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HUMAN ERROR IDENTIFICATION IN BUS DRIVER WORK USING SHERPA AND HEART

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ABSTRACT

Traffic accidents, especially with a large capacity such as bus, can be caused by several factors. According to the Indonesian Directorate General of Land Transportation of the Ministry of Transportation in 2012, the factors causing traffic accidents in Indonesia are a human factor of 93.52%, vehicle factor by 2.76%, road factor 3.23%, and environmental factor by 0.49%. Therefore, research is needed to identify which human error has the greatest probability of accident cause using Systematic Human Error Reduction and Prediction Approach (SHERPA) method to identify job desk using Hierarchical Task Analysis (HTA) and Human Error Assessment Reduction Technique (HEART) method to calculate Human Error Probability (HEP). Based on the calculation of Human Error Probability value known the highest HEP value is not running the vehicle in accordance with the provisions of the speed that has been set with 0.375. Next is not to record or forget to record the damage that occurred during the trip with a value of 0.21. It did not check Bus equipment with a HEP value of 0.19, did not report when there was a problem on the street with a HEP value of 0.18 and did not break for the next preparation for departure with a HEP value of 0.15..

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1. INTRODUCTION

Public transport is a passenger transport which is done by rent or pay system. Public transport of passengers consists of urban transport (bus), rail, water transport and air transport (Warpani, 1990). One type of public transport that has users increased is the bus from 2,254,406 units in 2011 to 2,420,197 units in 2015 (BPS, 2015). The development of transportation means a positive and negative impact on its users. The positive impact is that passengers have easy access to move from one place to another easily. The negative impact is a company that forced to meet the high demand to be beyond the ability so that an accident occurs. The victims from accidents of about 1.2 million people each year, and WHO estimate the traffic accidents in 2030 will be the fifth largest cause of death in the world (WHO, 2012). Traffic accidents can occur due to several factors. According to Chu et al., (2019), the accident caused by human factors due to driver behavior, fatigue, and so forth. Factors causing traffic accidents in Indonesia amounted to 69.70% were human factors, vehicle factors by 21.21%, and infrastructure factors by 9.09% (KNKT, 2016).

The largest percentage of accidents is caused by human ERRORS. Human error is a human failure in performing tasks that have been designed within the limits of accuracy, sequence, or a specific time (Love and Jesephson, 2004). In this research will be identified the cause of accidents based on a human error committed by the bus driver. Bus driver selection as an object due to the high accident rate of the bus. The number of collision bus accidents amounted to 68.29% and the number of buses rolled by 26.83% where the cause of the accident was 69.70% due to human factors (KNKT, 2016).

One of the proactive analysis methods for error analysis is Systematic Human error Reduction and Prediction Approach (SHERPA) (Bligard and Osvalder, 2014). Selection of SHERPA method because this method is a suitable method used for objects that have special skills, such as bus drivers who have SIM B1 that has been legal and meets the standards. In addition, the use of SHERPA a comprehensive, systematic and facilitate researchers in reducing errors that occur (Stanton, 2002). SHERPA can help illustrate hirearchy work is done (Annette & Duncan, 1967), and can easily identify errors that occur (Ghasemi et al., 2013)

Several studies related to SHERPA (Systematic Human Error Reduction and Prediction Approach) have been widely practiced. Ghasemi et al., (2013) study use SHERPA to identify the human error that caused the accident. Pasquale et al., (2015) estimate human reliability to determine optimal rest time. SHERPA is also used to examine human factors in the practice of anesthesia (Phipps et al., 2008). While Pouya and Habib (2015) reviewed and evaluated human error assessment methods and compared the results of SHERPA techniques. Enggar et al., (2016) combines HEART (Human Error Assessment Reduction Technique) and SHERPA methods to calculate HRA (Human Reliability Assessment) at DAOP VI Yogyakarta engineers. The reliability of the HEART method has also been proven to be used in the nuclear industry and in various industries such as aviation chemistry, railways, medicine, and so forth (Bell and Holroyd, 2009). Kurata et.al., (2015) conducted a study using the HEART method to reduce human error to increase cost efficiency in roasting areas in chicken processing companies. Kusuma's research (2017) also uses the HEART method to measure the level of work errors. And studies using HEART are also performed by Fallon et.al., (2015) to identify a human error and the potential impacts of brachytherapy.

