Special Issue on the Impact of Vehicle Movement on Exploitation Parameters of Roads and Runways

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THE IMPACT OF VEHICLE MOVEMENT ON EXPLOITATION PARAMETERS OF ROADS AND RUNWAYS: A SHORT REVIEW OF THE SPECIAL ISSUE

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A better understanding of roads and airports as a system requires the proposition of new methods and the advancement of existing ones focusing on understanding the relations among all factors that influence the performance of transport infrastructure. This Editorial presents a short review of all 18 original papers paper published in the current *Special Issue on the Impact of Vehicle Movement on Exploitation Parameters of Roads and Runways* (see Table). The first 10 papers (#1–10) of this Special Issue propose the assessment of new methods directed towards a better understanding and description of pavements as well as the relations among all the factors that influence pavement and performance during road and/or airport maintenance. The last 8 papers (#11–18) of this Special Issue present research findings from related to advanced criteria and performance-based roadway design objectives while taking into account road vehicle interaction, fuel economy, and emissions.

Paper #1 by Raslavičius *et al.* (current special issue: 133–141) focuses on the tire–pavement interaction on dry asphalt pavement surfaces in order to quantify the effect of micro-profile on vehicle performance while establishing its braking conditions. The paper presents data on a number of different indications (vehicle speed, adhesion coefficients calculated on the basis of braking and friction forces, maximum adhesion coefficient μ_{max} and its 'minimum' value $\mu_{100\%}$) and measurement results generated using an SRT-4 device for the investigation of two road stretches at intervals of 100 m. Moreover, the paper presents also the interdependence analysis of the variables μ_{max} and $\mu_{100\%}$ to show the usefulness of the method.

Paper #2 by Panáček *et al.* (current special issue: 142–146) details the analysis of driving and braking of the *Volvo V40 Cross Country* vehicle in curves with radius 30, 40 and 50 m with particular emphasis on usable values of the coefficient of adhesion between tire and road surface in the longitudinal and lateral directions. Individual dynamic driving and braking experiments in the curves were carried out while using both modes of the *Volvo* stability system DSTC, and results show that the range of values of the coefficient of adhesion in the longitudinal and lateral directions depends on the vehicle speed and the curve radius. Experimentally determined values are utilised efficiently for the calculation of the speed limit for a modern vehicle in a curve or, for instance, for the forensic reconstruction of a road accident.

Paper #3 by Ružinskas *et al.* (current special issue: 147–155) presents an analysis of the efficiency of Deicing Materials (DMs) used by the Lithuanian road maintenance agencies. Five different DMs were studied by performing ice melting tests in the laboratory where the DMs were evenly spread on the formed ice samples while taking the same amount of grains of uniform size. The ice mass dissolved by each DM was determined at different durations of melting action, ranging from 4 to 120 minutes, and at different ambient temperatures, ranging from –20 °C to –3 °C. The analysis of the results consisted of reporting findings for each DM and com-

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paring them under different temperature conditions. In addition, the deicing speed of each DM was calculated, the DMs were categorised according to their efficiency performance, and the price of one percent of melted ice was determined.

Paper #4 by Wang and Zhao (current special issue: 156–166) determined a rational overweight permit fee by using Mechanistic-Empirical (M-E) pavement design and Life-Cycle Cost Analysis (LCCA). The state-of-the-art pavement design software Pavement-ME was utilised to develop Load Equivalency Factors (LEFs) and estimate pavement service life under various traffic loading conditions. LCCA allowed calculating Marginal Pavement Damage Cost (MPDC) in terms of Equivalent Uniform Annual Cost (EUAC) while considering variations in maintenance strategies, analysis periods, and discount rates. The paper presents a methodological framework for the calculation of distance-based, weight-based, weight- and distance-based, and flat permit fees for overweight trucks. The implementation of the proposed methodology to a New Jersey (United States) case study allowed calculating example permit fees for the major and local road network with the thick and thin asphalt pavement structure, respectively. Results show that the truck-induced damage cost varies significantly between thin and thick asphalt pavements when considering different failure mechanisms in fatigue cracking and rutting. In general, overweight permit fee might not be fair to overweight trucks at different vehicle classifications if only the total overweight tonnage is regulated in the permit fee structure.

