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Evaluation of the Train Drivers Mental Workload to Increase Well-being

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Abstract

Indonesia's logistics system is crucial for economic growth, with high costs impacting competitiveness and the economy. Transportation is the most dominant component, ensuring mobility and impacting national development. PT Angkutan Barang (PT AB)provides efficient railway transportation services. Despite a 70% drop in passenger transportation revenue during the COVID-19 pandemic, freight transportation increased by 18.3% in 2021, supporting the company's performance during a crisis. The company's increased coal transportation targets require more train drivers, for smooth operation. However, strict training and tight schedules can disrupt train driver's fulfillment and increase the likelihood of overtime. Long working hours can cause fatigue and stress and increase the risk of accidents, impacting the company's operations and causing significant losses. Thus, train drivers play a crucial role at PT AB, and it is important to assess their mental workload to ensure their mental health using the RNASA-TLX method. The study examines the mental workload of 181 train drivers at Tanjungenim Freight Train Drivers Unit, finding an average score of 61.03, classified as "Moderate". Freight train drivers' mental workload is significantly influenced by visual, temporal, auditory, and mental demands, with schedule uncertainty and unique work environments being the most influential factors. Train driver's mental workload varies, with 52 having a low workload, affecting boredom, productivity, and human error, and 42 having a high workload, potentially requiring stress management training.

Keywords: Mental Workload, RNASA-TLX, Transportation, Trains Drivers

1. Introduction

Indonesia's logistics system is crucial for its economic growth, as logistics companies ensure smooth goods and services flow, driving development (ANTARA, 2023). According to Ministry of Finance of the Republic of Indonesia (2023), the country ranked 46th out of 160 countries in 2018 and has high logistics costs, reaching 23.5% of GDP in Q1 2021. Logistics costs significantly impact a company's competitiveness and the economy. Transportation is the most dominant component of the logistics structure, ensuring mobility and impacting national development. Indonesia's Minister of Transportation, Budi Karya Sumadi, highlighted the crucial role of transportation logistics in the country's economic growth, despite the Covid-19 pandemic's impact (Ferdian, 2021). Rail transportation is a popular mass transportation mode, facilitating the movement of people and goods between regions.

Vol. 8, No.03; 2024

ISSN: 2456-7760

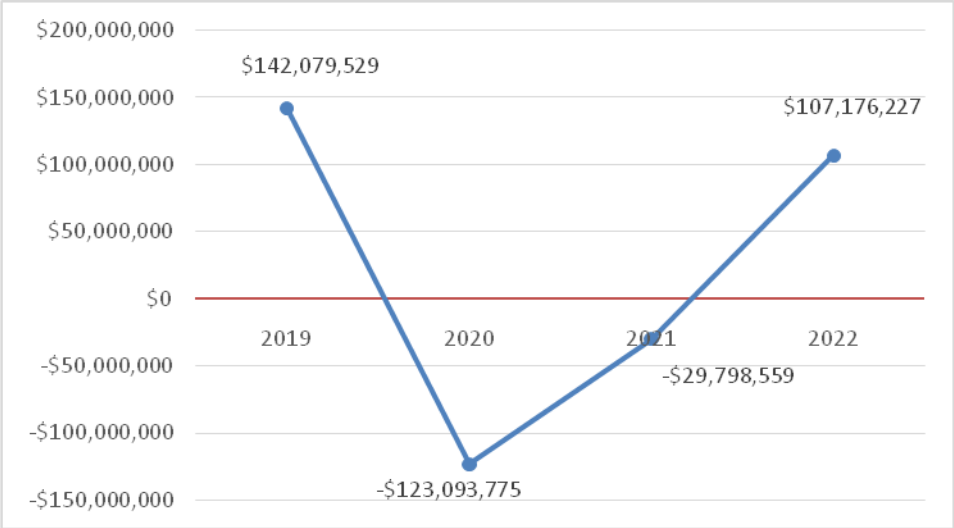

Figure 1. PT AB net income trend

PT Angkutan Barang, also known as PT AB, is an Indonesian company in the transportation sector crucial for the country's logistics and transportation needs. The company provides efficient and secure railway transportation services, ensuring a seamless logistics process and accurate distribution of passengers or goods. During the COVID-19 pandemic, passenger transportation revenue fell by 70,30% in 2020 and 17.49% in 2021 (Table 1), leading to a net loss of up to $123million in 2020 (Figure 1). However, freight transportation fell by 8,26% in 2020 but increased by 18.33% in 2021, making it a vital revenue stream that supports the company's performance during a crisis (Table 1).

