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THE USE OF MODERN DRIVER CONTROL SYSTEMS AS PART OF THE TRANSPORT COMPANY MANAGEMENT SYSTEM

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Abstract

Controlling operating costs and reducing them is one of the most important elements of transport management in today's highly competitive market. Actions taken by transport companies should be carried out in two ways. On the one hand, the company must strive to obtain new transport orders, on the other hand, it should also take actions aimed at optimising the activities currently being undertaken. The article uses the method of examining documents. The research problem and the purpose of the article was to answer the question whether the use of modern driver control systems can be used not only to improve safety and driving comfort, but also to reduce the cost of transport services. The article compares the costs of transport services on similar routes using modern fleet equipped with two types of cruise control: traditional and adaptive.

Key words: transportation costs, driver control systems, cruise control and adaptive cruise control.

Introduction

Trucking is the most commonly used transport sector in which passengers and cargo are transported on roads by means of wheeled vehicles in Poland (e.g. motor vehicles)[1], but is also a very important transport sector in other countries, for example in Canada and the USA[2].

This causes very high competition on the transport services market. Enterprises undertake a number of organisational and technical activities in order to gain

1 GUS, *Transport. Wyniki działalności w 2014 r.*, Warszawa 2015.
2 T. Chabot, F. Bouchard, A. Legault-Michaud, J. Renaud, L. C. Coelho, *Service level, cost and environmental optimization of collaborative transportation*, Elsevier, Transportation Research Part E 110, 2018, p. 1.

a competitive advantage, which is not easy to obtain and requires companies to use ever newer and better methods to organise their activities[3]. One such activity, apart from the basic activity - acquiring new clients, may be the use of modern ICT solutions to obtain a competitive advantage. The following article (using the method of document analysis) analyses the research problem, the aim of which was to answer the question whether modern systems improving driving comfort can be used indirectly to reduce the costs of business as a result of reducing the cost of services. Reducing costs, according to the authors, can be achieved, among other things, by the use of the aforementioned modern systems. The article focuses on the comparison of two such systems: traditional and adaptive cruise control and determining their impact on fuel consumption.

Trucking, as every transport branch, has its pros and cons of course. Its advantage is, among other things, the ability to deliver loads directly to the destination. Its drawbacks will be reduced more and more due to the use of increasingly new technologies, ecological focus and the installation of vehicles for improved safety (both active and passive) and eliminating driver errors.

Table 1 shows the percentage distribution of transport work per transport sectors (Polish transporters) in 2014.

Table 1

The percentage distribution of transport work per transport sectors in 2014 (Polish transporters)

Transport sector	**Transport work [tonne-kilometers in mln]**	**Percent [%]**	**Loads [tones in ths]**	**Percent [%]**
Road	103 789	82,5	116 295	62,7
Rail	21 885	17,4	68 383	36,8
Inland	177	0,1	896	0,5

Source: Own work based on: GUS, *Transport. Wyniki działalności w 2014 r.,* Warszawa 2015.

The table above lists the tonnage of freight carried and the transport work performed in international transport by Polish land transporters, representing three competing transport sectors. From the given data, we can see how road transport plays a significant role in the transport sector.

3 J. Długosz, *Kryteria oceny nowoczesnych technologii w transporcie*, Wydawnictwo Uniwersytetu Szczecińskiego, Szczecin 2006.

Costs of activity in transport company

The issue of transport costs (including, for example, their optimisation and simulation, and salesman games problems) has been considered for several years by many authors from different countries, for example[4].

From an enterprise perspective, transportation costs can be divided into fixed costs and variable costs[5]. The sum of these costs is the total cost of business. Fixed costs are the costs borne by the company irrespective of the volume of transport produced for example: the cost of ownership, annual sale tax, license fees and taxes, management & overhead cost and insurance cost[6]. Variable costs are those in which the volume depends on changes in the volume of transport services; for example, the costs of this factor are influenced, inter alia, by the factors of production, the size of the transported goods, the distance travelled and the speed of the means of transport[7]. In general, variable transportation cost is a function of truck utilisation[8].

Characteristic costs in road transport are set out in a generic scheme:

- amortisation of vehicles and other fixed assets,
- salaries,
- payroll fees,
- insurance of vehicles and cargo,
- purchase and use of mobile materials and oils,
- purchase and consumption of tires,
- service and repair of vehicles[9].

