Cognitive Systems Engineering

a course/workshop over five days

Presented by Dr. Gavan Lintern

Introduction

Cognitive systems engineering is a specialty discipline of systems development that addresses the design of systems containing humans. Drawing on contemporary insights from cognitive, social and organizational psychology, cognitive systems engineers seeks to design systems that are more effective and more robust. The focus is on amplifying the human capability to perform cognitive work by integrating technical functions with the human cognitive processes they need to support and on making that cognitive work more reliable.

Cognitive systems engineers assist with the design of human interfaces, communication systems, training systems, teams and management systems. They employ principles and methods that bear on the design of procedures, processes, training and technology.

Examples of systems that will benefit are military command and control, civil air traffic control, transportation, communication, process control, power generation. power distribution, health care and large-scale project infrastructure.

Course Availability

This course is available worldwide for public and on-site delivery (i.e. at client-provided facilities).

Course Objective

This 5-day course teaches methods of cognitive analysis and cognitive design, and illustrates how they can be applied to enhance human systems effectiveness and safety within system development and acquisition. It also offers an in-depth treatment of the rationale, strategies and benefits of cognitive systems engineering. The course introduces delegates to the analysis and design methods of naturalistic decision making, macro-cognition, the critical decision method, decision-centered design, cognitive work analysis, cognitive systems design, and functional (ecological) interface design. It provides an in-depth treatment of how methods of cognitive analysis and cognitive design can be deployed to good effect within the systems acquisition process and demonstrates the added value to the systems acquisition process of these techniques.

Having completed the course, delegates will understand the critical role that state-of-the-art methods of cognitive analysis and cognitive design play in achieving safe, human-centric engineering solutions. Delegates will be able to apply state-of-the-art methods of Cognitive Systems Engineering at a threshold level of competency. They will be able to identify the role that Cognitive Systems Engineering should play in an engineering project, to identify and evaluate sources of Cognitive Systems Engineering expertise, and to evaluate the work products of Cognitive Systems Engineering.

Training Methods and Materials

The course is delivered primarily in an interactive presentation format with brief participatory exercises. An experiential information-management exercise undertaken early in the first day provides a basis for delegates to develop a situational appreciation of the central ideas. The experiences gained by delegates during that exercise together with documented narratives of counter insurgency operations by US Marines are used throughout the day as source material for collaborative analysis and design activities. The analysis of counter insurgency operations will be based on a commercially available paperback book, which will be in included in the courseware provided to delegates.

Flash Presentation

Download a Flash movie from http://www.cognitivesystemsdesign.net/Workshops.html. This Movie, delivered by Dr. Lintern, is on the relationship between cognitive systems engineering and systems engineering. It is a 25-minute summary of the 5-day Cognitive Systems Engineering course.

Frequently Asked Questions

There are standards for this. Can't we rely on them?

Cognition is a problem area for standards. The human cognitive system is nonlinear and contextually dependent. There is currently insufficient knowledge to write meaningful standards that will guide a designer towards the development of effective cognitive support systems such as, for example, decision support systems and situation awareness support systems. Even where standards name a relevant problem area, such as workload, they offer no meaningful advice beyond the homily that workload should not be excessive. They offer no useful advice about how to assess whether or not workload is excessive or how to design so that it is not. The cognitive systems engineering course deals with this issue.

Can't we adapt standard engineering analysis and modeling tools for this?

The engineering professions have many powerful analysis and modeling tools that find valuable service in other disciplines. However, context dependence and nonlinearity were once largely ignored in the engineering disciplines and even now, remain as challenging problems. Cognitive systems engineering has, from its inception and by necessity, confronted context dependence and nonlinearity and, as a result, has developed sets of tools that can address these problems.

Additionally, humans are powerful, multi-function systems. Few engineering tools address the human in any way but those that do, typically treat the human as a user or operator rather than as a functional part of the system. Such an approach fails to take advantage of the unique capabilities that a human can contribute to system performance.

Why does it matter? If we do the engineering right, humans will adapt.

Humans are, indeed, adaptable. The more resourceful members of our species can make anything work for them. However, it does take effort. When the human operators have to struggle with a system to get it to work for them, they have less time and energy for productive work. Furthermore, any system that is difficult to use demands more extensive training, which is an additional cost. Most troubling, clumsy systems induce human error, which can result in huge costs in time, material, and human life.

