Cost and Benefit of E - Speed Supervisor In Express Bus

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Abstract **– Electronic Speed Supervisor, a device that discloses the real-time speed of express bus to passengers is proposed for express bus to solve both intentional speed violation and faulty engine speed limiter. Ex-ante cost-benefit analysis is carried out to assist managers in making decision between alternatives; (1) investment of RM3,000 per bus with monthly maintenance of RM100 per bus, (2) monthly rental and maintenance of RM300 per bus. Additional fare of 50cents per passenger is charged to gain revenue. alternative (1) is found to produce a better net present value, NPV and benefit cost ratio, BCR.**

Keywords **– Road accident prevention, intelligent speed adaption, cost and benefit, vehicle safety.**

1. Introduction

Fatal accidents involving express buses continue to occur even though the Malaysian government has made it mandatory to install a speed limiter device on the engine of every express bus and truck since 17 July 2016 [8].

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The enforcement was an immediate reaction to the incident where 10 vehicles were hit by an express bus at Kilometer 265.8 of the North -South Highway after it was believed to have brake problems while descending a hilly route on 10 July 2016.

Even more shocking, after the mandatory enforcement of speed limiter device a most horrific fatal accident occurred at Kilometer 137, PLUS Highway, northbound, near the Pagoh rest and treatment area, a day before Christmas, due to loss of control caused by high speed. The bus plunged into a deep ravine hitting a thick wall resulting 14 deaths including the bus driver and 16 injured. Following the incident, a series of fatal accidents as in table 1 involving express buses were recorded throughout 2017 to 2019. Recent incident before the Covid-19 pandemic movement restriction order happened on 27 April 2019 at kilometer 130, East West Highway, near Jeli claiming one death and 3 injured.

Table 1. Record of fatal accident after engine speed limiter enforcement

Date	Location	Injury	Fatal
27/4/2019	km130, East-West Highway	3	1
2/9/2018	km12.5 Ipoh – Lumut Highway	12	2
27/8/2018	km214 North-South Highway (PLUS)	20	1
3/6/2018	km142.5 North-South Highway (PLUS)	25	3
30/5/2018	Kampung Teglu, Mersing, Johor	12	2
6/12/2017	km294 North-South Highway (PLUS)	11	1
24/12/2016	km137 North-South Highway (PLUS)	16	14

Speed has been identified as the main cause of these fatal accidents in most of the reports (Astro Awani, 2021) even though the speed limiter is already made mandatory for all express buses. A good reason to explain this problem is the fact that engine speed limiter device could be easily

overridden at any time by the driver simply by pressing down hard on the throttle [14],[7].

This driver friendly feature is providing the opportunities for drivers to violate the speed limit without being reprimanded by anyone around. This problem could be solved by disclosing the speed of the express bus to its passengers because passengers' safety is at stake and they are the most potential party to influence the speeding behaviour [5], [9], [11].

A study on GPS tracking system for express bus [12], [4] has recommended an advisory intelligent system adaption device [15] called electronic speed supervisor (ESS) to be installed in express buses as a way to disclose the real-time speed to the passengers due to the critical flaw found in the express bus GPS tracking system for fleet management. Their study found that the speed is only recorded for post-accident analysis [12], [13]. They also recommended the features listed in table 2.

Table 2. Main features of Electronic Speed Supervisor for Express Bus

No	Features
1.	Always displays real-time speed to passengers
2.	Reminder voice emitted when speed limit violated
3.	Short pleasant music emitted before reminder voice
4.	Repeat reminder voice emitted at suitable interval
5.	Phone message sent to superior / authority if speed continually violated after presettable time of voice reminder

The recommended electronic speed supervisor (ESS) continuously displays the real-time speed of the bus to all passengers to alert passengers and driver in case the mandatory engine speed limiter faces faulty or the driver intentionally violate the speed limit. Based on the features suggested in table 2, when speed violation is detected, the electronic speed supervisor device emits a pleasant reminder sound followed by human voice that alerts the driver to comply the speed limit. The sound or voice will keep reminding at suitable interval so that the driver and passengers and will automatically send text phone message to the management of the bus or external authority after a pre-settable number of reminders. At the same time, passengers who are also alert with the speed violation could voice out their concern and advice the driver to comply to the speed limit to avoid accident. The speed record can be set to transmit data immediately to authority and bus management or keep it in the storage of ESS as a record. The situation is explained by Figure 1.

