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Analysis of the Application of the Rest Hour Maritime Labor Convention 2006 on MV. Pan Energen Crews to Improve Working Conditions with Analytical Hierarchy Process (AHP) Method

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Abstract

The contribution made by the crew is significant for the company's welfare and the performance on board. However, their well-being needs to be paid more attention in the maritime world. Heavy workloads and working hours and lack of implementation of rest hours trigger human error and are prone to fatigue. Implementing the Maritime Labor Convention 2006 has contributed significantly to improving the working conditions of the crew. This study aims to determine the right criteria and strategic solutions to help improve crew members' application of rest hours. Criteria and strategy solutions were obtained through the Analytical Hierarchy Process (AHP), and Expert Choice methods were used as supporting software for calculations. The stages of observation, interviews, dissemination of questionnaires, modelling and choice are processes carried out in data processing. Rest time criteria with a weight value of 0.534 and an inconsistency value of 0.004466 were the main criteria chosen by the respondents. Meanwhile, Sleep Duration is a strategy solution chosen as the top priority with a weight value of 0.220 and an inconsistency value of 0. The results of the two inconsistencies have a *CR* value of < 0.1, indicating that the effects of rest hour application data processing be declared consistent and accurate based on the 2006 Maritime Labor Convention can be declared consistent and accurate.

1. Introduction

Ship crews are the people who work and are in charge of the ship. Seafarers/sailors have dual roles as business operators and operators in transportation. In carrying out their job responsibilities, the crew members are required to increase job satisfaction to support the company' s goals [1]. As a worker in this field, there are numerous mental and physical demands, and the dual role of seafarers/sailors causes a lot of stress. Seafarers/sailors who lack rest time also affect the safety level of the ship. The human element experienced by seafarers/sailors is often referred to in the maritime industry regarding safety on boats. These include fatigue, lack of sleep, stress, loneliness, miscommunication, and education and training problems, among other factor [2].

Fatigue is defined by the International Maritime Organization (IMO) as a reduction of physical and mental abilities caused by excessive mental or emotional exertion that could affect almost all physical skills, including strength, agility, time reaction, coordination, decision-making, or balance [3]. Fatigue is not a trivial matter, and it requires a lot of attention. On the other hand, fatigue experienced by seafarers/sailors could cause accidents at sea due to their incompetence and ineffectiveness in carrying out their work. Fatigue is often associated with poor sleep quality, unsupportive work environment, heavy workload, high pressure, long working hours and less rest time [4]–[6]. Human capabilities in doing work are influenced by the rest time obtained. Providing enough rest time to the labourers will be able to help them work better until the end of their working hours. The provision of rest time aims to restore fitness and health both physically, mentally, and socially. The achievement of the job goals and the guarantee of safety depends on the health of the labourers. Vulnerability to fatigue and human error due to the lack of rest time is shown by several related studies. The correlation between the risk of shipwrecks and poor sleep quality and fatigue shows positive results [7]. However, the working conditions of ship crew could be developed [6], [8].

A study involving 1855 sailors has shown that a quarter of the respondents admitted to feeling tired or sleepy while on duty; meanwhile, almost half agree that fatigue could impact their attention span while on board [9]. In addition, a study conducted by the National Transportation Safety Board (NTSB) from January 1, 2001, to December 31, 2012, found that 20 per cent of accidents were caused by fatigue [10]. As a worker in this field, there are numerous mental and physical demands, and the dual role of seafarers/sailors causes a lot of stress. Seafarers/Sailors who lack rest time also affect the safety level of the ship.

Based on the description of the study results above, it shows that the crew experienced fatigue conditions due to lack of rest time but lacked solutions to solving these problems. A method with a decision support system is needed to determine the dominant aspects of implementing crew rest hours. The AHP method is selected in this study because the AHP method is a decision-making model that can break down an unstructured multi-criteria functional hierarchy into structured sub-problems based on a comparison of the preferences of the elements in order.

Five strategies can help implement crew rest hours to be more optimal: Sleep Duration, Strategic Napping, Environment Adjustment, Social Interaction, and Stimulant Intake [11]. Exposure to a marine environment that is too long will cause more significant stress. In addition, seafarers who live and work in the same place for a long time will face more obstacles, affecting their resistance. On the other hand, excessive Workload is one of the elements that can hold a sailor from reaching the stage of perfect sleep. In addition, stress can cause sailors to lose vitality and impact alertness. Typically, stress will occur when seafarers cannot cope with a risky environment or threat while on duty. A high degree of automation on board can help seafarers minimize their duties. However, technological improvements and automation have been seen as tools to reduce crew size. The reduction in crew size will cause existing seafarers to work hard to handle all available equipment and automation. In an emergency that requires many sailors, seafarers will experience fatigue.

