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User Systems Architectures – Two studies in design and assessment

Michael Tainsh

Krome Ltd, C Erg, FCIEHF, United Kingdom

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ABSTRACT

The concept of User System Architectures (USA) is introduced as part of the overall systems architecture. A USA is defined as a set of ergonomics information and knowledge assembled to represent system structure and content. It is described in the context of the system development lifecycle. The characteristics associated with a USA are outlined. These include layers of description, viewpoints, coherency and traceability. The concept of coherency between layers and the techniques for tracing the design characteristics back to the requirements (i.e. traceability) are discussed with their implications for ergonomics. Two studies (one design and one assessment) are used to demonstrate the use of USA techniques. The benefits, shortfalls and costs of using the USA technique are outlined for each case, and in a more general range of applications. The validity and reliability of the representations are discussed.

1. Introduction

The concept of architecture as expressed within a systems development context e.g. as expressed within MoDAF (MoD Architectural Framework) MoDAF (2009) is used widely. Systems architectures are assembled to represent physical, behavioural and information/communication systems. Hence the phrase User System Architecture (USA) is introduced to refer to that portion of an overall system architecture which presents the structure and content of the ergonomics information and knowledge supporting the development, of the product or service, expressed in a form that is comprehensible and beneficial to the designer and user communities.

MoDAF is closely linked with ISO 15288 which describes the development lifecycle for products and services. It includes the development of a system's architecture as a subset of its processes. ISO 15288 in turn is linked with ISO 26800 which addresses systems ergonomics issues within development projects.

There are already examples of systems architectures within the ergonomics literature which are assemblies of ergonomics information for major engineering projects. They are exemplified in railway systems by Nock et al. (2014), railway automation by Dadashi et al. (2014) and motor vehicles by Michon et al. (1990). Major computer based system developments have been reported to indicate how the architecture of the system reflects requirements and user needs (Roth et al. (2006)). However none of these or others provides guidance in support of a general systems ergonomics approach, to the development and use of USAs.

This paper provides a brief introduction with two studies to illustrate USA principles one from an Armoured Fighting Vehicle (AFV) design and the other from a COntrol of Major Hazards (COMAH) assessment project, in order to provide details on how USAs have been developed and used. Consideration is given, in each case, to the benefits, limitations and costs.

It is intended that these studies will help provide support for a more general approach to the development and use of USAs with associated benefits to stakeholders.

In practice a USA can be developed as a functional description which is:

- Valid as a result of taking a comprehensive approach to description, involving coherent layers and appropriate viewpoints.
- Open to assessment against objective criteria, and hence is reliable i.e. the same description will be produced on different occasions or by different assessors.
- Supports ergonomics activities throughout the development lifecycle including assessment studies.

2. The system development life cycle

ISO 15288 provides a starting point for the concept of a system development lifecycle. This is presented with four sets of processes:

- Technical (to turn requirements into a product or supply of services);
- Organisational (project management);
- Agreement (contract for acquisition and supply);
- Support (including human resources and quality).

E-mail address: mike.tainsh@kromeonline.info.

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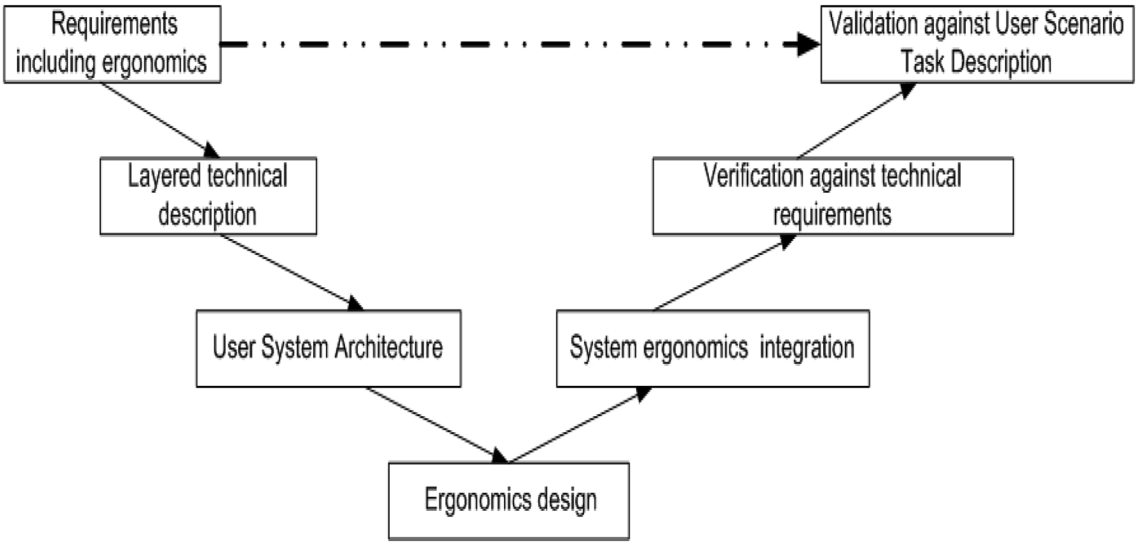

