Journal of the Korean Society of Marine Engineering, Vol.30, No.7, pp.782~790, 2006(ISSN 1226-9549)

An Analysis on Simulator Scenarios for the Integrated Evaluation when Applied to Teamwork by Deck and Engine Officers

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(Manuscript : Received AUG 10, 2006 ; Revised SEP 26, 2006)

Abstract : The evaluation systems in SHS(Ship Handling Simulator) or ERS(Engine Room Simulator) give trainees the opportunity to feedback how they responded, suggesting them the operation result by scores. If SHS and ERS are integrated each other by network to enable the synchronous training for both deck and engine officers, these systems need to include inherently the function of integrated evaluation which produces the evaluation score for the team play of deck and engine officers. The integrated evaluation is effective especially when assessing the responses at emergency situation of ship or the matter of efficiency of ship operation even if assessors feel difficult in editing simulation scenarios for integrated evaluation.

This study focuses on the property of integrated evaluation and considerations when editing them. It suggests also a useful procedure to estimate whether a scenario for integrated evaluation is reasonable and balanced or not based on the analysis in the proprieties and reasonabilities which are to be prepared by assessors before testing trainees or examinees.

Key words : Simulator(시뮬레이터), Scenario(시나리오), Integrated evaluation(통합평가)

1. Introduction

1.1 Background

There have been lots of studies and ideas about how to utilize simulators for the purpose of better training and evaluation for marine officers[1]-[3]. This paper intends to introduce the specific features of integrated evaluation using the integrated simulation system comprising Engine Room Simulator and Ship Handling Simulator. It includes some suggestions about concepts of how to assess scenarios to help the assessors to design efficient scenarios which evaluate the responses of seafarers in teamwork of deck and engineer officers.

To achieve reasonable evaluation, scenarios need to be designed in

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consideration of the effects on both sides of candidate activities when assessors choose malfunctions, actions and evaluation variables. And the required knowledge depth for the both sides and the matter of synchronization between candidates should be another concerns in the stage of design.

Integrated evaluation usually gives more difficulty in choosing stories for assessing because both sides of candidate's activities should be dependent on each other considerably. Also, its design should be based on the concept to keep balance between bridge and engine room situation in terms of the knowledge depth and the quantity of activities which are required for the intended candidates.

1.2 Activities and Evaluation on simulators

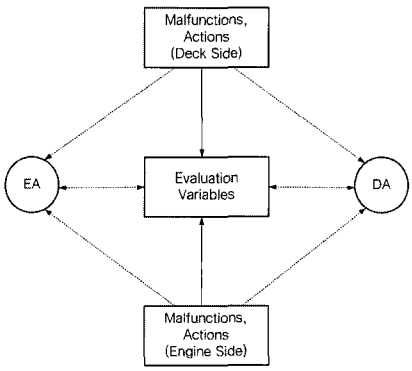


Fig. 1 Relation between interactive objects

To keep a vessel in desirable condition, the responses and activities of the officers in charge of deck and engine departments should be reasonable and competent, especially in case of serious situation which may happen to their vessel.

It is generally deemed that designing scenarios for integrated evaluation needs more consideration and discussions between assessors of both sides. The reason of the difficulties when designing such scenarios is caused from the limitation of available malfunctions or evaluation variables which are related commonly or interactive to both sides of candidates at the same time.

Fig. 1 shows the relation between interactive objects, where the dotted lines indicate the signal flows for Man-Machine Interface. For example, in the integrated simulation, a malfunction of an engine room simulator affects not only the variables or the candidate activities of engine side, but also those of deck side. As a result, a scenario for integrated evaluation needs to be configured to expect a good harmony of the responses by the activity of deck side candidates (DA) as well as that of engine side candidates (EA). The candidate activities can be synchronous or asynchronous according to the situation of the evaluation scenario. Whether candidate activities are made by synchronous responses (SR) or asynchronous responses (AR) shall be another concern in designing evaluation scenarios.