2. METHOD

2.1 Object and Subject

The research was conducted on bus drivers between districts and cities who worked on the company's bus. The object of this research is human error which is done by the bus driver in running a job job job. Research subjects are expert and bus drivers who become respondents to fill out questionnaires. Drivers who are made as respondents with the following inclusion criteria: (1) Having SIM B1; (2) Has worked at least five years as a bus driver; (3) Minimum work duration of five hours in one departure; and (4) Take the bus that leaves for a different district or city from the departure garage. While the expert who becomes the subject of subsequent research is the driver supervisor with the following inclusion criteria: (1) Have the duty to coordinate, direct and supervise and deal directly with the bus driver; (2) Has been working in the company of the automobile for at least 5 years; (3) to know and understand job desc owned by the driver; and (4) had worked as a driver before so can and have experienced how the conditions of work while on the road.

2.2 Material dan Research Procedure

The material used in this research is the job description owned by the driver and the questionnaire to find out the mistakes that had been done by the driver. Data collection using questionnaires was given to bus drivers who had worked for at least 5 years and interviews were conducted to the expert ie the owner of the bus, the driver supervisor, the driver and the manager of the transportation department. The steps of data processing using SHERPA method as follows: (1) Hierarchical Task Analysis (HTA); (2) Task Classification; (3) Human Error Identification (HEI); (4) Consequence Analysis; and (5) Recovery Analysis; and (6) Tabulation (Ghasemi et al., 2013). Furthermore, the calculation of probability values will use the HEART method involving expert judgment. After the job desc, the driver breakdown using HTA, until the last result of the tabulation containing the consequences analysis, recovery, and probability of error, this data will be the input in making the question in the questionnaire. Furthermore, the questionnaire was recapitulated and Human Error Probability (HEP) calculation using HEART with the following stages:

1. Record frequent errors based on SHERPA tabulation results with medium and high probabilities and identify the causes of these errors by referring to Table 1 (Error Producing Conditions/EPC). The EPC determination is performed by the driver supervisor as shown in Table 1 below.

Table 1. Errors that may occur

No	Error
1	Did not check Bus equipment
2	Did not check the remote and close lights by turning it on and switch it off using the switch
3	Did not check the lights by turning it on and off
4	Did not check the brake lights by turning it on and off
5	Did not ensure the reverse light is on when the router is used in the reverse position
6	Did not try the gas pedal to see the speedometer
7	Did not trying to activate the wiper/glass cleaner lever
8	Did not check the oil condition on the bus
9	Did not check the condition of the brake lining/brake suit before departure
10	Did not confirm the buffer state, whether it is good or needs repair
11	Did not check on the clutch head state
12	Did not reporting when a problem occurs on the road
13	Not doing or forgetting to write the form for damage that occurred
14	Incomplete road damage report
15	Drive more than 5 hours in one shift
16	Not using/forgetting to turn on the penny light
17	Did not follow road markings
18	The lowest speed is not 60 km in free flow conditions and 100 km for the highway.
19	Speed exceeds 50 km for urban areas
20	Speed exceeds 30 km for the residential area
21	Did not carrying the required licenses (SIM, STNK, Test Book, Card Supervision)
22	Forgot to report problems and damage/repairs that occurred on the trip
23	Rest for the next maximum departure
24	Did not check Bus equipment

2. Determining the value of Error Producing Condition (EPC). The determination of EPC is performed by the relevant expert according to the guidance in Table 2 below:

Tabel 2. EPCs according to the HEART method (Source: Williams, 1986)