4 L. Sun, A. Rangarajan, M. H. Karwan, J. M. Pinto, *Transportation cost allocation on a fixed route*, Elsevier, "Computers & Industrial Engineering" 2015, no. 83, pp. 61–73. S. Engevall, M. Gothe-Lundgren, P. Varbrand, *The traveling salesman game: An application of cost allocation in a gas and oil company*, "Annals of Operations Research" 1998, no. 82, pp. 203–218. P.C. Fishburn & H. O. Pollak, *Fixed-route cost allocation*, "American Mathematical Monthly" 1983, no. 90, pp. 366–378. M. Frisk, M. Gothe-Lundgren, K. Jornsten & M. Ronnqvist, *Cost allocation in collaborative forest transportation*, "European Journal of Operational Research" 2010, no. 205(2), pp. 448–458. O. O. Özener, O. Ergun, *Allocating costs in a collaborative transportation procurement network*, "Transportation Science" 2008, no. 42, pp. 146–165. M. Blaser, & L. Shankar Ram, *Approximately fair cost allocation in metric traveling salesman games*, "Theory of Computing Systems" 2008, no. 43, pp. 19–37.

5 M. Marufuzzaman, S. Ekşioğlu, R. Hernandez, *Elsevier Transportation Research Part A*: *Policy and Practice*, vol. 74, April 2015, pp. 16.

6 M. Berwick, M. Farooq, *Truck Costing Model for Transportation Managers*, Upper Great Plains Transportation Institute, North Dakota State University 2003, pp. 25–28.

7 Z. Łukasik, S. Olszańska, *Kształtowanie kosztów międzynarodowej obsługi transportowej w systemie Just - in – Time*, „Autobusy – Technika, Eksploatacja, Systemy Transportowe" 2016, 6, Radom 2016, p. 644.

8 M. Berwick, F. Dooley, *Truck costs for owner/operators*, Upper Great Plains Transportation Institute, North Dakota State University, Fargo 1997, pp. 16–17.

9 R. Kacperczyk, *Środki transportu*, part 2, Warszawa 2014, p. 238.

In road transport companies, it is typical that around 60-70% of the costs are made up of three generic groups:

- salary - 45% of the cost,
- consumption of fuels and road materials - 15-20% of costs,
- depreciation - 5-10% of the cost[10].

Other authors from the Motor Transport Institute report that in 2012, due to the increase in the cost of transport using motorcars in Poland, the percentage of fuel costs in general costs fluctuated as much as between 35 and 39%[11].

This indicates that the cost of transport (including fuel) is one of the most important cost elements of transport operations.

Costs is one of the most important factors influencing the competitiveness among enterprises of motor transport. The growing competition in the car transport market requires carriers to know the variability of unit costs.

Modern telematics systems used in road transport

Cruising Control System (CCS) is an electronic device that controls the propulsion system in such a way as to maintain the vehicle's constant speed, programmed by the driver, regardless of the angle of incline and other external factors. The driver, after setting the speed, doesn't press the accelerator pedal, the engine speed control is automatic. For vehicles equipped with an automatic gearbox, the device can also reduce gear ratios. Constant speed is obtained by automatically adjusting the pitch angle. For safety reasons, touching the operating brake pedal causes the cruise control to switch off immediately. In most modern solutions, it is possible to restore the previous speed of the vehicle since the last speed setting is stored and can be called up using the corresponding button. By pressing the accelerator pedal while operating the cruise control, the vehicle accelerates and when released it returns to the set speed. The system works after exceeding a given speed, which is most often 40km/h[12].

Adaptive Cruise Control (ACC) is a device that extends the functions of cruise control and automatic braking systems to help keep a safe distance from the vehicle ahead. The ACC system, in addition to maintaining the set speed, also controls and sets the distance from the preceding vehicle.

The driver sets the desired travel speed and the distance from the preceding car and the system recognises the vehicles themselves and determines which distance to

10 G. Biesok, *Logistyka usług*, Warszawa 2013, p. 63.

11 Z. Kordel, J. Waśkiewicz, W. Gis, *Problematyka kosztów i cen w transporcie samochodowym*, "Logistyka" 2014, no. 2, Poznań 2014, p. 131.