Fig. 1. "V" Diagram for ergonomics contribution to System Development Life Cycle.

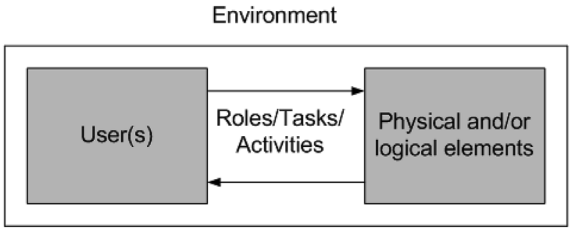

Fig. 2. System interaction as represented within ISO 26800.

The technical line is presented in the form of a "V" diagram. It is presented in Fig. 1 as a high level view of the ergonomics contribution within the system development lifecycle.

The technical process is specified in ways that are independent of implementation but all four may be dependent upon one another. The combination of four sets of processes and the stages within the "V" diagram help ensure a comprehensive approach.

However, these concepts have not been widely reported by ergonomists even though they are potentially useful in a general context, and open to development.

3. Layered system description

ISO 26800 provides an initial high level system description for ergonomics which fits into the lifecycle "V" diagram. It has four elements:

- User
- Equipment
- Tasks
- Environment

The relationship between these elements is interactive and hence they may be represented as in Fig. 2 where the main sets of interactions are between the users and the physical and/or logical elements within the context of an environment (physical or organisational). They are all important as if there are omissions then the validity of the description will be partial.

The "whole system" includes all elements. However large systems may be considered to be composed of smaller systems e.g. vehicles may have power systems, heating and ventilation systems or others. This gives rise to the concepts of "systems of systems" where each sub system may be considered to have its own lifecycle, system description and architecture.

Early stages of the project will include the development of layered descriptions (Winter and Fischer, 2007) which may cover all elements from the viewpoint of many disciplines which impact upon the user (Tainsh, 2013). The layers will be specified to meet the needs of the development lifecycle – typically with increasing accuracy and precision as the project develops. They will be populated with information as it becomes available. The description is a necessary prior stage to the specification of a USA.

Layers are sets of information which represent viewpoints of the system relevant to the User. Initial viewpoints may include (Nock et al., 2014):

- Strategic – requirements (including scenarios)
- System – a combination of equipment and users at work
- Technical – there may be a number of layers here to cover jobs, roles, tasks and activities, facilities, and equipment with various levels of technical detail or other characteristics.
- Assessment – techniques related to the criteria associated with the system/technical implementation and the techniques for assessment.

Within layers, there may be sub-layers – dependent on the characteristics of the system and its subsystems and the needs for the representation. All the layers and sub layers contain sets of representative information and knowledge.

The highest i.e. the strategic layer is adjacent to the requirements and represents the "what must be achieved with the adjacent layer indicating the business system which must work to achieve the strategic goals. The System layer presents a viewpoint on the system to be created to support the work of the business, with the Technical layer showing the contributions from the various sets of work that needs to be integrated within the system layer. Finally there may be a base layer which contains the information on the assessment techniques for the technical layer.

There may be viewpoints which cut vertically across layers. These might include e.g. communication or responsibility. Hence one might have a viewpoint associated with a class of devices or organisational entity, or role or task.

The concept of Layers should not be confused with the concept of hierarchies such as may be used in psychology to describe abilities or personality. "A Layer" is an organisational concept defined by a set of rules to determine which items of information and knowledge may or may not be included within it. A hierarchy of performance descriptions,