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Towards seamless door-to-door travelling within Europe: Transport operators' and passengers' perspectives

Danica Babić[a]1, Aleksandra Colovic[b], Slavica Dožić[a], Milica Kalić[a], Tatjana Krstić Simić[a], Katarina Kukić[a], Michele Ottomanelli[b], Salvatore Gabriele Pilone[b]

[a]*University of Belgrade-Faculty of Transport and Traffic Engineering, Vojvode Stepe 305, Belgrade 11000, Republic of Serbia*
[b]*Polytechnic University of Bari, Via Edoardo Orabona, 4, Bari 70125, Italy*

Abstract

Seamless door-to-door air passenger multimodal transport system is a new concept in the transport industry, and that is why data on system interoperability is lacking. In this paper a qualitative research method is applied, in order to get the transport experts' opinions and information on how the multimodal system should be designed. Although, they are aware that the collaboration should result in increase in the volume of passengers, the most challenging task is to convince transport operators to share the data among each other, due to the legal issues. To determine the customers' perspective for making multimodal choices in their journeys, the travel demand model is developed, based on survey data. The model reveals the importance for policy makers and transport operators serving the airport to address the access time reliability by carefully considering the passengers' preferences.

Keywords: Multimodal journey; seamless door-to-door; travel behaviour; binary logistic regression model.

1. Introduction

Seamless door-to-door (D2D) travelling that includes air transport is a new trend in the transport industry (Goletz et al., 2020). A major strategy of this new concept of mobility is the development of one multimodal journey instead of separate segments within one journey. Although, the technology to create seamless multimodal transport already exists, the majority of transport services are still being delivered to the customer in a disconnected way. Namely, if a passenger travels from home to the destination this involves switching from surface mode of transport (e.g., car, metro, train or bus) to an airplane and then again to the same or other type of surface mode. In addition, the passengers have

*Corresponding author. Tel.: +381-11-3091-264.
E-mail address: d.babic@sf.bg.ac.rs

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to pay separately for each segment of the journey i.e., to purchase separate tickets for each segment from the different operators providing corresponding transport service.

In order to improve transport services, the need to look at new ways to provide services for travellers, on one hand, and simplify the provision of services for operators, on the other hand, arises, (European Commission, 2011). Single ticket would be one of the main characteristics of the multimodal travel, followed up with document-free passenger service (one ID), single information platform for communication of all transport operators involved, etc. In system like this, timetables should be fully coordinated, responsibility should be shared among transport operators and passengers, location of terminals and stops should be better positioned to provide shorter walking distance between terminals during transfer, possibility of remote check-in would be offered, additional access facilities at transfer points (at terminals and stations) for all modes of transport should be provided. Therefore, seamless D2D service for air passengers requires a holistic, cooperative and collaborative decision-making environment, where the efficient use of different modes of transport, separately and in combination, needs to be balanced in order to achieve sustainable use of resources. The main goal is to make travel experiences more efficient, safer, greener, with less inconvenience, while optimizing total journey time. For that purpose, we investigated the opportunities for collaboration and data sharing in multimodal journey by taking into account experts' opinion, as well as customers' perspective for making travel choice in multimodal journey (in the SYN+AIR project[1]). Therefore, we applied a qualitative research method to obtain experts opinion related to opportunities, benefits, and barriers for data sharing in multimodal D2D trip. Additionally, we developed travel demand model for users' behaviour, i.e., Binary Logistic Regression, for capturing the travel mode choice as well as the attributes that influence such choice in multimodal trip.

Thus, to make this multimodal concept successful, it is important to encourage more passengers to use it. Therefore, this new D2D service must become more attractive i.e., to be easier and more convenient for people to make their D2D journeys using sustainable transport (e.g., public transport). This means that by providing multimodal D2D service by sustainable means, this service has to be convenient, seamless and as easy as getting in the car.

The paper is organised as follow. After introduction and literature review, proposed research methodology is presented. Then, transport operators' viewpoint based on experts' opinion as well as passengers' perspective with the developed demand model are given. Finally, conclusion and further research directions are provided.

2. Literature review

In the relevant literature, papers with different aspects and approaches to the multimodal transport service can be found. It should be emphasized that, in a group of papers, the use of more than one transport mode within a given period of time, referred to as multimodality.

