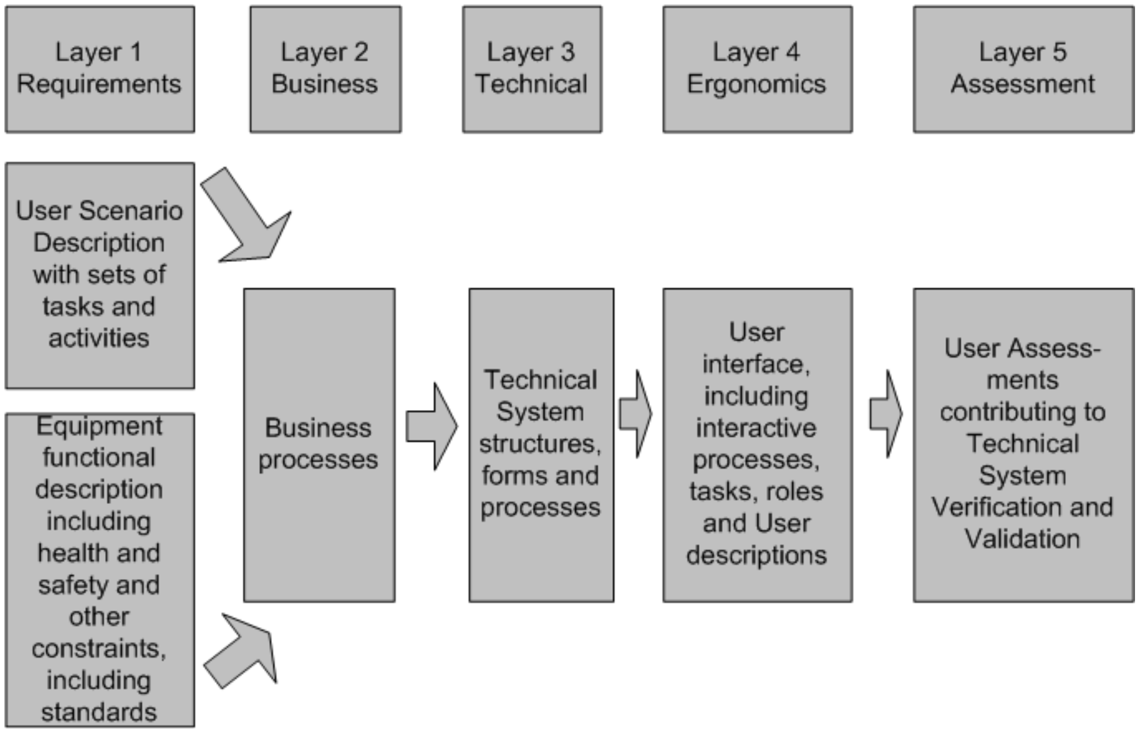

Figure 2: Representation of systems architectural framework layer with ergonomics

3.3 Specification of the system elements
The techniques for the specification of the system elements for a work system will need to be developed to take account of the requirements of larger and more complex systems. This may appear as subsets of current elements, or elements arising as a result of interactions between ergonomics and other technical systems.

3.4 Functional Relationships
The functional relationships between items, in some areas, are well understood e.g. the task description elements of User Scenario Task Description or the interactive tasks that are associated with the product. However as system characteristics continue to evolve, new relationships can be expected to emerge. These are likely to move beyond the considerations of the user, equipment interaction as shown in Figure 1.

3.5 Coherence functions
The layered content and structure will depend on the project requirements and the early high level design decisions on how to address them. However, there will certainly be requirements at the highest layer (which is numbered as 1) and assessment at the lowest (which is numbered as N). A possible set of coherence functions could be based on a mapping relationship such as shown in Table 1, in the case of identical elements.

Table 1: Example of simple mapping relationship showing mapping between Layers (N-1) and (N)

	Layer (N-1), Property 1	Layer (N-1), Property 2	Layer (N-1), Property 3
Layer N, Property 1	X		
Layer N, Property 2		X	
Layer N, Property 3			X

3.6 Traceability

The support to the mission from any particular activity or feature can be seen as the consequence of a combination of design outcomes and organising principles. The traceability relationships for a five layer model can be seen as below:

Support to mission is given by:

Contribution from Layer 5 $\mapsto$ Layer 4 $\mapsto$ Layer 3 $\mapsto$ Layer 2 $\mapsto$ Layer 1

“$\mapsto$ “is the symbol which signifies “is mapped onto”.

Traceability from requirements to the lowest levels is ensured through an understanding of the coherency of the relationships. Here a mapping relationship is exemplified. If the mapping is poor – for example there is only one cell partially filled then the design has a poor traceability back to the requirements and hence low validity.

3.7 Verification and Validation

The support to the mission is given by a change in the effectiveness of the business as defined by the requirement. Similarly changes in the business are produced by changes in the Technical System and contributing models including the User model. The extent of changes in the models by new designs are a result of the changes in jobs, roles, tasks and any activity or design feature. This is exemplified in Table 2, which is an example of a system ergonomics description including architectural concepts for a workstation such as might be found in a cockpit or vehicle cab.

Table 2: Systems Ergonomics Architectural Layers

Layer with Reference Number	Viewpoint - Work Space	Viewpoint – Control, Display relationships	Viewpoint – Work Organisation	Viewpoint – Environmental Conditions, Health and Safety Constraints
Layer 1 - Requirements				
Overall requirements	Size, form and movement	Situational awareness, controls and feedback	Roles, Jobs, tasks and workload	Ranges of conditions, safety implications
Layer 2 – Coherency function: mapping of business model onto requirements				
Business Descriptions	Architectural model	Sensors, Controls and communications	Occupational groupings	Hazard identification and assessment
Layer 3 – Coherency function: mapping Technical System description onto business model				
Technical System Description	Physical space including structures	Electronic architecture including power and communications	Organisational Options	Environmental and safety standards
Layer 4 – Coherency function: mapping of ergonomics contribution on to Technical System description e.g. starting with ISO 26800. Other contributing disciplines will be alongside				
Ergonomics system	Workspace layout	Usability of controls and displays	User roles, jobs and tasks	Local and legal requirements.
Layer 5 – Coherency function: mapping of assessment techniques on to ergonomics contribution with traceability back to User Scenario Task Description and equipment functions.				
Assessment	Architectural standards	Usability assessments	Satisfactory human resource outcomes	Environmental and safety compliance

4. Conclusions

The principle supported here is that expressed by Singleton and ISO 26800. It describes a User - Equipment System in terms of its elements, their interaction and the environment that surrounds them.

The possibilities for expanding the central set of ergonomics concepts in the case of large systems using an architectural approach is supported by experience in an engineering design context.
The importance of concepts such as viewpoints, layers, coherence and traceability is

clear from work in the contributing disciplines of architectural frameworks, and these concepts require development in applications that involve systems ergonomics to ensure that this approach is valid and effective. These developments are essential to support an understanding in every project of the contribution of ergonomics to the system model, in conjunction with other technical models, and hence the business model and its support to requirements. All these contributions will be reflected in the systems assessments.

References

ISO 26800:2011, Ergonomics — General Approach, Principles and Concepts.

Tainsh, M (2013), Hierarchical System Description (HSD), using MODAF and ISO 26800. Contemporary Ergonomics and Human Factors, Taylor and Francis.