SCI Keynote Address (1)

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INTRODUCTION

I am honored and delighted to be here today and to welcome all of you to Prague! I would like to acknowledge our hosts and thank them for inviting me to be a keynote speaker at this NATO symposium on "**Critical Design Issues for the Human-Machine Interface**".

I would also like to share my enthusiasm with you on this occasion since it is my privilege to be an American who has been decorated by the Czech Republic with their highest military honor, ***The Cross of Merit***.

His Excellency, Ambassador Martin Palous decorated me with ***The Cross of Merit*** in July 2002 in recognition for my scientific contribution in facilitating the development of research collaborations between the Czech Republic and the United States. This is my first public opportunity to thank the People and the Government of the Czech Republic for the great honor that they have bestowed upon me. I am deeply honored and forever grateful to all of you.

This is an historic time for us to be in Prague! During November 2002, the Heads of State and Government of NATO member and partner countries met in the Czech capital to change NATO's future course. At their meeting, NATO invited seven countries to commit themselves and their nations to forge new capabilities and to address the needs of the 21st century. It is my privilege to extend a very special and warm welcome to the symposium for NATO's newest partners, representatives from Bulgaria, Estonia, Latvia, Lithuania, Romania, Slovakia and Slovenia. This group represents the largest number of countries ever to join NATO at one time. The accession of these nations reflects the vision of the NATO leaders and their goal of building bridges across and among nations.

Today, I am here to address the theme of this symposium and to encourage each of you to forge scientific collaborations that will bridge across all nations. As we are becoming increasingly aware of the impact of advanced technologies on human performance, there is a need to transcend national/political boundaries and focus on the development of scientific collaborations that will serve as a bridge connecting nations and providing solutions.

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HISTORICAL COMPARISONS

In order to address the critical design issues for the human-machine interface, I would like to begin by highlighting the advances that we have made over the past century. Specifically, the human-machine interface has evolved from a fixed design system, comprised of hardware and software components that isolated the user from the information required to complete their task. The fixed design interface generated a gap between the system and the user so that humans had to reach across the gap to access, retrieve and manipulate information in order to achieve their goals. Today, the human-machine interface has evolved into a system that is flexible and dynamic. As we move forward in the 21st century, I can imagine the future interface as one that provides information to the user/decision-maker in a seamless, symbiotic system design.

The journey that we have made over the years is replete with stories of challenges, successes and failures. Indeed, the designs of the future continue to be shaped by the results of our efforts to integrate information/knowledge with the human experience. The gap between the human and the machine is being closed, as we attempt to capitalize on our knowledge of human sensory systems and cognitive processes; thereby modeling our mental model of the world and augmenting our reality.

However, before we discuss innovative interface development, I would like to provide a framework for our discussion on the critical issues in system design by focusing on some of the lessons learned from previous efforts. Namely, each designer seeks to develop and integrate interface designs in systems that operate in a complex environment and support the end user's goals and mission requirements. Given the advanced technological environment in which we all operate, our task is develop effective systems that link the human operator/decision-maker with the information/knowledge that will enhance their situational awareness and decision-making capabilities.

Yesterday and today are linked by the common constraints that we face as system designers. I would like to draw your attention to some critical issues that have withstood the test of time. Imagine if you will that it is 1911 and you are in the room with the designers of the Titanic. For its time, the Titanic was considered designed and equipped with state-of-the-art technology. The design priorities were speed and security. Their design requirements emphasized that their system should include a revolutionary turbine engine, a double plated hull and a sophisticated system of watertight compartments. In addition, the Titanic was equipped with a sophisticated wireless communications system that was intended to serve as a major communication link and provide situational awareness. Yet, despite all of the advanced technologies included in their design, the Titanic did not achieve its mission to arrive safely in New York Harbor. Rather than focus on the lessons learned regarding the failure of each of the technologies employed, I would prefer to draw your attention to the critical issues that were intended to be addressed by the inclusion of these technologies that might have contributed to a more successful end of their journey. I contend that the Titanic failed to address the interface between the systems placed on board and the human decision-maker. For a system or interface design is successful only if it supports the end user and their mission goals. Likewise, the ways in which the information is conveyed to the human could facilitate or impede achieving the mission goals. Specifically, system design focuses on the specific requirements that will facilitate achieving a successful level of performance.

SYSTEM DESIGN REQUIREMENTS

As we move forward in the 21st century, the complexities of system design highlight the need to address the critical issues that might otherwise impede human/system performance. One of the main challenges to the designer is, "Know thy User"! Who is this person? What are their goals? What is their experience? What are

the requirements of the user and the system? How might we facilitate faster, more effective decision-making? Lastly, how can we be innovative in our approach to system design while enhancing and empowering the end user?

As system designers and researchers, we are familiar with the challenges presented to us during the development stage of any system or interface. That is, integrating new interfaces with legacy systems is one of our principal challenges. Most often, budget constraints guide the design process. However, if we could begin with the set of requirements and move forward; we may begin to find a way to address innovation during the course of developing the new system. For example, all platforms are built from a set of requirements, regardless of whether you are designing a command and control center for a Surface Ship or a Space Shuttle. Each system begins with a set of requirements for the user, the system and its overall mission. Each requirement shapes the design space in which you will generate your specific program, interface or decision-support system that will enable the total system. Your goal as the designer is to define the end state that you wish to achieve with the human and the system. That is, if we have an understanding of the individual, their expertise, their goals and the timeframe of their tasking; then, we can begin to address how we might design an effective interface and system.

This is the critical point for system designs in the future that beckons for a change in the way that we design systems. The transformation of information management in the 21st century calls for a new means of dealing with the accelerated presentation of a plethora of information that places new and serious constraints on the end user.