The question: Does a high level of multimodality in England mean less car use? is investigated based on data collected through the period of 20 years (1995-2015) (Heinen and Mattoli, 2019). This study, as several other studies (Kilinger, 2017; Buehler and Hamre, 2016; Buehler and Hamre, 2015; Kuhnimhof et al. 2012) reported that multimodality had increased. Although, most studies suggest that car use is decreasing and multimodality is increasing, the study in England showed that the use of cars has not been changed despite the passengers use different modes of transport on their journeys (Heinen and Mattoli, 2019). What should be emphasized is that none of the above-mentioned researches consider the multimodality in the view of seamless D2D transport, neither in the view of integrated transport system. Moreover, none of researches consider air transport as a part of multimodal system. However, there are some papers that investigate integration of specific modes of transport, e.g., rail and air (Yuan et al. 2021; Jiang et al. 2021).

Mode choice of transport to/from the airport has been studied in many cities and regions across the Europe in order to identify the attributes that affect the mode choice behaviour (e.g., Bruderer Enzler, 2017, Gokasar and Gunay, 2017, Birolini et al., 2019, Bergantino et al., 2020, Gunay and Gokasar, 2021). Based on previous studies it is found that many attributes are contributing to the individuals' choices of transport mode to/from the airport and they are: socio-economic and demographic characteristics, characteristics of trip, characteristics of the transport facilities, etc. In more

[1] Synergies between transport modes and Air transportation (SYN+AIR) project under grant agreement No. 894116, funded by SJU.

particular, the influencing factors for airport access mode choice are availability, access time, cost, transport service frequency, reliability, punctuality, etc. The access time and price have been linearly correlated with the airport access distance at almost all land-side access modes across many European and US airports (Janić, 2019).

However, their main focus was exclusively on the ground access dimension. Modelling accessibility to airports is very important for improving airport landside planning but also for improving/integrating the air transport into multimodal system. One way to move towards the multimodal system is to integrate air transport with the whole surface network system which will further support sustainability objectives, such as promoting the use of appropriate modes, improving service levels and operational performances, optimizing D2D transport, etc. This paper aims at addressing this topic, contributing to previous literature by focusing on passengers' mode choice behaviour when they are confronted with airport ground access and what will encourage them to shift to public transport.

3. Methodology

In this paper, the main steps of approach proposed to investigate transport operators' and passengers' perspectives regarding multimodal service, are described. Multimodal system (as previously defined) is a new concept in the passenger transport industry that is not generally established, and that is why data on system interoperability is lacking. So, we applied a qualitative research method (interviews and workshop) in order to get the experts' opinions and data on how the multimodal system could and should be designed. The interviews and the workshop with different transport operators (airlines, taxi operators, public transport, railway, etc.) provided a number of opportunities that can encourage the development of the multimodal transport systems. Also, the participants of the events highlighted the major barriers for implementation of new multimodal service in terms of responsibility, revenue sharing, data protection, etc. All the results are given in Section 4.

In order to determine the customers' perspective for making multimodal choices in their journeys, the travel demand model for users' behaviour is developed. The proposed travel demand model is based on data from the survey that was conducted online. The main goal of the survey was to quantify the trade-offs that user considers when selecting travel alternatives and specifically trade-offs regarding the selection of particular transport mode. After being identified, the explanatory variables that affects the traveller's choice in their trips to/from airport are analysed. This analysis is further used to reveal the main travel attributes that determine customer's travel behaviour. For this purpose, a Binary Logistic Regression model is developed. The results of Binary Logistic Regression model are given in Section 5.

4. Transport operators' perspective regarding multimodal service

To determine the opportunities and barriers related to developing the multimodal service from a transport operators' point of view, several interviews and the workshop are organized. Both tasks aimed to explore the willingness of transport operators to collaborate and to share defined data sets among each other. The interviews are conducted as one-hour discussion with the transport operator's representatives. The participants were experienced representatives of transport operators from different modes of transport such as: airlines, associations, metro, tram, bus, taxi, information systems and management control (Mavromatis et al., 2021; Dožić et al., 2021).

