The Development of Performance Assessment and Comparison Model for Mariners Utilizing a Ship Bridge Simulator

Dr.Ozkan POYRAZ
Istanbul Technical University Maritime Faculty
81716-Tuzla-Istanbul-TURKEY
poyraz@itu.edu.tr

ABSTRACT

This paper describes the establishment of an analytical criteria for the assessment of marine cadet and experienced officer competencies through simulation. The study involves the application of Analytic Hierarchy Process (AHP) to develop an evaluation system including job task analysis and implementation of simulation scenarios. The main goal of this study is design a powerful and flexible assessment process to assist simulator instructors to set up priorities and make the reliable performance-based evaluation when both qualitative and quantitative aspects of a performance measure need to be considered.

1. Introduction

National administrations, shipping companies and international organizations have always been concerned with navigational safety within their own fleets. However, even on well found ships operated by trained crew, it has not been possible to eliminate navigation casualties. Investigation into casualties indicate that the major factor in their cause is a weakness in bridge organization and management. Thus, the involved parties seek some evidence to ensure the competency of bridge team members. Though, the traditionally mariners assessment has been knowledge based using writing examination, the 1995 amendments to STCW Convention mandate performance base competency assessment for members of bridge team [1]. Sections A/II-1 and II/-2 of the STCW code list the accepted methods for demonstrating competence knowledge, understanding and proficiencies. The assessment of evidence obtained from a reliable simulator test is one of the methods listed.

It is not always an easy process for a simulator instructor to evaluate his trainee s performance. The simulator instructors at ITUMF assessing both marine cadets and experienced officers as part of the bridge team management course over the past two years have been experiencing the same problem. The tangible lessons learnt from the difficulties of assessment of the trainees during ITUMF simulator courses donated the importance of developing a quantitative assessment and comparison method. Although there were some guidelines both in STCW Convention and related IMO Model Courses, they were found not to be analytically sufficient.

2. Literature Survey

The literature survey was carried out by the Author prior to the analytical approach it was observed that three prior studies were presented as research papers. One of these papers involved research on comparing task ratings of Alaskan Marine Pilots. The main emphasis given to the methodology, Content Validity of Ratio [2]. The majority of the other documents concluded that developing a curriculum under the supervision of the simulator instructor method proved to be more efficient in comparison to the analytical methods.

3. Task Analysis

The main critical objective of this study was to determine the task in the officers and masters job performance. The essential task on bridge would then be the basis of development of the intended performance evaluation system. In order to clarify the objective techniques for reliable assessment, the author had used the method of an iterative process of review and discussion until a consensus is reached by experienced master mariners and maritime simulator instructors. Capt. Carl F. Wass who has recently completed a variety of research projects on bridge operation in Chevron Texaco Shipping contributed vastly to the contents of this research works supporting the author by transferring the industry s vision at the different phases of the study involved. The analysts have suggested that the job task analysis essential to be conducted for one particular simulation exercise. Therefore, the author has developed two visual simulation scenarios of a typical passing fairway and approaching the pilot station in Europort/Rotterdam and Solent/UK regions Some new tasks were identified during the trials in simulation environment. When the study group is satisfied that they have collectively identified the critical tasks on the bridge, alternatives and criteria involved in the performance evaluation system, author has decided to configure the criteria into a tree-like hierarchy. The assessment criteria (task list) is shown in Table 1.

Table 1. The assessment criteria

Code of Criteria	Asssesment criteria
M1	Turning rate for altering course
M2	Wheel over positions
M3	Designated ship speed at the pilot station
M4	ETA s maintained at the pilot station
N1	Deviation from the planned track
N2	Frequency of position fixing
N3	To carry out the Parallel Indexing
N4	Rules of Road in TSS
W1	Visual look-out
W2	Compliance of CPA
W3	Early action for avoiding collision
C1	Internal Communication between bridge members
C2	Communication with VTS using SMCP
C3	Pilot /Master exchange of information
M: Maneuvering **N :** Navigation **W:** Watch keeping **C :** Communication	

3.1. Evaluation Process

Dr. Ahmet Paksoy from Istanbul University provided AHP procedures. The Analytic Hierarchy Process is analytical tool, supported by simple mathematics, that enables people to explicitly rank tangible and intangible factors against each other for the purpose of setting priorities. The process has been formalized by Saaty and used in a wide variety of problem areas. The process involves structuring a problem from a primary criteria to secondary levels of criteria. Once these hierarchies have been established, a pairwise comparison matrix of each element within each level is constructed. Participants can weigh each element against each other element within each level. Each level is related to the levels above and below it, and the entire scheme is tied together mathematically. The result is a clear priority statement of an individual or group.

To determine the importance of the task listed in Table 1, the author created a descriptive questionnaire. This survey was sent to 40 masters and mates. A Sample of the questionnaire survey is denoted in Table 2. A total of 29 masters and mates responded to the questionnaire. The objective of the questionnaire survey was to engage participants in breaking down their decisions into smaller parts, proceeding from the goal to criteria down to subcriteria, eventually reaching to simple pairwise comparison judgments throughout the hierarchy arriving at overall priorities for the tasks on the ship bridge.

