

Assessment on Mariner's Competency

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ABSTRACT

Recently, maintenance of clean ocean is very important issue. One part of the issue strongly relates to the safe navigation of vessels. Most parts of safe navigation depend on the mariner's competencies. STCW was established to guarantee the sufficient mariner's competencies. However the code does not indicate the each necessary competency clearly. Therefore, the understandings on STCW are not same among training institutes, and each training institute interprets them individually and executes them. As a result, it makes big differences among the institutes concerning training methods and contents and the assessment on mariner's competencies. The countries in EU have paid attention on this issue and the activities enhance the rational assessment of competencies through METNET.

In order to execute the rational assessments, it is necessary to clarify the techniques being assessed. And it means the necessity to clarify the necessary techniques for safe navigation and to assess the competencies to achieve them, and then we can attain the objectives of STCW.

In this paper, the necessary techniques for achievement of safe navigation are discussed and the methods of assessment of competencies are proposed. As we apply proposed assessment system, we can get the mariner's competency quantitatively and continuously through training period. Then we can know the trend of the competency that is the learning process. By clarifying the learning process of the techniques, we can decide the necessary training time to achieve the competencies. Furthermore, we can discuss the issues on conversion between training onboard and simulator used training by analysing the learning processes.

1. Introduction

IMO have issued international regulations on maritime techniques to realize safe navigation. However, assessing standards for evaluation on the competency have not been defined concretely. Seafarer has to complete the rational behaviour based on the knowledge as well as having the necessary knowledge for ship handling.

MET (Maritime Education and Training) is divided into two categories such as learning process on necessary knowledge and training process on the completion of rational behaviour. The assessment on mariner's competency should be done based on the knowledge and behaviour. Usually, the knowledge is judged by paper test. The assessment on the competencies of the knowledge is easier than one on the competencies of the execution. We have to discuss how to judge the competencies of the execution. As the objectives of assessing competency are divided into two items, following issues should be defined in each category,

What items should be assessed

What scale for assessing standard should be defined

In this paper, from point of mentioned view, firstly the necessary skills for safe navigation are discussed in order to clarify the objectives of assessment. Next, the standards for assessing the competency on each skill are explained. Furthermore, the concrete methods of the assessment are explained.

As the assessing objectives and the assessing standards will be decided clearly, it become possible that mariner's competency can be assessed correctly and quantitatively. Then, it becomes possible that the leaning process on the competency following the training progress can be measured. By measuring the learning characteristics on maritime techniques, we can estimate the necessary training periods. Furthermore, comparing the learning process in different training conditions, we can define the conversion ratio between them when combining plural training conditions are executed for MET.

2. Definition of Assessing Competency

STCW is the international standard as necessary techniques and the competency. Table 1 is a part of the positioning in STCW code. The competency and proficiency for requiring mariner is the competency for all condition. The definition on all condition relates to the instructor's knowledge and experiences. Criteria for evaluating competency shows also ambiguity expression and the interpretation depend on the decision of the

instructor extremely. On the other hand, if they try to carry out the training for all condition they can imagine, it takes lot of time. So, by the time limitation, the instructor abstracts the training condition according to their decision. As a result, though the training institutes keep the training objectives to follow the STCW, the different training may be executed according to the different understandings of the instructors. However, the techniques for safe navigation indicated in STCW are reasonable. The problem is caused by difficulty to express the concrete contents as a rule. Therefore in order to execute the training, we have to understand the objectives and analyse it for fitting the training based on the objectives of STCW. The objective of STCW is to complete safe navigation for all condition. However, the required techniques are expressed based on the situation and same techniques are appeared in the different situation frequently. Then we can find the necessary techniques for achieving safe navigation by analysing them based on the technique in the different situation. The result of analysing the techniques, we have found some important elemental techniques. The important techniques are basic unit of techniques, they can be called elemental techniques. And it is called elemental technique development to define the necessary techniques for the situation.

About 15 years ago, the concept that necessary techniques for completion of safe navigation is combination of basic techniques is proposed in IMO. It was called Functional Approach. However, the analysis on the necessary skill for safe navigation was not completed and the concept has been remained without the substance. The mentioned elemental technique development is to show the contents of Functional Approach. Then, the techniques for MET are clarified and the reasonable MET can be possible. Furthermore, by definition of necessary techniques, we can evaluate mariner's competency by assessing how much mariner attain the necessary techniques. The development of elemental techniques is the answer to solve the issues

We can define the techniques to teach and train by applying elemental technique development and the skill to be assessed are clarified. The process of discussion to define the elemental techniques is as following.

