From: Eric Thornsbury
To: Lois, Erasmia; Yerokun, Jimi
Date: 12/20/05 6:56AM
Subject: HRA Comments

Erasmia,

Dr. Apostolakis asked that I forward the attached document to you, which summarizes the suggestion he discussed at last week's HRA meeting.

Please note that this document represents the views of Dr. Apostolakis, and does not represent an official opinion of the ACRS.

Eric

CC: ACRS-Members; Delgado, Jessie; Flack, John; Larkins, John; Scott, Michael; Snodderly, Michael; Thadani, Ashok

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December 19, 2005

TO: Eric Thornsbury, ACRS Staff Engineer
FROM: George Apostolakis, ACRS Member
RE: Focus of Human Reliability Analysis

1. At the December 16, 2005 meeting of the ACRS subcommittees on human factors and reliability & probabilistic risk assessment, I suggested that the focus of Human Reliability Analysis (HRA) models should be the time the operators take to perform a given task. This memorandum summarizes my thoughts on this matter.

2. Traditional HRA models such as ATHEANA and SPAR-H focus on the probability that the crew will not perform a task successfully. This probability is produced by investigating the "context" within which the task is performed, or the Performance Shaping Factors (PSFs) that are relevant to the task. In tasks in which the available time for action is known, the models still focus on the probability of failure, which, in this case, means that the operators will take longer than the available time. How long they will take is not, in general, quantified.

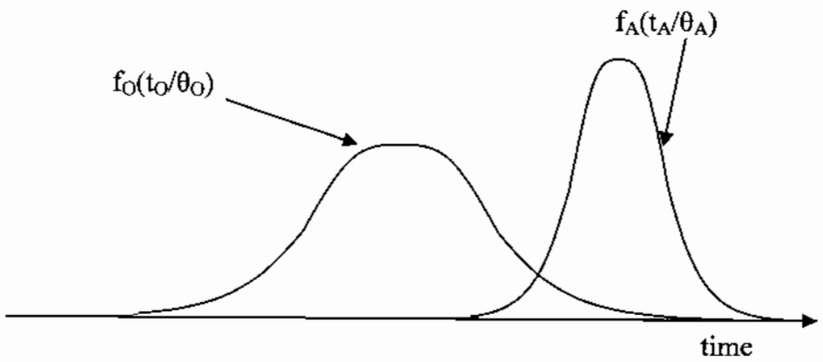
3. In traditional HRA models, the available time, as determined by the physics of the problem using, for example, thermal-hydraulic calculations, is primarily used as a PSF that affects the operator performance. It is not used explicitly in a comparison with the operator action time.

4. The formulation I am proposing proceeds as follows:

   a. Let T_A be the time available for action as determined by physics and engineering.
   b. Let T_O be the time required by the operators to diagnose the situation and act.
   c. Failure occurs when
   $$T_O > T_A \qquad (1)$$
   d. Each time in eq. (1) has aleatory uncertainty that is expressed in terms of probability density functions (pdf's) $f_O(t_O/\theta_O)$ and $f_A(t_A/\theta_A)$. These pdf's contain parameters θ that may be multidimensional (e.g., the two parameters of the normal distribution).
   e. Our epistemic uncertainty regarding the parameters is expressed in terms of pdf's as follows: $\pi_O(\theta_O)$ and $\pi_A(\theta_A)$.
   f. The probability of failure is then

$$\Pr(T_O > T_A) = \int\int d\theta_O d\theta_A \pi_O(\theta_O)\pi_A(\theta_A)\left[\int_0^\infty\int_{t_A}^\infty dt_A dx f_A(t_A/\theta_A) f_O(x - t_A/\theta_O)\right] \qquad (2)$$

g. To better understand eq. (2), we look at the following picture:



h. This picture shows the aleatory curves only. The double integral in the brackets of eq. (2) is the probability that $T_O > T_A$. To get the complete picture, imagine that each of the above curves is a member of a family of curves that are indexed according to the epistemic distributions $\pi_O(\theta_O)$ and $\pi_A(\theta_A)$.

5. The question now is where these distributions come from. This is where the insights from the Halden experiments and the time lines that HERA is developing from the LERs and the ROP will be utilized. In fact, both of these sources are structured to support the proposed formulation.

6. In some applications of the above formulation, the analysts assume that the aleatory uncertainties are dominated by the epistemic uncertainties. This means that the aleatory distributions $f_O(t_O/\theta_O)$ and $f_A(t_A/\theta_A)$ are neglected and the epistemic distributions refer to the mean available time and the mean operator action time. In the light of the Halden findings, I am not sure that this assumption would work here. They found that there was aleatory uncertainty in the actual response times. In any case, looking for simplifications is always a good idea.

7. While converting to the above formulation would require some effort, I believe it is worthwhile because it is more realistic and will be very useful in future applications that deal explicitly with time. We already have seen the issue of time treated in a judgmental way in power uprate requests.

Bibliography

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Hallbert, B., and Mosleh, A., "HERA Data & Bayesian Methods," presented at the meeting of the ACRS subcommittees on human factors and reliability & probabilistic risk assessment, December 16, 2005.