12 J. Wicher (2004), *Bezpieczeństwo samochodów i ruchu drogowego*, Warszawa, 2004, p. 200.

keep. To maintain the distance from the preceding vehicle, the speed of the vehicle to be driven will be adjusted by the ACC[13].

The speed is automatically increased again to the preset speed with a safe distance from the vehicle in front. If the distance between moving vehicles is below the permissible limit, automatic deceleration occurs; if there is any further danger, the retarder is activated or basic brakes and a warning signal.

Predictive Cruise Control (PCC) is a system that uses GPS technology to determine the exact location of a car and determine the factors that need to be taken into account for the nearest kilometres of the route. Depending on the vehicle manufacturer, providing the cruise control has its own name, Predective Cruise Control is the name used by DAF, but the principle of operation of the system is the same. This cruise control has a topographic three-dimensional terrain map, which recognises slopes and elevations and can predict them up to 2 km. Thanks to this, it can use the momentum of the vehicle downhill and, at appropriate times, reduces the load on the driveways; furthermore, it changes the gear ratios and starts idling to reduce fuel consumption. By predicting a change of terrain, the PCC can set a speed control and adjust the shift strategy to save fuel[14]. The reduction of transport costs through speed control has also been demonstrated in[15].

Conducted research

This paper presents data on fuel consumption in vehicles using a cruise control system and an adaptive cruise control system from a transport company that uses three IT programs to monitor and manage the fleet: AutoControl3, Navi24 and Dynafleet Online. These systems show some differences, but the principle of tracking the current position of rolling stock is the same. The main task of telematic fleet monitoring and control systems is to specify the geographical coordinates of a moving object that accurately determine its location. Modern solutions used in the described vehicle monitoring systems, with the help of telematics, information and telecommunications services, continuously determine the position of vehicles and keep uninterrupted control of the fleet.

Implemented telematics systems in the company include many fleet management functions that have a significant impact on the costs of carrying out transport services. The study used only two Navi24 telematics systems and Dynafleet Online, because they are installed in the analysed vehicles.

13 D. Starkowski, K. Bieńczak, W. Zwierzycki, *Samochodowy transport krajowy i międzynarodowy*, Kompendium wiedzy praktycznej, Poznań 2010, pp. 350–351.

14 *Tempomat PCC*, 2016, http://www.daftrucks.pl/pl-pl/trucks/comfort-and-safety-systems-euro-6/predictive-cruise-control [accessed: 20.12.2016].

15 M. Salehi, M. Jalalian, M. Mahdi Vali Siar, *Green transportation scheduling with speed control: trade-off between total transportation cost and carbon emission*, Elsevier, "Computers & Industrial Engineering" 2017, no. 113, p. 393.

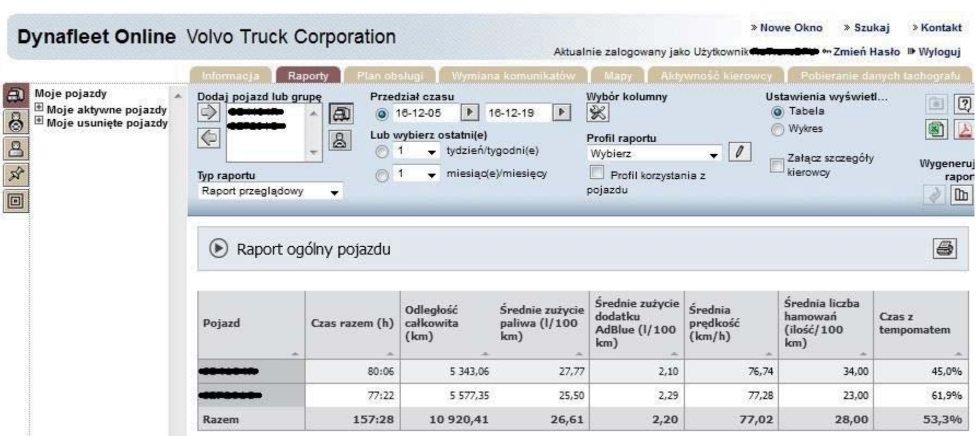
The impact of modern electronic systems on fuel consumption

One of the most important areas of management that has a high outlay on the cost of doing business in a transport company is fuel consumption control. Expenditure on consumables, including fuel, accounts for as much as 1/4 to more than 1/3 of the cost of doing business. The implementation of driver monitoring systems has allowed for the inspection and analysis of key fuel consumption issues. Combustion of diesel fuel by a truck depends on many factors, such as the use of cruise control, engine idling, vehicle speed, proper tire pressure and frequency of use of the main brake.