Table 2 Sample of the questionnaire

Code Of Criteria	Equal Importance	Which is more Important?	How Much Important?		
			Minor Importance	Important	Highly Important
M1 -M2	a				
- M3		M3			a
.					
N2 —W1		N2	a		
.					
W2 —C3	a				

The Author provided a AHP table of priority based on the result of this survey. The tasks importance hierarchy is shown in Table 3 and Table 3a. Table 3 indicates that main criteria maneuvering was agreed to be most important.
The second phase of this study consists of quantitative components beyond this point. Tasks were graded using the importance scale. However it should be taken into account that there will be some differences in the task list between the simulated sea region.

Table 3. The task importance hierarchy between the main criteria

	M	N	W	C	**Weight**
M	1	1,07	1,33	2,73	**0,328**
N		1	1,27	2,87	**0,319**
W			1	1,20	**0,217**
C				1	**0,135**
					CR=0,016

Main Criteria	
M	**Maneuvering**
N	**Navigation**
W	**Watch keeping**
C	**Communication**

Table 3 a. The task importance hierarchy between the sub criteria

M	**M1**	**M2**	**M3**	**M4**	**Weight**
M1	1	1/1,33	1/1,87	1,07	**0,197**
M2		1	1/2,07	1/1,13	**0,211**
M3			1	1,20	**0,356**
M4				1	**0,236**
					CR=0,019
N	**N1**	**N2**	**N2**	**N4**	**Weight**
N1	1	1/2,27	2,33	1/2,40	**0,175**
N2		1	3,07	1/1,73	**0,306**
N3			1	1/3,67	**0,095**
N4				1	**0,425**
					CR=0,020
W	**W1**	**W2**	**W3**	**Weight**	
W1	1	3,47	1,20	**0,470**	
W2		1	1/3,00	**0,134**	
W3			1	**0,396**	
				CR=0,0	
C	**C1**	**C2**	**C3**	**w**	
C1	1	1/1,07	1/2,07	**0,245**	
C2		1	1/1,60	**0,279**	
C3			1	**0,476**	
				CR=0,003	

3.2. Scoring Scheme and Performance Measures

A grading sheet was designed for the exercise consisting of fourteen tasks that the assessor is asked grade. A five point rating was given for the assessment of each task. This is an integrated component of the training and provides more useful feedback to the survey than a simple pass-fail scoring system. This scoring method is developed on the tasks which were rated by participants of the questionnaire surveys. Table.4 indicates the grading sheet and subcontent of the assessment [3]. Performance measures in the scoring system ranged from parameters like value rated to the achieved or not achieved and parametric . It was thought to be extremely important for an assessor to observe all tasks in the passage plan which was conducted by the bridge team during the briefing stage of simulation. The deviations from the sailing plan resulted in deficiency and a loss of points.

Table 4. The grading sheet

Code	Description of Criteria	Loosing point ← → Loosing point Scoring				
	...	.				
M3	Designated ship speed at the pilot station	Speed<3kt	3-5 kt	6 kt	6-8 kt	8 kt<speed
	...	.				
N1	Deviation from the planned track	Dev >0.5 nm to port	0.5-0.1mil to port	0 nm	0.5-0.1 nm to stb.	0.5nm<Dev. to stb.
		→ Loosing Point →				
C2	Communication with VTS using SMCP	SMCP & Speaking & Understanding	Speaking & Understanding	Understanding	Speaking	Can not Communicate
	..				.	.
W2	Compliance of CPA	CPA >1 nm	1- 0.5 nm	0.5 nm	0.5-0.3 nm	0.2-0 nm
	..	.				

4. Implementation on the Ship Bridge Simulator

The author invited the four cadets and the four ship mates intending to be promoted to chief mate license and another four master mariners for simulation trails to the ITUMF. The mariners were then separated into three balanced bridge teams, each of four participants, namely master, chief officer, 3rd mate, and observer. A helmsman was provided by ITUMF Staff.

4.1. Scenario

The author created two scenarios. Events were planned in the scenarios to ensure all of the various tasks that were identified by Subject Matter Experts.

In the first scenario, the vessel approaches the pilot station for Europort/Rotterdam. Due to rough sea condition the vessel were requested to proceed further inshore to pick up the pilot. Strong currents and conflicted crossing traffic were encountered in the pilot embarkation area. While still in the buoyed channel the vessel was advised by VTS to reduce speed and hold in the channel until a loaded VLCC clears the turning basin and enters the inbound lane. Once the pilot was aboard the vessel and had the con, a rudder command was carried out incorrectly which could put the vessel in danger if not corrected.

The second scenario the vessel was developed in the East Solent region. The vessel picked up the anchor in the East Solent and proceeded to Southampton. During the turn into the Thorne Channel, the pilot became incapacited and the Bridge team had to decide if to abort the transit and anchor or proceed using shore base pilotage. Events were planned in the scenarios to ensure all of the various tasks that were identified by the experts.

