INVESTIGATION ON THE FACTORS OF VTS OPERATORS’ MENTAL WORKLOAD: CASE OF TURKISH OPERATORS

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ABSTRACT
The level of VTS Operators’ (VTS-Os’) Mental Workload (MWL) was clarified in the previous experimental studies by utilising physiological and subjective approaches. The objective of this paper is to determine the factors to cause and increase VTS-Os’ MWL. For this purpose, the questionnaire was prepared and submitted to Turkish Operators (including VTS Operators and VTS Supervisors) who have been employed at the Istanbul VTS Centre and Çanakkale VTS Centre. The questionnaire consisted of multiple aspects of operators’ mental workload such as ergonomics, occupational stress, physical and social conditions and environmental aspects, etc. Turkish Operators evaluated all variables related to their tasks based on affecting to increase their mental workload by using a five-point Likert scale ranging from “Never” through to “Always”. The higher score of the questionnaire item, the more effect on operators’ mental workload. Then, Exploratory Factor Analysis was applied to the questionnaire by using SPSS v.13.0 to obtain significant mental workload factors. The reliability of questionnaire was also tested by Cronbach’s Alpha and it was determined a powerful internal consistency. Moreover, the respondents’ number was enough (73% of the total number) to understand whole picture of Turkish Operators’ mental workload factors. In the further analyses, the mental workload factors were tested whether operators had similar effects or not, and the root of these differences was investigated. Moreover, the relationship between factors and profile variables (such as age, marital situation, sea experience, VTS experience, educational level and competency) was investigated by using proper statistics techniques (e.g. Student t Test and ANOVA). The results revealed that the proposed factor model would explain Turkish VTS Operators’ MWL by 79.1% and no significant differences among them were also determined.

Keywords: Vessel Traffic Services; VTS Operators; Mental Workload

1. INTRODUCTION
The role of Vessel Traffic Services (VTS) in marine traffic is to provide and operate the vessel traffic information and management systems in the ports and confined waterways by considering safe and efficient management of vessel movements within these areas. VTS Operators (VTS-Os) provide necessary information to the vessels and advising them for a safe and efficient handling of traffic. This interaction between vessels and VTS is different from controlling of the traffic, due to vessels have freedom to accept or reject information given by VTS.

Nowadays, a VTS is equipped with the highest and the latest technological devices. VTS-Os provide the information by using these equipments; e.g. radar displays, AIS Information, weather and current information, position of ship with a large number of other details as course, speed, cargo, etc. and communication tools. VTS-Os have to maintain the whole picture of marine traffic sufficiently in detail and in a limited time. When they have perceived risky relationships among vessels and it is needed to solve these potential threats beforehand, they should leave the Ship Master to decide their own situation with the others. Moreover, this loop continues with new incoming vessels, which to create new traffic relations for the assessment.
The concept of mental workload has become an important issue for all kinds of industry after the 1960’s. The main reason of this is “computer”; it has become an indispensable component of life. That is one of the expected results since the operating systems are designed in the central of human operator. Therefore, it is necessary to consider operators’ workload at the design stage of human-machine systems. Understanding and assessment of VTS-Os’ mental workload could provide useful information that might be obtained during the design of VTS such as workload bottlenecks, operators overload conditions, etc. According to the international standards such as ISO 10075 (1991) and ISO 10075 (2004), the evaluation of mental workload is a key point for the usability enhancement of the components of a technical system and for the quality improvement of a design.

In addition, sophisticated control and display units in the VTS require heavy demands on VTS-O’s information processing capabilities. Such complicated technologies include also large volumes of information, and as a result; it could exceed the limited information processing capacity of VTS-Os (Pretorius and Cilliers, 2007). The main objective of assessing mental workload is to achieve manageable workload and to avoid overload/underload situation. When workload is in low levels (underload situation) that lead to boredom, reduce the attention and loss of situation awareness. When the operator capacity is not enough to perform the task, due to high increase workload (overload situation); operator may not succeed to handle task demands. Furthermore, this situation tends the operator to stress, and easily to make error. That’s why, the acceptable workload can be determined as the level of workload not to impede the operator, but to manage the system safely and effectively (Jung and Jung, 2001).