The purpose of the study was to assess the impact of the electronic maintenance and adjustment system of cruise control on fuel consumption. Reduction of this cost, even by a few percent, can significantly change the company's financial performance. The analysis used:

- detailed reports prepared using the Dynafleet online telematics program,
- two Volvo FH trucks.

With Dynafleet online, detailed reports have been created and analysed to compare fuel consumption on specific routes. For the best accuracy of the test, two vehicles of the same brand, Volvo FH, were used. Both vehicles were equipped with diesel engine DK13K500. For the most precise measurements, only crossings on similar routes were selected, which was possible because the analysed vehicles are the most frequent in Poland - Spain and Poland - Portugal. These tractor units have a similar configuration of equipment, but a significant difference between the 2015 and 2016 vehicle is the I-See system PCC cruise control. For the purposes of this article, the vehicles were named according to the type of cruise control they used: Volvo CCS (classic cruise control) and Volvo I-See (predictive cruise control). The data needed for the analysis, such as total time, distance travelled, average fuel consumption, average speed, average number of brakes and stops and cruise speed, are recorded in the tables for each route. Below is a sample report created using Dynafleet Online for route 1.



Source: Program Dynafleet Online, https://www.dynafleetonline.com [accessed: 2.12.2016].

Fig. 1. Sample report created using Dynafleet Online

Individual, analysed routes

- Route 1: Kraków - Valladolid (Spain) - Krakow, 05.12.2016 - 20.12.2016

− According to Google maps, drivers had to travel 2 650 kilometres, the optimal way in one direction, and the route was identical to the difference in the place of unloading.

Table 2

Summary of data from route 1

Vehicle	Volvo CCS	Volvo I-See
Time (h)	80:06	77:22
Distance (km)	5 343,1	5 577,4
Average fuel consumption (l/100 km)	27,8	25,5
Average speed (km/h)	76,7	77,3
Average number of brakes (no./100 km)	34,0	23,0
Average number of stops (no./100km)	10,0	8,0
Time with the cruise control [%]	45,0	61,9

Source: Own work based on Dynafleet online reports.

- Route 2: Kraków - Valladolid (Spain) - Katowice, 29.08.2016 - 07.09.2016

− The optimal route in Google maps is approximately 5,300 km.

Table 3

Summary of data from route 2

Vehicle	Volvo CCS	Volvo I-See
Time (h)	74:33	74:00
Distance (km)	5 333,1	5 573,1
Average fuel consumption (l/100 km)	25,7	24,6
Average speed (km/h)	77,4	79,0
Average number of brakes (no./100 km)	31,0	21,0
Average number of stops (no./100km)	9,0	6,0
Time with the cruise control [%]	39,8	66,2

Source: Own work based on Dynafleet online reports.

- Route 3: Katowice - Chmielów - Nelas (Portugal), 19.09.2016 - 23.09.2016

− Optimal route according to Google maps is about 3,500 kilometres, which includes two loading locations in Poland and unloading in Portugal.

Table 4

Summary of data from route 3

Vehicle	Volvo CCS	Volvo I-See
Time (h)	47:42	48:19
Distance (km)	3 644,4	3 677,0
Average fuel consumption (l/100 km)	26,9	24,3
Average speed (km/h)	79,1	78,5
Average number of brakes (no./100 km)	24,0	19,0
Average number of stops (no./100km)	4,0	5,0
Time with the cruise control [%]	49,6	63,2

Source: Own work based on Dynafleet online reports.

- Route 4: Kraków - Valadollid (Spain) - Krakow, 30.09.2016 - 13.10.2016
  - According to Google maps, the optimal route is about 5400 km.