Necessary techniques indicated STCW are analysed and categorized based on necessary techniques for safe navigation. Then we defined basic techniques. We also examined the necessary techniques by hearing opinions from over 100 experienced licensed mariners. One part of questionnaire is shown as Figure 1. In the questionnaires, necessary techniques are categorized as the difficulty that means the techniques which class of licensed mariner should attain are defined. Higher classes should complete the techniques mariner having lower class license have to attain.

By completing the studies, necessary techniques for completion of safe navigation are defined as 9 Elemental Techniques. Table 2 shows the contents of 9 elemental techniques. Each elemental technique contains various

Table1. Basic Concept of MET (A Part of Table A-II/2 in Chapter in STCW CODE)

Competence	Positioning
Knowledge, Understanding and Proficiency	Position determination <i>in all condition</i>
Criteria for Evaluating Competency	The primary method chosen for fixing the ship's position is the most appropriate <i>to the prevailing circumstances and condition</i> . The obtained fix is within accepted accuracy level and the accuracy of resulting fix is properly assessed.

No.	TASK	Required Skill		
		2/O	C/O	Master
1	To plan the navigation schedule considering own ship, sea and weather condition	Yes	Yes	Yes
2	To estimate ETA at important for the navigation	Yes	Yes	Yes
:	:	:	:	:
8	Actions abided by law when meeting with two or more vessels	Yes	Yes	Yes
:	:	:	:	:
17	To fix the position by more than one method	Yes	Yes	Yes
18	To carry out the parallel indexing	Yes	Yes	Yes
:	:	:	:	:
23	To use the standard maritime communication phrases properly	Yes	Yes	Yes
24	To communicate with VTS using VHF and together needed information	No	Yes	Yes
:	:	:	:	:
43	To understand the ability of crew and conduct the bridge team as a leader	No	No	Yes

Figure 1. Questionnaire Related to Necessary Techniques for Safe Navigation

required skills. The contents of technique depend on the license rank. For instance, the technique shown as manoeuvring in elemental technique development is to handle the ship to realize the planned motion. However, all of handling techniques are not necessary for all of licensed mariners. The competencies for berthing jetty and/or handling in complicated condition such as narrow waterway under strong external disturbance are not required for 3rd class licensed mariner. These high-grade skills are needed for 1st class licensed mariner. On the contrary, most of techniques on lookout, positioning, communication, instrument manipulation and rule of road are requested for 3rd grade licensed mariner. These techniques are the basic skill for maintaining the safe navigation in normal navigational conditions. The techniques for emergency and management belong to the high-grade mariner. The contents of each technique are explained in the following section as handling guideline.

Figure 2 shows the relation between ship-handling situation and mainly related elemental techniques for handling ship in the situation. In the training, we usually reappear the real ship-handling situation. We can recognize elemental techniques contained in each handling situation as shown in Figure 2. For instance, in handling for avoiding collision, 3 elemental techniques that are technique on lookout, manoeuvring and rule of road are trained. In following section, necessary preparations for the execution of assessments on competency are discussed.

Table 2. Elemental Technique Development
9 Elemental Techniques for Safe Navigation

1	Lookout	The technique to identify and recognize the moving targets and the fixed targets and to gather information of the direction, distance and speed and to estimate the future situation of the targets
2	Positioning	The technique to fix the position of ship by selecting and recognizing proper obstacles by visual observation, radar etc.
3	Manoeuvring	The technique to control own ship course, speed and her position by steering rudder and controlling main engine etc.
4	Instrument Manipulation	The technique to properly utilize instruments for lookout, positioning, manoeuvring etc.
5	Communication	The technique to exchange information among member in bridge and inside and/or outside of the ship
6	Rule of Road	The technique to navigate according to the Regulations for Preventing Collision at Sea etc.
7	Planning	The technique to gather information concerning the navigational environment conditions and to make an operational plan and the navigational plan
8	Emergency	The technique to repair malfunction of a main engine and a steering system etc. and a react to activity properly
9	Management	The technique to make good use of members ability and enhance the bridge team's performance etc.