Humans are the problem. Can't we avoid all this by automating everything and getting rid of the human?

Those who think this ignore the fact that human errors are typically induced by poor design. Additionally, this sort of attitude assumes implicitly that systems are always well-designed and well maintained and that design engineers can anticipate all contingencies. The extensive record on industrial disasters shows otherwise. Indeed, human adaptability and resourcefulness are strengths, without which, complex modern systems could not work.

Automation is the holy grail of human systems integration. However, humans are inevitably participants as designers, managers and benefactors. The idea of a fully automated system that can deal with all contingencies without human intervention is a science-fiction fantasy. Once we retreat from that ideal and allow humans some interventionist role, the interface between the machine and the human must be configured on the basis of cognitive systems engineering principles. The cognitive systems engineering course deals with this issue and offers a sensible perspective on the way that automation can be used to good effect.

What is the added value?

What is the added value for anything? If you add insulation or double-glazed windows to your home to save energy costs, you can calculate the costs and estimate the savings. That is straightforward enough. Large-scale engineering projects are not as straightforward. To assess the added value of cognitive systems engineering, we would have to track and compare projects that used no cognitive systems engineering versus those that used a minimal amount versus those that used a decent amount, and even then, we would have to assess the quality of the cognitive systems engineering that was used. Those sorts of data are not available anywhere. The course does, however, discuss a small set of selected projects in which a modest amount of cognitive systems engineering saved many times its cost. The course also covers incidents in which flawed cognitive performance has resulted in huge costs in terms of loss of productivity and loss of human life.

Can we afford this? Won't it increase costs and delay system delivery?

A well planned cognitive systems engineering effort is more likely to decrease costs and to speed design. The real issue is whether the human interfaces and the cognitive supports are done well or poorly. It will certainly cost more and delay system delivery if they are done poorly at first and then have to be redone.

How is cognitive systems engineering different to human factors engineering?

Cognitive Systems Engineering is a professional discipline that uses formal methods of cognitive analysis and cognitive design to ensure that cognitive work is both efficient and robust. The aim is amplify and extend the human capability to know, perceive, decide, plan, act and collaborate by integrating system functions with the cognitive processes they need to support.

Human Factors Engineering is a professional discipline that uses formal methods of analysis and design to ensure that work is both efficient and robust. Note the similarity of this definition to the one for Cognitive Systems Engineering; the only difference being that all references to cognition have been removed. Human factors engineering is a broader discipline that takes account of physical as well as cognitive work. Alternatively, it could be said that Cognitive Systems Engineering is a sub-discipline of Human Factors Engineering.

Does cognitive systems engineering link in any way to systems engineering?

Yes, cognitive systems engineering is just one piece of systems engineering but it has an important role to play. A module in the course covers this in extensive detail.

Systems engineering already has the 9 domains for human systems integration. Isn't this already covered there?

Yes, it is covered there but its role is not well described. Cognitive Systems Engineering can be deployed to good effect in any information-intensive work domain. Health care, military command-and-control and industrial power generation are just three work domains that can benefit from the systematic analysis and design of cognitive work. The focus is on helping workers think more effectively by design of support technologies, work processes or training. In that regard, Cognitive Systems Engineering seems most relevant to the Human Systems Integration domains of Manpower, Training, Human Factors Engineering and Safety as defined in the INCOSE Systems Engineering Handbook (V 3.1, August 2007, Appendix M).

That is not to belittle the remaining domains of Personnel, Environment, Occupational Health, Habitability and Survivability, or even to claim that Cognitive Systems Engineering could not contribute in those areas, but rather to point out that the current work in the Cognitive Systems Engineering does not currently offer much that is useful for those remaining domains.

Cognitive systems engineers speak in tongues. Can't we do this some other way?

As with any engineering or scientific discipline, cognitive systems engineers have their own jargon and tend to be parochial. The treatment of cognitive systems engineering in this course cuts through the jargon to bring a consistent and understandable terminology to the discussion. Once you understand the basic concepts and strategies and can talk about them in generally understandable language, you should be able divert cognitive systems engineers from their parochial concerns and have them pay attention to your concerns.