Transactions of the Korean Nuclear Society Spring Meeting
Chunchеon, Korea, May 25-26 2006

Verifying TACOM measure by the comparison between TACOM and OPAS scores

Jinkyun Park and Wondea Jung
Integrated Safety Assessment Division, Korea Atomic Energy Research Institute,
P.O.Box 105, Duckjin-Dong, Yusong-Ku, Taejon, 305-353, Republic of Korea.
kshpjk@kaeri.re.kr, wdjung@kaeri.re.kr

1. Introduction

In general, good procedures guarantee several benefits including the reduction of human performance related problems, particularly if a task is to be carried out under very complicated and stressful conditions [1]. Ironically, a significant portion of human performance related problems could be attributed to procedures [2]. Therefore, it is obvious that a systematic approach that can properly evaluate the complexity of procedures is indispensable for reducing the side effects of complicated procedures.

From this standpoint, in order to quantify the complexity of tasks prescribed in the emergency operating procedures (EOPs) of nuclear power plants (NPPs), Park et al. suggested TACOM (Task Complexity) measure based on graph entropy concepts [3]. In addition, the appropriateness of TACOM measure is preliminarily verified by comparing task performance time data. In this study, for an additional verification activity of TACOM measure, operators' performance data that were measured by Operator Performance Assessment System (OPAS) are compared with TACOM scores.

2. Introduction to TACOM and OPAS

2.1 TACOM measure

TACOM measure consists of five sub-measures that represent complexity scores due to five kinds of complexity factors. The definition of each sub-measure is as below [3].

- The step information complexity (SIC) represents a complexity due to the amount of information to be processed by operators;
- The step logic complexity (SLC) denotes a complexity due to the logical sequence of the required actions to be accomplished by operators;
- The step size complexity (SSC) implies a complexity due to the amount of required actions to be accomplished by operators;
- The abstraction hierarchy complexity (AHC) indicates a complexity due to the amount of system knowledge that is indispensable for identifying the problem space of the required actions;
- The engineering decision complexity (EDC) connotes a complexity due to the amount of cognitive resources that are necessary to establish the proper decision criteria for the required actions.

Based on the above sub-measures, TACOM measure is defined by:

$$TACOM = \begin{bmatrix} (\alpha \times SIC)^2 + (\beta \times SLC)^2 + \\ (\gamma \times SSC)^2 + (\delta \times AHC)^2 + \\ (\varepsilon \times EDC)^2 \end{bmatrix}^{\frac{1}{2}} \quad (1)$$

2.2 OPAS

OPAS has been developed by HAMMLAB of the OECD Halden Reactor Project, and it combines advantageous elements of a task-analytic modeling technique and a subjective expert judgment [4]. First of all, for a given task, process experts conduct a task analysis in order to identify a main goal, sub-goals and sub-stages including critical operator activities that are presumed to be carried out by most operators. Here, critical operator activities are classified into three categories, such as detections, operations, and sequences. Detections imply a passive registration of events, such as alarm information. Operations denote a direct intervention with the process of interest, active information gathering, verification, or a behavior defined by operating procedures. Sequences mean the critical order of operations and/or detections to be performed by operators.

After these identifications are finished, process experts prepare OPAS sheets. During the preparation of OPAS sheets, sub-goals are weighted according to their importance for the completion of a main goal. Similarly, critical operator activities that belong to sub-stages are weighted according to their importance for the completion of sub-goals.

Finally, based on the presumed (or ideal) activities for the given task, process experts observe operators' behaviors in a real time in order to determine whether the presumed activities are performed or not. Based on the results of observations, OPAS scores that reflect the discrepancy between an expert's analysis and an operator's response [4].

OPAS scores lie in the interval [0, 100], and a higher score means a better operator performance. In other words, OPAS scores are proportional to the amount of actually performed activities that were presumed as critical activities by process experts.