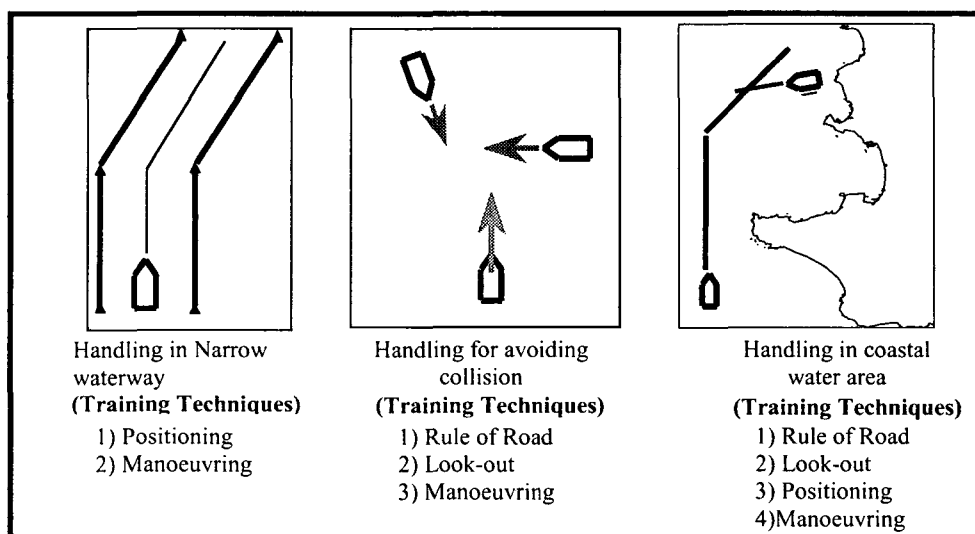


Figure 2. Relation between Training Scenario and the Trained Elemental Technique

3. Standard Competency

Generally speaking, it is necessary for the education to show the knowledge explicitly that trainee has to master. Especially, in the technical education, it is a very important to show the correct reactions for the given condition. The necessary behaviour for the given condition should be defined in the guideline concretely and clearly. The development of handling guideline is necessary to complete the condition.

Table 3 shows one part of handling guideline. When we make guideline, it is effective way to describe them based on category of elemental techniques, because trainees can easier understand the necessary techniques in the systematic technical construction. The contents of elemental techniques change according as the license rank. In this guideline, the column indicated Master shows the techniques for Master, the column indicated Master and C/O shows the techniques for master and chief mate and the one indicated Master, C/O and 2/O shows the techniques for master, chief and 2nd mate. In other words, the higher-grade licensed mariner has to complete the competencies that the lower grade licensed mariner has to complete.

By the way, we would like to consider the meaning of training here. Figure 3 shows the meaning of education and training for mariner. In the right figures, the horizontal axis indicates the navigational conditions and the vertical axis indicates the mariner's behaviour. When mariner not having sufficient competency faces the condition shown by x_0 , his behaviours are not fixed as specific one shown by y_0 . His behaviour shows wide variation. On the contrary, after training, mariner masters sufficient competency, the behaviour concentrate on the required one. The variation of the behaviours is very small. This is the meaning of the education and training. The objective of training is to let mariner execute the required behaviour for the specific condition. The required behaviours for specific condition are listed in the guideline. In the guideline, the items that are the target techniques of assessment are listed and the standard competency are also defined.

Table 3. Handling Guideline (Part of Manoeuvring and Management)

E/Technique	Guidelines to Manoeuvre	Rank
Manoeuvring	<ul style="list-style-type: none"> • Turning rate for altering course less than 5deg/min except in case of avoiding dangerous • Deviation from charted course line less than 0.3mile. • To control ship based on understanding manoeuvring ability and circumstances. 	Master C/O 2/O
	<ul style="list-style-type: none"> • To reduce ship's speed as planned (see an example of speed-reducing plan). • Ship speed at pilot station less than 6k'ts and to keep ship's posture. • To anchor inside 1/2L circle centring around planned anchorage. 	Master
Management	<ul style="list-style-type: none"> • To understand the navigational plan and shared duties before the training start. • To keep communication with other bridge members, ships and VTS etc. 	Master C/O 2/O
	<ul style="list-style-type: none"> • To put each crew in charge of the task from viewpoint of each ability. • To reply to the reports suitably and direct each crew to show their ability. 	Master C/O

