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Measurement of Mental Workload with The NASA-TLX Method on Employees of PT XYZ

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ABSTRACT

PT XYZ is the largest maritime industry in Indonesia. The company focuses on producing ships and repairing ships both domestically and abroad. Human resources are the most important aspect in determining the success of a company. To increase employee work productivity, companies must pay attention to the physical workload and mental workload felt by employees. Uneven workload can cause complaints, so that productivity decreases and gets less than optimal results. Therefore, a mental workload measurement was conducted to determine the level of mental workload of employees using the National Aeronautics and space Administration Task load Index (NASA-TLX) method. The NASA-TLX questionnaire was distributed to 8 workers of the ISO, Standardisation and Calibration Department. Based on the highest WWL average value of 81.3 with a very high category. To improve the mental workload, the company is advised to evaluate labour needs in other departments or divisions to support additional employees through job rotation, provide regular job training to improve employee skills and speed in completing work, provide a storage area for tools to be calibrated so that employees are not disturbed by tools that accumulate in the workspace, procure new tools to support the increasing workload, conduct monitoring and job evaluation.

INTRODUCTION

The manufacturing industry is one of the sectors that helps in economic growth in a country, by expanding employment and increasing the level of public welfare. Vision and mission in a company is very important, because it will be the basis for the company to determine the strategy that will be carried out in the future [1]. In the operational process, every industry needs adequate facilities and infrastructure in achieving the productivity and effectiveness targeted by the industry [2].

To achieve goals, companies need to set up a management system so that it can run optimally by optimising their resources [3]. Human resources are one of the things that can determine the success or not of the industry in achieving its goals [4]. So it is important for employees to continue to improve their quality and abilities because it can affect performance in carrying out their work. Each employee has a different performance because it is related to the employees skills in completing the job. With good work skills, employees can improve work performance so that they get rewards from the company [5].

PT XYZ is the largest maritime industry in Indonesia. The company focuses on producing ships and repairing ships both domestically and abroad. In its production, PT XYZ prioritises modern and sophisticated technology in shipbuilding. So that employees must have adequate skills and abilities in accordance with the workload. To increase employee work productivity, companies must pay attention to the physical workload and mental workload felt by employees [6].

PT XYZ has a Technology & Quality Assurance (TQA) Division with 5 departments in it. The ISO, Standardisation & Calibration Department is one of the departments in the TQA Division. This department focuses on company standardisation and calibration services from internal and external parties. Each employee has different but continuous tasks. The work received by employees must be in accordance with the employee's capacity. There are two types of workload, namely, mental workload and physical workload [7]. [8] Workload or can be called work load is a comparison of the capacity or ability of the job with the demand or work that must be completed. The unevenness of the workload can cause complaints, so that productivity decreases and gets less than optimal results. So the company needs to measure workload, especially the mental workload of employees. When viewed physiologically, mental activities are a kind of light work that requires a low amount of calories. Whereas in terms of responsibility and morals, mental activities are very heavy if measured by the difference with physical activities because mental activities involve brain performance or can be called white-collar rather than physical performance or blue-collar [9].

This analysis was carried out by applying the National Aeronautics and space Administration Task load Index (NASA-TLX) method [10] NASA-TLX has 6 (six) dimensions to determine workload parameters, such as: mental needs (Mental Demand), physical needs (Physical Demand), time needs (Temporal Demand), performance (Performance), effort level (Effort), and frustration level (Frustration Level). From the six dimensions of the NASA TLX method, information on the level of employee workload is obtained and can be used as material for future decision making [11].

MATERIALS AND METHODS

The research was conducted at PT XYZ, ISO, Standardisation and Calibration Department using the NASA-TLX method. This research was conducted in December 2024. The NASA-TLX method is a method to analyse the mental workload faced by employees in doing work [12]. following are the steps used in conducting the research:

1. Problem Identification
   Problem identification is done by interview and direct observation with employees.
2. Literature Study
   Literature study is carried out to obtain information as the basis for the author's thinking in conducting research, using references in the form of books, existing research and journals.
3. Data Collection
   Data was collected using interviews and questionnaires to gather relevant information. With interviews, researchers can interact directly with employees, so as to know their perspectives regarding the workload that is being faced. The questionnaire used to collect data is the NASA-TLX questionnaire which contains rating and weighting assessments.
4. Data Processing
   collecting data, the data will be processed to measure the mental workload of employees. Data processing is done in the following way:

a. Calculating workload weights
b. Calculating the rating
c. Calculating Weighted Workload (WWL), product value, and average Weighted Workload WWL.
d. Workload categorisation [13]