Research on Fatigue Among Seafarers in Malaysia shows the results with the criteria that Fitness weighs 0.1824, Long Working Hours weights 0.1697, Rest Hours weight 0.1694, Workload has a value of 0.1509, Psychology and Emotional have a value of 0.0965, Noise and Vibration has a value of 0.0930. Crew Reduction has a value of 0.0799, Ship Design and Stability has a value of 0.0383, automation has a value of 0.0246 and Alternative Strategies Ship Condition are Well Maintained has a value of 0.7274, Ship Ergonomic has a value of 0.7258, Increase Crew Awareness has a value of 0.5555, Job Rotation has a value of 0.3494, Strategic Napping has a value of 0.3271, Adequate Rest has a value of 0.2613 [12].

Mental health also has a close relationship with human performance. According to the World Health Organization (WHO), mental health is a state of well-being in which the individual realizes their abilities, can cope with the pressure of everyday life, can work productively and beneficially, and can contribute to their communities. Being able to overcome life challenges, being happy, prosperous, and harmonizing between thoughts, behaviors, and feelings is also an analogy that mental health is not only free from distractions.

Various types of work have different rest periods. Work involved in operational things like seafarers/sailors is affected by the level of Fitness, performance results, and health. Based on the explanation above, it can be concluded that the primary purpose of doing a job is to achieve a specific goal that has been agreed upon by the company and the human resources, as its workers must maintain safety while doing their job by paying attention to their health as a primary driving source of the body.

2. Methods

2.1 Object of Study

he objects that will act as decision makers in helping to determine the results of the decisions in this study are ship crews. The ship crew is a human labour force that works and is responsible on board. The ship's crews that act as respondents are divided into several positions shown in Table 1.

2.2 Data Collection and Processing

In the research process, data collection is divided into three stages: interviews, crew members observation, and distribution of questionnaires. Interviews were conducted with the crew members of the MV. Pan Energen. The process of these interviews is to collect data related to the problems in implementing the rest hour and the factors affecting the implementation of the rest hour. Data collection along with the interviews were conducted by the positions of Master Chief Officer, 2nd Officer, 3rd Officer, Chief Engineer, 1st Engineer, 2nd Engineer, 3rd Engineer, Bosun, Ordinary Seaman, No.1 Oiler, Wiper, Chief Cook, Cook, Deck Cadet, Engine Cadet which were one person each, and the position of Able-bodied Seaman and Oiler were 3 people each with a total of 22 respondents. This research conducted personal observations and examined and studied the processes that occurred in the field with scientific ethics. It does not use the author' s opinions but is based on science. After interviews and observations in the field, the questionnaire was created to select the criteria, and alternative strategy solutions were offered to the respondents. Questionnaires were distributed to determine the priority criteria for improving the implementation of the rest hour and choosing strategic solutions that can be the guidelines for the performance of the solution rest hour.

Table 1. Details of MV. Pan Energen respondents

Positions	Number of Respondents
Master	1
Chief Officer	1
2nd Officer	1
3rd Officer	1
Chief Engineer	1
1st Engineer	1
2nd Engineer	1
3rd Engineer	1
Bosun	1
AB (Able-bodied Seaman)	3
OS (Ordinary Seaman)	1
No.1 Oiler	1
Oiler	3
Wiper	1
Chief Cook	1
Cook	1
Deck Cadet	1
Engine Cadet	1

2.3 Analytical Hierarchy Process (AHP) Method

Several variables were selected according to the problem's purpose with a structured hierarchical analysis process. Figure 1 describes AHP process which creats alternative solustion. This decision-making model is comprehensive. AHP can solve multi-objective or multi-criterion issues based on a comparison of the preferences of each criterion in the hierarchy [12]. AHP works by simplifying and placing a complex and unstructured problem hierarchically. The weighting level of the values on each variable is then subjectively assigned a numerical value according to relative importance compared to other variables. Synthesis was carried out from the weight of these considerations to determine which variables have the highest weight of importance value and, of course, play a role in influencing the problems made [13].