	Error Producing Condition (EPC)	**Value of EPC**
1	Unfamiliarity with a situation which is potentially important but which only occurs infrequently or which is novel	17
2	A shortage of the available for error detection and correction	11
3	A low signal-to-noise ratio	10
4	A means of suppressing or overriding information or features which is too easily accessible	9
5	No means of conveying spatial and functional information to operators in from which they can readily assimilate	8
6	A mismatch between an operator's model of the world and that imagined by the designer	8
7	No obvious means of reversing an unintended action	8
8	A channel capacity overload, particularly one caused by simultaneous presentation of	6

	Error Producing Condition (EPC)	Value of EPC
	non-redundant information	
9	A need to unlearn a technique and apply one which requires the application of an opposing philosophy	6
10	The need to transfer specific knowledge from task to tasks without loss	5.5
11	Ambiguity in the required performance standards	5
12	A mismatch between perceived and real risk	4
13	Poor, ambiguous or ill-matched system feedback	4
14	No clear direct and timely confirmation of an intended action from the portion of the system over which control is to be exerted	4
15	Operators inexperienced (e.g. a newly qualified tradesman, but not an 'expert')	3
16	An impoverished quality of information conveyed by procedures and person-person interaction	3
17	Little or no independent checking or testing of output	3
18	A Conflict between immediate and long-term objectives	2.5
19	No diversity of information input for veracity checks	2.5
20	A mismatch between the educational achievement level of an individual and the requirements of task	2
21	An incentive to use other more dangerous procedures	2
22	Little opportunity to exercise mind and body outside the immediate confines of the job	1.8
23	Unreliable instrumentation (enough that it is noticed)	1.6
24	A need for absolute judgments which are beyond the capabilities or experience of an operator	1.6
25	Unclear allocation of function and responsibility	1.6
26	No obvious way to keep track of progress during an activity	1.4
27	A danger that finite physical capabilities will be exceeded	1.4
28	Little or no intrinsic meaning in task	1.4
29	High-level emotional stress	1.3
30	Evidence of ill-health amongst operatives, especially fever	1.2
31	Low workforce morale	1.2
32	An inconsistency of meaning of displays and procedures	1.2
33	A poor or hostile environment (below 75% of health or life-threatening security)	1.15
34	Prolonged inactivity or highly repetitious cycling of low mental workload tasks	1.1
35	Disruption of normal work-sleep cycles	1.1
36	Task pacing caused by the intervention of others	1.06
37	Additional team members over and above those necessary to perform task normally and satisfactorily	1.03
38	Age of personnel performing perceptual tasks	1.02

3. After determining the EPC value, the next step is to determine the value of Proportion of Assessed Effects (PoA) with the following table.

Tabel 3. *Propotion of Assessed Effects* (Williams, 1986)

Assessed Proportion	Detail
0	The EPC has no effect on the HEP
0.1	Can affect the HEP if an EPC frequently (frequency > five times per shift) occurs with at least three other EPCs
0.2	Can affect the HEP if an EPC frequently (frequency > five times per shift) occurs and with at least two other EPCs
0.3	Can affect the HEP if an EPC frequently (frequency > five times per shift) occurs with at least one other EPC
0.4	Can affect the HEP if an EPC frequently (frequency > five times per shift) occurs without another EPC
0.5	Can influence the HEP if an EPC frequently (frequency two–five times per shift) occurs with at least two other EPCs
0.6	Can affect the HEP if an EPC frequently (frequency two–five times per shift) occurs with at least one other EPC
0.7	Can affect the HEP if an EPC frequently (frequency two–five times per shift) occurs without any other EPC

0.8	Can directly affect the HEP if an EPC occurs and is accompanied by at least two other EPCs
0.9	Can have a direct influence on the HEP if an EPC occurs and is accompanied by at least one EPC
1	Can have a direct influence on the HEP if an EPC occurs and is not accompanied by another EPC

The determination of this PoA is based on questionnaires and interviews with experts and drivers and is based on the level of linkage between EPC and Human Error Probability (HEP). The greater the influence of EPC on HEP the greater the PoA value.