2. Configuration of Integrated Evaluation

Fig. 2 is the configuration diagram which explains an integrated simulator system. In the diagram, the solid lines indicate the signal flows which run in the simulators by on-line, and the dotted lines

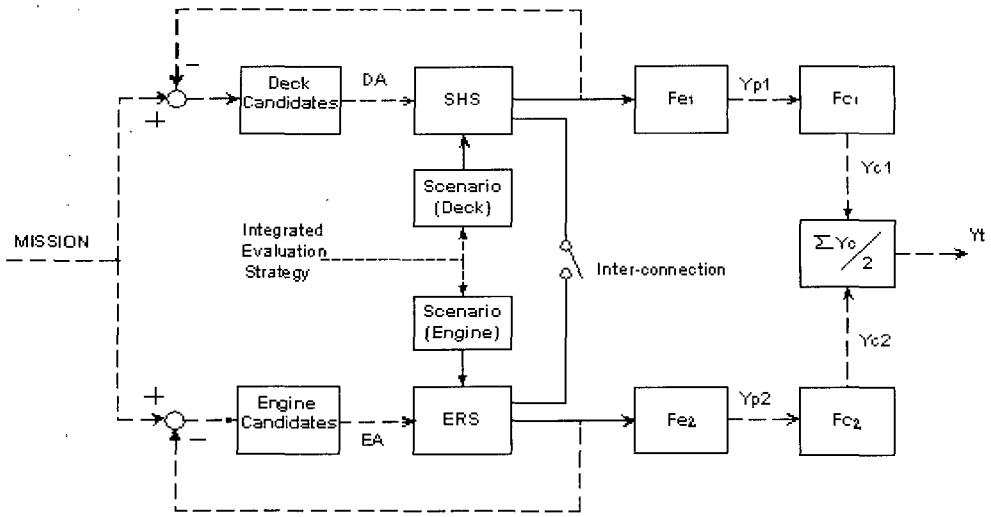


Fig. 2 Integrated simulator system

are for off-line signal flows of activities by assessors or candidates.

A ship is operated by connection of human and ship systems. If a mission is given to crew members or candidates to keep good ship condition in terms of efficiency and safety, they shall manage to acquire the goal as close as possible. As shown in Fig. 2, the assessors shall consider the evaluation strategy, especially for the case of integrated candidates.

Here, Fe_1 and Fe_2 mean the evaluation functions for deck and engine side respectively, and they are based on the penalty sum as in Eq. (1) which has been used generally[4),(5)].

$$Y_P = \sum_{j=1}^{N} \sum_{k=1}^{T/\tau} C_j \left| v_{jk} - v_{jM} \right| \qquad (1)$$

Where, $if\ v_{jk} > v_{jM100}\ then\ v_{jM} = v_{jM100}$, $if\ v_{jk} < v_{jM0}\ then\ v_{jM} = v_{jM0}$

v_{jk} : The value of a evaluation variable at 'k'th sampling

v_{jM100} : Constant value designated as upper limit for penalty counting

v_{jM0} : Constant value designated as lower limit for penalty counting

τ : Sampling period

T : Evaluation time

Cj : Coefficient for 'j'th evaluation variable

N : Number of evaluation variables

Yp : Candidate's Penalty Sum (Yp_1: Deck side, Yp_2: Engine Side)

The penalty value Yp is actually the sum of the deviated values from the normal operation ranges which have units of different dimensions one another. In terms of physical point, sum of values with different dimensions is meaningless. If necessary, we can get sum of dimensionless values Yp' as described in Eq. (2).

$$Y_P' = \sum_{j=1}^{N} \sum_{k=1}^{T/\tau} W_j \frac{\left| v_{jk} - v_{jM} \right|}{\left| v_{jM\,100} - v_{jM\,0} \right|} \quad (2)$$

Where, W_j is the weight factor for 'j'th evaluation variable. From Eq. (2), C_j is expressed as follows.

$$C_j = \frac{W_j}{\left| v_{jM\,100} - v_{jM\,0} \right|} \quad (3)$$

C_j can be inputted on the evaluation editor by the column called 'Weight' in case of Konsberg simulation system.

On the other hand, F_{C1} and F_{C2} are the functions to convert the result of penalty sum into scores (Yc) which are based on the 100%.

$$Y_C = \frac{Y_M + y}{Y_P + y} \quad (4)$$

Where, Y_M is the results of penalty sum acquired by experts or veterans which correspond to 100 points on a one-hundred-point basis. And the value y is a constant to compensate the values of Y_P. The result Y_t of team evaluation is derived from the average of Y_{C1} (the score of deck side) and Y_{C2} (the score of engine side).