Therefore, the Analytical Hierarchy Process method is used to compile criteria agreed upon by respondents related to being processed with a series of analytical processes in the form of a hierarchy. Each criterion was assessed for the dominant criteria formed to be processed to the stage of providing alternative strategy solutions for the application of rest hours to the crew members. The basic principles of the AHP method include [14]:

1) Decomposition: Identify the problem and determine the correct alternative solution to solve the existing problems, then compose the hierarchy of the issues encountered. Creating a hierarchy is done by determining goals to solve problems, which is the goal of the whole system.
2) Comparative Judgement: A pairwise comparison is conducted where the selected elements are determined according to the calculated criteria. The numbers representing the relative importance of one element are filled into the matrix.
3) Synthesis of Priority: Once the pairwise comparison matrix is completed, the next step is gathering various considerations to estimate the whole relative priorities.
4) Logical Consistency: All elements are categorized uniformly and logically based on the selected criteria. The consistency calculations were carried out by multiplying the matrix between the options.

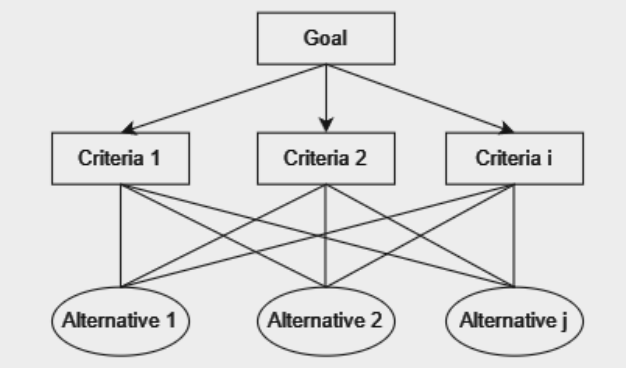

Figure 1. Hierarchical overview of AHP methods

Table 2. Index random value

Matrix Size	Random Index
1.2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51
12	1.48
13	1.56
14	1.57
15	1.59

Consistency ratios have been used to detect response inconsistency [15]–[18]. Comparison of the matrix of the Consistency Index (*CI*) and Random Index (*RI*) in a matrix called Consistency Ratio (*CR*). Table 2 shows the average consistency of the matrix. Consistency Index (*CI*) value could be expressed with Equation 1.

$$CI = \frac{\lambda max - n}{n - 1} \quad (1)$$

Where λmax is largest total of eigen value, and N is the number of criteria

Therefore, the *CI* value could be known from the average of *CM* (Consistency Measure). The next step is to find the Ratio Index (*RI*) determined by the order of the matrix (number of criteria). In this case, five criteria and five strategic solutions are chosen, therefore using a matrix order of 5 x 5 according to Table 1, which shows that if the matrix order is 5 x 5, then the RI value is 1,12. From the results of *CI* and *RI*, the Consistency Ratio (*CR*) value could be calculated using Equation 2.

$$CR = \frac{CI}{RI} \quad (2)$$

If *CR* produces a value less than 10 per cent, it can be said that the weighting results that have been processed are consistent and can be accounted for. However, if this condition is not achieved, a new weight determination is needed [19].

Table 3. Pairwise comparison scale

Intensity of Importance	Variable Definitions	Description
1	Both elements are equally important	Both elements have the same influence
3	One of the elements is a little important than the others	Statement of judgement is a little impartial and can be tolerated rather than the other elements
5	One of the elements is more important than the others	Statement of judgement is a little impartial and can be tolerated rather than the other elements
7	Clearly more important than the other elements	Statement of judgement strongly favors an element rather than the others
9	One of the elements is absolute clear from the others	One of the elements is strongly dominated in its application
2,4,6,8	Adjacent values between two considerations	Evidence that the element is more important and cannot be sued by other elements
Opposite	If component a has one value above when compared with element b, therefore element b has the opposite value when compared with element a	

2.4 Pairwise Comparison Scale

The next step n the analysis of the assessment hierarchy is the comparison of importance between components of the elements in a hierarchical level. The assessment was carried out by comparing the combinations of elements n each hierarchy. It is necessary to determine each element's weight through a pairwise comparison scale table such as Table to get a quantitative assessment.

2.5 Expert Choice (*EC*)

The supporting software used in this research is Expert Choice (*EC*). An application program that decision-makers can use to make their decisions. *EC* gives various abilities, from selected criteria and solutions data input to determining results. *EC* could be operated with relatively easy use. *EC* can do quantitative and qualitative analyses, which give rational results. Supported by the two-dimensional graphic pictures, *EC* software is easier to understand and interesting. It is necessary to know that *EC* is based on the analytic hierarchy process (AHP) method [20].