In this paper, Authors’ specific objectives were: (1) to determine factors to cause (especially tend to increase) mental workload of VTS Operators, (2) to obtain the impact levels of mental workload factors based on subjective assessment, (3) finally, to achieve an approach for predicting and assessing the level of VTS-Os’ mental workload.

2. LITERATURE SURVEY

According to Webster Online Dictionary, workload is defined as the amount of work that expected to be done by an operator in a specified time. Workload has a multidimensional scale and it is generally classified as Physical Workload (PWL) and Mental Workload (MWL). PWL means how much effort expended for the physical resources while performing the task and it can be measured by physical resources. On the other hand, MWL is defined as the level of processing capacity while performing the task, or the difference between the capacity to affect the usable real performance and human-information processing system (Eggemeier and Wilson, 1991). MWL is also considered as the demand on the brain and sensory system (eyes, ears, and skin) because of the tasks (Zhang and Luximon, 2005).

Herein, the question would be that MWL could be understood, and how? MWL cannot be obtained directly, but it can be sensed directly. On the other hand, we cannot directly measure MWL, although the impact of MWL can be achieved (that means perceived MWL). So, it can be measured indirectly throughout assessing the variables to cause MWL by using analytical models, subjective assessments, performance measures and physiological techniques (Moray, 1988; Wierwille and Eggemeier, 1993; Tsang and Wilson, 1997). Stanton et al. (2005) explained different measure techniques related to human factors in detail, such as; task analysis techniques, human error and human reliability techniques, situation awareness measurement techniques, mental workload assessment techniques, performance assessment techniques, etc.

According to Meshkati (1988), MWL has multidimensional variables that can be affected by many factors; also classified the factors that influence MWL into causal factors and effect factors. Casual factors consist of task and environmental variables, operator characteristics, and moderating variables. Effect factors contain the difficulty, response and performance variables and MWL measures. The factors to cause MWL are investigated out of the maritime field, and in a common sense, the workload factors are obtained as follows;
- Nature of work,
- Work equipments (ISO 10075, 1991),
- Physical and social conditions of working environment (ISO 10075, 1991; ISO 10075, 2004; Leplat, 1993),
- Structure of task, task aims and operator’s task perception (Hart and Staveland, 1988),
- Task size (ISO 10075, 1991; ISO 10075, 2004),
- Time pressure and individual knowledge (Xie and Salvendy, 2000),
- Physical activities and postural discomforts (Karwowski et al., 1986).

Considering the environmental workload, physical and social conditions of working environment consist of climate, thermal environment, lighting, noise, vibration and gasses, etc. Grandjean (1985) reported the
researches related to these environmental factors, and he pointed; strong and continuous force that occurred in the working environment, affect the operator and increase the occupational stress.

Considering the postural workload; especially sitting every time on the chair for VTS-Os, operators could have insufficient circumstances because of the reverse postures. Haslegrave (1994) described the working position as to adjust the position of body, head and limbs based on the nature of task and task properties. There are some studies related to positional workload to increase operators’ workload (Dieën and Vrielink, 1998; Jung and Jung, 2001).

In the literature survey, there are a few paper related to behaviours of VTS-Os, especially considering mental approaches. They mainly focused on situational awareness and VTS-Os performance; e.g. Wiersma and Hooijer (1997), Wiersma and Mastenbroek (1999), Wiersma and Butter (2002), Butter and Wiersma (2002). Also, very few studies related to mental workload are attained in the maritime field, but they did not focus on VTS-Os. Understanding VTS-Os’ MWL could help to minimise operators’ error; and that would improve safety of system meanwhile increase productivity and operators’ satisfaction (Moray, 1988).