The objective of the Paper #5 by Khan *et al.* (current special issue: 167–176) was (i) to develop a methodology for targeted pavement friction data collection based on the analysis of weather-related crashes, and (ii) to identify threshold values of pavement friction characteristics indicating a significant impact on safety prompting the need for maintenance and improvements. Spatial analysis using Local Moran's *I* statistic identified hotspots from a master database that included Wisconsin State Trunk Network road attributes, hotspots of weather-related crashes, and pavement friction data. Results support hotspot analysis as a viable procedure for targeted pavement friction data collection to enable efficiency and cost reductions. Classification tree analysis using the GUIDE (Generalized, Unbiased, Interaction Detection and Estimation) algorithm explored further the relations between pavement friction characteristics and safety. Empirical results showed statistically significant hotspots below a pavement friction number of approximately 57 and very high hotspots below a pavement friction number of approximately 42. These findings suggest that pavement friction thresholds identified in the literature between 20 and 32 may be too low and that safety may be impacted at friction numbers as high as in the forties. These findings also show differences in friction and safety for various types of pavement surfaces and, most relevantly, indicate that the use of weather-related crashes provides a data-driven and cost-effective method of prioritising locations for pavement friction data collection and maintenance. This is essential for practitioners in the initial steps of systemic road safety management procedures.

Paper #6 by De Luca *et al.* (current special issue: 177–182) deals with the decay phenomenon of surface characteristics related to contamination from rubber deposits. Surfaces of airport pavements are subject to contamination that can be very dangerous for the movement of aircrafts, particularly on the runway. A recurrent problem is the deposits of vulcanised rubber of aircraft tires in the touchdown area during landings and lesser during take-offs, which causes a loss of grip that compromises the safety of aircraft movements. The experiment was conducted by correlating the pavement surface characteristics to air traffic before and after the de-rubberizing operation, and two models were constructed for the assessment of the functional capacity of the runway before and after the de-rubberizing operation.

Paper #7 by Ahmed *et al.* (current special issue: 183–191) shows that newly constructed and reconstructed highway pavements deteriorate progressively under the effect of traffic loading and climate severity, and they need a preservation intervention after a certain number of years following their construction. In the literature, the term 'rest period' has been used to refer to the number of years that elapse between the construction completion and the first major repair activity. This period is a critical piece of information that agencies use not only to plan and budget for the first major repair activity, but also to develop more confidently their life-cycle activity schedules for life cycle costing, work programming, and long-term plans. However, the literature lacks established procedures for predicting rest periods on the basis of pavement performance thresholds, and highway agencies rely mostly on expert opinions for establishing the rest periods for their pavement sections. In addressing this issue, this paper presents a statistical methodology for establishing the rest periods for newly constructed or reconstructed pavements and application to in-service pavements in a Midwestern state in the US. Results show that the rest periods of newly constructed and reconstructed highway pavements are significantly influenced by their functional class, surface material type, traffic loading level, and climate severity.

Paper #8 by Aydin and Topal (current special issue: 192–201) presents lateral lane utilisation and longitudinal driving behaviour on a deformed two-lane road. Various road surface deformations generally occur on urban and rural roads due to infrastructure and superstructure deficiencies, as well as excessive heavy vehicle loads. In addition to driver-based errors, many accidents happen due to these mentioned surface deformations. The paper analyses the effect of these deformations on drivers' lane selection, lane utilisation, and traffic flow movements by analysing vehicles travelling through four different deformation zones on a two-lane road in Izmir (Turkey) where parameters were collected about the lateral position, speed, acceleration/deceleration and location. The collected data was evaluated with

Table. Contents of the Special Issue on the Impact of Vehicle Movement on Exploitation Parameters of Roads and Runways