3. Results and Discussions

Results and discussions in this study were obtained from the respondents regarding the filling of questionnaires, which describe criteria that could affect the implementation of rest hour quality with a weight value of each criterion according to the nine respondents. From the results of the collected questionnaire, the criteria's weight value was quantitatively obtained, and then the Analytical Hierarchy Process (AHP) was analyzed. In the hierarchical decision of this study, it is explained that the goal is to determine the best alternative strategy for improving rest hour implementation by considering aspects of the criteria that affect the selection of the alternative strategy mentioned. There are five aspects of the selected criteria such as rest time, boredom, work environment, mental state, nutritional content of food.

Also, there are five alternative strategic solutions which are recommended to improve the implementation of rest hours on crew members, such as:

1) Sleep Duration

Decent sleep duration aims to overcome excessive fatigue, which could cause effectiveness in work.

2) Strategic Napping

Naps between activities require long-time consciousness with a brief duration.

3) Environment Adjustment

Work environment adjustment or management of conducive rest time improves comfort in doing activities. Includes factors like noise, temperature, light, and body position.

4) Social Interaction

Interaction between humans has the purpose of maintaining consciousness while doing activities.

5) Stimulant Intake

Intake of stimulants that can help with fatigue instantly.

3.1 Modeling Stage

The modelling stage mentioned is hierarchical modelling with an Analytical Hierarchy Process (AHP). Before the questionnaire results, a hierarchy chart is composed, including the aim, criteria, and selected alternative solutions to simplify the selection process. The picture of AHP′ s decision hierarchy is shown in Figure 2.

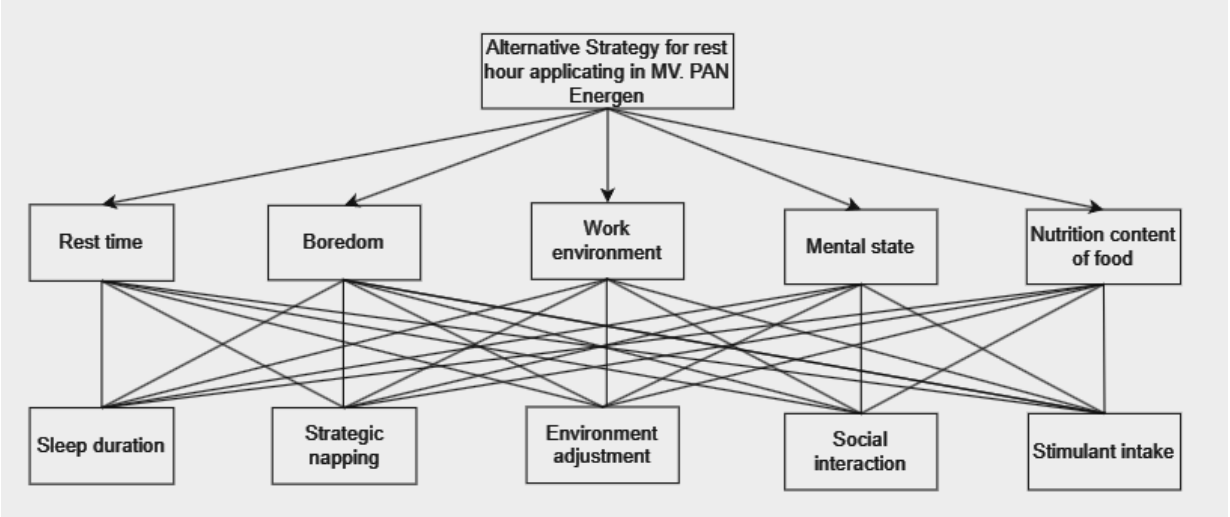

Figure 2. AHP chart

3.2 Choice Stage

This stage is where a selection of comparing every criterion and selected alternative solutions is carried out. The first step of the selection is to assess pairwise comparison. Every aspect of the criteria given and the solutions of the decision offered are determined by the weight value with pairwise comparison. The selection of weight value of the criteria was taken from the first aspect of the criteria, where weight was taken based on respondents.