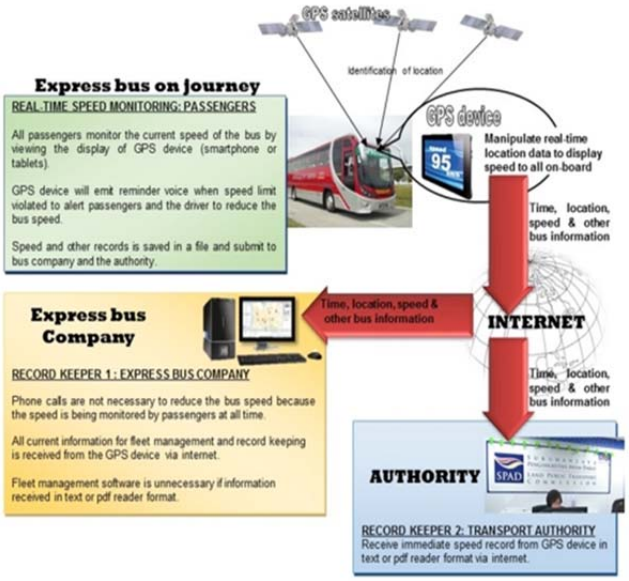

Figure 1. Electronic Speed Supervisor operation

Unlike some cost and benefit studies that identified the total cost to implement a government project in order to determine its impact on the economy of the country under studies [2], [6], [3], [4] this research is interested to present a framework on analyzing cost and benefits of installing the electronic speed supervisor from management perspective for a single unit of express bus through two simple alternatives, (1) owning or (2) renting.

This article evaluates and presents the annual profitability (sustainability) of the project based on the different between present value of the annual benefit and cost. Total financial impact of the project on express bus operator can be identified by simply multiplying the total cost or benefits to the number of fleet the company possess. This article is expected to provide a framework for a good decision making on behalf of the bus operators that are interested to provide extra value added in term of safety for their passengers not only solely based on the cost and benefit, but also by looking into the financial resources.

2. Methods

This study utilizes ex-ante cost-benefit analysis which refers to the estimation of the costs and benefits prior to the full implementation of the project in order to evaluate the feasibility and whether the project requires any adjustment before coming into the decision [3]. Ex-ante benefit-cost analysis is difficult because the project has not fully happened yet, thus required some amount of assumptions which leads to less accurate results [4].

It is common for authors to mix all costs incurred by project owner with other different parties such as government, vendor companies and individual users, into single calculation of cost or benefits. For example, [4] in the costs and benefits study of the national implementation of intelligent speed adaptation (ISA) has mixed all the costs incurred by the government and vehicle owners into a single calculation of benefit to cost ratios. Among the costs listed are (1) digital maps and sensors infrastructure and maintenance costs (2) in-vehicle equipment (3) issue of annual map updates. All of the cost for in-vehicle equipment which is borne by vehicle owners is not separated from the costs incurred by government. In term of savings, they list fuel savings as one of the benefits although fuel savings are benefits obtained by vehicle owners instead of the government.

It shows that in the analysis of cost and benefit representing a country, all benefits and costs from different parties are listed together regardless of the party holding the benefit and costs. In considering the cost and benefit for a business, study should be carried out separately based on the party which actually bears the costs and receives the benefits. The costs and benefits on behalf of the government such as cost of construction and maintenance of infrastructure, increase in gross domestic product, taxation, fees or licenses, should not be considered in cost-benefit analysis of a project by a business.

Finding the cost involved in any project is usually straight forward because it is clearly a cash expenses. However, in the attempt to demonstrate the worthiness of the expenses and investment, most cost-benefit studies, especially those related to government projects, need to include imaginary cash which is actually not a real cash benefits. Some article places many assumptions for interpolation models while disregards some trade off effects such as the study of e-bike super highway [10]. The imaginary cash benefits are invalid for profitability calculation and it is a fact that no company could survive, or even capable to pay for any incremental cost by depending on imaginary cash or profit.

