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On the Evaluation of Berthing Training for Pilot Trainees Using a Ship Maneuvering Simulator

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Abstract: After the introduction of a new pilot training and certification system by the Japanese government, Tokyo University of Marine Science and Technology started the education and training of a young pilot trainee with a limited amount of ship-handling experience. As the ship maneuvering simulator training is at the core of the above education and training, it is desirable to develop a new evaluation method of ship-handling performance that can be completed within a short period of time after each training session. From the above point of view, the authors propose a new evaluation method that compares, at the de-briefing, the time histories of ship's motion during berthing by trainees and those by instructors. The authors conducted experiments using a ship maneuvering simulator and confirmed that the proposed evaluation method is effective and helpful to improve the simulator training.
Keywords: Pilot education and training, SMS training, Evaluation of SMS training

1. INTRODUCTION

Due to the significant reduction in the number of Japanese seafarers, a shortage of pilots is expected in the near future. In 2007, the Japanese government introduced a new grade-base pilot education, training and certification system in order to keep a constant supply of experienced pilots. The career opportunity to become a pilot has long been open only to ex-masters with seagoing experience of at least three years. Experience as a master is not necessary in the new system. For pilots in the 3rd grade category, a career history that includes service on ships of 1,000gt or more for a period of one year or longer as a cadet or officer is necessary. To follow the above new government's policy, Tokyo University of

Marine Science and Technology started a new pilot training program as one of its master's programs under the Course of Maritime Technology and Logistics.

Ship maneuvering simulator (SMS) training is at the core of the technical training and is conducted by servicing pilots with abundant experience. Usually, ship-handling performance of a trainee is evaluated subjectively by instructors based on their ship-handling experiences. In order to improve SMS training for young pilot trainees with a limited amount of ship-handling experience, it is desirable to develop a new evaluation method of their ship-handling performance at the de-briefing of the training within a short period of time using objective indicators.

Okazaki et.al [1] proposed an evaluation method of berthing performance using the Minimum Time Berthing Solutions. However, the Minimum Time Berthing Solutions try to estimate the limitation of a ship's maneuverability for berthing by solving the minimum time berthing problem, and it is difficult to utilize them as the ship-handling performance evaluation indicators. In a recent paper, Okazaki et.al [2] proposed a method that aims at deriving the safety margins of the minimum time berthing problem such as speed, approaching angle and lateral distance to the berth by analyzing the berthing training data using a SMS. The authors paid attention to the output of the time histories of ship's motion during SMS training and propose a new evaluation method that compares the time histories of ship-handling by trainees and those by instructors.

This paper describes the above proposed evaluation method and the results of experiments using a SMS aiming at assessing the effect of the proposed method for improving SMS training.

2. DEVELOPMENT OF THE EVALUATION TOOL

2.1 Evaluation method

In the berthing training of pilot trainees (hereafter the trainees), the instructor makes a brief explanation on the training scenario and then demonstrates an exemplary berthing before pilot trainees. After that, the same simulator sessions are performed by the trainees under the same environmental conditions. During the training, the trainees tend to follow the sequence of maneuvers demonstrated by the instructor. The authors paid attention to the above and created an evaluation method that compares the output of the time histories of the ship's state variables (hereafter indicators) during the ship-handling by trainees and those by instructors.

In general, pilots conduct their berthing utilizing the following standard factors; approaching angle to the berth, speed, lateral distance at the berth front, which are determined for each of the ship type and of the berth. Therefore, the authors evaluate the ship-handling performance of each trainee by comparing the mean and standard deviation (SD) of each of their following indicators with those by instructors: speed, distance to the berth, approaching angle, lateral distance to the normal line of the berth (hereafter lateral distance) at the designated points on the planned track. The evaluation points of the indicators are arranged on the planned course line at 3L (L; ship's length), 2L, 1L and 0.5L away from the berth.

After finishing each SMS session, the ship-handling analysis is performed automatically using the software developed by the authors and a diagram like the one shown as Figure 1 in 2.2 is generated. This makes it possible to evaluate the ship-handling

performance of trainees quantitatively within the short period of time and the instructor can give necessary advice on their ship-handling.

2.2 Effectiveness of the evaluation indicator

Experimental SMS berthing sessions to the Tokyo Ohoi No.4 berth were performed in order to confirm the effectiveness of the proposed method using a 70,000 G.T. container ship (300L×38.7B×12d). In the experiment, the instructor performed exemplary ship-handling 4 times and the same session was performed by 13 1st grade pilot trainees and one 3rd grade trainee. The 1st grade trainees had 2 years or more sea service experience as a master and the 3rd grade trainee had no sea service experience as a master. The ship-handling performance of the 1st grade trainees and the 3rd grade trainee were compared with that of the instructor.