Table 1.PT AB Revenue Stream Trend 2019-2022

Revenue Source	2019	2020	2021	2022
Passenger Transportation	15,86%	-70,30%	-17,49%	194,70%
Freight Transportation	8,72%	-8,26%	18,33%	31,87%
Other Revenue	11,08%	-11,07%	8,80%	8,06%

Freight transport has contributed significantly to PT AB revenue stream, accounting for more than 40% of total revenue from 2020 to 2022 (see Figure 2).

Vol. 8, No.03; 2024

ISSN: 2456-7760

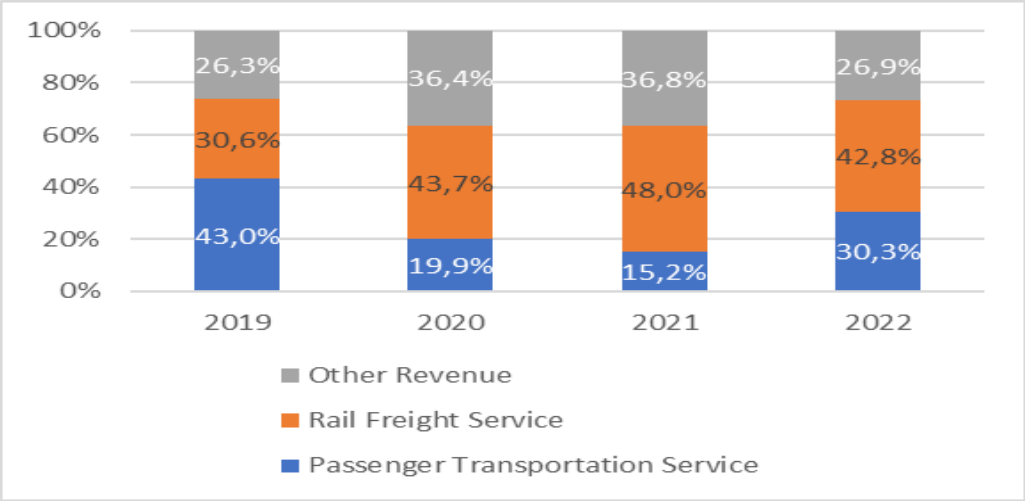

Figure 2.PT AB Revenue Composition (%)

PT AB accelerated its freight transport performance, transporting 48,4 million tons in 2020,53,6 million tons in 2021, and 61.9 million tons in 2022 (Figure 3). The consistent upward trend in freight transportation from year to year indicates a growing demand for freight services that can drive increased revenue and company growth.

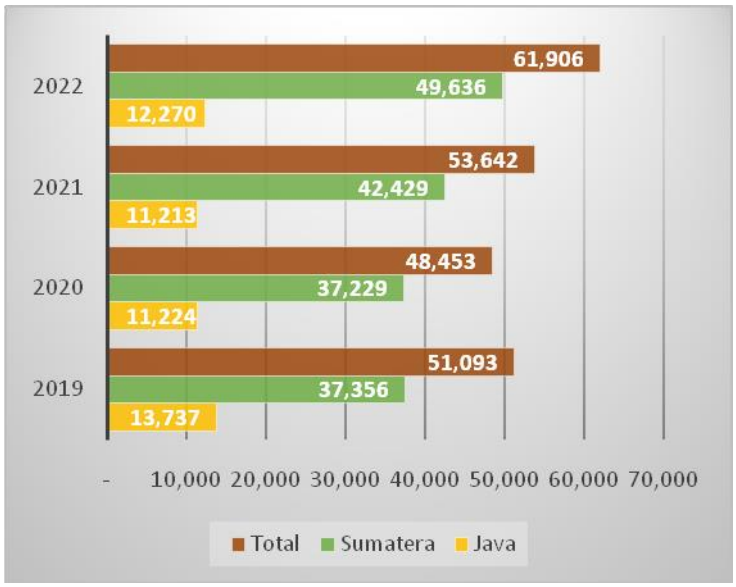

Figure 3.PT AB Proportion of freight transports area in thousand tons

The freight transportation sector has vast prospects in Java and Sumatra. In Java, the company can shift container transport from highways to railways, leveraging the advantage of the congested road network. In Sumatra, the freight transportation potential spans commodities such as coal, cement, fuel, Crude Palm Oil (CPO), and other goods. Coal is a freight commodity with the largest proportion transported by rail, reaching more than 80% in an average of four years of

Vol. 8, No.03; 2024

ISSN: 2456-7760

total rail freight transportation (Table 2). Rail freight for coal is in Sumatra area, with Tanjung Enim as the primary mining location, with 28.81 million tons in 2022 (PT Bukit Asam Tbk, 2023) or 58.04% of the total freight transportation in Sumatera (49.6 million tons). President Director of PT Bukit Asam Tbk, Arsal Ismail, announced that the coal transportation volume for Tanjung Enim Baru - Tarahan and Tanjung Enim Baru - Kertapati relations will increase to 35 million tons in 2027 following the signing of the coal transportation cooperation agreement (Mahardhika, 2023).