Table 1. Indicators in the NASA-TLX Method

Scale	Code	Description
Mental Demand	MD	How often does your job involve mental activity, such as making decisions, quick thinking, or recall.
Physical Demand	PD	How often does your job involve physical activity, such as lifting, driving, pushing, and so on.
Temporal Demand	TD	To what extent do you feel pressure related to work completion deadlines? Is your work slow and leisurely, or fast and energising?
Performenc	P	To what extent have you been successful and how satisfied do you feel with your achievements?
Effort	EF	To what extent does your work involve physical and mental activity to complete your task?
Frustation	FR	To what extent do you feel safe, not hopeless, disturbed, or disturbed, compared to your feelings of security, comfort, and self-satisfaction?

Table 2. Workload classification [14].

Number	Value Range	Load Category
1	0% - 9%	Low
2	10% - 29%	Medium
3	30% - 49%	Somewhat High
4	50% - 79%	High
5	80% - 100%	Very High

Weighting

Table 3. Pairwise Comparison Questionnaire for Indicators [15]

Indicator Weighting		
Physical Demand	or	Mental Demand
Temporal Demand	or	Mental Demand
Performance	or	Mental Demand
Effort	or	Mental Demand
Frustration	or	Mental Demand
Temporal Demand	or	Physical Demand
Performance	or	Physical Demand
Effort	or	Physical Demand
Frustration	or	Temporal Demand
Performance	or	Physical Demand
Effort	or	Temporal Demand
Frustration	or	Temporal Demand
Effort	or	Performance
Indicator Weighting		
Frustration	or	Performance

Effort	or	Frustration

Rating Questionnaire

Respondents were asked to rate six indicators of mental workload, subjective rating with a range of 0% - 100% [16].

Table 4. *NASA-TLX method rating*

Indikator	Question	Rating
Mental Demand	To what extent does your job require mental and perceptual activity (such as thinking, making decisions, calculating, remembering, seeing, searching, and so on)? Does the work feel easy or difficult, simple or complex, and flexible or strict?	0% - 100%
Physical Demand	To what extent does your job require physical activity (such as pushing, pulling, twisting, controlling, etc.)? Does the work feel easy or difficult, slow or fast, relaxed or rushed, and continuous or does it allow time to rest?	0% - 100%
Temporal Demand	To what extent is time pressure experienced during work? Is the work done slowly and leisurely, or is it fast and energy-draining?	0% - 100%
Performance	To what extent did you achieve your work targets? Are you satisfied with your performance in achieving them?	0% - 100%
Effort	How much effort is required, both mentally and physically, to complete the work at the performance level?	0% - 100%
Frustration	To what extent do you feel insecurity, discouragement, offence, disregard, pressure and annoyance compared to feeling safe, content, suitable, cared for, relaxed and comfortable while doing the job?	0% - 100%

To perform data processing, the following is the formula for calculating Weighted Workload, product value, and average WWL:

a. *Weighted Workload Calculation*
   WWL = ∑ Products [17]
b. Product Value Calculation
   Product Value = rating x factor weight [18]
c. WWL Average Calculation
   Skor = $\frac{\sum(\text{Rating} \times factor\ weight)}{15}$ [19]

RESULTS AND DISCUSSIONS

1. *Respondent Data*

The amount of respondent data in this research is 8 employees. The following is the respondent profile data and indicator comparison data for each respondent.

Table 5. Respondent Profile

Respondents	Age	Gender
Respondent 1	34	Male
Respondent 2	27	Male
Respondent 3	33	Male
Respondent 4	49	Women

Respondent 5	34	Women
Respondent 6	36	Male
Respondent 7	38	Male
Respondent 8	25	Male