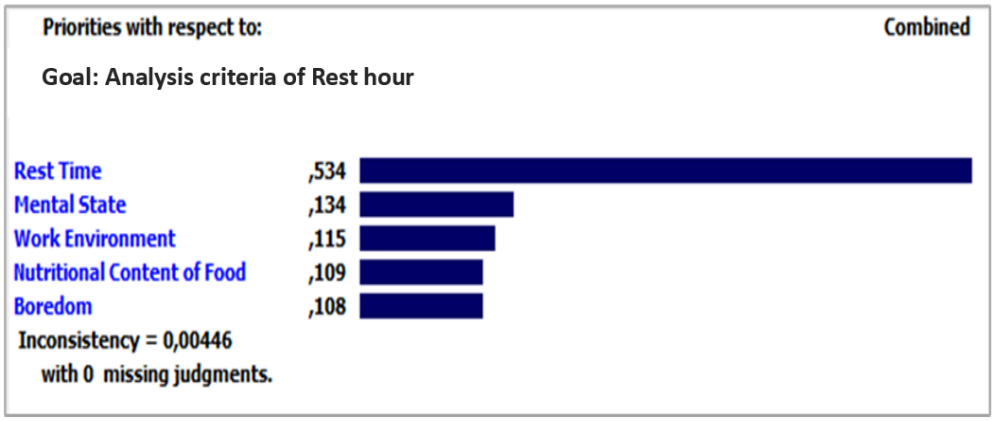

Figure 3. Weight comparison and consistency ratio value on all criteria

Figure 3 shows the results of the weight of criteria processed with Expert Choice. Based on the results of the calculations, all of the criteria have the inconsistency value of 0.00446 with the elaboration that aspects of the rest time criteria are the most noticeable aspect and are the main priority among all criteria with the value of 0.534, the second criteria are the mental state with the value of 0.134. The third most important criteria are the work environment, with a value of 0.115; the nutritional content of food, with a value of 0.109; and the last criterion is saturation/boredom, which has the last place in importance with a value of 0.108.

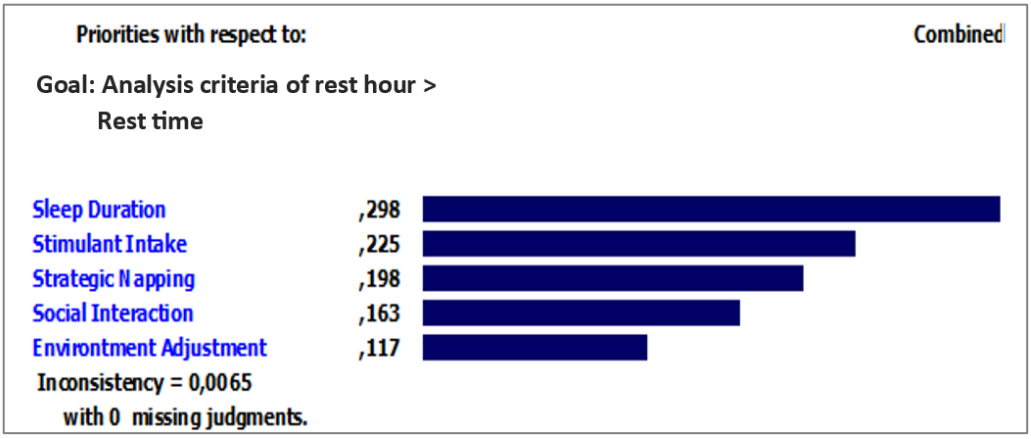

Figure 4. Comparison of weight of the solution and consistency ratio value on rest time criteria

After knowing the aspects of the criteria which determined to improve the alternative strategy, the selection of the alternative strategic solution was made by inserting the assessment results of all respondents while considering all aspects of the criteria; therefore, the selection of the alternative strategy of rest hour implementation on the crew members of international ships is the sleep duration with the value of 0.220 and has the inconsistency vale of 0.00 where it could be stated that the results of calculation and the solution selection were processed with consistency by all of the respondents. The results of the alternative strategy solution on each criterion is shown in Figure 4 to 9.
Figure 4 shows that aspects of the rest time criteria give an inconsistency value of 0.0065. The alternative strategy of sleep duration has the largest importance value of 0.298, and the second place of importance value is stimulant intake with a value of 0.225 then the strategic napping with a value of 0.198, social interaction has a value of 0.163 and the last place is the environment adjustment with the value of 0.117.