3. Evaluation Variables of Integrated Scenarios

3.1 Evaluation Variables on the Space DA-EA

The evaluation variables or malfunctions available for integrated evaluation are more restrictive in usability rather than the case of non-integrated evaluation. As shown by dark area on Fig. 3, the set of variables for this purpose is much limited in both simulators. Here, the dotted selection loop for searching variables in integration mode is a symbolic circle to indicate this situation.

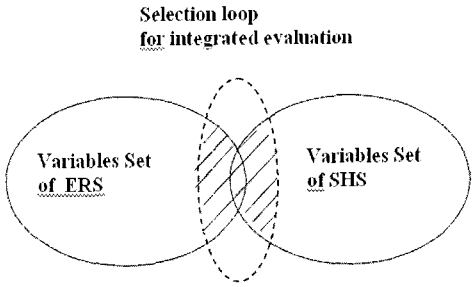
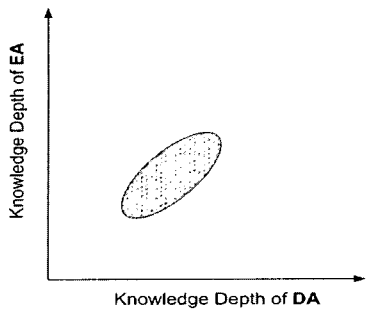


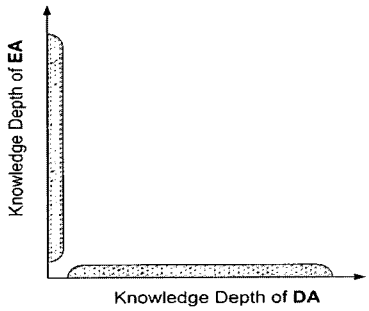
Fig. 3 Variables sets and selection loop for interactive relation

An integrated scenario is assessed by how well it can cause reasonable and balanced responses by candidates during evaluation. If necessary, an assessor needs to make a lot of discussion with the counterpart from the time of design stage for scenario.

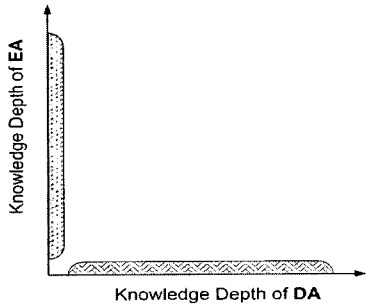
The pattern of how an integrated scenario has been designed can be characterized specifically on the space by DA and EA as illustrated in Fig. 4 where the quality of activities has been represented by "Knowledge Depth" in range of index 1 to 10. The knowledge depth of an evaluation variable is required to be decided by the assessor who designs the evaluation scenario. If the scale on an axis corresponds to index 10, it means that the variable for evaluation can cause candidate's activities but is the most difficult for them to solve the given situation.



〈Optimum Case〉



〈Synchronous Case〉



〈Asynchronous Case〉

Fig. 4 3 Cases on DA-EA space diagram by the relation of knowledge depth

The horizontal axis of X indicates the knowledge depth for the candidates of deck officers. And, the axis Y shows the knowledge depth of marine engineers who manipulate the engine room simulator. A point on the DA-EA space can be located by the expression of 2 numbers. If a point of evaluation variable is designated by (5, 3), it means that the required knowledge depth is 5 for deck candidates, but 3 for engine candidates. Here, index 5 means the medium level for solving the situation relating to the evaluation variable. If the deck side of variable does not cause any activities of engine candidates, then the index number should be '0' or '1' rather than 3. The more an index number of evaluation variable goes to 10, the more the candidates need to be busy in brain and physical activities.

From the view of the expression on DA-EA space, evaluation scenarios can be classified into 3 standard patterns as described in Fig. 4. The first case among them is called Optimum Case (OC) because the scenario says that candidate's activities are well balanced. In OC, the activities are at least in mode of synchronous responses each other, not in asynchronous responses. But, the difficulty in designing scenarios by OC is the most due to lack of corresponding stories and materials.

The second diagram of Fig. 4 shows scenarios which are more usual in integrated evaluation where the evaluation area has been separated on the diagram but the activities of both sides are synchronous (the case of SC). When malfunctions or actions are given to engine simulator system or deck simulation system, they should affect both sides of activities at the same time.