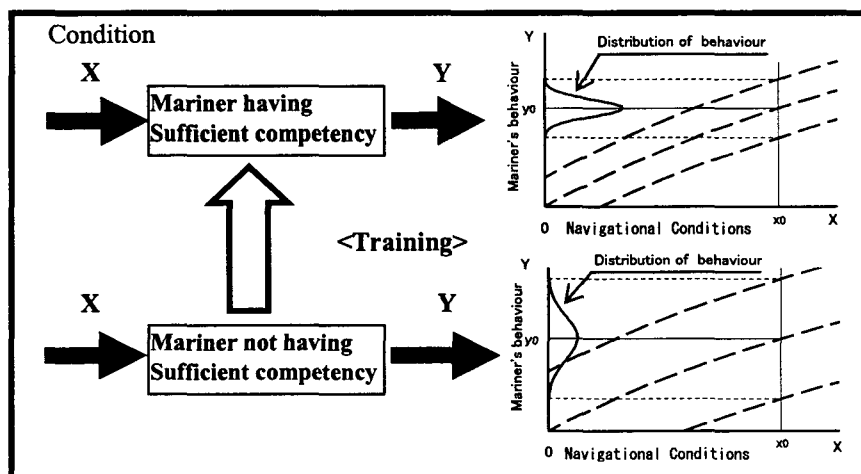


Figure 3. The Meaning of Training Concerning a Change of Mariner's Competency

4. The Development of Assessment System

Next one is a development of assessment system. The assessment system is important for evaluation of mariner's competency. It is also very important issue for training. Assessment system decides the quality of the training. Instructor has to assess the trainee's competency correctly and then he has to decide the proper training in next step based on the assessed trainee's competency.

In order to develop the assessment system, we have to discuss the following items. First one is to make assessing sheet in which all assessing items are listed. In case of handling for avoiding collision, following assessing items are important factors,

- The distance at the detection on the target vessel
- The estimation of future situation of target vessel
- The planning how to avoid risky situation
- The methods how to manoeuvre the ship
- The legality concerning rule of road

Second one is to define the standard level of competency. Regarding the items mentioned above, the distance at detection on target vessel is decided as a function of the own ship characteristics that are ship's size, speed and manoeuvring characteristics and it also relates to the navigational condition that are water area, traffic condition and weather condition. The quantitative value has to be defined based on these conditions. The estimation on future situation is possible when mariner lookout the target motion continuously. Assessor observes mariner's behaviour on the lookout and evaluates the competency. The planning can be observed as the handling contents. Assessor evaluates the start timing of avoiding action, steered rudder angle, changing course angle, distance at CPA and the timing of returning to original course. Standards quantitative value of each items are clarified in guideline.

Third one is to make assessment sheet along the training scenario's progress. It is important matter when assessment is carried out. In one navigational situation, there are many related techniques. It is necessary to assess the competency whenever the situation where competency is required is appeared. It is not appropriate to assess the competency at the end of training. The memory of assessor become vague quickly and his subjective

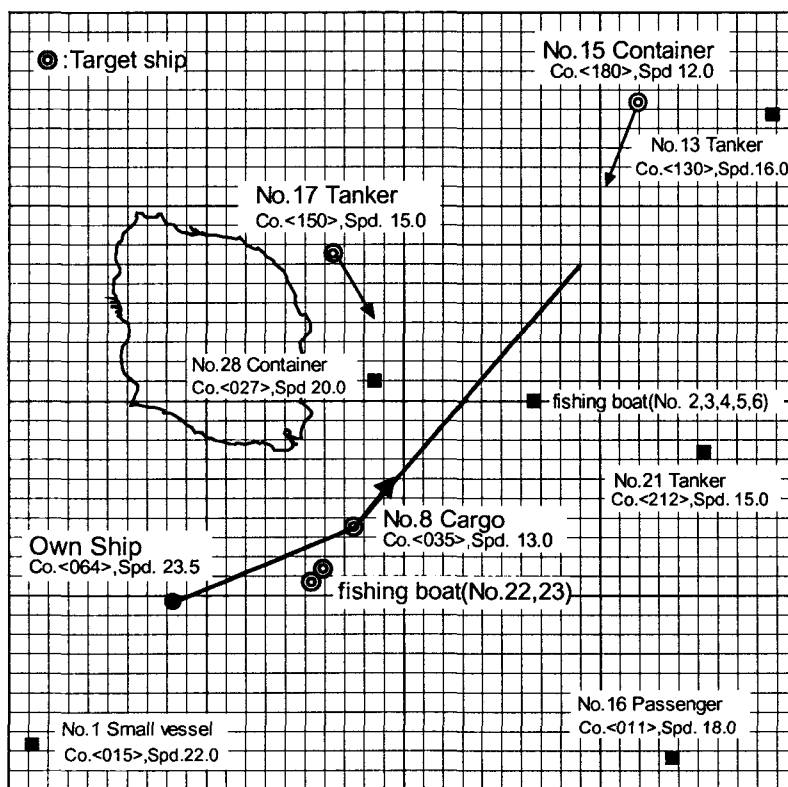


Figure 4 . The Training Scenario for Cadets

memory remain. The assessment becomes subjective and the result cannot be thought as impartial assessment. By assessing the mariner's behaviour step by step based on the assessment sheet, we can evaluate one's competency quantitatively and objectively. We can measure the change of the attained level.