Source: data processed 2024

Indicator Comparison Table

Table 6. Indicator Comparison

Respondent	PD or MD	TD or MD	P or MD	E or MD	FR or MD	TD or PD	P or PD	E or PD	FR or TD	P or PD	E or TD	FR or TD	E or P	PD or P	E or FR
Respondent 1	MD	TD	P	MD	MD	TD	P	E	TD	P	TD	FR	P	PD	FR
Respondent 2	MD	TD	P	E	FR	TD	PD	E	TD	P	TD	TD	P	P	FR
Respondent 3	MD	MD	MD	MD	MD	TD	P	E	TD	P	E	TD	P	P	E
Respondent 4	MD	TD	MD	MD	MD	TD	P	E	TD	P	TD	TD	P	P	E
Respondent 5	PD	MD	P	E	MD	PD	P	E	TD	P	E	TD	P	PD	E
Respondent 6	PD	TD	P	MD	MD	TD	P	E	TD	P	TD	TD	P	P	FR
Respondent 7	MD	MD	P	MD	MD	TD	P	E	TD	P	TD	TD	P	P	E
Respondent 8	MD	MD	P	MD	FR	TD	P	PD	FR	P	E	FR	P	P	FR

Source: data processed 2024

2. Weighting

The value of weighting involves selecting influential descriptors and calculating their weights [20]. From the indicator comparison table data, respondent data is weighted. The following table recapitulates the weighting of respondent data:

Table 7. Recapitulation of Weighting Results

Respondents	Indicators						Total
	Mental Demand	Physical Demand	Temporal Demand	Performance	Effort	Frustation	
Respondent 1	3	0	4	4	1	3	15
Respondent 2	1	1	5	4	2	2	15
Respondent 3	5	0	3	4	3	0	15
Respondent 4	4	0	5	4	2	0	15
Respondent 5	2	2	2	4	4	1	15
Respondent 6	2	1	5	5	1	1	15
Respondent 7	4	0	4	5	2	0	15
Respondent 8	3	1	1	5	1	4	15
Total	24	5	29	35	16	11	
Percentage	20%	4%	24%	29%	13%	9%	

Source: data processed 2024

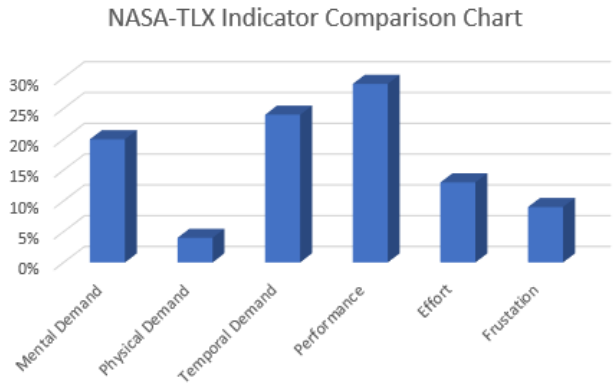

Figure 1. NASA-TLX Indicator Comparison Chart

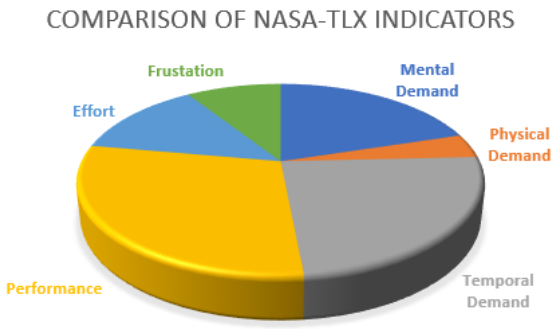

Figure 2. Comparison of NASA-TLX Indicator

From the NASA-TLX indicator comparison chart obtained from 8 respondents, it shows the weight of mental demand with a total of 24 and a percentage of 20%, physical demand with a total of 5 and a percentage of 4%, temporal demand with a total of 29 and a percentage of 24%, performance with a total of 35 and a percentage of 29%, effort with a total of 16 and a percentage of 13%, frustration with a total of 11 and a percentage of 10%.

The results of this study differ from research conducted by Adikarana et al. [16], in this study the indicator with the highest value is performance with a value of 29%. while by Adikarana et al. [16] performance indicators have a percentage value of 14%. As a comparison, Yasmin el al. [18] using the NASA-TLX method on measuring mental workload found that the temporal demand indicator was the dominant factor with a percentage value of 25.1%. In this study, the temporal demand indicator only reached a value of 24%. This difference can be caused by differences in the type of work received by employees and differences in the level of employee skills in completing work.