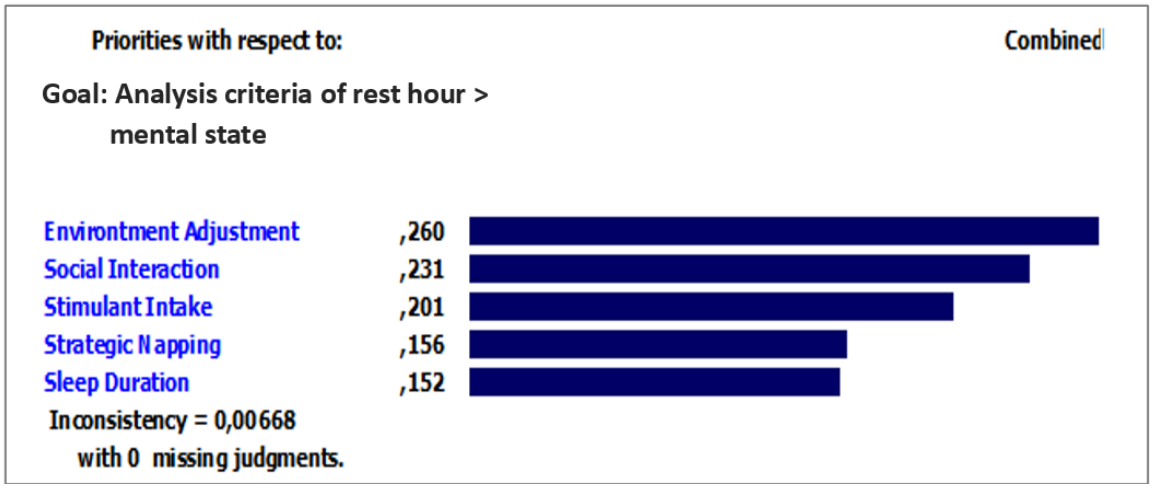

Figure 5. Comparison of weight of the solution and consistency ratio value on mental state criteria

In Figure 5 of the results of the solution calculation with an inconsistency value of 0.00668 shown in the mental state aspect, the highest assessment weight chosen is environmental adjustment of 0.260 then the second importance value of social interaction is 0.231, stimulant intake of 0.201 occupies the third importance value, followed by strategic napping with an importance weight value of 0.156 and finally sleep duration is 0.152.

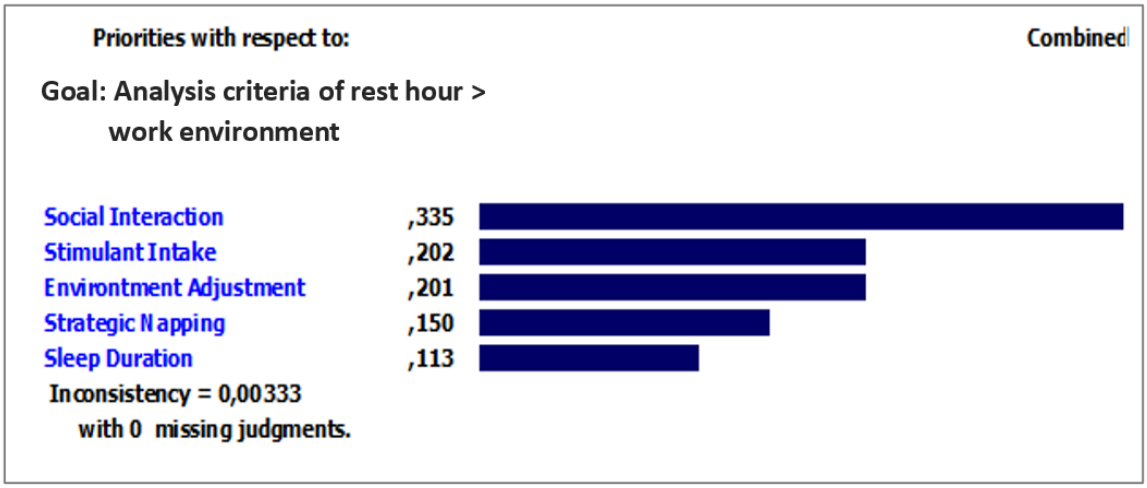

Figure 6. Comparison of weight of the solution and consistency ratio value on work environment criteria

Figure 6 on the aspect of work environment criteria shows that social interaction is the highest choice with a value of 0.335, stimulant intake occupies the second choice with a weight value of 0.202, and environment adjustment has a weight value of 0.201. Strategic napping has a weight value of 0.150. and the last place is occupied by sleep duration with a weight value of 0.113. Overall, the inconsistency value obtained is 0.00333.