	Title of the paper	Authors of the paper	Country
Paper #1	Investigation of asphalt texture roughness on friction evolution for wheeled vehicles	Laurencas Raslavičius, Algis Pakalnis, Artūras Keršys, Ramūnas Skvireckas, Darius Juodvalkis	Lithuania
Paper #2	Impact of usable coefficient of adhesion between tyre and road surface by modern vehicle on its dynamics while driving and braking in the curve	Vladimír Panáček, Marek Semela, Vladimír Adamec, Barbora Schüllerová	Czech Republic
Paper #3	Laboratory investigation and efficiency of deicing materials used in road maintenance	Andrius Ružinskas, Matas Bulevičius, Henrikas Sivilevičius	Lithuania
Paper #4	Development of overweight permit fee using mechanistic-empirical pavement design and life-cycle cost analysis	Hao Wang, Jingnan Zhao	United States
Paper #5	Incorporating safety into targeted pavement friction data collection and maintenance procedures	Ghazan Khan, Andrea R. Bill, Kevan Shafizadeh, David A. Noyce	United States
Paper #6	Field measurements on runway friction decay related to rubber deposits	Mario De Luca[1], Francesco Abbondati[2], Thomas J. Yager[3], Gianluca Dell'Acqua[4]	[1, 2, 4]Italy, [2]United States
Paper #7	Estimation of rest periods for newly constructed/reconstructed pavements	Anwaar Ahmed[1], Tariq Usman Saeed[2], Samuel Labi[3]	[1]Pakistan, [2, 3]United States
Paper #8	Effect of road surface deformations on lateral lane utilization and longitudinal driving behaviours	Metin Mutlu Aydin, Ali Topal	Turkey
Paper #9	The influence of pavement–vehicle interaction on highway fuel consumption by field measurement	Xin Jiao, Michael Bienvenu	United States
Paper #10	Appraisal of Takagi–Sugeno type neuro-fuzzy network system with a modified differential evolution method to predict nonlinear wheel dynamics caused by road irregularities	Hamid Taghavifar[1], Asad Modarres Motlagh[2], Aref Mardani[3], Ali Hassanpour[4], Ashkan Haji Hosseinloo[5], Leyla Taghavifar[6], Chongfeng Wei[7]	[1–4, 6]Iran [5]United States [7]United Kingdom
Paper #11	Evaluating the effects of road geometry, environment, and traffic volume on rollover crashes	Mehdi Hosseinpour[1], Ahmad Shukri Yahaya[2], Ahmad Farhan Sadullah[3], Noriszura Ismail[4], Seyed Mohammad Reza Ghadiri[5]	[1]Iran, [2–5]Malaysia
Paper #12	A procedure for evaluating the influence of road context on drivers' visual behaviour	Nicola Bongiorno, Gaetano Bosurgi, Orazio Pellegrino	Italy
Paper #13	Light vehicle model for dynamic car simulator	Alessio Pieroni[1], Claudio Lantieri[2], Hocine Imine[3], Andrea Simone[4]	[1, 2, 4]Italy, [3]France
Paper #14	Sight distance analyses in road design process: Serbian practice	Dejan Gavran, Sanja Fric, Vladan Ilić, Filip Trpčevski	Serbia
Paper #15	Operating speed as a key factor in studying the driver behaviour in a rural context	Francesca Russo, Salvatore Antonio Biancardo, Mariarosaria Busiello	Italy
Paper #16	Roadside public survey approach in black spot identification on rural roads: case study	Miladin Nešić, Krsto Lipovac, Milan Vujanić, Dragan Jovanović	Serbia
Paper #17	Setting speed limits in interurban single-carriageway highways using expert's judgment	Ana Bastos Silva, Alvaro Seco, Nuno Gregório	Portugal
Paper #18	Microsimulation-based passenger car equivalents for heavy vehicles driving turbo-roundabouts	Orazio Giuffrè[1], Anna Granà[2], Sergio Marino[3], Fabio Galatioto[4]	[1–3]Italy, [4]Uited Kingdom

chi-square (χ^2) goodness of fit test evaluated whether the parameters follow a normal distribution, given the assumption that, in ideal conditions, the distribution of the lateral position of vehicles in a lane is similar to a normal distribution. Results indicate that, if a deformation zone has a wider area and less depth, it will be less effective on lateral lane utilisation of vehicles. In addition, the variation in other parameters such as deformation type, depth, and height, is associated with the lateral lane utilisation of drivers. Additionally, drivers' characteristics such as perception and aggressiveness are seen as the most important factors influencing the longitudinal vehicle behaviours while passing through the deformation zones.

Paper #9 by Jiao and Bienvenu (current special issue: 202–210) captured fuel differences between flexible and rigid pavements while controlling for other fuel-related factors. An analysis of covariates shows that rigid pavements imply lower fuel consumption and better fuel efficiency when compared to flexible pavements. Results are in good agreement with a Phase I field study, at the level of 2 to 3%, and also reveal that the fuel differences increase with the increase of vehicle weight, although not linearly. It is worth to mention that both phases focus on fuel efficiency on highway driving condition instead of city/rural conditions.