The last of Fig. 4 shows another case where the evaluation area has been separated and also asynchronous in activities without affecting other side resulting in inefficient and time consuming evaluation (the case of AC).

On the other hand, the length of arm which shows knowledge depth is short on OC. The reason is that the integrated evaluation needs to focus more on the team play for given situation rather than to emphasize on the matter of each specialty.

3.2 Knowledge Spectrum of Evaluation

In the scenarios for non-integrated evaluation, the width of knowledge spectrum necessary for candidate's activities is much wider than the case of integrated evaluation as illustrated in Fig. 5 where 8 of vertical lines are expressed by the given knowledge depth and the evaluation weight W_j for each 8 evaluation variable. The enveloped curve of spectrum lines on Fig. 5 is an imaginary line which can be drawn continuously if the number of evaluation variables becomes infinite and each evaluation has its evaluation weight.

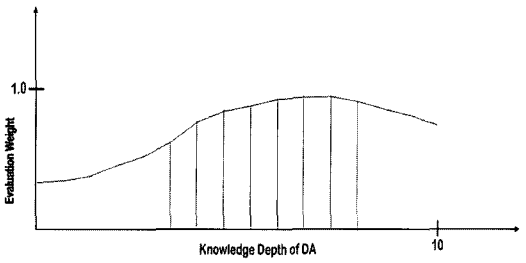


Fig. 5 Knowledge spectrum available for evaluation by non-integration mode

Scenarios for integrated evaluation not only need more considerations in the designing stage but also take longer time during candidate's evaluation. To meet the requirement of intending evaluation, distribution of knowledge spectrum need to be appropriate in terms of the level of candidate's ability.

4. An Example of Integrated Evaluation

4.1 Instance of integrated scenario

An integrated scenario has been introduced to assess the suitability of it on the simulator system of Konsberg. The own ship of oil tanker (VLCC) is under full speed passing through the Strait of Gibraltar. After taking the duty of the own ship, candidates are given the situation of rough sea by wind force up to 7.

Table 1 and Table 2 show the pages of evaluation editor including the indices of knowledge depth (1 to 10) for both sides of activities which need to be decided by assessors. On the other hand, the range of weight W_j for each evaluation variables has been given by the value from 0 to 1.0.

Table 1 Evaluation table for SHS

No.	Evaluation Variables	Weight (Wj)	Knowledge Depth(DA)	Knowledge Depth(EA)
1	Minimum distance from all ships	0.9	5	1
2	Heading	0.1	4	1
3	Inside all track sectors	0.2	6	1
4	Distance to P1	0.4	7	1
5	Distance to P2	0.3	7	1
6	Rate to turn	0.1	8	1
7	Rudder angle	0.1	4	1
8	Roll	0.1	5	2
9	Pitch	0.1	5	2

Table 2 Evaluation for ERS

No.	Evaluation Variables	Weight (Wj)	Knowledge Depth(DA)	Knowledge Depth(EA)
1	start DG1	0.7	1	7
2	cut-in DG1	0.2	1	7
3	start DG2	0.3	1	8
4	cut-in DG2	0.1	1	8
5	cut-out TG2	0.2	1	5
6	stop TG	0.1	1	4
7	cut-out SG	0.2	1	6

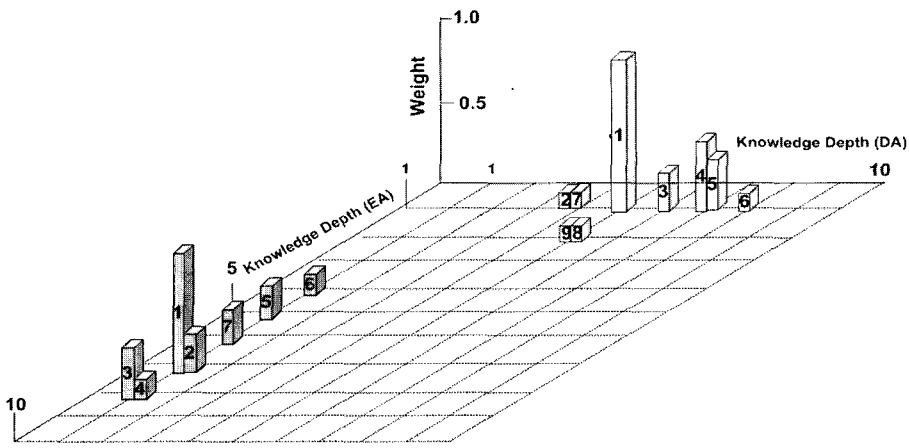


Fig. 6 Mapping diagram on the DA-EA space

4.2 Mapping on the DA-EA space

To consider the property of the evaluation scenario based on the DA-EA space, all evaluation variables of Table 1 and Table 2 need to be plotted together by using the columns of knowledge depth as illustrated in Fig. 6.

