Hancock, P.A., & Scallen, S.F. (1997). Triggering dynamic function allocation (letter).
Ergonomics in Design, 5 (3), 5-6.

Who Does What? Human or Machine?

The article, "The Future of Function Allocation," by Hancock and Scallen in the October 1996 issue very well explains the paradigm shift that has taken place in this area of human factors. One has to admit that with the evolution of complex systems, adaptive or dynamic function allocation is far superior when compared with static function allocation.

However, the question as to who will trigger the dynamic function allocation was left unanswered in the article. One may ask, should the machine be given the prerogative of triggering function allocation by making it monitor issues such as critical events, human performance, measures, and so on based on an algorithm, or should this responsibility be assigned to the humans, considering that they also have the ability to self-monitor (e.g., "Do I feel extremely fatigued? Am I about to be overwhelmed because of mental and/or physical overload?") using such heuristics as meta-cognition?

I feel that at this juncture, researchers should also place emphasis on determining how best to trigger dynamic function allocation. Maybe it is time to start thinking about adaptive triggering, too, where situational variables will decide who (human or machine) will trigger *what* and *when*.

Moin Rahman

The Authors Respond

Moin Rahman's letter raises crucial implementation issues for adaptive function allocation. Although we have addressed the question of triggering adaptive allocation in previous work (e.g., Hancock & Chignell, 1987), Rahman is correct that we did not address this concern in the limited space in our original article. We thank him for his comments and the opportunity to elaborate on this important question.

There are three general domains in which to locate an adaptive allocation trigger: the operational environment, the operator performance, and the operator state. In the operational environment, some threshold characteristic may be specified as the trigger. Preset marker conditions, the occurrence of unidentified objects, various environmental perturbations, or transitions across threshold levels are possible forms of environmental trigger.

The effectiveness of the operational environment approach relies largely on the ability to anticipate. This tactic has been used in early adaptive systems, as characterized by the "contractual" Pilot's Associate program. This is a surrogate electronic crew member that provides input and recommendations at an advanced level, sufficient to begin to replicate an additional human crew member. In effect, the program acts as an adaptive and adapting agent in the system.

Success with environmental triggers has also been achieved when the trigger is specified in relation to the vehicle or system itself. Here the trigger for adaptive allocation is a function of the vehicle's operational limitations. Adaptation based on limitations is perhaps the easiest form to create because performance information on the vehicle is readily available. This strategy is currently employed in some safety features of the "fly by wire" aircraft that prevent the pilot from generating dangerous stall conditions.

Although this approach may work for the relatively stable conditions of commercial transportation, it is a much more problematic question in high-performance tactical aircraft. Attempts to define "safe" limits of tactical operations are paradoxical in light of the fact that these operations are by their very nature "unsafe."

Problems in defining such concepts and "safe" and "unsafe" demonstrate how the use of the operational environment to define an adaptive trigger is, in practice, limited. Requirements of anticipation and flexible reaction undermine the purpose of retaining the human in the system. Conditions that are completely predictable are those for which full system automation seems best suited. Unfortunately, such anticipation of properties of the environment becomes unlikely. Environmental variables – even predictable ones – can also interact to produce unexpected and unpredictable variables.

Operator performance is a second trigger. When performance levels decline, a dynamic shift in allocation is initiated. Both quality and quantity of performance can be considered in this process. Performance assessment has high face validity because the overall goal of adaptive allocation is the efficient performance of the total human-machine system. However, there is a flaw in this reasoning. In aviation, for example, the purpose of the pilot in high-performance aircraft is to perform those functions not easily replicated by the machine. Many of these functions are intimately linked to reaction and decision-based responses to unexpected or unusual conditions. The inability to foresee all conditions that bound pilot behavior obviates the formalization of human performance goals.

Because we are unable to specify all the goals and reactions of the pilot, we cannot tell what is "efficient" and what is "inefficient" flight performance in different circumstances. Moreover, even if some comprehensive database of pilot performance information could be compiled, the on-line comparison of pilot performance with such information would be entirely reactive. What such a design really ends up accomplishing is making the human do tasks that the designer cannot think how to automate (Bainbridge, 1983).

A third trigger is operator state. This includes the measurement of some psychophysiological parameter as an indicator of workload. Several promising physiological measures have been shown to reflect workload, including heart rate variability, pupil dilation, and event-related potential. Recently, Byrne and Parasuraman

(1996) reviewed the application of psychophysiological indices to adaptive allocation. Some drawbacks do exist, including the need for sophisticated signal processing algorithms that challenge real-time processing and the fragility and expense of the sophisticated measurement sensors.

Consequently, the most logical and practical adaptive trigger lies in a fourth alternative: a hybrid strategy. Elements of the environment, performance, and physiology can be viewed together to create a performance model (as opposed to performance measurement) on which to base adaptation. Initial research employing this hybrid strategy for adaptive allocation has already shown some promise (Parasuraman, Mouloua, & Molloy, 1996; Scallen, 1997).

Rahman's communication also addressed the question of "responsibility" for adaptation. Whatever the source of the trigger, who or what is responsible for its invocation? Initially this appears to be either the human or the machine. But the either-or conceptualization can be limiting. With respect to human control, we have experimented with two hybrid procedures, one in which the machine invokes the adaptive allocation episode but the operator can negate this invocation, and a second in which the machine recommends allocation change but takes no further action. The authority for change remains with the human in this case. The question of control and responsibility can then be viewed as a continuum from machine at one end to human at the other. Our preliminary studies indicate that level of operator involvement may be a crucial factor in the overall efficiency of adaptive allocation.

We hope that Rahman's letter is an indication of growing interest in the area of adaptive allocation. If adaptive allocation has any hope of alleviating real design problems, the human factors community must now respond with opportunities for dialogue and increases in research efforts.

P. A. Hancock & S. F. Scallen

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No Dummies Here

In the January 1997 issue, Doug Griffith gave us a delightful commentary on the number of "dummy" books proliferating on bookstore shelves. His call was for consumers to demand that software products they buy be "easy to use."

I suspect we can save our breath. Cents have replaced sense.

Once upon a time, there was no question that a product had to be usable, or the customer (usually the military) didn't accept it. But in the world of LANs, WANs, and PCs, we're talking about shuffling paper, not launching missiles. If we hit the wrong function key or confuse whether to click or double click on the mouse, we're not going to start a thermonuclear war. There is no compelling reason we have to get it right the first time.

It's a whole new world – one where every penny counts and business sectors are created by generating a need. Economically, it makes sense to develop software programs that are less than intuitive or "user friendly." As dedicated ergonomists, we wince. But don't take it personally.

It was an economic decision. The resulting chaos gave birth to a whole new secondary business called "help desks." And, as a tertiary fallout, "publications." Together they have