It is no longer sufficient to consider the ways in which information is merely presented on a display. Rather, we have moved into a new generation of knowledge presentation that forges us forward and charges us with the task of developing systems that can provide support to the end user and assist them in assimilating the knowledge being presented. Suddenly, designers are no longer limited in the method of the interface design. Rather, information must be presented to the end user that can be assimilated as part of their mental model of the world in which they operate, formulate plans and make decisions. Information and knowledge management are critical issues that must be integrated into the designs of the 21st century interface.

We need to address ways in which knowledge is presented and information is required in an on-line and real-time format. As human factors experts across all domains, we are called upon to develop innovative interface and system designs that support the end user while enhancing their performance, decision-making and facilitating achieving their mission.

We are living in a century of immediate information processing requirements and one in which the penalties for system failure may be overwhelming. We cannot afford to ignore the impact of failure in interface and system design since knowledge management and situational awareness are critical to the success of all systems; regardless whether these systems are elements of the land, sea and /or military domains. I would suggest that one potential approach to this challenge is to explore innovative designs that will augment our cognition and facilitate rapid and accurate decision-making in the future system designs. In an environment in which information demands are immediate, designers who are looking for innovative systems that can facilitate human performance often turn to automation as one potential solution.

HUMAN-MACHINE INTERFACE: COGNITIVE COSTS AND BENEFITS OF AUTOMATION

Humans are required to monitor, manage and maintain situations under conditions of uncertainty across many domains, including military operations and emergency management. Therefore, it is critical to consider developing interfaces that clarify ambiguous information and provide information that supports situational understanding and effective decision-making. Given the complexities of these environments, system designers have sought to remove and/or replace the human in the loop only to learn that the human's capacity for adaptation plays a pivotal role in dealing with complex tasks in a dynamic environment.

There are a number of benefits to be gained from integrating automated systems as components of the system that support situational awareness. However, the fundamental feature of achieving situational awareness is the unique ability of the human to perceive, assess and adapt to dynamic events in their operational environment. The operator's unique perspective is a concatenation of the perceptual elements of their environment that occur within the context of a precise moment in time and space, as well as their understanding of the situation at hand and their ability to project their state of being into the near future (Endsley, 1995).

This is a challenge for interface designers as they attempt to integrate information into a cohesive picture/ display that conveys an understanding of the complex environment to the end user.

It is the challenge of the interface designer to address the complex and dynamic requirements that support the operator's situational awareness. Designers should be aware that automation may provide benefits such as reducing the cognitive workload; automation may also increase the stress factor related to resolving situational awareness when the stakes and penalties for human error are high. As there is an increasing demand to process greater amounts of information, there is also an increased requirement to develop systems and interfaces that will support the presentation of information to the user/decision-maker in a meaningful format. One of the challenges for interface designers of the future is to provide a means of integrating information as part of the human experience to ensure total situational awareness and information access in a relevant, timely manner. Augmented cognition is one such method of focusing on ways in which information can be presented and integrated with the experience and knowledge of the user/decision-maker.

AUGMENTED COGNITION

Until recently, interface designers focused on the format and clarity of presentation and the display of information. Once again, this system implied a gap that needed to be crossed between the user and the interface. Today, designers are discovering that there is no longer a need to isolate information from the user. Rather, we can design seamless information systems that support the user's requirements and mission goals. For example, the closer that we can bring the information to the user and interface them with the task that they want to accomplish, the closer we have moved them toward achieving their individual and mission goals. In our daily life, we install GPS systems into our cars, carry Palm Pilots, Blackberries, and wear mobile telephone headsets to augment our knowledge and awareness of tasks to be done. These technologies combined with our mental model of the world, our tasks/goals and perceptions, help to enhance and shape our situational awareness and attune us to changes in our dynamic environment.

If we were to extend the notion of the human as part of the interface itself, one could imagine that we could add to our capabilities considerably by providing multi-sensory cues that can prompt us to attend to meaningful information as it moves up the hierarchy of importance for our situational awareness.

Thus, situational awareness would become a multi-modal processing system integrated with the human's mental model. The interface of the 21st century will be the emergence of a multi-modal processing system seamlessly integrated with the human's mental model of the world in which they operate. A new, shared and integrated mental model would facilitate faster, more accurate decision-making and extend our capabilities to adapt to changes in a complex environment in real-time.

This notion of cognition-centric interface design would move us away from the fixed human-computer interaction of days gone by and catapult us into a new era of human-computer symbiosis. This new interface will be the product of a catalytic integration between the heuristic-driven, context-sensitive capacities of the human and the detail-oriented, data management capabilities of computer computation. The challenge is to explore new ways to enhance knowledge management and design interfaces of the future by integrating information with the individual user's reality. As we project into the future and envision new interface designs, there is a need to design systems that will augment cognitive processes of the human and enhance their situational awareness.

CONCLUSIONS

In conclusion, there are critical issues associated with interface design. This is an especially challenging time in that never before has the human been so overwhelmed with information and data. Knowledge management is the most significant issue of the 21st century. The world of the 21st century is complex and fast paced. The pressure to make decisions is intense and immediate with the potential for great penalties associated with human errors in decision-making.

I would add that I hope that you will make an effort to address these challenges by forging scientific collaborations among nations. I encourage you to look for ways to invite young researchers from each of your countries to take an interest in science and the development of innovative technologies. The mental model of the young person of today is less rigid than that of previous generations. Their experiences set them apart in defining novel approaches to technology design. Invite them to join in the discussion.

I would like to thank you in advance for your efforts and commitment to the progress that you are making by participating in this symposium. I leave you with a challenge that is the Hallmark of Humanity! Innovate! Create! Be the interface and bridge ideas among nations here at this symposium and when you return home. I wish you a very successful symposium!

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