On the other hand, the workshop was organized as hybrid events, with three groups of participants – two of them were participated online, while one group was onsite in Barcelona. The participants in the workshop were not only the transport operator representatives (e.g., airports, taxi, railway operators, etc.) but also the representatives from other relevant organizations (e.g., universities, associations, etc.) (Dožić et al., 2021). A wide range of topics related to multimodal transport were covered in the workshop, among others, the possible collaboration among different transport operators, the main obstacles of this type of collaboration and other issues related to the service characteristics and performances. The main findings from these events are summarized below.

4.1. Opportunities and willingness to share the data

There are number of opportunities for transport operators that arose from offering the multimodal service with new or improved public transport infrastructure. The interviews and workshop considered three specific opportunities in developing multimodal transport system and they are improving service level, providing user-centric environment and increasing efficiency (reducing costs and increasing revenue). For these benefits, data sharing among transport operators is required.

Improving service level. Many transport operators, potential partners in multimodal service, are motivated to collaborate and, recognize data sharing as beneficial and worth introducing. They want to provide a product of a higher quality and to make their service more attractive, for current and future customers. The workshop participants argued that an increasing implementation of barcodes and QR codes can facilitate usage of the single ticket in different modes of transport. For example, in order to improve travellers' experience, agreements with airlines should be set, allowing the use of other modes of transport by showing the boarding card as required ticket. The inclusion of integrated baggage system should be considered, too.

User centric environment. Transport operators' representatives agreed that the key prerequisite for implementation of the new service is an integrated data sharing platform. The goal is to create a user-centric environment and to put the user in the focus, therefore, transport operators should serve users in synergic way instead of providing transport for them. The information systems play a significant role in transport operators' collaboration, providing appropriate digital platforms for data and information sharing among them, but also for communication with users as well. Those data sharing platforms should be used for two-way communication, i.e., for transport operators to feed the platform with data for users, but also for users to feed the platform with the data back to transport operators. Those would be very valuable data about user behaviour which in turn will allow the transport operators to improve upon their services.

Increasing efficiency. The workshop participants also referred to the ways in which multimodality can improve the efficiency and performances of transport operators. In particular, data sharing can improve planning activities by encouraging some innovation or support research that can help transport operators to plan better service and operate more efficiently. For example, when transport operators share data of transport routes, schedule, and their vehicles that could encourage the development of suitable travel applications that provide trip planning and vehicle arrival information to users. Another example is to enable cost savings for transport operators by using outside resources for data processing and analysis. It is also pointed out that the loyalty cards could be used to motivate and encourage people to shift to more environmentally friendly transport. Also, the cooperation among transport operators could increase the visibility on the market for each partner by the greater presence through other partners' platforms and services, which in turn should attract more customers, and ultimately generate more revenue.

Although many transport operators are willing to cooperate and share the data, when it comes to realization, many of them hesitate to enter in this type of partnership because they need legal guaranties and some regulatory framework (rules and procedures on data sharing) that will support this collaboration. Moreover, the collaborative process must indicate which participants are responsible for making which decisions. Also, preparation data for sharing can be technically very challenging for some transport operators in terms of data cleaning, processing, and storing, including the application of appropriate cybersecurity and privacy protection measures. Data standardization is another issue in data sharing specially for the data for the route, schedule, and vehicle location. The data provided must be accurate and updated in a timely manner, and this is the only way to ensure that each transport operator will be able to make optimal decisions, and ultimately for the multimodal system to function and to be efficient.

4.2. Barriers to multimodal service implementation

Generally, barriers for implementation of fully integrated multimodal system refer to all the risks related to digital data sharing that must be addressed by transport operators. Each transport system generates a substantial amount of data, and commonly those datasets include information on routes, schedules, vehicle location, records of passenger boarding and fare transactions, and disruption alerts. Most types of passenger data contain records of personal data or records of a specific card or device that has the potential to identify an individual. This is a critical distinction for data sharing, because the sharing of individual records possesses a privacy risk. This means that each transport operator should take full responsibility for the protection of their customer data. More precisely, the consent from customers' needs to be provided allowing to share their data among different operators. The workshop participants suggested to have defined in advance which kind of data is available to which transport operators, i.e., to have limited access to the data, and corresponding terms of use or a data sharing agreement, which will be defined by smart contract framework.