3. Comparing TACOM and OPAS scores

First of all, averaged OPAS scores for 18 tasks were collected with the cooperation of HAMMLAB. In addition, TACOM scores for all the tasks are quantified. Table 1 summarizes averaged OPAS scores with the associated TACOM scores.

< Table 1. OPAS and TACOM scores for 18 tasks >

Task	TACOM	OPAS	Task	TACOM	OPAS
1	1.457	72.5	10	1.298	90.5
2	1.294	75.0	11	1.526	55.0
3	1.795	86.2	12	1.533	82.3
4	0.945	100.0	13	1.389	97.8
5	1.865	70.5	14	1.560	72.0
6	1.147	100.0	15	1.148	67.8
7	1.515	74.2	16	1.230	94.5
8	1.477	56.2	17	1.571	67.5
9	1.315	83.3	18	1.698	68.8

Based on the data shown in Table 1, the regression analysis is conducted with ANOVA (analysis of variance). As a result, it is observed that TACOM scores seem to be inversely proportional to OPAS scores ($R = -0.503$, $F(1, 16) = 5.391$, $p = 0.034$). Therefore, it is anticipated that operators who are faced with a complicated task (i.e., a high TACOM score) are apt to show a degraded operator performance (i.e., a low OPAS score).

4. Discussions and conclusion

Up to now, for the additional verification activity of TACOM measure, TACOM scores have been compared with operators' performance represented by OPAS scores. Here, there are two rationales indicating that OPAS scores are necessary for the verification of TACOM measure.

First one is that OPAS scores could be useful in clarifying the relationship between TACOM measure and another important dimension of human performance. According to previous studies, it has been suggested that human performance can be measured by three unique dimensions, such as time, error and inefficiency [5]. This means that it is important to compare OPAS scores with TACOM scores, because OPAS scores are susceptible to the level of deviations between the presumed activities with the actual behaviors. In other words, although the deviation from the presumed activities does not directly indicate the occurrence of human error, if we realize the fact that the possibility of human error is proportional to the increase of the level of deviations [6], then it is not absurd to anticipate that OPAS scores are insightful for verifying the effect of a task complexity on human error.

In addition, as for the second rationale, it should be emphasized that OPAS scores are susceptible to the level of a task complexity [4]. This strongly alludes to the fact that OPAS scores could be regarded as reference data for verifying the appropriateness of TACOM measure.

From the above rationales, it is expected that TACOM measure seems to be meaningful for quantifying the complexity of tasks, since the increase of TACOM scores is statistically correlated with the impairment of OPAS scores. Therefore, the following conclusion could be drawn from the results of this study – "It is believed that the TACOM measure can be regarded as a useful tool for quantifying the complexity of tasks to be done by operators."

REFERENCES

[1] A. Degani and L. Wiener, "Human factors of flight-deck checklists: The normal checklist", National Aeronautics and Space Administration, NASA/CR-177549, 1990.

[2] M. Paradies, L. Unger, P. Haas, and M. Terranova, "Development of the NRC's human performance investigation process (HPIP)", U.S. Nuclear Regulatory Commission, NUREG/CR-5455, Vol. 1, 1993.

[3] J. Park and W. Jung, A study on the development of a task complexity measure for emergency operating procedures of nuclear power plants, Reliability Engineering and System Safety, Accepted for publication, 2005.

[4] G. Skraaning, Jr., "Experimental control versus realism: methodological solutions for simulator studies in complex operating environments," PhD thesis, Norwegian University of Science and Technology, 2003.

[5] R. L. Henneman and W. B. Rouse, Measures of human problem solving performance in fault diagnosis tasks, IEEE Transactions on Systems, Man and Cybernetics, Vol. SMC-14, No. 1, p. 99-112, 1982.

[6] L. Reason, D. Parker and R. Lawton, Organizational controls and safety: The varieties of rule-related behavior, Journal of Occupational and Organizational Psychology, Vol. 71, p. 289-304, 1998.