Table 4 shows one example of assessment sheet in the training for cadets. The training scenario is shown in Figure. 4. Own ship proceeds along the island. There are some fishing vessels, traffic vessel and one altering course point. In the last part, own ship will approach the congested water area and trainee have to call the master and report the navigation situation. One of important events is the handling for avoiding collision. In this event, elemental technique of lookout, rule of road, communication and manoeuvring are contained in the assessment. The contents of assessment and the target are listed. Standard assessing levels are defined as shown in Table 4. If trainee detect target ship # 17 at distance over 5 miles, his score is +1. If he cannot detect her at the distance less than 3 miles, his score is -1. Standard assessing levels are defined corresponding to elemental techniques. The method and the conversation are also assessed. The standard procedures are indicated in the guideline.

Table 4 An Example of Assessment Sheet

No.	TASK	Object	Elemental Technique	Assessing item	+1	0	-1	Score
1	<General> Positioning Recognition on situation	FB	Positioning Positioning/Planning Lookout	Positioning every 15 min. Recognize current effect and correct course Detect objects by proper ways	attain attain attain	lacked lacked lacked		
2	<Alt. Course> Maneuvering Positioning		Maneuvering Positioning Positioning / Maneuvering	Handle ship based on Guide-line Positioning after altering course Correct course if deviating	attain attain attain	lacked lacked lacked		
3	<Ship crossing> Recognition Stand on VHF Avoid Collision	#17	Lookout Rule of Road Lookout/ Communication Communication Communication Lookout/ Maneuvering Lookout/ Maneuvering Maneuvering	Detect objects by proper ways Perform based on rule of Road Understand the intention applying VHF or Horn Initial Contact Apply IMO standard communication Time to start avoiding Distance at CPA is proper Handle ship based on Guide-line	dist>5' attain attain attain attain dist>3' depa>1' attain	5'-3' lacked lacked lacked lacked 3'-1' 1'-0.5' lacked	3'>dist missed 1'>dist 0.5>depa	
4	<Ship same way> Recognition VHF Avoid Collision	#8	Lookout Rule of Road Lookout/ Communication Communication Communication Lookout/ Maneuvering Lookout/ Maneuvering Maneuvering	Detect objects by proper ways Perform based on rule of Road Understand the intention applying VHF or Horn Initial Contact Apply IMO standard communication Time to start avoiding Distance at CPA is proper Handle ship based on Guide-line	dist>5' attain attain attain attain dist>3' depa>1' attain	5'-3' lacked lacked lacked lacked 3'-1' 1'-0.5' lacked	3'>dist missed 1'>dist 0.5>depa	
5	<Vessel end on> Recognition VHF Avoid collision	#15 #8	Lookout Rule of Road Lookout/ Communication Communication Communication Lookout/ Maneuvering Lookout/ Maneuvering Maneuvering	Detect objects by proper ways Perform based on rule of Road Understand the intention applying VHF or Horn Initial Contact Apply IMO standard communication Time to start avoiding Distance at CPA is proper Handle ship based on Guide-line	dist>5' attain attain attain attain dist>3' depa>1' attain	5'-3' lacked lacked lacked lacked 3'-1' 1'-0.5' lacked	3'>dist missed 1'>dist 0.5>depa	
6	<Report to Capt.>		Positioning Communication Lookout/ Communication	Confirm distance to reporting position to Captain Inform Captain at defined position Report surrounding situation to Captain	attain attain attain	lacked lacked lacked	missed	

5. Learning Process

By using rational assessment system, we can understand the change of the competency continuously during training period. The trend of measured competency is the learning process to training time. Figure 5 shows the learning process of mariner in the training period. Left figure shows the learning process in case of training onboard and left one shows one in case of simulator used training. Horizontal axis indicates the progress of training and vertical axis shows the measured competency by applying the assessment system mentioned above. Black symbols indicate the measured competencies at the each training. In case of the learning process of mariner trained onboard, his competency was measured by using the assessment system in simulator training centre at every 3 months. The competency level becomes improved in both cases as the training time is increased. Solid line is the predicted line of the learning process on mariner's competency. The learning process is defined by the formula (1).