Fig. 6 describes how the evaluation variables of each side are located on the DA-EA plane and the distribution of knowledge spectrum is revealed in detail. And it says that the instanced evaluation scenario is at least not the optimum case described in Fig. 4. Though the diagram does not provide the information about the synchronization in both sides of activities, it can be derived partially from the time curves of penalty records generated by candidate activities.

4.3 Evaluation Record of Candidates

The evaluation edit page of Kongsberg Simulator System provides the sum of penalty value for every sampling time. The variation of penalty sum according to the time passing can be useful for analysing candidate activities. Also, the time curves from both sides give the information of the synchronization.

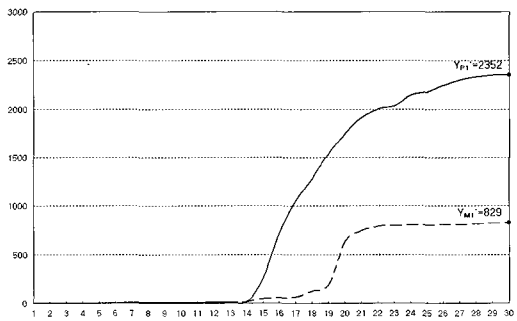


Fig. 7 Time curves of the penalty sum for deck candidates

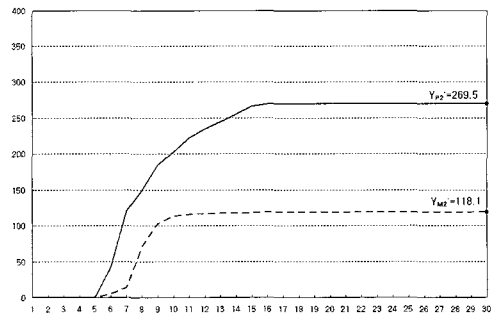


Fig. 8 Time curves of the penalty sum for engine candidates

Figs. 7 and 8 show the variation where the solid lines indicate the result of candidates and the dotted lines are made by experts. Each result corresponds to Y_{M1}' and Y_{M2}' of Eq. (4).

From the figures, we see $Y_{M1}'=829$, $Y_{M2}'=118.1$, $Y_{P1}'=2352$ and $Y_{P2}'=269.5$. If we put $y1=y2=0$, then the evaluation result of team candidates is acquired as 39.5 according to Eq. (4). In the matter of synchronization, the given malfunction (heavy sea condition) affected both sides of activities as much as it can be recognized, but not so much as Optimum Case. So, it shows that the activities are not strongly correlated each other in synchronization.

4.4 The result of Analysis

The results say that the instanced scenarios can be expressed as the mixture of SC and AC described in Fig. 4 based on the distribution on DA-EA space and the relation of synchronization. From the time curves, the activities of bridge side are shown much delayed than engine side. The reason of asynchronous responses can be found by checking related evaluation variables. If assessors modify unreasonable parameters and adding evaluation variables which are more related commonly to both sides of activities, the scenarios can be moved to the case of SC, OC, or the mixture of SC and OC.

5. Conclusion

Designing a scenario for integrated evaluation is more complicated than non-integrated case, and assessing the quality of integrated scenarios has become another issue to assessors who want to know how reasonable their scenarios are for integrated candidates.

The assessing concept introduced here is based on the designation of knowledge depth for each side of candidates to solve given situation during evaluation. By plotting both sides of evaluation variables on the DA-EA space, we could bring the evaluation design to a visible graph which provides useful information to keep balanced sense for both sides of evaluation.

And by plotting time curves which show the variation of penalty sum at both sides, the matter of how synchronous both activities of candidates are could be disclosed. The proposed concepts and procedures were applied to instanced scenarios to get some graphs and the effectiveness was able to be confirmed.

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