Considering the importance of the real cash and profitability, this study only present benefits associated to real cash that is very likely to be collected from the installation of ESS. It could also help to avoid the complexity of non-cash benefit conversion. In this case, profit is not a main concern but safety is the priority instead, therefore, the term financial sustainability is sometimes used interchangeably with profitability which is defined as the ability to self-finance or the difference between the cost and the revenue generated.

Review of prior articles have shown that most cost and benefit articles do not evaluate projects from profitability perspective, on behalf of the project implementer although financial sustainability has been recognized as the key performance indicator for all business directors or leaders. Based on these shortcomings, this article takes into account the annual profitability or financial sustainability of the project to ensure that the project could sustain for a long period without disturbing any revenue gained from other normal operation, without ESS on board.

To provide minimum alternatives for the express bus management to consider before decision making, this study proposes 2 alternatives to be evaluated by the interested express bus operator. Alternative 1: Purchase to own the ESS (including installation) and pay monthly maintenance and calibration. Alternative 2: fully rent the ESS from vendor and pay maintenance and calibration cost at RM300 per month. Initial investment for the implementation of alternative 1 is quite expensive if the express bus company has a large fleet. For example, if the company owns 100 buses and the price of a unit of ESS at that time is RM3000 per unit then the investment required to start implementing alternative 1 is about RM300,000 whereas for alternative 2, the initial investment to install the ESS could be only RM30,000 which is only 10% compared to alternative 1.

Worthiness of the project is assessed using cost and benefit analysis including benefit cost ratio (BCR) and net present value (BCR).

$$\text{BCR} = \frac{\sum_i (Bi/(1+r)^i)}{\sum_i (Ci/(1+r)^i} = \frac{BPV}{CPV} \quad , \quad i = 0, 1, \ldots..\text{T} \qquad (1)$$

$$\text{NPV} = \text{BPV} - \text{CPV} \qquad (2)$$

where B_i and C_i are respectively the monetary benefit and cost of ESS implementation per unit in period i; T = 4 because the smart phone and tablet devices usually considered too old after 3 years, the discount rate or interest rate r is 3% which is considered reasonable based on the value within 10 years (2007 to 2017) is at around 2.0% to 3.4% per year [1]. CPV is present value of the total project cost and BPV is present value of total project benefit.

2.1. Components Of Cost

Formula used by [6] for total cost is calculated from the sum of annualized costs in 4 categories, namely building cost (C_B) and equipment cost (C_E), labor cost (C_L) and administration cost (C_M) as the formula below:

$$\text{TC} = C_E + C_B + C_L + C_M \qquad (3)$$

There is no cost incurred for land and building (C_B) in this study, but there is a cost of equipment which is the ESS device. The ESS device is a smart

phone or tablet with big screen size of about 10 inches, enclosed in a transparent housing so that it is protected from any modification or vandalism. The ESS application system or the software is installed in the tablet comes together with the purchase or rental. Backup 12V battery is also stored in the housing for use in case of power disconnection.

Express bus companies can choose to install ESS through 2 ways; Alternative 1: Purchase to own (including installation) at RM3,000 and pay monthly maintenance and calibration at the cost of RM100 per month. Alternative 2: Rent the ESS from vendor and pay maintenance and calibration cost at RM300 per month. The maintenance fee paid to the vendor covers the labour cost (C_L) and administration cost (C_A). For alternative 1, the amount for maintenance and calibration is RM100 while for alternative 2, these two costs are combined together into the rental cost, which is RM300 per month

2.2. Cash Benefit

As mentioned earlier, this cost and benefit article is not interested in analysing non-monetary benefits or imaginary cash benefits. Non-monetary benefits are usually appearing in the corporate social responsibility activities (CSR) of the company instead of income statement. The monetary benefit gained for this case is the revenue that is most likely to be achieved through the use of ESS. The estimation is based on the percentage of passengers who are willing to top up an extra of less than 50 cents into the existing fare. The formula used to earn the revenue per trip (RPT) is as below:

$$RPT = 50cents * WTP * APT \quad (4)$$

Where WTP is the percent of passengers who are willing to pay extra fare of 50cent; APT is the average passengers per trip of the express bus. The WTP value is obtained from the result of passenger's survey who agreed to pay the additional fare of not more than 50cents as in item 5 of table 3.