Table 5

Summary of data from route 4

Vehicle	Volvo CCS	Volvo I-See
Time (h)	75:37	75:11
Distance (km)	5 569,9	5 546,4
Average fuel consumption (l/100 km)	27,9	26,9
Average speed (km/h)	79,0	76,7
Average number of brakes (no./100 km)	32,0	22,0
Average number of stops (no./100km)	10,0	6,0
Time with the cruise control [%]	52,1%	60,8%

Source: Own work based on Dynafleet online reports.

- Route 5: Krakow - Rivabellosa (Spain) - Krakow, 21.10.2016 - 02.11.2016
  - According to Google maps, the optimal route is about 5000 km.

Table 6

Summary of data from route 5

Vehicle	Volvo CCS	Volvo I-See
Time (h)	68:11	65:55
Distance (km)	5 158,0	5 213,3
Average fuel consumption (l/100 km)	27,4	26,5
Average speed (km/h)	79,8	80,9
Average number of brakes (no./100 km)	30,0	14,0
Average number of stops (no./100km)	5,0	4,0
Time with the cruise control [%]	47,1%	64,8%

Source: Own work based on Dynafleet online reports.

- Route 6: Tarnów - Barcelona (Spain), 01.08.2016 - 05.08.2016
- According to Google maps, the optimal route is 2350 km.

Table 7

Summary of data from route 6

Vehicle	Volvo CCS	Volvo I-See
Time (h)	34:55	36:48
Distance (km)	2 499,1	2 503,3
Average fuel consumption (l/100 km)	27,8	26,2
Average speed (km/h)	78,2	77,3
Average number of brakes (no./100 km)	25,0	19,0
Average number of stops (no./100km)	9,0	6,0
Time with the cruise control [%]	49,7%	57,3%

Source: Own work based on Dynafleet online reports.

- Route 7: Katowice - Nelas (Portugal)
- According to Google maps, the optimal route is less than 3000 km.

Table 8

Summary of data from route 7

Vehicle	Volvo CCS	Volvo I-See
Time (h)	44:15	42:00
Distance (km)	3 079,2	3 047,1
Average fuel consumption (l/100 km)	26,0	24,9
Average speed (km/h)	74,0	75,9
Average number of brakes (no./100 km)	33,0	26,0
Average number of stops (no./100km)	9,0	6,0
Time with the cruise control [%]	32,2%	54,5%

Source: Own work based on Dynafleet online reports.

- Route 8: Chmielów - Oiartzun (Spain) - Chmielów, 03.01.2017 - 14.01.2016
- According to Google maps, the optimal route is about 5100 km.

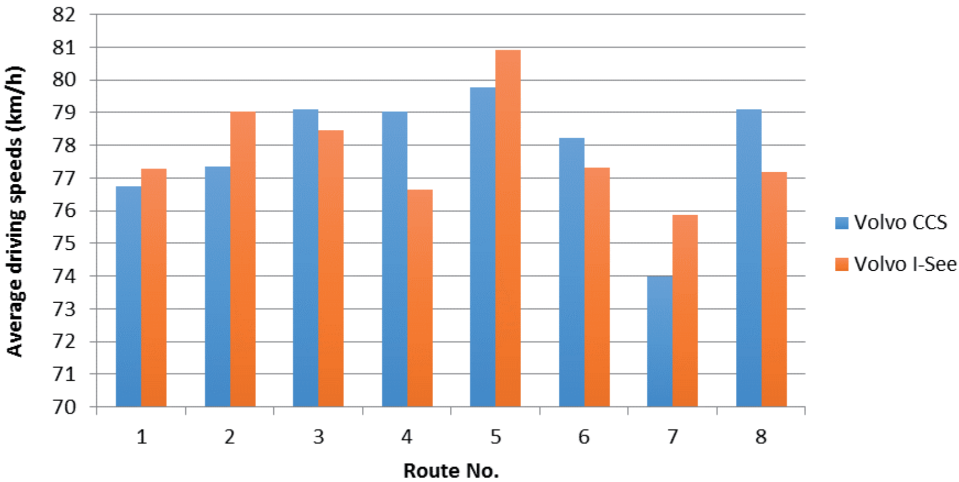
Table 9

Summary of data from route 8

Vehicle	Volvo CCS	Volvo I-See
Time (h)	76:11	75:16
Distance (km)	4 978,7	5 293,7
Average fuel consumption (l/100 km)	29,6	27,8
Average speed (km/h)	79,1	77,2
Average number of brakes (no./100 km)	27,0	26,0
Average number of stops (no./100km)	5,0	7,0
Time with the cruise control [%]	30,2%	59,6%

Source: Own work based on Dynafleet online reports.