Investigating and predicting of MWL are originally developed for air navigation and military applications. Then, its importance is substituted in the land navigation by assessing car drivers’ MWL. Nowadays it becomes a vital issue in the maritime field. As mentioned by Koester (2002), maritime accidents are often caused by lack of attention due to high/low levels of workload. Moreover, in the report of U.K. Maritime Coastguard and Agency-MCA Report (2006), three hundred and eleven maritime accidents (from the four different accident databases) are examined to determine whether the MWL is a factor in these accidents or not. Some of them are demonstrated for the example of accidents due to high/low levels of MWL, and it is also pointed that MWL levels are indeed related to the occurrence of human error. In addition, the performance influencing factors for the mariners that affect the level of workload are defined in the MCA Report (2006). According to this report, the factors affect the level of workload are; time of the incident, stage of the person’s shift, number of persons on watch, type of vessel, how the technology used, weather conditions, the area of the incident, fatigue and environment. Furthermore, there were some researches on assessment of the navigators’ mental workload by using physiological measures such as; Muri et al. (2004) and Kum et al. (2004).

On the other hand, Authors’ previous studies were focused on understanding VTS-Os’ mental workload by utilising subjective and physiological techniques. VTS-Os’ heart rates were investigated in Kum et al. (2007a) as a physiological index of mental workload, and their results revealed that ship took a pilot (or intending to take pilot), ships’ specifications (especially length over 150 m and vessels carry dangerous cargo), traffic density and ships’ sailing area had remarkable effects on the Operators’ MWL. VTS-Os’ eye movement patterns was particularly investigated in the field viewing of Operator Console in Kum et al. (2007b). Their study indicated that VTS-Os’ eye movements had significantly the same pattern and the differences among them depended on the operators individual choosing based on their primary task via VTS Sectors. They also considered the ergonomics of Operator Console had remarkable effects on VTS-Os’ eye movements. Moreover, the level of VTS-Os’ MWL was quantitatively obtained by using NASA Task Load Index in Kum et al. (2008) that was the first attempt to apply one of the subjective MWL measures to VTS-Os. In addition, it is also pointed in the pervious studies of authors that the profile variables had partial effects on VTS-Os’ MWL.

3. METHOD
3.1. Subjects: Turkish Operators
Turkish Operators (TR Operators including VTS-Os and VTS-Ss) who employed at the Istanbul and Çanakkale VTS Centres, filled the questionnaire. The number of TR Operators is 48 in the Istanbul VTS Centre (VTS-C) and 34 operators in the Çanakkale VTS-C. 32 of VTS-Os in the Istanbul VTS have engaged actually for the system operation (who sit on the Operator Console and make communication with the vessels), 4 VTS-Ss have engaged for administrative tasks and 12 VTS-Ss actually in the operation. In the Çanakkale VTS-C, 24 VTS-Os have engaged for the operation and 2 VTS-Ss have engaged for administrative tasks whilst 8 VTS-Ss in the operation.

3.2. Procedure: Questionnaire
A proposed model of VTS-Os’ MWL was theoretically obtained after having focus group meeting with the experts. This proposed mental workload factors implemented to the questionnaire, then it was submitted to
the TR VTS Authority (Directorate General of Coastal Safety) for getting permission. TR VTS Authority has kindly accepted to implement the questionnaire without interfere with any items.

The questionnaire included multiple aspects of VTS-Os’ MWL such as ergonomics, occupational stress, social conditions and environmental aspects, etc. and it consisted of; the demographic items (such as age, sea and VTS experience, education level, etc.), the assessment of variables to cause mental workload. It was also finalised by comments, remarks and thanks to the operators.

TR Operators should evaluate all variables related to their tasks based on affecting to increase their mental workload by using a five-point Likert scale ranging from “(1) Never” through to “(5) Always”. Herein, it is assumed that when the questionnaire score increased, the effect on mental workload parallel increased. The questionnaire was analysed by using Exploratory Factor Analysis of SPSS v.13.0.

3.3. Results

Total TR Operators is 82 persons, and 76 of them are directly related to the operation. Table 1 shows the number of questionnaires and the successful responses are 60 that are enough to represent all TR Operators.