Paper #10 by Taghavifar *et al.* (current special issue: 211–220) aimed at predicting wheel dynamics caused by road irregularities by using a Takagi–Sugeno type neuro-fuzzy network system with a modified Differential Evolution (DE) method. The experimental phase to validate the developed model used a single-wheel testing rig in a soil bin facility that provided a controlled experimental medium while different operating conditions and tire parameters were included. Straight-line functions were adopted due to their considerable simplicity whereas uniformly triangular membership functions were selected for superior accuracy. Results show that the Takagi–Sugeno Fuzzy model with DE optimisation yielded a model with Root Mean Squared Error (RMSE) of vertical and horizontal forces at 0.069 and 0.310, respectively and coefficients of determination for vertical and horizontal forces of 0.97 and 0.96, respectively. Findings from this study indicate that the Takagi–Sugeno Fuzzy model with DE optimisation is a promising tool for the prediction of different phenomena of wheel-ground kinetics and kinematics, as it outperformed Adaptive Neuro-Fuzzy Inference System (ANFIS) to solve the problem at different membership function shapes. It can also be used as an approach to yield a model that can be used in any future research framework without any need to repeat the experiments to find the behaviour of wheels when collided with obstacles and cleats. It was finally noted that the proposed model is applicable and suitable to be used for the modelling of wheel–obstacle collisions with satisfactory performance when compared with numerically based simulation tools such as finite element method.

Paper #11 by Hosseinpour *et al.* (current special issue: 221–232) aims at applying a set of crash prediction models in order to estimate the number of rollovers as a function of road geometry, environment, and traffic conditions. To this end, seven count-data models, including Poisson (PM), negative binomial (NB), heterogeneous negative binomial (HTNB), zero-inflated Poisson (ZIP), zero-inflated negative binomial (ZINB), hurdle Poisson (HP), and hurdle negative binomial (HNB) models, were formulated and estimated using crash data collected on 448 segments of Malaysian federal roads. The comparison of model results showed that the HTNB was the best formulation for modelling the frequency of rollovers. Light vehicle traffic, horizontal curvature, access points, speed limit, and centre line median were positively associated with the crash frequency while unpaved shoulder width and heavy vehicle traffic were found to have a negative correlation. Findings from this study suggest that rollovers could potentially be reduced by developing road safety countermeasures such as managing access to driveways, straightening sharp horizontal curves, widening shoulder widths, designing better centre line medians, and posting lower speed limits and warning signs in areas with higher rollover tendency.

Paper #12 by Bongiorno *et al.* (current special issue: 233–241) analyses drivers' visual behaviour while travelling on a road regularly opened to traffic in order to evaluate the effectiveness of traditional scientific models and, at the same time, propose additional measures for understanding the complex phenomenon. It is known that drivers acquire the necessary information about the road geometry by visually detecting certain areas of the surrounding context. Some models in the literature have shown in a simple and convincing way these mechanisms, but they are valid only with specific assumptions, often very restrictive, such as a two-lane road, horizontal signs clearly visible, no interactions with other vehicles. For this reason, this study investigated different conditions by estimating the visual strategy of regular drivers on a three lane road in the presence of other vehicles. The visual behaviour was surveyed with the *Tobii Glasses Eye Tracker*®, and the resulting raw data were manipulated to extract valuable information. The authors quantified the driver's dedicated attention to the various elements present in the environmental context, both static (e.g., road edges, road signs, dashboard) and dynamic (e.g., other vehicles), that could potentially collide with the vehicle trajectories. Results highlight the limits of the validity of findings from some recent studies and propose indices useful for a better understanding of the visual behaviour in order to detect any eventual weakness of the road.