Table 2.PT AB Composition Freight Transport Volume

Freight Transport	2019	2020	2021	2022	Average
Coal	78,21%	81,45%	82,89%	85,47%	82,01%
Cement	6,58%	5,29%	4,16%	2,76%	4,70%
Container	5,61%	5,03%	4,46%	4,29%	4,85%
Feul (BBM)	4,10%	4,42%	4,15%	3,79%	4,11%
Plantation	1,90%	1,97%	1,49%	1,30%	1,67%
Parcel	3,13%	1,42%	2,08%	2,17%	2,20%
Other	0,47%	0,42%	0,77%	0,22%	0,47%

The increase in coal transportation targets necessitates a rise in train trips, necessitating effective trip management and increased train drivers amount for smooth train operation. To fulfill train drivers' needs, the company recruits and trains workers, taking two years to become competent. However, the long training process and strict certification requirements can disrupt train driver's fulfillment. In addition, the increase in coal transportation targets has led to increased train schedules. This increase has resulted in tighter train schedules, leaving little room for flexibility.

In scenarios with constraints or disruptions to the journey - such as delays due to maintenance, weather conditions, unforeseen incidents or tarin driver's shortage - these tight schedules can cause significant challenges. One of the most notable implications is the increased likelihood of train drivers having to work overtime. As a result, some train drivers work overtime to meet freight transportation targets. In 2022, the average overtime of train drivers will be 50.11 hours each month (Human Resources Division of PT AB), which can cause fatigue and stress so increase the potential for train accidents.

Train accidents occur yearly, with 18 accidents in 2020 and 2021 and 10 accidents in 2022. Despite the decrease, the accident realization is still above the company's tolerance. Palembang has the highest accident rate, with six, eight, and three accidents, respectively, from 2020 to 2022 (Safety Division of PT AB). According to the Directorate General of Railways, factors contributing to train accidents include facilities, infrastructure, human resources, operations, and supervision.

Freight transportation is a major source of income for the company, which can support the company during a crisis. However, the company needs adequate resources, including train drivers. Long working hours for train drivers at the Tanjungenim Freight Train Drivers Unit, a large coal loading yard, can cause fatigue and stress, affecting train drivers' physical and mental

Vol. 8, No.03; 2024

ISSN: 2456-7760

health. This condition increases the risk of train accidents and decreases the productivity of train drivers, impacting the company's operations and causing significant losses. So, this research aims to measure the train driver's mental workload using RNASA-TLX and to provide recommendations for PT AB on how to optimize train driver's mental workload management.

2. Literature Review

Muslimah & Hastuti (2017) researched measuring the mental workload experienced by train drivers using the RNASA-TLX method when the work is carried out morning-afternoon and evening and knowing the noise exposure on the PRAMEKS Train (passenger train transport). The results showed that PRAMEKS train drivers exhibit high RNASA-TLX scores (>80), indicating a "high" mental workload.

The most influential factor in mental workload is visual demand, followed by auditory demand, the second most influential factor. Mental demand is the third most influential factor, and temporal demand is the fourth most influential factor. The two factors that have the least influence on mental workload are difficulty in understanding information and difficulty in driving.

3. Method

Workload management is crucial in today's world, as companies aim for productivity and workers seek reduced tasks. De Waard & Brookhuis (1996) defines workload as the effect of demand on information processing and energy, while Hart (2006) defines workload as mental or physical effort to reach a specific performance level.

Modern studies have shifted focus from physical workload to broader types like psychomotor, perceptual, and communication workload (Miller, 2001). Mental workload is increasingly important, especially for jobs that don't require physical energy, like drivers (Miller, 2001). Mental workload (MWL) measures the resources required by a task or combination of tasks (Stanton et al., 2017) and can be conceptualized as the interaction between system structure and tasks, as well as the capabilities, motivation, and state of the human operator (Pauzie, 2008). Accurate measurement of mental workload is crucial in different situations (De Waard & Brookhuis, 1996).

Miller (2001) identifies three methods for measuring workload: Performance, Physiological, and Subjective. Performance measures the effectiveness of accomplishing a task (Paas & Vanmerrienboer, 1993), while Physiological measures determine the body's response to mental work. Primary and secondary tasks are two basic techniques for Performance measures (Yeh & Wickens, 1988). However, these measures may not accurately reflect workload when tasks are too simple (Miller, 2001).