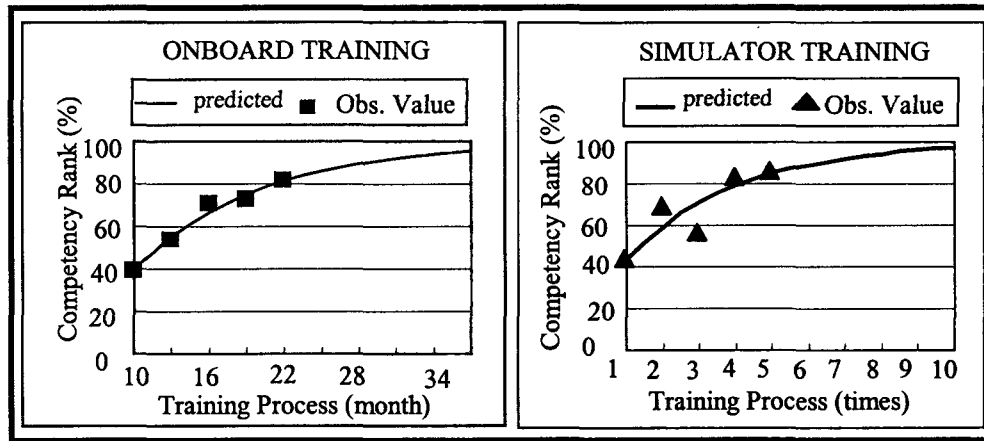


Figure 5. Learning Process of Onboard Training and Simulator Training

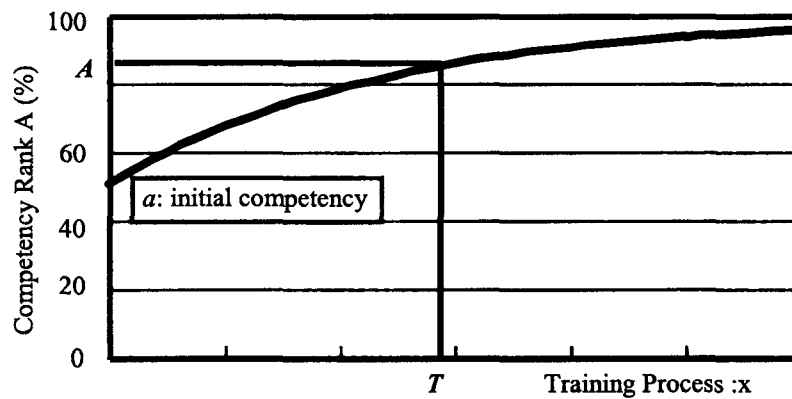


Figure 6. The Characteristics of Learning Process

$$A(n) = 1 - (1 - a(n)) \exp \left(- \frac{x}{T(n)} \right) \quad (1)$$

where A : the achieved level of the technique,
 n : variable indicating the kind of technique to be trained,
 a : the achieved level of the technique at the starting time of the training,
 T : time constant indicating the speed of learning process,
 x : proceeding time for learning

The learning process is decided by 2 constants that are 'a' and 'T'. 'a' indicates the initial competency at the beginning of training as shown in Figure 6. 'T' indicates the speed of improvement of the competency. We can estimate these constants by analysing measured competencies. As we can get the predicted learning process on many trainees, we can discuss the standard learning process without one-sided characteristics.

6. Training Period

Next, the definition of passing mark and training period are discussed. When we decide the necessary training period, firstly we have to define the passing mark. However, we cannot find the quantitative passing mark in any document, even in STCW code. We have to decide them by ourselves. Firstly we have to predict the standard learning process by measuring the change of competencies of plural trainees to training time. Next, in order to define the passing mark, we measure the licensed mariner's competency on same training contents. His score should be the passing mark of the training scenario. It is necessary to select the licensed mariner who has just gotten the license. Because, in case of the mariner having a time onboard after getting the license, his competency already improved and is higher than required competency.

By combining the passing mark and learning characteristics, we can estimate necessary training period as shown in Figure 7. After deciding the required competency that is 87.5 in case of the figure, we can define the necessary training period based on the standard learning characteristics. In case of this example, it is 17.6 times training. As a result, we have to prepare the 18 times training for the trainee.

As I mentioned above, we can measure the competency for each related elemental technique as well as total competency of trainee for training scenario. The passing mark mentioned above and the training period are decided based on the total competency. We have to consider the learning process on the each elemental technique. Figure 8 shows the process on decision of the training period based on the relation between total competency and the competency on each elemental technique. In this case, the passing marks of total and maneuvering are 83.8 and 87.5 respectively. And the necessary training periods are 2.2 and 17.6 training times. The necessary training period for maneuvering is longer than one for total technique. In this case we have to decide the training period based on the longest training period. So the necessary training period should be 18 times.