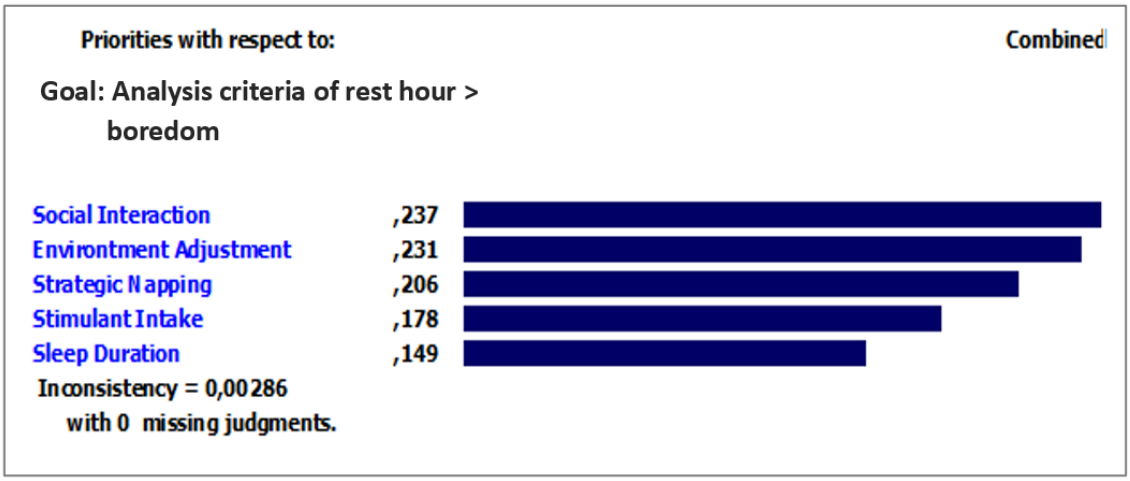

Figure 7 Comparison of weight of the solution and consistency ratio value on saturation/boredom criteria.

Figure 7 shows an aspect of the saturation/boredom criteria with an inconsistency value of 0.00286, and the selected alternative strategy solution is Social Interaction with a value of 0.237, followed by Environment Adjustment with a weight value of 0.231, then Strategic Napping with a value of 0.175, and the last choice is Sleep Duration with the weight value of 0.149.

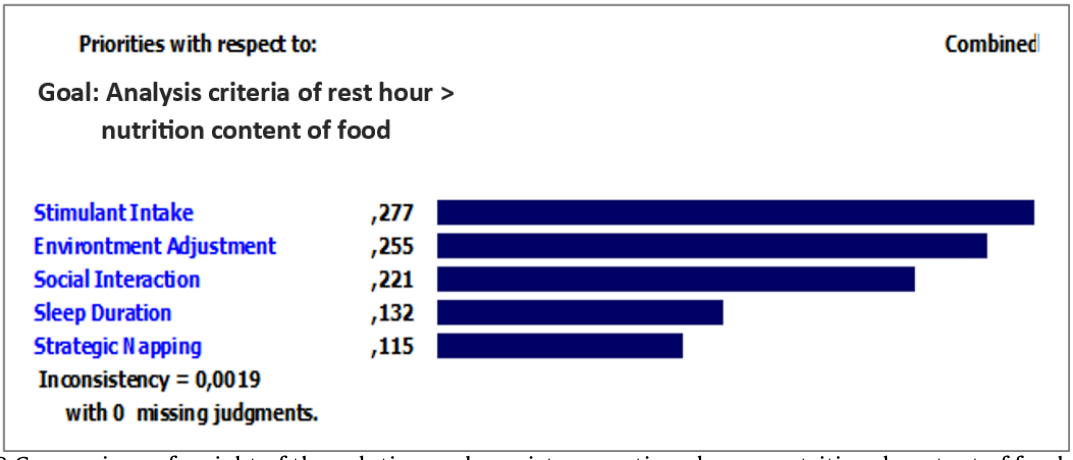

Figure 8 Comparison of weight of the solution and consistency ratio value on nutritional content of food criteria

Figure 8 shows that the aspect of nutritional content of food provides an inconsistency value of 0.0019, and the alternative strategy of stimulant intake occupies the highest importance with a value of 0.277, followed by the second place of environment adjustment with a value of 0.255 followed by social interaction of 0.221, sleep duration of 0.132 and the last place occupied by strategic napping with the value of 0.115.