Physiological measures measure the body's response to physical activities, such as heart rate and breathing, but this may not always be valid due to physiological responses to other factors than the amount of mental work. (Miller, 2001). Subjective measures reflect the amount of information used in working memory (Yeh & Wickens, 1988). Despite the differences between

Vol. 8, No.03; 2024

ISSN: 2456-7760

subjective and physiological workload assessments, research has shown a correlation between subjective evaluations and physiological indicators of workload (Tattersall & Foord, 1996).

Miller (2001) said "According to Hill et al. (1992), citing the results of Sheridan (1980), opponents of physiological measures argue that subjective measures are accurate indicator of workload, and increasing numbers of studies have found operator ratings to be a more direct indicator of workload than physiological measures".

Miller (2001) explains Subjective evaluations can be classified into unidimensional and multidimensional ratings. Unidimensional scales are easy to use due to their lack of complex analysis methods, while multidimensional scales, encompassing three to six aspects, are more complex and time intensive. NASA Task Load Index Scale (NASA-TLX), Subjective Workload Assessment Technique (SWAT), and The Multi-descriptor scale (MD) are some multidimensional workload calculation techniques. NASA-TLX is the most widely adopted and recognized multidimensional method for accurately assessing subjective workload.

Hill et al. (1992) argue that NASA-TLX is highly effective for measuring mental workload and is known for its sensitivity to workload changes and high diagnostic value. The NASA-TLX uses six dimensions: mental demand, physical demand, temporal demand, performance, effort, and frustration. The final workload score ranges from 0 to 100.

According to Cha and Park (2001), citing the result of Pauze et al's (1995), NASA-TLX has several problems, such as not considering vehicle automation trends, not considering perceptive and cognitive aspects of workload, and performance not considering objective data. Cha and Park (1997) tested different NASA-TLX versions to find the optimal one for Korean drivers called Revised NASA Task Load Index (RNASA-TLX). RNASA-TLX measures the mental effort needed to use a car's information system, including mental demand, temporal demand, difficulty in driving, visual, auditory, and information-related factors.

Cha and Park (2001) compared four tools for measuring driver mental workload during in-car navigation-based tasks, finding that RNASA-TLX was the most sensitive and acceptable method. It specifically assesses driver workload in the same step as NASA-TLX, using modified dimensions such as mental demands, visual demands, auditory demands, temporal demands, difficulty in driving, and difficulty understanding information. So, the RNASA-TLX is a method used to accurately assess the mental workload experienced by train drivers while operating the train (Damayanti & Yuke, 2012).

3.1 RNASA-TLX Method

The study uses the Revised NASA Task Load Index (RNASA-TLX) method to analyse train driver's mental workload. The RNASA-TLX is a multidimensional rating procedure that provides an overall workload score based on six subscales: mental demand, visual demand, temporal demand, auditory demand, difficulty in driving, and difficulty in understanding information (Cha and Park, 1997). The data collected from questionnaires is then analyzed using the RNASA-TLX method, which typically involves several stages.

Vol. 8, No.03; 2024

ISSN: 2456-7760

Each participant's responses are evaluated based on the six subscales of the RNASA-TLX. According to Hill et al. (1992), participants were instructed to assess two subscales using the pairwise comparison method. During this procedure stage, a numerical value is allocated to each dimension. The weight can vary between 0, representing the minimum value, and 5, representing the maximum value. The total weight attributed to the dimensions is 15. This sum represents the quantity of pairwise comparisons conducted in the study. The approach to allocating weight guarantees that every dimension is adequately included in the comprehensive analysis. The data analysis considers all relevant elements, offering a well-rounded and thorough perspective (Hill et al., 1992). The tally count for each dimension will determine the weight assigned to the related subscale.

The participants were also instructed to evaluate the six subscales. The ratings were assessed using a numerical scale ranging from 0 to 100 (Hill et al., 1992), with 0 indicating the minimum level of the measured attribute and 100 indicating the maximum level. These scores indicate the unprocessed ratings.

Table 3.RNASA-TLX Questionnaire

RNASA-TLX			
No	Subscale	Endpoints	Description
1.	Mental Demand (MD)	Low / High	How much mental stress is involved in running trains, i.e., staying on track, complying with signaling & watchwords, and other train-running-related activities?
2.	Visual Demand (VD)	Low / High	How much visual activity is required to recognize information such as signals, watchwords, or other things while running the train?
3.	Temporal Demand (TD)	Low / High	How much time pressure is experienced when operating trains?
4.	Auditory Demand (AD)	Low / High	How much auditory activity is required to recognize or hear information while operating the train?
5.	Difficulty in driving (DD)	Low / High	How difficult it is to operate a train compared to other vehicles?
6.	Difficulty in understanding information (DU)	Low / High	How difficult is it to understand the information on the locomotive control system, signaling, or watchwords when operating a train?