The ship-handling indicators of the trainees were compared with those of the instructor, and the results are shown in Figure 1 and Table 1. In the figure, the horizontal axis shows the distance between the ship and the berth, the solid line shows the history of the indicator of the 3rd grade trainee, and the white marks and the half black marks show the mean and SD of the indicators respectively. In the table, minus sign of the approach angle means the targeted berth exists on her port side. When we pay attention to the indicators of the instructor's ship-handling, their standard deviations are generally small at all evaluation points. Therefore, it is considered that the instructor's exemplary ship-handling has reproducibility, and we can use it as the evaluation standard.

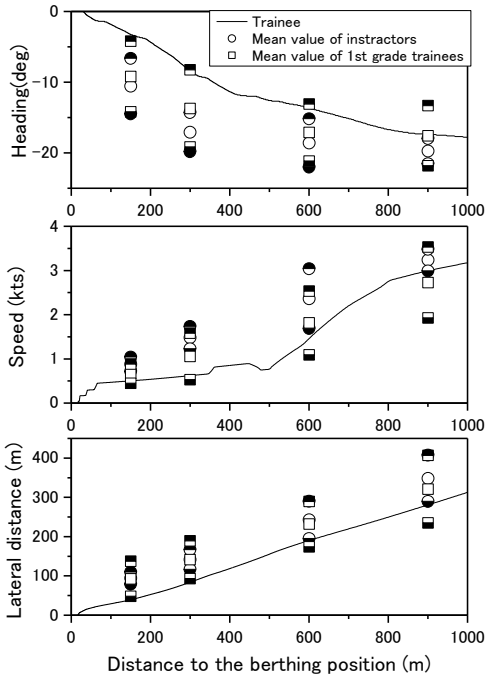


Figure 1 Ship-handling results of the 3rd grade trainee

Table 1. Comparison of indicators between instructor and trainees

Evalua-tion point	Instructor						1st grade pilot trainees						3rd grade pilot trainee		
	Lateral Distance(m)		Speed (kts)		Approach Angle(deg.)		Lateral Distance(m)		Speed (kts)		Approach Angle(deg.)		Lateral Distance(m)	Speed (kts)	Approach Angle(deg.)
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	—	—	—
3L	348.2	59.0	6.1	0.4	-19.8	1.8	309.6	100.4	5.1	1.9	-17.5	5.1	281.5	5.7	-17.4
2L	242.4	47.5	4.6	1.3	-18.6	3.4	225.5	58.7	3.2	1.7	-17.4	3.6	190.5	2.9	-13.7
1L	141.4	25.0	2.9	0.4	-17.1	2.8	136.1	39.9	1.9	1.1	-14.2	5.8	84.3	1.1	-8.5
0.5L	93.9	15.3	1.7	0.4	-10.6	3.9	88.9	37.1	1.3	0.6	-10.0	5.0	39.2	1.0	-3.3

On the training results of the 1st grade trainees, their SD of the lateral distance at 0.5L is two times greater than that of the instructor and speed mean value is generally smaller than that of the instructor. The above results mean that they needed more time to complete their berthing ship-handling than the instructor and seem to prove the fact that the trainees had less experience in berthing than the instructor.

Turning to the training results of the 3rd grade trainee, remarkable differences in the mean value of the indicators are observed compare with those of the instructor and the 1st grade trainees. The 3rd grade trainee was able to follow the speed reduction procedure in the exemplary ship-handling, however, the lateral distance at the 0.5L point is too close to the normal line of the berth and is dangerous.

2.3 Total ship-handling performance evaluation

Next we discuss an evaluation method of the total ship-handling performance of 3rd grade trainees. Table 2 shows the difference of the mean values of the indicators at each of the evaluation points between the instructor and the trainees. It can be seen that the value differences between the 3rd grade trainee and the instructor are greater than those between the 1st grade trainee and the instructor for all the indicators at all evaluation points. The approaching speed of the 3rd grade trainee is slower than that of instructor and his lateral distance is closer to the normal line of the berth than that of the instructor. These values in table 2 indicate that the 3rd grade trainee deviated too much from the planned track and that the speed was too slow. These results indicate the fact that the 3rd grade trainee's ship-handling skills are far less adequate than those of the 1st grade trainees. Therefore, we considered that the ship-handling training of the 3rd grade trainee is better to be started targeting the ship-handling performance of 1st grade trainees.