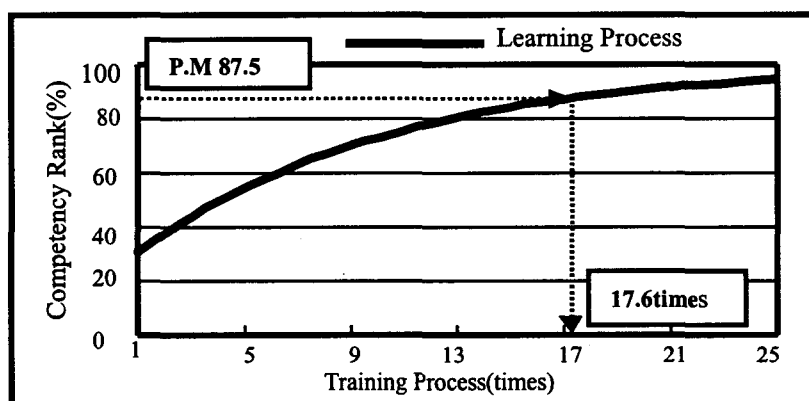


Figure 7. The Estimation of Necessary Training Times Corresponding to Required Competency

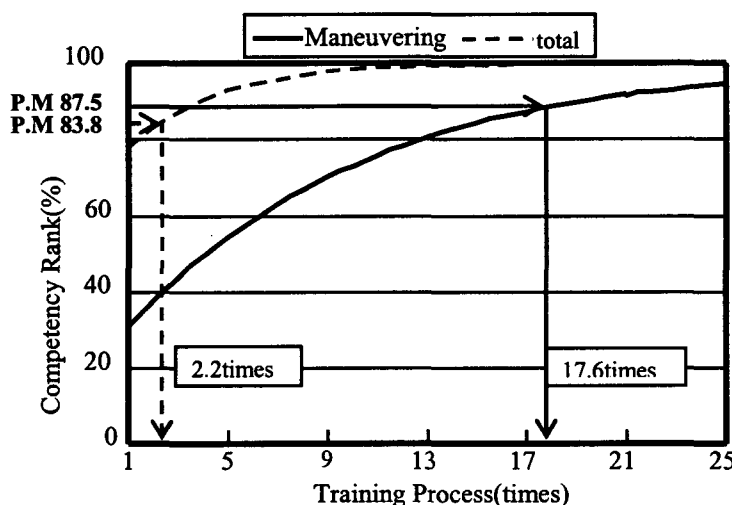


Figure 8. The Estimation of Necessary Training Times Corresponding to Total Competency and Elemental Techniques

7. Conversion among Different Training Systems

Regarding to training period, the comparison between training onboard and simulator used training have been a big issue. We can discuss the relation between them by applying the leaning characteristics mentioned above. The competency of mariner trained onboard shows the similar tendency as one of mariner who was trained using simulator as shown in Figure 5. Figure 9 shows the relation between the training onboard and the training using simulator. Left figure shows the learning process in simulator and right one shows one onboard. As we can predict both learning processes, we can find the necessary training periods for both training system to attain the specific competency. In case of the figure, specific level is assumed as a_{all} . Then we can define the necessary training period for both conditions for achieving the same level of competency based on the learning characteristics. ' t_{all} ' is necessary training period in case of simulator used training and ' τ_{all} ' is one in case of onboard training. As a result, we can define the conversion ratio of training period between them. The conversion ratio k is defined by following relation.

$$k = t_{all} / \tau_{all}$$

As referring the relation between the different training systems, we can estimate the conversion method when we apply the training by combining different training systems. In case of the figure, it become possible to substitute the training period of ' t_{sim} ' in simulator used training for the training period of ' τ_{ship} ' in training onboard.

$$t_{sim} = k \times \tau_{ship}$$

Table 5 shows the conversion ratio when we carry out training system mentioned later. The required training periods on board are defined by IMO shown in Table 5. Necessary training periods using simulator for achieving same competency were estimated as a result of studies. Finally, we can define the conversion ratio shown in Table 5. Applying this result for chief mate training, we can estimate necessary training time using simulator instead of onboard training. For instance, we can estimated that 3 month training on board can be converted to 4.5 days training using simulator.