Hill et al. (1992) propose a method to determine the overall weighted workload (OWL) score. This score is obtained by multiplying each rating by its corresponding dimension weight which is called weighted workload (WWL) and dividing the sum by 15, representing the total weight

Vol. 8, No.03; 2024

ISSN: 2456-7760

subscale. This technique evaluates the influence of each aspect based on its significance, providing a more comprehensive understanding of the whole task.

In the last phase, the data is analyzed, conclusions are drawn, and recommendations may be formulated based on the results. Hancock & Meshkati (1988) as cited in Handoko & Erlangga, (2020) classified the interpretation of scores on the RNASA TLX into three unique categories (see Table 4).

Table 4.Overall Weighted Workload Category

Score	Category
<50	Low
50-80	Moderate
>80	High

3.2 Participant Characteristics

Tanjungenim Freight Train Drivers Unit is a unit that manages train drivers as train operators who handle freight railway transportation. The number of train drivers in Tanjungenim Freight Train Drivers Unit is 181, and it has 81 prospective train drivers and two prospective workers (Human Resources Division of PT AB).

Train drivers are workers who have passed the certification of skills as train drivers and can legally operate trains. Prospective train drivers are workers in the training stage as train drivers, so they can only run trains once they complete training and pass certification as train drivers. Prospective workers are new workers still in the apprenticeship and induction program stages. In this study, to assess the mental workload of train drivers, the sample used was 181, which is the number of train drivers who have been assigned to operate trains, so the sample is workers who feel the mental workload when operating trains. This research was conducted from November 2 to 10, 2023 in Tanjungenim, Palembang.

3. Results& Discussion

According to Operation Division of PT AB, train driver act as a leader, and completes various documents and reports. Before operating a train, they undergo a medical examination and pre-service assessment, including a readiness interview, proficiency demonstration, and ensuring they have all necessary documents and equipment. Once declared fit, they hand over the locomotive to a train inspector, check the completeness of go and no-go items, and test the operational readiness of the train set. Once everything is in order, they begin operating the train according to the scheduled timetable to the destination. The Tanjungenim Freight Train Drivers Unit currently has 181 train drivers operating freight trains.

3.1Train Drivers Mental Workload (RNASA-TLX) Score

According to Table 5, The study reveals that 48.07% (87) of train drivers out of 181 respondents fall into the 'Moderate' category, followed by 'Low' (20.73%) and 'High' (23.20%).

Vol. 8, No.03; 2024

ISSN: 2456-7760

Table 5. Proportion of Category RNASA-TLX

OWL Category	Quantity	Percentage
Low	52	28,73%
Moderate	87	48,07%
Hight	42	23,20%

Table 6 displays a total weighted workload score of 11,046.67 for a group of 181 train drivers, with an average score of 61.03 per person. The score suggests a mental workload that is at a "Moderate" level. This discovery is consistent with the data shown in Table 5, which indicates that 48.07% of train drivers reported encountering a moderate level of mental workload.

Table 6. Average RNASA-TLX

Respondent	Subscale Product	Rating*	Weight**	Amount***	WWL****	OWL*****	Average OWL******	Category
181	MD	8040	587	29630	165700	11046,67	61,03	Moderate
	VD	14690	629	51880				
	AD	13530	442	33130				
	TD	10450	584	35150				
	DD	7120	185	7190				
	DU	5460	288	8720				

Notes:

* : Σ each subscale rating from the respondent

** : Σ each subscale Weight from each respondent

*** : Σ rating × weight from each respondent

**** : Σ amount

***** : WWL ÷ 15

***** : OWL ÷ Σ Respondent

The study's findings contrast with those of Muslimah & Hastuti (2017), who categorized the mental workload of PRAMEK train drivers as "High". The study reveals a discrepancy between the results and Muslimah & Hastuti's (2017) findings, possibly due to differences in train types. PRAMEKS, a passenger transportation train, has an on-time schedule, requiring train drivers to focus without rest, resulting in a high mental workload score. In contrast, freight trains in the Palembang area operate with schedule uncertainty due to potential disruptions or delays, resulting in waiting periods for drivers and providing rest and breaks. This work pattern, characterized by periods of activity and rest, likely explains the "Moderate" mental workload

Vol. 8, No.03; 2024

ISSN: 2456-7760

level observed among the sample of freight train drivers at Tanjungenim Freight Train Drivers Unit. This explanation was obtained during an interview with a train driver with extensive experience operating trains in Java and Sumatra regions.

3.2RNASA-TLX Subscale Evaluation

Train driver's mental workload is assessed based on six subscales: mental demands (MD), visual demands (VD), auditory demands (AD), temporal demands (TD), difficulty in driving (DD), and difficulty in understanding information (DU).