3. *Rating*

Employees are asked to rate the six mental workload indicators in the NASA-TLX method, Mental Demand (MD), Physical Demand (PD), Temporal Demand (TD), Performance (P), Effort (E), and frustration level (FR). Rating filling is subjective with a range of 0-100% according to the workload felt by employees. The following are the results of the recapitulation of ratings from employees of the ISO, Standardisation and Calibration Department.

Table 8. Rating

Respondents	Indicators					
	MD	**PD**	**TD**	**P**	**E**	**FR**
Respondent 1	75%	80%	75%	70%	75%	70%
Respondent 2	45%	45%	75%	70%	45%	25%
Respondents	**Indicators**					
	MD		**MD**		**MD**	
Respondent 3	90%	20%	75%	75%	75%	70%
Respondent 4	45%	40%	45%	40%	45%	45%
Respondent 5	70%	60%	90%	80%	90%	70%
Respondent 6	50%	50%	25%	45%	25%	40%
Respondent 7	95%	40%	60%	90%	75%	25%
Respondent 8	70%	45%	60%	90%	70%	40%

Source: data processed 2024

4. Produk Product Value Calculation

The following is the formula for calculating product value [18]:

Product Value = Rating x Factor Weight

Table 9. Product Value Calculation

Respondents	Indicators					
	MD	**MD**	**MD**	**MD**	**MD**	**MD**
Respondent 1	225	0	300	280	75	210
Respondent 2	45	45	375	280	90	50
Respondent 3	450	0	225	300	225	0
Respondent 4	180	0	225	160	90	0
Respondent 5	140	120	180	320	360	70
Respondent 6	100	50	125	225	25	40
Respondent 7	380	0	240	450	150	0
Respondent 8	210	45	60	450	70	160

Source: data processed 2024

5. C*alculate Weighted Workload (WWL)*

In calculating Weighted Workload (WWL), it can be done by adding up all product values. The following are the results of the Weighted Workload (WWL) calculation. The following is the calculation formula[17].

Weighted Workload **= ∑ Products**

Table 10. Weighted Workload (WWL) calculation

Respondents	Indicators						Total
	MD	**MD**	**MD**	**MD**	**MD**	**MD**	
Respondent 1	75	80	75	70	75	70	1090
Respondent 2	45	45	75	70	45	25	885
Respondent 3	90	20	75	75	75	70	1200
Respondents	**Indicators**						**Total**
	MD	**KF**	**MD**	**PK**	**MD**	**TF**	
Respondent 4	45	40	45	40	45	45	655

Respondent 5	70	60	90	80	90	70	1190
Respondent 6	50	50	25	45	25	40	565
Respondent 7	95	40	60	90	75	25	1220
Respondent 8	70	45	60	90	70	40	995

Source: data processed 2024

6. Calculation of Average Weighted Workload (WWL)

In calculating the average Weighted Workload (WWL) can be done by dividing the Weighted Workload value by the number of indicators as many as 15. The following are the results of the calculation of the average Weighted Workload (WWL).

$$\textbf{Skor} = \frac{\sum(\textbf{Rating} \times \textbf{Factor Weight})}{\mathbf{15}}$$ [19]

Table 11. Calculation of Average Weighted Workload (WWL)

Respondents	Indicators						Total
	MD	KF	MD	PK	MD	TF	
Respondent 1	75	80	75	70	75	70	72.7
Respondent 2	45	45	75	70	45	25	59.0
Respondent 3	90	20	75	75	75	70	80.0
Respondent 4	45	40	45	40	45	45	43.7
Respondent 5	70	60	90	80	90	70	79.3
Respondent 6	50	50	25	45	25	40	37.7
Respondent 7	95	40	60	90	75	25	81.3
Respondent 8	70	45	60	90	70	40	66.3

Source: data processed 2024

7. Score Interpretation

Score interpretation in the NASA-TLX method is done by classifying the average weighted workload (WWL) value that has been obtained into predetermined categories.