Table 2 Difference of the mean value of indicators between instructor and trainees

Evaluation point	1st grade pilot trainee			3rd grade pilot trainee		
	Lateral Distance (m)	Speed (kts)	Approach Angle (deg.)	Lateral Distance (m)	Speed (kts)	Approach Angle (deg.)
3L	38.6	1.0	2.3	-66.7	-0.4	2.4
2L	16.9	1.3	1.2	-51.9	-1.7	4.9
1L	5.3	1.0	2.9	-57.1	-1.7	8.6
0.5L	5.0	0.4	0.6	-54.7	-0.8	7.3

From the above discussion, we propose the following method of evaluating the total ship-handling performance of the 3rd grade trainee by utilizing the indicators. The indicators are put into scores as follows:

1. Score A (3 points); Indicator of the trainee is within 1 σ of that of instructor
2. Score B (2 points); Indicator of the trainee is within 1 σ of that of 1st grade trainee
3. Score C (1 point); Indicator of the trainee is within 2 σ of that of 1st grade trainee

These scores are weighted for the total evaluation of ship-handling performance in such a way that the weights at the 3L, 2L, 1L and 0.5L evaluation point are 1, 2, 3 and 4 respectively. The total ship-handling performance evaluation result of the 3rd grade trainee is shown in Table 3. In the table, "Grade" means the conversion of total points to 100 points.

In the case of this trainee, the scores from 3L to 2L evaluation points are mostly "B" and it can be evaluated that his ship-handling performance at the first stage of the approach is almost the same as the 1st grade trainees. However, his scores from 1L to 0.5 evaluation points are mostly "C" and these scores show that he could not adjust the ship's motion decisively by using sufficient engine and rudder commands when the ship deviated from the planned track. As his total ship-handling performance is evaluated to be 47 points, the instructor can judge that he needs further SMS training.

Table 3. Example of total ship-handling performance evaluation sheet

Evaluation point	Indicator	3rd grade trainee
3L	Speed	B
	Approach angle	A
	Lateral distance	B
2L	Speed	B
	Approach angle	B
	Lateral distance	C
1L	Speed	C
	Approach angle	C
	Lateral distance	C
0.5L	Speed	C
	Approach angle	B
	Lateral distance	C
Total points (90)		42
Grade		46.7

3. APPLICATION TO SMS TRAINING

We performed further experimental sessions in order to confirm the effectiveness of the proposed evaluation tool described in the previous section. The training scenario was the berthing of a 10,000 G.T. container ship (148L×23.3B×6.89d) to the Yokohama Honmoku D-4 berth using a tugboat. In this experiment, the ship-handling performance evaluation indicators of three 3rd grade trainees are compared with those of the instructor and the 1st grade pilot trainees. The standard statistics of the indicators shown in Table 4 were obtained from 6 exemplary ship-handling sessions by the instructor and the ship-handling results by 28 1st grade trainees.

Table 4. Standard statistics of the indicators

Evaluation point	Instructor						1st grade pilot trainees					
	Lateral Distance(m)		Speed (kts)		Approach Angle(deg.)		Lateral Distance(m)		Speed (kts)		Approach Angle(deg.)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
3L	97.9	15.0	3.8	0.2	-0.8	1.9	122.3	38.0	3.8	0.6	-5.8	7.9
2L	95.6	15.2	3.4	0.0	-6.1	3.3	107.5	23.9	3.0	0.8	-8.8	6.1
1L	77.1	13.9	2.5	0.0	-10.2	3.3	77.7	26.0	2.1	1.0	-7.6	6.8
0.5L	57.8	12.8	1.5	0.4	-7.5	2.6	51.5	27.3	1.1	0.6	-4.2	6.8

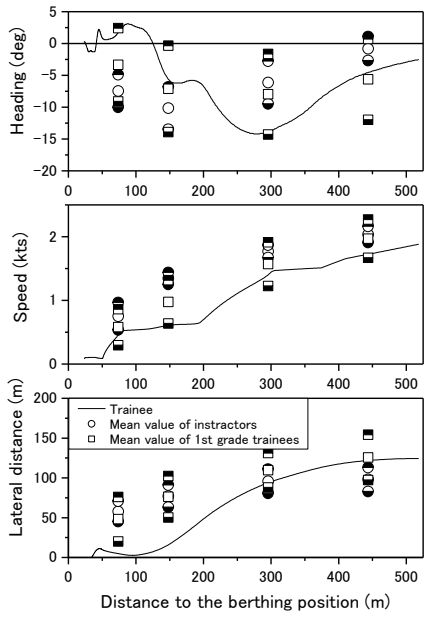
The ship-handling results of each of the 3rd grade trainees are shown in Figure 2 and their total ship-handling performance evaluation results are shown in Table 5.