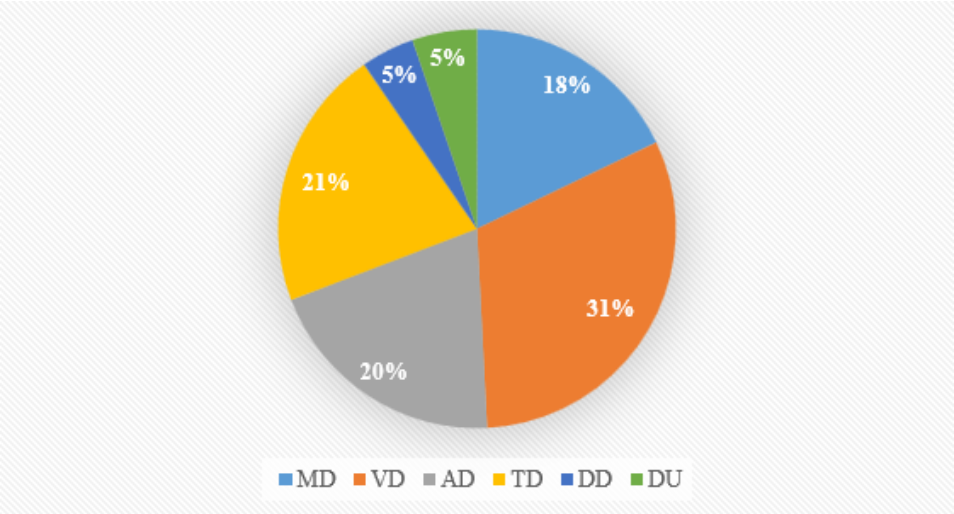

Figure 4 RNASA-TLX subscale score proportion

The study (see Figure 4) reveals that visual demand, which accounts for 31% of the overall mental workload, is the most significant factor affecting freight train drivers' mental workload. This is due to the high visual activity required to recognize information such as signals and track conditions during a train trip. On the other hand, Train drivers who operate trains on tracks with minimal disturbances often experience boredom and sleepiness, which can lead to a heavy focus on visual activities. Temporal demand accounts for 21% and is the second-highest influence on freight train drivers' mental workload, likely due to schedule uncertainty. Freight trains often encounter delays and disruptions due to loading/unloading queues in the Sumatra region, leading to adjustments by train drivers, such as modifying stopping points and potentially leading to longer travel times. The study differs significantly from Muslimah & Hastuti's (2017) study, which identified Temporal Demand as the fourth most impactful factor on passenger trains with fixed schedules, highlighting the significant impact of scheduling variations on mental workload in freight train operations.

Auditory demand, which accounts for 20%, is the third most influential factor on freight train drivers' mental workload. This demand refers to the cognitive effort required for processing auditory information during train operation. Train drivers engage in various auditory activities, such as communication with the control centre or station officer via radio, voice signals, and remaining vigilant for unusual sounds from the locomotive or track.

Vol. 8, No.03; 2024

ISSN: 2456-7760

Mental demand is the fourth most influential factor affecting freight train drivers' mental workload, contributing 18%. This is partly due to the unique work environment, such as operating in remote forest areas away from populated settlements, which can amplify the perceived risk and potentially heighten mental demands. The study's findings align with Muslimah & Hastuti's (2017) emphasis on Mental Demand, but the slight discrepancy likely stems from the focus on environmental factors and inherent job responsibilities rather than uncertain work schedules.

Difficulty in driving and difficulty in understanding information are the least influential factors on freight train drivers' mental workload, each contributing only 5%. The continuous comprehensive training provided to train drivers, including government-issued licenses and regular assessments, will likely equip them with the necessary skills and knowledge to handle routine driving tasks, minimizing the impact on overall mental workload.

4. Conclusion

4.1Tanjungenim Freight Train Drivers Unit Mental Workload

A train driver's task is operating a train, acting as a leader, and completing necessary documents and reports. Before operating the train, they undergo a medical examination and pre-service assessment, which includes a readiness interview, proficiency demonstration, and ensuring they have all necessary documents and equipment.

As a company's coal transportation targets rise, there is a corresponding increase in train travel. This necessitates effective travel management and an expansion in the workforce of train drivers. The surge in train schedules can lead to a tightly packed timetable. In situations where there are travel constraints, train drivers may be forced to work overtime. This can result in fatigue and stress, escalating the risk of train accidents. Furthermore, stringent training and certification prerequisites can pose challenges in meeting the demand for train drivers. This often results in existing train drivers having to take on additional work schedules to compensate for the shortage of train drivers.