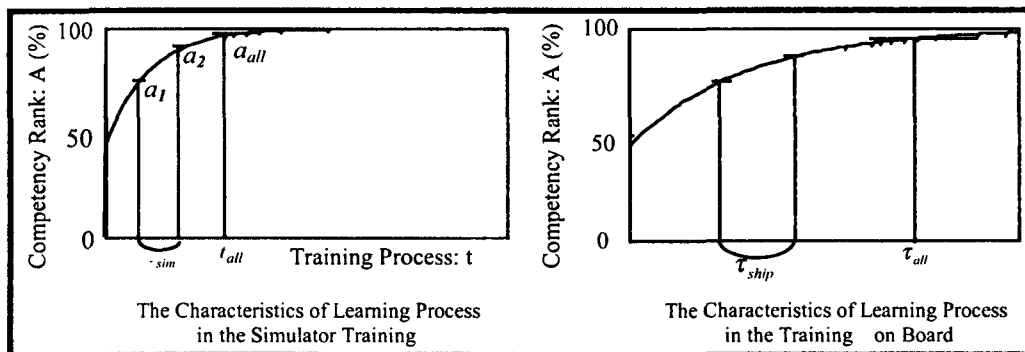


Figure 9. Comparison on Learning Process Onboard and Simulator Used

Table 5. Conversion Ratio for Each License Rank

Rank of License	Required Onboard Training	Required Simulator Training	Conversion Ratio
Master	2Year(730days)	36times(18days)	40.5
	1Year(365days)	36times(18days)	20.25
Chief Mate	1Year(365days)	31times(16days)	22.8
2nd Mate	1Year(365days)	126times(63days)	5.7

8. Meaning of assessment on Mariner's Competency

The mariner's competency IMO regulations focus is very important issue from both viewpoints of attainment of safe navigation and maintenance of clean ocean. In order to execute exact assessment, it is necessary to clarify the techniques to be assessed. The discussions on the necessary techniques for safe navigation were carried out

again. The results of discussion crystallize the concept of Functional Approach IMO proposed about fifteen years ago. The necessary techniques for safe navigation are clarified by Elemental Technique Development and new concept have defined the competency to be assessed.

In the next step of the execution of assessment, the standards for judgment on the competencies are necessary. These standards correspond to the function that should be carried out in ship handling. Assessing competency equals to measure the degree of achievement of the function to be executed by mariner. In order to avoid the ambiguous assessments, it is necessary to list the necessary functions for mariner clearly. Then these listed functions are same meanings of guideline for ship handling.

The results of assessment in which assessing techniques and the competency are clarified, show the process of the progress of trainee's competency quantitatively. To identify general mariner's learning process on the technique, we can estimate the necessary training period. Furthermore, as we compare the learning processes in different training conditions, we can develop the more effective and higher qualified training system by combining the different training conditions. And the discussions on the compatibility between the different training conditions have solved the issue of the conversion of onboard training to the simulator used training.

9. Conclusion

Recently, the sense of value in the world is seemed to tend to the supreme principle of profit more and more. Furthermore it becomes general tendency that the assessment of the effectiveness executes on the results in short term. This tendency may give a false colour to the evaluation on the technology of ship handling. We have to understand the necessary techniques for safe navigation rightly and recognize the mariner having sufficient skills rightly. If we do not evaluate the technologies and the competency, the judgment of efficiency of ship handling becomes the economic principle. When the fact that the ship handling can be done by low cost is standard, the guarantee for safe navigation will disappear soon. Corresponding to this situation, IMO issues several regulations to maintain the necessary competency. And then, it becomes important issues how to evaluate the competency whether it is sufficient or not.

Author writes this paper for wishing the correct understandings on the techniques and competency for ship handling. Firstly, the necessary techniques for ship handling are discussed and the concrete techniques are systematized. This process is necessary for the clarification of the techniques to be assessed. Next, the assessment standards for the clarified techniques to be assessed are proposed. The standards of assessment correspond to the required level of competency and to the objectives of maritime trainings. Therefore, when we express the assessing standards of techniques in the textbook on maritime technologies, it is expected that effective learning and certain training become possible by using the text. These standards correspond to the guideline of the practical manual for handling ship, so this is called as ship handling guideline in this paper. Ship handling guideline is used as the text for the trainee. It is also used for the guideline for the standards of assessment when assessing the competency. The importance of the assessing timing is pointed out. Instructor has to assess the trainee's competency step by step whenever the required competency is appeared. Totalised assessment is not proper for the evaluation of competency. Because it is necessary methods for avoiding the subjective judgment of assessor and for clarify the assessing situation.

As we make the system of necessary techniques for safe navigation and the advanced discussion on the rational assessment for the competency, the efficient and certain maritime education and training methods can be proposed. Our objective is to enhance the sufficient competency for ship handling. In order to attain our objectives, it is necessary to make right assessment on competency and to bring up the good mariners.

Maritime education and training methods generated from the discussion of rational assessment system are proposed in the guidelines shown in reference. The detail discussions and the results of studies are mentioned in the publishing matters (Japan Maritime Simulator and Simulation Committee, 2000, 2002, 2003) edited by Japan Maritime Simulator and Simulation Committee.

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