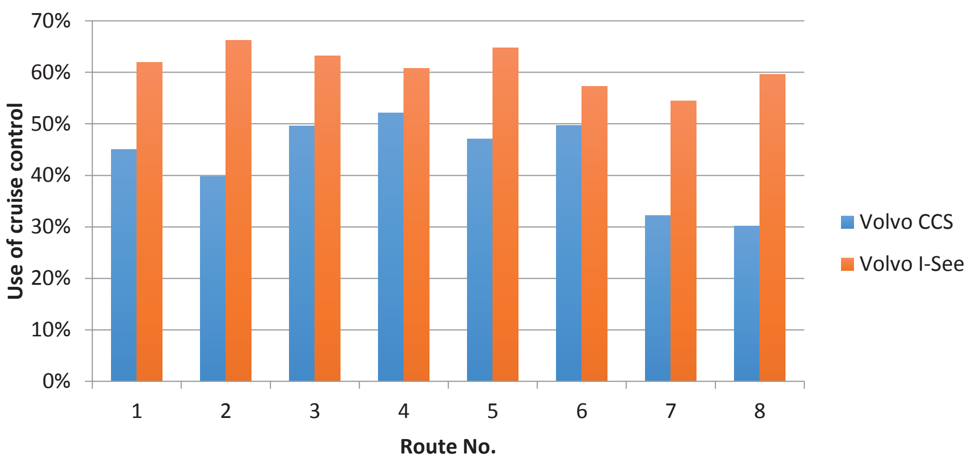
The figures 2-5 shows data from tables 2-9 in graphical form.



Source: Own work based on tables 2-9.

Fig. 2. Comparison of average driving speeds

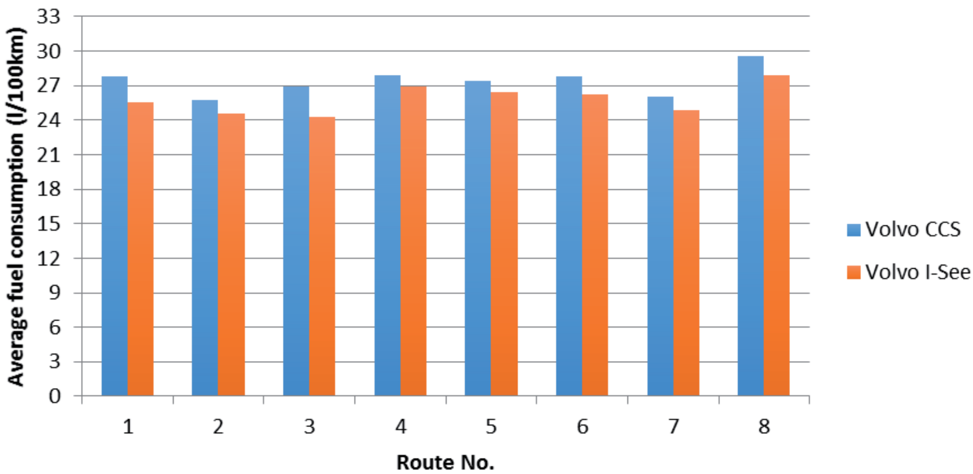
Figure 2 shows a comparison of the average speed of the analysed Volvo vehicles. The difference in average vehicle speeds was less than 2 km/h, but on one of the tracks, the limit was exceeded to 2.39 km / h. There is no advantage for any of the vehicles as the arithmetic mean of all driving speeds is 77.91 km/h for Volvo CCS and 77.84 km/h for Volvo I-See.



Source: Own work based on tables 2-9.