The topic of the Paper #13 by Simone *et al.* (current special issue: 242–249) concerns the development of a brand new dynamic model for an existing car simulator owned by LEPSIS laboratory (*Laboratoire d'Expliotation, Perception, Simulateurs et Silulations – Laboratory for Road Operations, Perception, Simulators and Simulations*) belonging to COSYS (*COmposants et SYStems*), which is a department of the IFSTTAR institute (*Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux* – French

Institute of Science and Technology for Transport, Spatial Planning, Development and Networks). Driving simulators have become a suitable tool oriented towards improving the knowledge about the driving research domain. The investigations that can be conducted with this type of tool concern driver behaviour, vehicle design/control, test of assistance systems for driving, and test of the impact of roadway infrastructure. The paper describes the benefits of simulation studies that are the lack of any real risk to users, reproducible situations, time savings and reduced testing costs. In addition, their flexibility allows testing situations that do not exist in reality or at least they rarely and randomly exist. The paper also highlights imperfections and limitations of existing driving vehicle models consisting of two degrees of freedom. Subsequently, the structure of the brand new vehicle model, designed by means of *Matlab–Simulink* software, is illustrated through the theoretical framework. Since the vehicle model must refer to a real one, an instrumented *Peugeot 406* has been chosen because all its technical features are provided and inserted into both the presented model and *Prosper/Callas 4.9* software by OKTAL to create a highly sophisticated and accurate virtual version of the commercial car. The validation of this new vehicle model was performed and the results returned by several different driving scenarios are compared with the ones provided by the Prosper software. All the scenarios were simulated with both existing and new vehicle models uploaded in the driving simulator, and the outputs were subsequently compared with the ones returned by *Prosper* in order to demonstrate the improvements done. Finally, being the number of outputs provided by the new model definitively higher with respect to the previous one, additional validations concerning the further results are accomplished.

Paper #14 by Gavran *et al.* (current special issue: 250–259) deals with new Serbian policies on road design to introduce the concept of operating speeds. Decades ago, national policies were based on the concepts of constant design speed. Among other design parameters, in relation to that constant design speed, minimum radii of horizontal and vertical road geometry were determined. The introduction of the concept of operating speed provides for more realistic prediction of speed levels along the road. Unlike the constant design speed, operating speed levels vary along the road, reaching higher levels in curves with larger radii, on straight sections, and on reverse curves, and dropping down to the design speed level in horizontal curves with the minimum radius. Consequently, besides a constant Stopping Sight Distance (SSD), which is calculated from the constant design speed, a Required Sight Distance (RSD) is introduced. The RSD varies along the road, as it is calculated from the operating speed that also varies along the road, and appropriate RSD analyses are crucial to road rehabilitation projects, since a simple resurfacing that enables higher speed levels, without providing increased RSD, may hamper the safety of a newly resurfaced road. Software tools for predicting operating speed levels and optical analyses of the road are also presented in this paper. Software tools for RSD analyses enable the import of lines of sight into the 3D model of the roadway and their export into the cross sections extracted from the model, thus facilitating the obstacle removal. Also demonstrated are tools for determining the Available Sight Distance (ASD) that is based on triangulated 3D models of the roadway as well.

Paper #15 by Russo *et al.* (current special issue: 260–270) aims at exploring the effects of geometric road features on driver speed behaviour in order to identify unsafe road segments where high reductions in speed between successive road elements occur. The empirical analysis focuses on two-lane rural roads on flat terrain (vertical grade less than 5%) in Southern Italy, totalling 184 km without spiral transition curves between the tangent segments and circular elements. The testing was carried out on 567 study sites, of which 248 are on circular curves and 319 on tangents. Speed data collection was carried out via a laser in the following environmental and traffic conditions: dry roads, free flow conditions, daylight hours, and good weather conditions. The main goal was to calibrate and validate different operating speed prediction models: (i) a model on tangent segments; (ii) a model on circular curves; (iii) a joint model for tangents and circular curves. The validation process involved almost 10% of the total road network length, which was removed from the calibration phase. The speed measurements of each were grouped into ten homogeneous substrates for the first two datasets (i, ii) while sixteen substrates were defined for the remaining dataset (iii) by using a hard *c*-means algorithm. The Chauvenet criterion and the Vivatrat method were used to remove anomalous operating speed values from each group of three datasets, with the former to be preferred to the latter since it showed more homogeneous samples guaranteeing a higher correlation coefficient and lower residuals of the predictive models during the validation phase. Ordinary Least Squares (OLS) models were estimated with covariates including total segment length, lane width, the curvature of the road element, the curvature change rate on homogeneous road segments, and number of residential driveways per km. ANOVA and additional synthetic statistical parameters allowed checking the effectiveness of using a joint model to predict operating speeds on tangents and circular curves. Results suggest the reliability of this hypothesis and its effectiveness in the application phase.