4. Determine the classification and value in the Generic Task like the following table.

Table 4. Generic Task using the HEART method (Williams, 1986)

	Generic Task	Range
(A)	Totally unfamiliar, performed at speed with no real idea of likely consequences	0.55 (0.35–0.97)
(B)	Shift or restore the system to a new or original state on a single attempt without supervision or procedures	0.26 (0.14–0.42)
(C)	The complex task requiring a high level of comprehension and skill	0.16 (0.12–0.28)
(D)	The Fairly simple task performed rapidly or given scant attention	0.09 (0.06–0.13)
(E)	Routine, highly practiced, a rapid task involving a relatively low level of skill	0.02 (0.007 - 0.045)
(F)	Restore or shift a system to original or new state following procedures, with some checking	0.003 (0.0008 - 0.007)
(G)	Completely familiar, well-designed, highly practiced, routine task occurring several times per hour, performed to the highest possible standards by highly motivated, highly trained and experienced	0.0004 (0.00008 - 0.09)
(H)	Respond correctly to system command even when there is an augmented or automated supervisory system providing an accurate interpretation of system stage	0.00002 (0.000006 - 0.009)
(M)	The miscellaneous task for which no description can be found. (Nominal 5th to 95th percentile data spreads were chosen on the basis of experience suggesting long-normality)	0.03 (0.008 - 0.11)

The determination of generic task based on expert judgments classified according to codes A through M. is included in a foreign, routine, simple, complex, etc. work, and the value given based on the reliability of the worker.

5. Determine the value of EPC ', which is obtained by multiplying the value of EPC against the PoA value. Both predetermined values are calculated by the following formula (Williams, 1986):

$$EPC' = ((EPC - 1) * PoA) + 1 \quad \text{……………………………………………………………(1)}$$

Which:
EPC = Error Producing Condition
PoA = Proportion of Assessed Effects

6. Calculate the HEP value (Human Error Probability)

To calculate the human error probability, the human unreliability values obtained from the experts based on work groupings are multiplied with the range of values set out in Table 3. The following formula can be used for the HEP (Williams, 1986):

$$HEP = [rx \prod EPC'] \quad \text{…………………………………………………………………(2)}$$

Which:
HEP = Human Error Probability
r = Human Unreliability Nominal
EPC′ = Error Producing Condition

Input in the form of errors which often done in running the job desk driver will be tabulated using SHERPA, this is done to see the error mode, consequences, and improvement strategies and the probability of errors that occur. Error with probability H (High) and M (Medium) will be the next input in questionnaire making. After the questionnaire is recapitulated, the result will be continued by calculation using the HEART method. The calculation results are shown in Table 7.

Table 7. Calculation results using HEART

Error Producing Conditions	Error Producing Conditions (EPC)	Human Error Probability
The lowest speed is not 60 km in free flow conditions and 100 km for the highway.	The urge to use other, more dangerous procedures	0.375
Speed exceeds 50 km for urban areas	The urge to use other, more dangerous procedures	0.375
Speed exceeds 30 km for a residential area	The urge to use other, more dangerous procedures	0.375
Not doing or forgetting to write the form for damage that occurred	The available time is limited or short to detect and correct errors	0.21
Did not check Bus equipment	Override information or features that are too easily accessible	0.19
Did not report when a problem occurs on the road	The available time is limited or short to detect and correct errors	0.18
Rest for the next departure	High levels of emotion and stress	0.1495

Error in running job description can be affected more than one EPC value. However, the EPC value chosen as the most influencing factor is the value of the calculation with the largest HEP value. Based on the calculation, it is known that there are five errors with the largest HEP value that is often neglected by the bus driver, that is not running with the speed specified in the highway, urban and residential with a HEP value of 0.375. Most drivers control the speed using only the feeling and opportunity. If the driver feels able to accelerate the speed with busy and crowded road conditions, then this alternative will be done. In addition, the driver's lack of consciousness with the importance of safety and the best decision-making while on the move makes the driver not think about the bad possibilities that occur if the rules are still violated. This is also supported by the statements of Bird et al., (1990) stating that working at an improper speed causes traffic accidents. It is also influenced by the knowledge of the driver.