An enumerator was assigned to board the express bus under study for the purpose of data collection. Beside to ensure the ESS functioned well throughout the bus journey, she is responsible for the distribution of questionnaires to bus passengers. The questionnaire was distributed to passengers when the express bus was in the middle of two similar route, with ESS and without ESS. In both trips, the same two bus drivers are on duty alternately between the start station and the final destination. The completed survey form was collected from the passengers before the bus arrived at the destination. The 2 trips have produced a total of 67 completed questionnaires were collected.

Table 3. Questionnaire for passengers

No	Question	Yes	No
1.	I feel safer because the bus is monitored and supervised at all time		
2.	Electronic speed supervisor is useful to avoid fatal accident		
3.	I will travel by bus installed with electronic speed supervisor again		
	If your answer for no. 3 is no, please answer these 2 questions:		
4.	i. State the reason(s) :…….. ii) I will travel by this bus only if: ……		
5.	I am willing to pay an additional fare of not more than 50cents for electronic speed supervisor in the bus		

Choose either yes or no based on your own judgement APT value is estimated based on the prior data of the bus operator. Each bus operator has different average passengers per trip, and it is the manager's choice to assume the value based on the history of trips and associated events. In this study, a reasonable value for APT chosen, which is 30, based on the range of seat numbers in express bus in Malaysia which is between 26 to 60 (APAD, 2008).

To estimate the revenue generated in a year, the revenue per year (RPY) formula below is used.

$$RPY = 12month * (RPT) * (TPM) \quad (5)$$

Where TPM is the number of trip per month and 12 is representing the number of months in a year. TPM value for this study is 28 trips per month.

3. Results

The following sections present the result of the survey and the cost-benefit analysis.

3.1. Passengers Survey

Based on the survey result (table 4) it is clear that almost all passengers feel safer travelling in the bus equipped with electronic speed supervisor (97%). They also agree that the device is useful to avoid fatal accident (97%). However, only 90% of the respondents agree to travel again by the bus installed with ESS in the future due to some reason including reminder voice loudness and worry of late arrival. Nevertheless, they might take the bus with ESS if the reminder loudness is reduced and placed at every seat in the bus. Not all of the passengers who choose the bus with ESS over buses are willing to pay extra 50cents for their fare. Only 76% of the passengers is willing to pay (WTP) additional of 50 cents (maximum) to have the electronic speed supervisor in the bus.

Table 4. Result of the passenger survey

	Item	% agree
1	I feel safer because the bus is monitored and supervised at all time	97
2	Electronic speed supervisor is useful to avoid fatal accident	97
3	I will travel by bus installed with electronic speed supervisor again	90
4	i) Reasons for not choosing ESS: - reminder voice too loud - worry of late arrival ii) Condition to choose ESS: - Reduce reminder voice volume - ESS at all seats	
5	I am willing to pay an additional fare of not more than 50cents for electronic speed supervisor in the bus	76

3.2. Cost-Benefit Analysis

The following sections discuss the result and analysis of cost and benefits.

3.2.1. Alt1: Purchase and Monthly Maintenance

Based on the costs section in table 5, the cost required to purchase and install an Electronic speed supervisor (ESS) is estimated at RM3000 as discussed in the earlier. In the starting year or year 0, the annual cost for maintenance is derived from the reasonable rate for cost of maintenance and calibration of ESS device, which is at RM100 per month. Therefore, every year, the cost to be incurred by the express bus operator for a bus fitted with an ESS device is RM1200 (RM100 x 12 months). Using the present value formula, PV for the year 1 to year 5, the total annual cost spent by the company is obtained and exhibited in table 5.

Next is the work of calculating the cash income that is expected to be earned from the installation of ESS in the bus. Based on the results of the passengers' survey that 76% of the passengers are willingness to pay an extra fare of not exceeding 50cents (WTP), then the projected revenue earned each month can be projected using formula (4). By inserting the WTP as 76% and APT as 30 passengers into formula (4), the revenue per trip, RPT is equivalent to RM11.40 per trip. Then multiply the figure to the 28 numbers of trip per month and 12 months per year, it is estimated that the ESS has the potential to generate RM3,830.40 in the first year.