Table 1: Number of Questionnaire and Respondents among the VTS Centres

<table>
<thead>
<tr>
<th>VTS Centres</th>
<th>Submitted</th>
<th>Received</th>
<th>Respondents</th>
<th>Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>İstanbul (Ist)</td>
<td>48</td>
<td>41</td>
<td>41</td>
<td>85.4%</td>
</tr>
<tr>
<td>Çanakkale (Cnk)</td>
<td>34</td>
<td>19</td>
<td>19</td>
<td>55.9%</td>
</tr>
</tbody>
</table>

Reliability of the questionnaire items was tested by Cronbach’s Alpha. In the reliability analysis, “Cronbach's Alpha if item deleted” was used to determine items’ effects and also to increase the reliability of the questionnaire. It was determined that all items had a powerful internal consistency, due to none of the items’ alpha value was higher than total scale of the questionnaire. The questionnaire reliability was determined as $\alpha = .969$ and a few items in the questionnaire correlated with the total scale to a low degree (less than 0.30). The result of Friedman's ANOVA also revealed the questionnaire scale was significant $[\chi^2(87) = 818.46, p < .01]$. Therefore, any item was neglected from the data set, and the significance level was set to 5% not only for the Factor Analysis, but also for the further analysis.

3.3.1. Demographics of Turkish Operators

The demographic information was obtained from operators’ responses to the questionnaire, and the results revealed that all TR Operators is male and 83.3% of them are married. 86% of Operators are engaged as VTS-Os.

TR Operators are in age from 30 to 55 years with the average of 39.1 years as shown in Figure 1 (a). Figure 1 (b) also shows the percentage of their age classification based on the VTS Centres; 2% of Operators is less than 30 years old, 70% of them are between 30 and 40 years old, 22% is between 40 and 50 years old and 6% of them are older than 50 years old.
Figure 1: Age Graphics of TR Operators

TR Operators had an on-board experience in average 13.6 years (5.4 years as a Master). Figure 2 shows the total sea experience before employed as an operator. All TR Operators had more than 5 years on board experience, and 66.7% of them had more than 10 years sea experience. Operators who employed at the Istanbul and Çanakkale VTS-Cs had similar sea experience in years. Also, they mainly had sea experience on bulk carriers (76.7%), and then tankers (11.7%).

Figure 2: TR Operators’ Sea Experience

The Turkish VTS (officially called as Turkish Straits VTS) has been in service since 2003. So, TR Operators had mainly less than 5 years VTS experience as shown in Figure 3. It was not determined any relationship between having sea experience and being engaged as VTS-O or VTS-S and also that was not related whether having VTS experience or not (Figure 2 and Figure 3). Therefore, it does not mean that if the operator has more sea experience, he could be engaged as VTS-S, or if the operator has more VTS experience he could be
engaged as VTS-S. It can be assumed that to be engaged as VTS-O or VTS-S depends on the individual knowledge and skill of operator.

All of TR Operators were graduated from a maritime faculty at four years undergraduate program of university with the Bachelor Science degree. All of them have the ocean going ship master certificate. They also had onboard experience to navigate through the Istanbul and Çanakkale Straits; the majority of passing through the Turkish Straits was over 50 times (31.7%). 25% of Operators had between 20 and 50 times passing through the Turkish Straits whilst 6.7% had no passing.

![VTS Experience](image)

Figure 3: TR Operators’ VTS Experience

3.3.2. Factor Analysis

After testing reliability of the questionnaire, the Exploratory Factor Analysis (EFA) was performed to determine the factors to increase VTS-Os’ MWL. The extraction method was Principal Components (with Varimax Rotation) in order to maximize loadings and to eliminate multiple loadings, and the loading factor of 0.50 was selected as item criteria (Field, 2005).