Fig. 3. Comparison of use of cruise control on analyzed routes

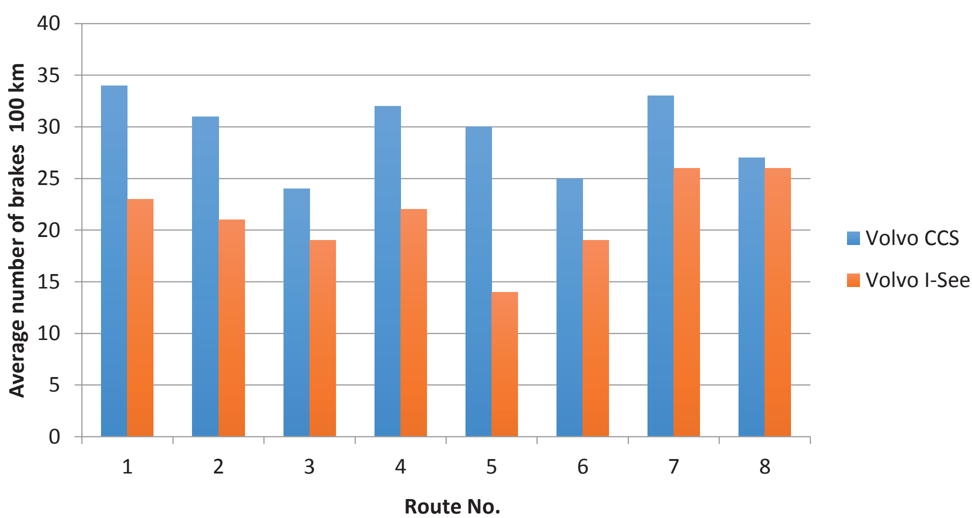
Figure 3 shows the percentage comparison of the driving time of both types of vehicles using the cruise control for each route. There was a decisive advantage in using a car system with an adaptive cruise control (ACC) line of up to 49.3%. The results show that the type of cruise control has a great influence on the driver's use of the cruise control. This is due to the adaptive cruise control capability of the "normal" cruise control.



Source: Own work based on tables 2-9.

Fig. 4. Comparison of average fuel consumption depending on the type of cruise control

Figure 4 shows the comparison of average fuel consumption in Volvo FH vehicle units depending on the type of cruise control. The vehicle with the adaptive cruise control burned less diesel fuel on each of the analysed routes.



Source: Own work based on tables 2-9.

Fig. 5. Comparison of average number of brakes

Equally important, as shown in Figure 5, is the average number of brakes. It has been found that a truck driver with a predetermined cruise control that maintains a safe distance from the preceding vehicle uses significantly less pressure on the main brake, which also affects the cost of the transport task carried out by reducing the consumption of consumable items such as tyres and the friction elements of the brake system.

Table 10 summarises the average diesel consumption per 100 kilometres.

Table 10

Summarises average diesel consumption per 100 kilometres

Route No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Volvo CCS [l/100km]	27.8	25.7	26.9	27.9	27.4	27.8	26.0	29.6
Volvo I-See [l/100km]	25.5	24.6	24.3	26.9	26.5	26.2	24.9	27.8
Combustion difference [%]	8.3%	4.3%	9.7%	3.6%	3.3%	5.8%	4.2%	6.0%

Source: own work.

The average fuel consumption for a classic cruise control vehicle was 27.4 [l/100km], while for vehicles with an adaptive cruise control rating it was 25.8 [l/100km]. The difference in combustion, taking into account the distance travelled, allows fuel consumption to be significantly reduced by using adaptive cruise control vehicles and thus reducing transport costs.

Summary

Based on a study conducted using Volvo FH tractors with different types of cruise control, it was found that the predicted cruise control has a significant impact on fuel consumption. The use of a vehicle with cruise control of this type reduces combustion as well as improves safety thanks to the system which controls the distance from the preceding vehicle. On average, on selected routes, which consisted of approximately 36,000 kilometres, the I-See tractor unit consumed 5.7% less fuel.

The above percentile in this particular case translates into 563 litres less diesel. Assuming an annual mileage of 120,000 km, the savings will amount to nearly 1900 litres of diesel per truck, which, given the diesel price, can translate into significant reductions in variable costs and increased competitive advantage for the transport company.

The results of analyses (carried out on the basis of the analysis of documentation) clearly showed that the goal adopted in the article in the form of an answer to the question whether modern systems improving driving comfort can be used indirectly to reduce the costs of the company's activity has been achieved. The results obtained clearly indicated the positive impact of modern cruise control systems used in trucks to reduce operating costs and an indirect increase in competitive advantage.

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