Table 12. Score interpretation

Respondents	Age	Average WWL	Classification
Respondent 1	34	72.7	High
Respondent 2	27	59.0	High
Respondent 3	33	80.0	Very High
Respondent 4	49	43.7	Somewhat High
Respondent 5	34	79.3	High
Respondent 6	36	37.7	Somewhat High
Respondent 7	38	81.3	Very High
Respondent 8	25	66.3	High

From the data above, it shows that the level of mental burden felt by employees in the ISO, Standardisation and Calibration Department during work as follows respondent 3 and respondent 7 are included in the very high category, due to the complexity of tasks obtained such as, being responsible for implementing ISO, determining SOP documents and decrees, planning and coordinating the activities of the quality assurance work program, being responsible for the results of calibrating equipment. Respondent 1 is in

the rather high category, because the tasks obtained such as ensuring quality and compliance with ISO standards apply in the company, being responsible for managing the quality management system, standardisation, and calibration, and coordinating across divisions and departments to support the success of company projects. Respondent 2, respondent 5 and respondent 8 fall into the high category, this is because the tasks obtained are simpler such as controlling calibration documents, inputting data on tool calibration results, processing calibration data, and calibrating tools. Respondent 4 and respondent 6 fall into the rather high category, with the tasks received by employees, namely calibrating tools and making reports on calibrated tools. With an average weighted workload (WWL) value of respondent 1 of 72.7; respondent 2 of 59; respondent 3 of 80; respondent 4 of 43.7; respondent 5 of 79.3; respondent 6 of 37.7; respondent 7 of 81.3; and respondent 8 of 66.3. The following is a graph of the NASA-TLX score of each respondent.

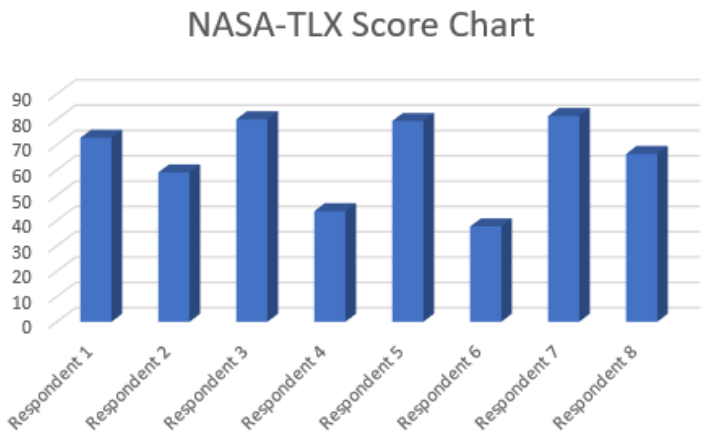

Figure 3. NASA-TLX Score Chart

CONCLUSION

Based on the results of mental load data processing using the NASA-TLX method, it is found that employees of the ISO, Standardisation and Calibration Department who fall into the rather high category are 2 people, the high category is 4 people, and the very high category is 2 people. With an average weighted workload (WWL) value of respondent 1 of 72.7; respondent 2 of 59; respondent 3 of 80; respondent 4 of 43.7; respondent 5 of 79.3; respondent 6 of 37.7; respondent 7 of 81.3; and respondent 8 of 66.3.

Each indicator shows the average results obtained, where the performance indicator has the highest value of 29%, which indicates that employees find it difficult to meet the expected performance standards. Meanwhile, the temporal demand indicator is in second place with a value of 24%, which indicates that employees feel pressured by the deadlines of the tasks that must be completed. Then the mental demand indicator is 20%, which shows that employees more often do mental-related work, such as decision making, thinking quickly or remembering. The fourth order is the effort indicator at 14% which shows that employees often do work that requires excessive multitasking. In fifth place is the frustration level indicator at 9% which shows employees have a low level of stress in doing work and in the last place is the physical demand indicator at 4% which shows employees rarely make physical efforts in completing work.

Based on the results of the analysis that has been carried out, the level of workload in the ISO, Standardisation and Calibration Department is quite high. This can be seen from the results of the scores obtained from respondents which show that employees feel pressured by the workload received. The analysis above shows that there are 3 most dominant indicators, namely performance indicators, temporal demand, and mental demand. Then 3 indicators in the lowest order are indicators of effort, indicators of frustration levels, and indicators of physical demand. The following suggestions for improvement can be made, namely evaluating labour needs in other departments or divisions to support additional employees through job rotation, providing regular job training to improve employee skills and speed in completing work, providing a storage area for tools to be calibrated so that employees are not disturbed by tools that accumulate in the workspace, procuring new tools to support increased workloads, conducting monitoring and evaluation of work every week, and providing rewards if employee work results are very good.

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