Assuming that the same revenue is expected to be generated in the next 4 years, then the expected discounted revenue to be generated each year up to the 4th year is as shown in benefit section in table 5. Total revenue earned in the 5 years, namely the value of BPV, estimated at RM18,068.37.

The value of annual profitability is identified based on the difference between revenue and cost, as exhibited in the cost benefit analysis section in table 5. It can be clearly seen that the one-time cost of purchasing and installing the ESS device and maintenance/calibration cost is listed in the cost section. The total value of the project cost, CPV is obtained from the summation of installation cost and the total maintenance cost, which is RM8,660.52.

The difference between the cumulative cost and benefit is the value of net present value, NPV as indicated in table 5. It can be clearly seen that for alternative1, the NPV earned within 5 years is RM 9407.86. While the benefit to cost ratio, BCR for alternative 1 is 2.09. Payback period is calculated for alternative 1 because it involves an amount of investment for the device. The table shows that the payback period for ESS installation is less than 2 years.

3.2.2. Alt 2: Rental with maintenance

In alternative 2, no purchase and installation costs are borne by the company as it is the responsibility of the vendor to purchase of manufacture the ESS device for installation. Vendors are responsible for installing and maintaining ESS and charge the bus operator a monthly cost of RM300 per month, which is equivalent to RM3,600 per year. This annual rental and maintenance cost is discounted using the present value formula to get the present value of the annual cost for year 1 to 4 as in the cost section of table 6.

The amount of money gained at the end of year 5

Table 5. Cost and Benefit Analysis of Alternative 1

	Present value (r=3%)					
	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
			Benefit			
Revenue		3,830.40	3,718.83	3,610.52	3,505.36	3,403.26
			Cost:			
ESS Installation	3,000.00					
Maintenance		1,200.00	1,165.05	1,131.12	1,098.17	3,403.26
			Cost-Benefit Analysis			
Annual Profitability		2,630.40	2,553.79	2,479.40	2,407.19	2,337.08
CPV						8,660.52
BPV						18,068.37
NPV						9,407.86
BCR						2.09
Payback period		Less than 2 years				

Table 6. Cost and Benefit Analysis of Alternative 2

Present value (r=3%)						
	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
			Benefit			
Revenue		3,830.40	3,718.83	3,610.52	3,505.36	3,403.26
			Cost:			
Maintenance		3,600.00	3,495.15	3,393.35	3,294.51	3,198.55
			Cost-Benefit Analysis			
Annual Profitability		230.40	223.69	217.17	210.85	204.71
CPV						16,981.55
BPV						18,068.37
NPV						1,086.82
BCR						1.06

For benefit section of table 6, the revenue gained every year is exactly the same as in the benefits of table 5 because there is no change in the estimation of the revenue earned from installation of the ESS for both alternative 1 and alternative 2.

Due to increase in the maintenance cost for alternative 2, the present value of total project cost, CPV also increased significantly to RM16,981.55 causing a significant reduction in the annual profitability. However, it can be clearly seen from the cost-benefit analysis section of table 6 that the expected profitability is still positive each year. It prove that for both alternatives, the use of ESS will not consume any earning from the normal operation of the company.

The cost-benefit analysis section of table 6 also revealed that the net present value, NPV for alternative 2 is RM1,082 which is lower than the NPV alternative 1 with a difference of RM8,312.04 per bus. If the bus operator has a hundred buses, then the different in amount will be as huge as RM8312,040 in 5 years. Table 6 also exhibit a lower benefit cost ratio, BCR for alternative 2 (1.06).

Based on the amount of investment for purchasing and installing the device and more attractive monetary gained, only financially strong express bus companies are advised to proceed with alternative 1. could be used to replace the device with a new one.

For a financially weaker operator, profitability should not be the main concern. Safety perception of the passengers should be a priority by installing ESS. Alternative 2 should be the best choice for immediate zero cost implementation of additional safety features for express bus operators of any size.