Table 5. Total ship-handling performance evaluation results,

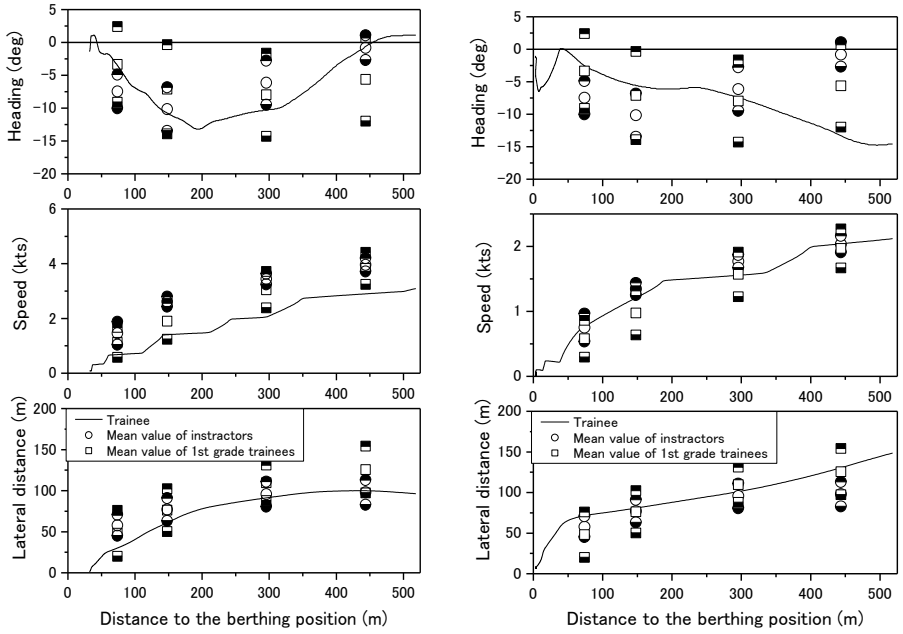
Evaluation point	Indicator	trainee		
		1	2	3
3L	Speed	B	C	A
	Approach angle	B	A	C
	Lateral distance	B	A	B
2L	Speed	B	C	B
	Approach angle	B	B	A
	Lateral distance	A	A	A
1L	Speed	C	B	B
	Approach angle	B	A	B
	Lateral distance	D	B	A
0.5L	Speed	B	B	A
	Approach angle	C	B	B
	Lateral distance	C	B	B
Total points (90)		45	64	71
Grade		50.0	71.1	78.9

Trainee 1 followed the exemplary ship-handling at the first stage of approaching and his ship's motion controlling at this stage is evaluated to be relatively good. However, the lateral distance at the final stage of approaching was too close due to the mishandling of the tugboat and the data like this indicate that advice on appropriate tugboat handling at slow speed by the instructor is necessary. The total ship-handling grade of this trainee was 50 points and it can be judged that the further ship-handling training using the same scenario is necessary.

On the ship-handling of trainee 2, the approaching speed from 3L to 2L point was too slow compared with that of the exemplary ship-handling but at the last stage of approach her speed was sufficiently controlled and the lateral distance was kept wide enough for safe approaching. His total ship-handling grade was evaluated to be 71 points and the results suggest that the speed control training at the first stage of approaching is necessary.



Trainee 1



Trainee 2 Trainee 3

Figure 2. Ship-handling results of the 3rd grade trainees

The third trainee missed the setting of her approaching angle at the 3L point, however, he was able to adjust her heading at the 2L point by appropriate rudder control. His speed reduction procedure was appropriate and the safety range of the lateral distance was maintained through the approaching ship-handling. The indicators of this trainee were within the deviating range of the exemplary ship-handling on the whole and his total ship-handling grade was evaluated to be 79 points. His ship-handling performance seems to be almost the same as that of the 1st grade trainees.

From the above results of this experiment, the author considered that the proposed method is effective and useful for the evaluation of the ship-handling performance. The instructors can evaluate the ship-handling performance of a trainee within the short period after the training and identify the ship's motion controlling methods to be improved almost immediately.

4. CONCLUSIONS

The authors proposed a new method of evaluating the ship-handling performance by using the evaluation indicators obtained from the ship's motion analysis after SMS training. The effectiveness of the proposed method was confirmed by the ship-handling training experiments using a SMS. The results obtained by this study are summarized as follows:

(1) As the training of a trainee is performed after an exemplary ship-handling, a trainee can understand the ship-handling skill that are necessary to be mastered before hands.
(2) The mean value and SD of the indicators of the 1st grade trainees are obtained from the training results of trainees who have little actual berthing experience and considered to be a suitable scale to judge the ship-handling level of the 3rd grade trainee.
(3) The proposed method can evaluate the ship-handling performance of a trainee without disturbing his training because the evaluation indicators are calculated after SMS training from the ship's state variables that are obtained from the ship-handling results.
(4) The proposed evaluation method is effective and helpful to improve the SMS training. Instructors can evaluate the ship-handling performance and feedback the evaluation results to trainees almost immediately after training, thus making the SMS training more effective and useful.

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