Paper #16 by Nešić *et al.* (current special issue: 271–281) examined the possibility of applying the Subjective Black Spot Identification Method on state roads. A survey was conducted about the attitudes of 659 drivers about the existence of Black Spots, on nine sections of state roads in the Republic of Serbia. A total of 124 locations were obtained which drivers deemed as Perceived Dangerous Locations (PDLs). A set of hypotheses was defined in order to examine whether a particular PDL is a Black Spot by using Bayesian Multiple Testing (BMT). Since an actual Black Spot has not been recognised as a PDL in the survey, which consequently

is not subject to the BMT, a new concept was introduced to include the frequency of mishits in identifying real 'Black Spots' (RPM) and real 'non-Black Spots' (RNM), as well as the frequency of hits in identifying real 'Black Spots' (RPH) and real 'non-Black Spots' (RNH). Optimisation methods were applied for the selection of the optimum threshold t via the minimisation of the frequency of mishits (RPM and RNM) and the maximisation of the frequency of hits (RPH and RNH). Two operatively usable solutions were offered. If the consumption of resources and the effectiveness of fund spending for identification are primarily low, then the best result is obtained by using the optimisation with the minimisation of the sum of mishits frequency. Then t = 24.7%, and the ratio of correctly and wrongly selected Black Spots is 1:1.16. On the other hand, if the goal is to detect as many real Black Spots as possible, regardless of the reduction in the effectiveness of fund spending, then the best results is achieved by using the optimisation with the equalizing of the frequencies of mishits. Then t = 7.7% and the ratio of correctly and wrongly selected Black Spots is 1:7.15.

Paper #17 by Bastos Silva *et al.* (current special issue: 282–294) developed a speed management methodology with a widespread application to single carriageway roads in interurban areas crossing different road surrounding environments with heterogeneous rural, urban or mixed characteristics. The methodology was a decision support method for the definition of the appropriate speed limit on each stretch of a road, based on criteria related to speed consistency and road layout homogeneity, as well as on the drivers' willingness to naturally accept successive changes in speed limits in successive stretches of the road. With this purpose, an analytical model was developed to accurately identify the acceptable speed limit on the basis of a set of easily measurable variables characterising each stretch of the road under analysis and its surrounding areas. A Multinomial Logit discrete choice model was estimated for a case study involving 55.4 km, and the model was validated for additional 11 km of rural roads crossing different environments. The model was estimated based on the judgments of four traffic safety experts about each direction of each road stretch (200 m long). Before the modelling development, a Factor Analysis involving the whole set of variables was carried out in order to detect not directly observable common features on its structure that may influence the final outcome of model estimation. This analysis allowed to corroborate the overall variable selection process. Without loss of explanatory power, it was possible to avoid the presence of subjective explanatory variables greatly enhancing the model's robustness and transferability to other locations and countries. The model also facilitates the interpretation of the validation process and enables the models to be developed to represent different levels of safety related sensitivity existent amongst the expert community by using a 'conservative expert' evaluation. The validation results have shown the models to be useful as decision support tools applied to the evaluation of speed limits.

Paper #18 by Giuffrè *et al.* (current special issue: 295–303) addresses the question of how to estimate passenger car equivalents for heavy vehicles driving turbo-roundabouts. Due to its geometric design, turbo-roundabouts impose greatest constraints to the vehicular trajectories; consequently, one can expect a negative impact of heavy vehicles on the traffic conditions with respect to other types of roundabouts. A microsimulation approach proved to be a useful tool for evaluating the variation of the quality of traffic in the presence of mixed fleets (i.e., different percentages of heavy vehicles). Based on the output of multiple runs of several scenarios simulation, capacity functions for each entry lane of the turbo-roundabout were developed and variability of the passenger car equivalents for heavy vehicles was calculated by comparing results for a fleet of passenger cars only with those of the mixed fleet scenarios. Results show the dependence of passenger car equivalents for heavy vehicles on operational conditions which characterise the turbo-roundabout. Assuming the values of passenger car equivalents for roundabouts provided by the 2010 HCM, underestimation or overestimation of the effect of heavy vehicles on the quality of traffic conditions was found to be dependent on entering manoeuvring.