4. Conclusion

Express bus operator could consider installing electronic speed supervisor as an additional safeguard to ensure the safety of the passengers from fatal accident. Beside bringing peaceful and confidence on bus safety, the device is also capable to generate some revenue to support the cost of maintaining the device where 76% of the passengers in the bus under study agreed to pay an extra fare of 50cents. Based on the result of the cost and benefit analysis, both alternative 1 and alternative 2 have shown a positive NPV where alternative 1 has a better NPV (9,407.86) compared to alternative 2 (1,086.82) as well as better BCR for alternative 1 (2.09) than alternative 2 (1.06). The management decision to choose alternative 1 or alternative 2 should be based on their ability to invest for the installation of the new ESS into their buses as well as the net benefit for the company.

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References

[1]. Bank Negara Malaysia. (2019). Treasury Bills and Bank Negara Bills Interest Rates. Retrieved from: https://www.data.gov.my/data/en_US/dataset/treasury-bills-and-bank-negara-bills-interest-rates [accessed: 18 September 2021].

[2]. Benardos, A., Sourouvali, N., & Mavrikos, A. (2021). Measuring and benchmarking the benefits of Athens metro extension using an ex-post cost benefit analysis. *Tunnelling and Underground Space Technology*, *111*, 103859.

[3]. Buncle, A., Daigneault, A. J., Holland, P., Fink, A., Hook, S., & Manley, M. (2016). *Cost-benefit analysis for natural resource management in the Pacific: a guide*. Secretariat of the Pacific Regional Environment Programme.

[4]. Carsten, O. M., & Tate, F. N. (2005). Intelligent speed adaptation: accident savings and cost–benefit analysis. *Accident Analysis & Prevention*, *37*(3), 407-416.

[5]. Chung, E. K., Choe, B., Lee, J. E., Lee, J. I., & Sohn, Y. W. (2014). Effects of an adult passenger on young adult drivers' driving speed: Roles of an adult passenger's presence and driving tips from the passenger. *Accident Analysis & Prevention*, *67*, 14-20.

[6]. Hsu, E. (2021). Cost-benefit analysis for recycling of agricultural wastes in Taiwan. *Waste Management*, *120*, 424-432.

[7]. Leggett, T. (2019). Are speed limiters the best way to reduce road deaths?. Retrieved from: https://www.bbc.com/news/business-49090755 [accessed: 19 September 2021].

[8]. Mstar. (2016). Bas Ekspres Diwajib Pasang Alat Penghad Kelajuan Serta-Merta. Retrieved from: https://www.mstar.com.my/lokal/semasa/2016/07/17/bas-pasang-pengesan-had-laju [accessed: 05 October 2021].

[9]. Orsi, C., Marchetti, P., Montomoli, C., & Morandi, A. (2013). Car crashes: The effect of passenger presence and other factors on driver outcome. *Safety science*, *57*, 35-43.

[10]. Rich, J., Jensen, A. F., Pilegaard, N., & Hallberg, M. (2021). Cost-benefit of bicycle infrastructure with e-bikes and cycle superhighways. *Case studies on transport policy*, *9*(2), 608-615.

[11]. Rosenbloom, T., & Perlman, A. (2016). Tendency to commit traffic violations and presence of passengers in the car. *Transportation research part F: traffic psychology and behaviour*, *39*, 10-18.

[12]. Sidek, S., Abdullah, A. R., & Rahman, A. A. (2015, November). The critical flaw in the implementation of GPS tracking system in express bus industry. In *2015 IEEE International Conference on Service Operations And Logistics, And Informatics (SOLI)* (pp. 71-76). IEEE.

[13]. Sidek, S. (2015, December). Paradigm change in express bus fleet management: Real-time speed record keeping to real-time speed monitoring. In *2015 IEEE International Conference on Data Science and Data Intensive Systems* (pp. 738-739). IEEE.

[14]. U-pull-it. (2019). What is a Speed Limiter and How Will it Affect Your Car? Retrieved from: https://www.u-pull-it.co.uk/news/driving/what-speed-limiter-and-how-will-it-affect-your-car [accessed: 05 October 2021].

[15]. Warner, H. W., & Åberg, L. (2008). The long-term effects of an ISA speed-warning device on drivers' speeding behaviour. *Transportation research part F: traffic psychology and behaviour*, *11*(2), 96-107.