This study examines the mental workload of 181 train drivers at Tanjungenim Freight Train Drivers Unit using an RNASA-TLX instrument, resulting in an average score of 61.03, categorized as "Moderate". Semi-structured interviews with freight and passenger train drivers reveal distinct workload profiles: freight train operation presents opportunities for intermittent rest during queueing, whereas passenger trains demand continuous focus due to stringent schedules. These contrasting work demands suggest that overtime may have a differential impact on mental workload, with passenger train drivers potentially experiencing greater strain. Investigating this relationship within the specific context of Tanjungenim Freight Train Drivers Unit, where freight train overtime is prevalent.

4.2Treatment for Low-High Mental Workload Train Driver's

According to Table 5, a total of 52 train drivers (see) out of 181 samples had low mental workload. Based on interviews with train driver instructor supervisors, train drivers with low mental workloads are due to the train driver's confidence in their ability to run trains because the work is routine, so it is not a burden for train drivers. According to Ghanavati et al. (2019), low mental workload can negatively impact worker productivity and work capacity. Research has

Vol. 8, No.03; 2024

ISSN: 2456-7760

indicated that a decreased mental workload might result in decreased job ability and performance, along with increased human errors. When workers have a low mental workload, they may experience boredom, which can lead to disengagement and reduced motivation (Mawson, 2022).

So, the company needs to provide development in the form of a moving workplace that requires a train driver to understand a new line that has different and more complex environmental conditions. By offering these opportunities, organizations can help train drivers acquire new competencies. This process can increase their mental workload, as they are required to process new information and apply it to their roles. This strategy also provides valuable insights for continuous learning and performance improvement. In addition, the company also needs to recognize train drivers' efforts and provide constructive feedback to boost morale and motivation. It's important to note that these strategies should be implemented carefully to avoid overwhelming train drivers, which could lead to burnout. Balancing these elements effectively is critical to maintaining a productive and engaged workforce. These recommendations could be beneficial for train drivers with low workloads, as they provide avenues for growth and engagement.

Based on Table 5, 42 train drivers have a high mental workload. High mental workload is associated with reduced work ability and performance, as well as increased human errors (Ghanavati et al., 2019). According to Causse (2022), High mental workload can lead to increased stress and cognitive strain, which may negatively impact workers' well-being and productivity. Based on the explanation from the train driver instructor supervisor, train drivers who have a high workload are train drivers who are new to the Tanjungenim area and workers who have personal problems outside of work. The company needs to provide training in stress management, cognitive strategies, and task-specific skills to reduce the mental workload of new train drivers working in the region. Hence, workers cope with high mental workload more effectively. As for train drivers who have personal problems that interfere with work, companies need to regularly monitor train driver's mental workload and provide support when signs of excessive strain are identified. This action can help prevent adverse outcomes.

4.3Factors Affecting Train Drivers Mental Workload

A study reveals that visual, temporal, auditory, and mental demands are the biggest factors affecting freight train drivers' mental workload. Visual demand, accounting for 31% of the overall mental workload, is due to the high visual activity required to recognize information during a train trip. Temporal demand, 21%, is due to schedule uncertainty, with delays in the South Sumatra region causing train drivers to adjust stopping points and travel times. Auditory demand, 20%, is the third most influential factor, with mental demand contributing 18% due to working responsibly and the unique work environment. Difficulty in driving and difficulty in understanding information are the least influential factors.

4.4Research Limitation and Future Research Directions

While this study sheds light on the mental workload of train drivers, its generalizability is limited by focusing solely on freight train drivers at the Tanjungenim Unit. Future research should address this by investigating a broader sample of train drivers across diverse sectors (passenger

Vol. 8, No.03; 2024

ISSN: 2456-7760

rail, high-speed rail) and geographic locations. This will allow researchers to assess if the observed workload patterns hold true for different train types and operational contexts. Additionally, future studies could delve deeper into specific factors influencing workload beyond extended working hours. Examples include route complexity, train variations, and passenger interactions (especially relevant for passenger train drivers). By incorporating these elements, future research can provide a more comprehensive picture of the mental workload of train drivers and pave the way for targeted interventions to ensure optimal well-being and safety across the entire rail industry.

References

ANTARA News. (2023). *Dukung Pertumbuhan Ekonomi Nasional, Perusahaan Logistik Terus Berikan Dampak Positif*. Retrieved on December 15, 2023, from https://www.antaranews.com/.

Causse, et al. (2022). *Facing successfully high mental workload and stressors: An fMRI study*. Human Brain Mapping, 43(3), 1011-1031.

Cha, D. W., & Park, P. (1997). *User required information modality and structure of in-vehicle navigation system focused on the urban commuter*. Computers & Industrial Engineering, 33(3-4), 517-520.