Hidayati & Hendrati (2016) shows that the level of education can affect the occurrence of traffic accidents. A person with a good educational background will be disciplined against the applicable traffic rules. The second highest probability is not to record the damage that occurred during the trip with a HEP value of 0.21. On-the-go improvements are common. Usually, the damage can be mild to severe. Minor damage can be done by a driver when traveling. When you arrive at the garage, the driver only provides a simple report on the circumstances or improvements made during the trip. According to HSE (2004), there are several individuals involved in workplace supervision, one of whom is supervisor. The role of the supervisor is needed in the monitoring of reporting and to ensure the damage that occurred during the trip. This is because the damage is small and can be fixed. The next error with the value of HEP 0.19 is incomplete checking of the equipment of the service box. According to some Bus driver recognition, most of them do not check the contents and the existence of the box containing various keys, jack, and other equipment because it is complete and continue to be on the Bus. Not infrequently they realize losing some equipment after the bus was in the garage. This must be observed by the Bus driver, because on the road improvement and the required tools are not available will hamper travel time and troubling passengers. The worst possibility is to force the bus to continue running to the next stop or until the destination. The next high probability error is not reporting when damage occurs on the street with a value of 0.18.

This is due to time constraints and assumes that the damage can still be handled, so drivers do not report to the office and directly undertake repairs themselves is inappropriate behavior than they should, according to Dahlke (2015) is one of the causes of the work accidents. The next highest error probability is not to break the maximum for the next departure with a value of 0.1495. Due to unstable emotional levels, changing sleep cycles and lack of discipline in using maximum rest periods. This is supported by the research of Chen & Jou (2019) showing that there is a significant relationship between the driving duration factor and the break time in the cause of the accident. So to minimize accidents, it takes an optimal and linear break with the duration of driving. According to Chu et al. (2019), it can be seen that internal and external factors can affect the performance of workers and sometimes these factors are responsible for the occurrence of human error. Internal factors can be a lack of training, experience, and high levels of fatigue. While external factors can be the state of the work environment.

4. CONCLUSIONS

Based on the results of the research, it can be concluded that from 24 possible errors made by the driver, five of them have the greatest HEP value and should get attention and countermeasures, namely: not running the vehicle in accordance with the stipulated speed with HEP value 0.375. This is due to initiation to use other more dangerous procedures. The second highest value of HEP with a value of 0.21 is not to record or forget to record the damage that occurred during the trip due to the limited or short available time to detect and correct errors. Furthermore, it is not checking the Bus equipment with a value of 0.19 for overriding and assuming that this is not so important, then not reporting when a problem occurs on the street with a value of HEP 0.18 for a limited time and the last one is not the maximum break for preparation of departure which then with a HEP value of 0.1495 due to high levels of emotion and stress.

RECOMMENDATION

Based on the research that has been done, the advice given by the researcher is to make travel reporting containing checklist before departure, damage, and repair that has been done during the trip. Make Standard Operational Procedure (SOP) in performing tasks, including pre-departure preparation, departure and after departure, attached to the appendix. Carry out driver delivery in the rotation to follow the guidance provided by the Transportation Department. Encouraging the driver to make a certificate legalized by the Transport Department as a bus driver who has passed through a special stage. Giving standardization job description for all companies bus so that all companies have standardization job description the same and clear.

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References

Annette, J., & Duncan, K. D. (1967). Task Analysis and Training DesignJournal of Occupational Psychology, 41, pp. 211-221.

Bligard, L. O., & Osvalder, A.L. (2014). Predictive use error analysis e Development of AEA, SHERPA and PHEA to better predict, identify and present use errors. *International Journal of Industrial Ergonomics, 44*, 153-170.

Bell, J., & Holyroyd, J. (2009). *Review of Human Reliability Assessment Methods.* HSE Book: Research report 679.