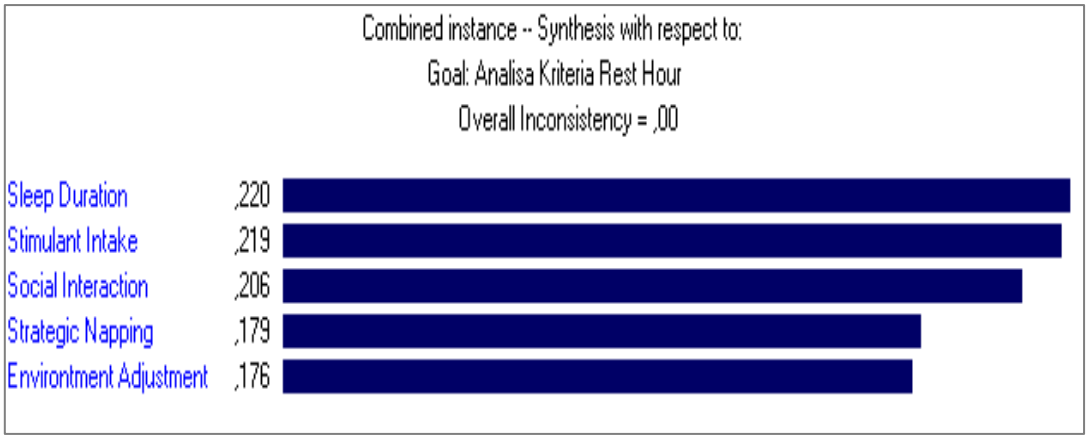

Figure 9. Comparison of weight of the solution and consistency ratio value on all solutions

From the five alternative solutions that have been selected by related parties and considering five aspects of the specified criteria. Figure 9 shows that the result of the overall calculation of the inconsistency values is 0.00. with the highest alternative strategy solution result being sleep duration with the weight value of 0.220. Then followed by second solution chosen is stimulant intake with the weight value of 0.219, the third place occupied with the social interaction of 0.206, fourth place is strategic napping with the weight value of 0.179 and the last fifth place is environment adjustment with the weight value of 0.176.

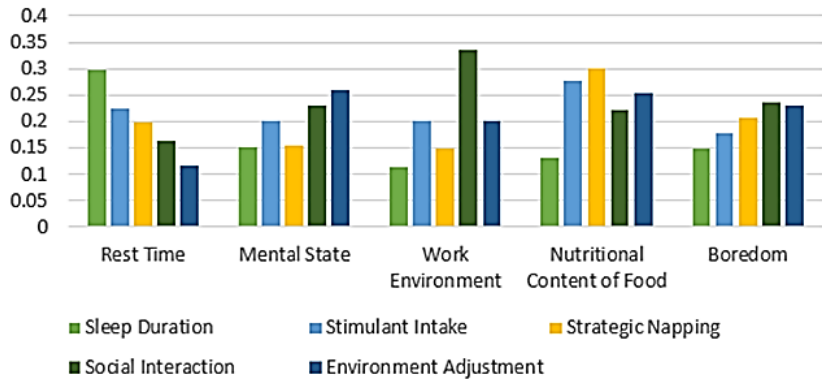

Figure 10. Comparison chart of five alternative strategy solutions based on aspects of the criteria

Figure 10 shows a comparison chart between the five alternative strategy solutions considering five aspects of criteria-related parties that have chosen to implement rest hours for crew members of international ships.

4. Conclusions

From the results of this study, it was concluded that the aspects of rest time criteria have a weight value of 0.534. This shows that rest time is a top priority for the crew members. The criteria of mental state, work environment, food nutritional content, and saturation/boredom were then followed. The weight value of all criteria has the inconsistency value of 0.00446, where the CR value is <0.1 or 0.00446 <0.2, indicating that data processing was carried out consistently and is accurate.

There is a selection of alternative strategy solutions that are prioritized, namely Sleep Duration with a weight value of 0.220. followed by the next alternative strategy solution of Stimulant Intake, Social Interaction, Strategic Napping, and the last position is Environment Adjustment To improve the implementation of rest hours based on the Maritime Labor Convention 2006, The weight of the inconsistency value of the entire solution is 0.00. The Sleep Duration strategy, being the main choice, shows that sleep duration can help the crew members perform better.

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