Cha, D. W., & Park, P. (2001). *Comparative study of subjective mental workload assessment techniques for the evaluation of ITS-oriented Human-Machine Interface systems*. Journal of Korean Society of Transportation, 19(3), 45-58.

Damayanti, K. A., & Cantikawati, Y. (2012). *Pengukuran Beban Kerja Mental Masinis Kereta Api Rute Jarak Jauh (Studi Kasus Pada PT KAI DAOP 2)*.

De Waard, D., & Brookhuis, K. A. (1996). *The measurement of drivers' mental workload*.

Ghanavati, et al. (2019). *Assessment of mental workload and its association with work ability in control room operators*. La Medicina del Lavoro, 110(5), 389.

Hancock, P. A., & Meshkati, N. (Eds.). (1988). *Human mental workload (Vol. 52)*. Amsterdam: North-Holland.

Handoko, H., Churniawan, E., & Erlangga, A. W. (2020). An Analysis of the Impact of Workload towards the Risk of Fatigue Level on PT KCI Machinists. International Journal of Multicultural and Multireligious Understanding, 7(10), 70-78.

Hart, S. G. (2006). *NASA-task load index (NASA-TLX); 20 years later*. In Proceedings of the human factors and ergonomics society annual meeting (Vol. 50, No. 9, pp. 904-908). Sage CA: Los Angeles, CA: Sage publications.

Hill, S. G., Iavecchia, H. P., Byers, J. C., Bittner Jr, A. C., Zaklade, A. L., & Christ, R. E. (1992). *Comparison of four subjective workload rating scales*. Human factors, 34(4), 429-439.

Ferdian, A. (2021). *Pentingnya Transportasi Logistik bagi Perekonomian Indonesia*. Retrieved on December 16, 2023, from Kompas.Com. https://otomotif.kompas.com/read/2021/06/08/192100115/pentingnya-transportasi-logistik-bagi-perekonomian-indonesia.

Vol. 8, No.03; 2024

ISSN: 2456-7760

Mawson, A. (2022). *How an understanding of mental workload can boost performance*. Personnel Today. Retrieved January 5, 2023, from https://www.personneltoday.com/hr/how-an-understanding-of-mental-workload-can-boost-performance/.

Ministry of Finance of the Republic of Indonesia. (2023). *Tantangan Sektor Logistik di Indonesia*. Retrieved on December 15, 2023, from https://www.kemenkeu.go.id/informasi-publik/publikasi/berita-utama/Tantangan-Sektor-Logistik-di-Indonesia.

Miller, S. (2001). *Literature review: Workload measures*. The University of Iowa.

Muslimah, E., & Hastuti, B. D. (2017). *Evaluasi Beban Kerja Mental Masinis Kereta Api Prameks dengan Metode RNASA-TLX (Studi Kasus: PT. KAI DAOP 6 YOGYAKARTA)*. In Prosiding Seminar dan Konferensi Nasional IDEC.

Mahardhika, L. A., & Hafiyyan. (2023, October 12). PTBA Gandeng KAI, Targetkan Angkutan Batu Bara 35 Juta Ton. Retrieved on December 17, 2023, from https://market.bisnis.com/read/20231012/192/1703593/ptba-gandeng-kai-targetkan-angkutan-batu-bara-35-juta-ton.

Paas, F. G., & Van Merriënboer, J. J. (1993). *The efficiency of instructional conditions: An approach to combine mental effort and performance measures*. Human factors, 35(4), 737-743.

Pauzié, A., Sarpedon, A., & Saulnier, G. (1995). *Ergonomic evaluation of a prototype guidance system in an urban area. Discussion about methodologies and data collection tools.* In Pacific Rim TransTech Conference. 1995 Vehicle Navigation and Information Systems Conference Proceedings. 6th International VNIS. A Ride into the Future (pp. 390-396). IEEE.

Pauzié, A. (2008). *A method to assess the driver mental workload: The driving activity load index (DALI)*. IET Intelligent Transport Systems, 2(4), 315-322.

PT Bukit Asam Tbk. (2023). *Pengangkutan*. Retrieved on December 17, 2023, from https://www.ptba.co.id/bisnis-kami/batubara.

Stanton, N. A., Salmon, P. M., Rafferty, L. A., Walker, G. H., Baber, C., & Jenkins, D. P. (2017). *Human factors methods: a practical guide for engineering and design*. CRC Press.

Tattersall, A. J., & Foord, P. S. (1996). *An experimental evaluation of instantaneous self-assessment as a measure of workload*. Ergonomics, 39(5), 740-748.

Yeh, Y. Y., & Wickens, C. D. (1988). *Dissociation of performance and subjective measures of workload*. Human factors, 30(1), 111-120.