Chen, T.Y., Jou, R.C. (2019). Using HLM to investigate the relationship between traffic accident risk of private vehicles and publictransportation. Transportation Research Part A: 119, pp. 148–161

Chu, W., Wua, C., Atombo, C., Zhang, H., Özkane, T. (2019). Traffic climate, driver behaviour, and accidents involvement in China. Accident Analysis and Prevention: 122, pp.119–126

Dahlke, G. (2015). Ergonomic criteria in the investigation of indirect causes of. *Applied Human Factors and Ergonomics and the Affiliated Conferences* (pp. 4868 – 4875). Poland: ScienceDirect.

Enggar, R., Susilo, M., Tatak, Zulfikri, & Purnomo, H. (2016). Analisa Human Error pada Pekerjaan Masinis Kereta Api Menggunakan Metode SHERPA dan HEART. *4th SEANES International Conference on Human Factors and Ergonomics in South-East Asia 2016.* Indonesia.

Fallon, E. F., Galicic, M., Chadwick, L., & Putten, W. v. (2015). An analysis of the impact on trends in automation on human error potential in brachytherapy. *6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the AffiliatedConferences, AHFE 2015*, 234-241.

Bird, F., Germain, G., Clark, D. (1996). Practical Loss Control Leadership. Book : Third Edition. DNV GL - *Business* Assurance.

Ghasemi, M., Nasleseraji, J., Hoseinabadi, S., & Zare, M. (2013). Application of SHERPA to Identify and Prevent Human Errors in Control Units of Pethrochemical Industry. *International Journal Of Occupational Safety and Ergonomics*, 19 (2), pp. 203-209.

Hidayati, A., Hendrati, L.Y. 2016. Analisis risiko kecelakaan lalu lintas berdasar pengetahuan, penggunaan jalur, dan kecepatan berkendara. Jurnal Berkala Epidemiologi, Vol. 4 No. 2, hal. 275–287

HSE. 2004. Investigating accidents and incidents: A workbook for employers, unions, safety representatives and safety professionals. HSE Book: HSG245.

Kurata, Y. B., Acula, D. J., Galingan, R. L., Palines, A. M., & Viterbo, J. C. (2015). Human error reduction for cost efficiency improvement in the butchery area of a chicken processing company. *6th*

International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015, 346-353.

Kusuma, F. (2017). *Human Reliability Asessment sebagai Upaya Pengurannagan Human Error dalam Penerapan K3*. Undergraduate Thesis. Industrial Enggineering Departement, Universitas Islam Indonesia, Yogyakarta.

KNKT. (2016). *Data Investigasi Kecelakaan LLAJ Tahun 2010-2016*. Jakarta: KNKT.

Love, P., & Josephson, P. (2004). Role of Error Recovery Process in Project. *Journal of Management Engineering*.

Pasquale, V. D., & Miranda, S. I. (2015). *A Simulator for Human Error Probability Analysis (SHERPA)*. Reliability Engineering & System Safety: Volume 139, pp. 17-32.

Phipps, D., Meakin, G. H., Beatty, P. C., Nsoedo, C., & Parker, D. (2008). Human Factors in Anaesthetic Practice: Insights from A Task Analysis. *British Journal of Anaesthesia, 100(3)*, 333-43.

Pouya, A., & Habib, E. (2015). The comparative study of evaluating human error assessment and reduction technique and cognitive reliability and error analysis method techniques in the control room of the cement industry. *International Journal of Enviromental Health Engineering*, Vol. 4, Issue 1. Pp. 1-5.

Stanton, N. A. (2002). *Systematic Human Error Reduction and Prediction Approach*. New York: CRC Press.

BPS. (2015). *Statistik Transportasi Darat*. Badan Pusat Statistik

Warpani, P. S. (1990). *Merencanakan Sistem Perangkutan*. Book. Publisher: ITB, Bandung.

WHO. (2012, May). *Fact Sheets*. Retrieved from World Health Organization Webiste: http://www.who.int/mediacentre/factsheet s/fs358/en/

Williams, J. C. (1986). A Proposed Method for Assessing and Reducing Human Error. *9th Advance in Reliability Technology Symposium (ARTS)*. Bradford: University of Bradford