The questionnaire consisted of 90 items, and two of them (related to sailing area) were separated from the database to assess individually. Initially, the EFA gave a model that had included ten factors by covering fifty three (53) items and all of them were available for the EFA; Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was higher than 0.50 [KMO = 0.713] and Bartlett's Test of Sphericity was so significant [p = .00]. But, some of items had loading less than 0.50 and loaded on two factors or more. That’s why, these items were neglected from the data set and the same procedure was re-applied till to obtain the strongest model for all factors. At the final, using Principal Components with Varimax rotation, the EFA suggested that 67 items should be neglected and that the remaining 21 items was the best to be represented by five factors rather than ten factors. When there had been ten factors (at the initial stage) the total variance explained was 75.6%; and after neglecting 67 items from the questionnaire, the total variance explained by five factors increased to 79.1% [KMO = 0.737 and Bartlett's Test of Sphericity, p = .00]. However, the questionnaire reliability reduced [α = .874; χ²(20) = 398.32, p < .01]. Finally, the factors to increase Operators’ MWL as follows;

- Factor-1: The effect of satisfaction with other operators
- Factor-2: The effect of tankers over 150 m
- Factor-3: The effect of the attitude of Ship Master (and Pilot)
- Factor-4: The effect of keeping watches in holidays
- Factor-5: The effect of vessel cargo

Using the data from the EFA, Confirmatory Factor Analysis was performed to determine whether this factor model (obtained by the EFA) was significant or not. The result of Confirmatory Factor Analysis with Maximum Likelihood rotation revealed that the goodness-of-fit was significant for the exploratory factor model [χ²(74) = 99.9, p = .02].
Considering further analyses and deciding the proper analysing technique, the distribution of mean values was tested by One-sample Kolmogrov Smirnov for all factors. The results revealed that the factors had the normal distribution (all \( p > .01 \)), so there would be not any problem to apply parametric techniques for the further analyses.

### 3.3.2.1. Ranking of the Factors and Effect Levels

The Friedman Test was applied to obtain ranking of the factors (which factor has highest effect on VTS-Os’ MWL). It was determined that the factors were significantly different (all \( p < .01 \)) from each other based on the effectiveness to increase MWL as shown in Table 2. Table 2 also shows how many percent of variance could be explained by these factors. According to the result of the Friedman Test; Factor-3 “the attitude of Ship Master (and Pilot)” had the highest effect to increase VTS-Os’ MWL, then the other factors; “The effect of tankers over 150 m”, “The effect of satisfaction with other operators”, “The effect of keeping watches in holidays” and “The effect of vessel cargo” had the minimum influence on VTS-Os’ MWL.

Descriptive statistics and histograms were used to assess effect levels of TR Operators’ MWL factors. TR Operators have felt “The effect of the attitude of Ship Master (and Pilot)” to increase their mental workload very often, and that was similar for the variables represented by Factor-3, they very often affected to increase VTS-Os’ MWL.

Table 2: Ranking of the Factors and Percentages of Variance Explained by the Factors

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean Rank</th>
<th>df</th>
<th>Chi-Square</th>
<th>Significance</th>
<th>Percentage of Variance (%)</th>
<th>Cumulative Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor-1</td>
<td>2.98</td>
<td>4</td>
<td>122.614</td>
<td>.000</td>
<td>21.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Factor-2</td>
<td>3.74</td>
<td></td>
<td></td>
<td></td>
<td>19.2</td>
<td>40.2</td>
</tr>
<tr>
<td>Factor-3</td>
<td>4.44</td>
<td></td>
<td></td>
<td></td>
<td>17.7</td>
<td>57.9</td>
</tr>
<tr>
<td>Factor-4</td>
<td>1.98</td>
<td></td>
<td></td>
<td></td>
<td>11.8</td>
<td>69.7</td>
</tr>
<tr>
<td>Factor-5</td>
<td>1.87</td>
<td></td>
<td></td>
<td></td>
<td>9.4</td>
<td>79.1</td>
</tr>
</tbody>
</table>

It was obtained that “The effect of tankers over 150 m” has very often increased Operators’ MWL. It was also similar for the items of Factor-2; “when the ship is an oil tanker”, “when the ship is Liquefied Gas Carriers”, “when the ship has deep draft” and “when the ships’ length is 200-250 m” and “when the ship’s length is over 250 m” that very often increased their mental workload whilst Operators have sometimes felt high mental workload for the ships between 150 m and 200 m.

Operators’ mental workload very often increased due to “the effect of satisfaction with other operators” and the items of Factor-1.