4.2. Briefing

Prior to conducting the scenario a full briefing was given to participants, and all charts and publications, such as tide tables and ship s routing information were supplied. Authors introduced the initial exercise setting in relation to the voyage situation, and allocated roles to the team. The suitable time was allocated for the master in order to organize the ships navigational plan in cooperation with his mates.

4.3. Simulation

The first part of the simulation, three sessions with the same scenario was followed, but played by three different groups. After studying the information collected the second scenario was executed with the same group. A separate observer from each team and an assessor evaluating the participants were utilized during the simulation process. The Assessor observed the executions through the TV cameras on the bridge and slave radar monitors in the control station. Three data sheet have been developed to track task against group performance. There were no major failures such as collision or grounding at the end of the simulation.

5. Assessment and Comparison

Descriptive data was generated for each group during the simulation. One weakness of the process was the marginal number of the focus groups and scenarios. Ideally more data must be accumulated for assessing and comparing the groups, but these data could be the subject of an additional analysis. Table 5 shows the performance comparison values of three focus groups. Table 6 summarizes the final scores of the performance comparison after the second scenario.

Table 5. The Final Performance Comparison Values of Three Focus Groups at the end of the First Scenario

	0,197	0,211	0,356	0,256	
	M1	**M2**	**M3**	**M4**	w_M
Masters	0,637	0,455	0,637	0,333	**0,534**
C/Off.	0,258	0,455	0,258	0,333	**0,324**
W/O	0,105	0,091	0,105	0,333	**0,163**
	0,175	0,306	0,095	0,425	
	N1	**N2**	**N3**	**N4**	w_N
Masters	0,714	0,714	0,600	0,091	**0,439**
C/Off.	0,143	0,143	0,200	0,455	**0,281**
W/O	0,143	0,143	0,200	0,455	**0,281**
	0,470	0,134	0,396		
	W1	**W2**	**W3**	w_w	
Masters	0,429	0,429	0,600	**0,497**	
C/Off.	0,429	0,429	0,200	**0,338**	
W/O	0,143	0,143	0,200	**0,166**	
	0,245	0,279	0,476		
	C1	**C2**	**C3**	w_C	
Masters	0,778	0,429	0,600	**0,596**	
C/Off.	0,111	0,429	0,200	**0,242**	
W/O	0,111	0,143	0,200	**0,162**	

	0,328	0,319	0,217	0,135	
	M	**N**	**W**	**C**	**Result**
Masters	0,534	0,439	0,497	0,596	**0,503**
C/Off.	0,324	0,281	0,338	0,242	**0,278**
W/O	0,163	0,281	0,166	0,162	**0,199**

Table 6. The Final Performance Comparison Values of Three Focus Groups at the end of The Second Scenario

	0,328	0,319	0,217	0,135	
	M	**N**	**W**	**C**	**Result**
Masters	0,414	0,395	0,505	0,389	**0,424**
C/Off.	0,331	0,303	0,314	0,219	**0,274**
W/O	0,275	0,303	0,181	0,392	**0,325**

From the assessment and comparison, following result were obtained.

There was a tendency by the experienced officers to handle all the work themselves. They could establish the priority among the different tasks. As a result many low priority items were not taken care of. In addition to look out and collision avoidance, adjustment of course by parallel indexing, estimation of leeway, and reducing speed at pilot point became most important tasks for the experienced masters. The frequency of the position fixing and using SMCP with message markers were found to be relatively poor [4].

The cadets taking the test in the simulation had very limited sea experience. They have had 5 months at sea as a cadet but their experience had been in the role of an observer. The weight of Criterias N4, W2 and W3 were very good evidence for the cadets who had very good knowledge of rule of the road in TSS, but recognition of danger and early action for avoiding collision were found to be relatively poor. They waited too long for action. The weight of Criterias W1 and C2 showed that the cadets had some difficulties establishing priority. They respected to check off lists and Standard Maritime Communication Praises, but the secondary tasks overloaded them and these tasks took the priority over immediate navigation concern. Ship s deviation from planned track was relatively high and ship speed at the pilot station was too much during the scenario. The criteria M3 and N1 indicate that the cadets were in lack of consideration on margin of safety and ship speed. The deviation between scheduled position of reducing speed and maneuvering results were bigger than master s result.

6. Conclusions

Author has developed an assessment and comparison system based on rank ordering of the tasks by criticality factor. standards and performance measures depended on the condition of the assessment. This problem was minimized by using simulator and AHP method - Subject Matter Experts ideas. The model provided a quantitative method of grading and comparing seafarer s skill during bridge simulation. By utilizing the performance assessment and comparison values the effective training curriculum can be constructed. Therefore insufficient degree of abilities can be trained intensively.

Abbreviations

AHP: Analytic Hierarchy Process
ITUMF: Istanbul Technical University Maritime Faculty
CPA: Closest Point of Approach
ETA: Estimated Time of Arrival
VTS: Vessel Traffic Services
TSS: Traffic Separation Scheme
SMCP: Standard Maritime Communication Phrases

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