It was also obtained that the impact of Factor-4 “The effect of keeping watches in holidays” has occurred rarely. And, that was similar for the items of Factor-4; “when the watch is at the weekend and in the official holidays” have rarely increased their MWL. They have also rarely felt the impact of Factor-5 “The effect of vessel cargo”.

### 3.3.2.2. Profile Variables and Mental Workload Factors

The relationship between profile variables and MWL factors was investigated. Student \( t \) Test for Independent Samples was performed depends on VTS Centres. It was determined that operators who employed at the Istanbul VTS-C had no significant (all \( p > .05 \)) different effects with the operators who employed at the Çanakkale VTS-C among the VTS-Os’ MWL factors.

According to the Independent Student \( t \) Test, it was determined that;
- There was not significant relationship between marital condition and MWL factors \( \left( t(58), \text{all} \ p > .05 \right) \),
- VTS-Os did not have different impacts of MWL factors with VTS-Ss, they had similar mental workload \( \left( t(55), \text{all} \ p > .05 \right) \),
- Operators who had less than 3 years VTS experience had similar impacts of MWL factors with operators had more than 3 years VTS experience, the relationship between VTS experience and MWL factors was not significant \( \left( t(58), \text{all} \ p > .05 \right) \).

The results of ANOVA revealed that there was no significant relationship between age and MWL factors, sea experience and MWL factors;
- Operators had similar impacts of mental workload factors based on their age \( \left( F(3, 46), \text{all} \ p > .05 \right) \).

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- There was not determined any significant difference based on different sea experience levels \([F(1, 58), \text{all } p > .05]\).
- It was also obtained that there was not statistical relationship between MWL factors and Operators’ passing ratio through the Turkish Straits \([F(5, 54), \text{all } p > .05]\).

### 3.3.3. Other Remarkable Results of Questionnaire

During executing the Factor Analysis, it was obtained that some items became one factor by itself. When the descriptive of these items were investigated, the results revealed as follows:
- “Q_38: When the ship takes a Pilot that increases my mental workload”. Pilot had an effective weight on VTS-Os’ MWL and increasing in mental workload has sometimes occurred due to taking a pilot.
- “Q_61: When my salary is not enough that increases my mental workload”. Operators have felt that when they were not satisfied with the salary, this very often increased their MWL as shown in Figure 4. 51% of TR Operators have always felt high mental workload due to the influence of salary.

![Figure 4: Distribution of TR Operators’ Rating on the Questionnaire Item 61](image)

- “Q_75: When the vacation is not enough that increases my mental workload”. The impact of this item has sometimes increased Operators’ MWL.
- “Q_77: My mental workload increases for coming at the end of ordinary watch”. Operators have very often felt to increase their MWL for coming at the end of watch.
- “Q_79: When the breaks among the watches is not enough that increases my mental workload”. Operators have felt that the breaks among the watch was not enough, and it affected to sometimes increase their MWL. Herein, it could be assumed that working condition had a remarkable effect on VTS-Os’ MWL. In addition, it was also determined that operators who engaged at the Istanbul VTS Centre had statistically similar ratings with the operators engaged at the Çanakkale VTS-C. They did not have any significant differences; not only based on the above items but also based on all items of the questionnaire due to all \(p > .05\), except Q_3 “When the traffic direction is two-way that increases my mental workload” \([t(56) = 2.68, p < .01]\) and Q_39 “When there is miss-communication with Pilot that increases my mental workload” \([t(56) = 2.29, p < .05]\).

Operator had significant difference impacts on their MWL considering to Q_3 and Q_39, Operators in the Istanbul VTS had felt high mental workload than Operators in the Çanakkale VTS based on these two items. The items (Q_71 and Q_72) were related to the area that ship navigating depended on her direction and whether this situation increased VTS-Os’ MWL or not. Figure 5 shows Operators’ judgments based on the Likert scale to illustrate how they have felt the variations of their mental workload while ship navigating in the different areas through the Istanbul Strait. The left side of Figure 5 illustrates when the traffic is North to South and the right side shows when the traffic direction is South to North. It was determined that the sub-items of 71 and 72 were significantly different (all \(p < .05\). Operators sometimes had high mental workload for the South Entrance of the Strait, then the area between Vaniköy and Kanlıca (known as critical area). Moreover, it was not determined any relationship among the profile variables and operators judgements for these items.
4. DISCUSSION

TR Operators’ MWL factors were obtained throughout the subjective assessment by carrying out a questionnaire survey. The results of Factor Analysis suggested that there were mainly five factors to affect Operators’ MWL. The model of these five factors could explain 79.1% of total variance. The results also revealed that the ship’s type and ship’s length became an added impact for the tankers, so they were assessed in combined as tankers that have over 150 m length.

It was determined that there were no significant differences among the TR Operators (in the Istanbul and Çanakkale VTS Centres) depended on MWL factors. In addition, it was determined that profile variables had no effect on MWL factors in the same safety culture. It is also important for the VTS Authorities to take operators’ opinions when there would be some changes, improvements related to VTS operation system.

The scale of questionnaire provided some meaning on the level of VTS-Os’ MWL and some factors frequently affect to increase mental workload whilst some of them did not. But it was a relative measure to assess the mental workload levels. On the other hand, the model of MWL factors could be considered to obtain VTS-Os’ MWL levels in quantitative. Herein, it is suggested to use Analytic Hierarchy Process (because of all factors were obtained independent) for the further study, then it can be obtained quantitative mental workload level for VTS Operators. Authors’ pervious study also pointed another quantitative mental workload level by using NASA Task Load Index as a common mental workload measure (Kum et al., 2008). So, the results of these two different indexes would be compared whether they would proof each other or not. Moreover, if the questionnaire has submitted to other VTS-Os in the different nationalities, it would have obtained different model of mental workload factors. But, it is assumed to obtain some sharing factors affecting VTS-Os’ MWL. A common assessment tool (e.g. VTS-Os’ Loading Index – VTS-O’LI) could be developed by using these sharing patterns.

To consider keeping operators’ mental workload in optimum level, in general, there are some ways to scale mental workload such as; changing or modifying the task, and changing operator’s internal conditions, modifying working and environment conditions (include modifications in ergonomics), training and system procedures, etc. These issues should be considered at the design stage of tasks; e.g. complicated tasks could be assigned to VTS-Ss or to VTS-Os who have more experience, the traffic density in one VTS Sector should be not over to handle by one operator, or it should be divided. Task scheduling and rostering of VTS-Os should also be considered by the management of VTS. Moreover, when the operators’ workload levels increase, the management of VTS is able to accommodate task sharing by considering VTS-Os’ manning. If the task items are so complex (or the task numbers are so high), the tasks also should be divided among the operators. And, if the multitask environment is too difficult for the operators, VTS-O’s competency should be considered. Furthermore, considering the design stage of VTS Centres, this study is just in good timing. Because Turkey commences the new 5 VTS Centres at Izmit Bay, Iskenderun Bay, Mersin Bay, Izmir Bay and Aliaga/Nemrut Region, where dangerous goods are handled, high traffic density is encountered and passenger transportation is carried out. The feasibility of these centres is currently underway in 2008.
5. CONCLUSION
This study is the first attempt to investigate VTS-Os’ MWL throughout the subjective assessment, and the mental workload factors are basically defined in this paper, as follows;

- The mental workload factors were obtained from the Factor Analysis as (highest effect to lowest); attitude of Ship Master (and Pilot), tankers over 150 m, satisfaction with other operators, keeping watches in holidays and vessel cargo. These factors could explain 79.1% of total variance increasing in the operators’ mental workload.
- It was also determined that some items had remarkable effects on operators’ mental workload such as; the ship takes pilot, ship’s sailing area, satisfaction with salary and working conditions, caused to increase VTS-Os’ mental workload
- It was not determined any significant relationship between profile variables and operators’ mental workload.

The assessment of VTS-Os’ MWL could offer several advantages to the management of VTS, such as; appropriate management strategies to minimize operator error for a given designed operation condition, either through preventative or mitigate strategies. These strategies may consist of assignment (and/or modifying) of the task, ergonomic aspects of the design (operation room and operator consoles), operators’ employment criteria, etc.

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7. REFERENCES