In the European Union, the General Data Protection Regulations (GDPR), defines a comprehensive set of regulations related to privacy. But again, for developing new multimodal service, it should be improved to help transport operators to access more external data and to remove barriers to the sharing of their data.

Beside passengers' data, transport operators can be requested to reveal part of their private information, such as intended routes, vehicle location data, operations data, and financial data. It is reasonable to assume that they might hesitate to share all confidential information due to competition or legal issue. Although, these data types typically do not contain privacy risks, there may be security risks or the risk of data misuse (for example, the concern that it could be used to attack transport infrastructure and the people who use it). These are just some of problems that bothers transport operators. Another possible obstacle could be the ownership of the transport operators, which could prevent collaboration between public and private actors, since it usually includes political influence. However, the current trend (e.g., the emerging field of Mobility-as-a-Service) shows that this distinction between private and public stakeholders is less and less important.

The responsibility issue in the case of disruptions (e.g., schedule disturbances) and in the case of passengers with reduced mobility should be addressed, and precisely defined, as well. This includes taking responsibility for enabling the journey to be finished, as well as the provision of real-time information to passengers. Only in this way the multimodal transport service providers can keep the passengers' satisfaction at a high level.

5. Passengers' perspective regarding multimodal service

Multimodal transport could bring certain benefits to all parties involved (transport operators, passengers, municipalities, environment, etc.). In order to gain as much benefits as possible, public transport (PT) should be extensively used by passengers. Generally, private car is dominant passengers' choice for accessing the airport (Mavromatis et al., 2021). One of the goals of the multimodality is to influence airport access choice by shifting people from private vehicles to more sustainable and more environmentally friendly modes of transport. To consider the customers' perspective in terms of multimodal system development, this paper presents the results of proposed travel demand model which reveals the main factors that drive a shift from private vehicles to public transport. The proposed travel demand model is based on data collected from the survey that was conducted online (because of Covid19 pandemic) and distributed in five languages (Greek, Spanish, Italian, Serbian, and English).

The survey consists of 29 questions related to socio-demographic information, passengers' habits, purpose of travel, travel frequency, the factors that influence the mode choice and provided scenarios regarding the combination of travel modes. Total sample includes total of 2199 respondents, originated mostly from Spain, Italy, Serbia and Greece, but also from the other countries (Mavromatis et al., 2021). For the purpose of the paper, we focused only on the questions relevant for the airport access mode choice analysis. Therefore, considered questions are related to gender, household income, the most common purpose of travel, mode choice to/from the airport in the case if different transport modes are available, factors that influence mode choice when travelling to/from the airport. It should be noted that factors that influence mode choice are rated by passengers using Likert scale (from the lowest importance 1 to the highest 5).

The respondents to the survey are predominately female with the 54.4% of share, male respondents with 44.5% of share, while 0.1% individuals chose not to declare their gender. The average income of the respondents, in a scale from Low to High, was Average for the 61.1%, with just 20.6% indicating that their household income is High. Regarding the travel purpose, Mostly for business travel 28.2% and Only for leisure 26.7% of respondents. The lower percentage, 3.1%, travel Only for business, while the largest percentage can be observed Mostly for leisure, 42%.

To explore how passengers make their choices and what are factors which influence their choices, statistical analysis and Binary Logistic Regression are used. Binary Logistic Regression is used to reveal the factors affecting choice of private (i.e., Car (park at/near the airport), Car (someone drops me off/picks me up)) and public modes (i.e., Bus, Metro, Other, Taxi, Train) of transport. Considering transport mode as a dependent variable, available alternatives are merged in two possible choices: private (car) and public transport (train, taxi, bus and metro). Combination of modes was not considered, because theoretically, it could be formed by both private and public modes, Figure 1. The considered sample consists of 2083 valid responses: 1220 respondents preferred private (binary choice equal to 0), while 863 preferred public transport (binary choice equal to 1). To determine the factors that affect public transport as airport access mode choice, binary logistic regression is used (1), where with

$$OR = \frac{p}{1-p} \quad (1)$$

is denoted Odds Ratio, p is probability of choosing public transport modes, while (1-p) represents probability of not choosing public transport modes. The logarithm of the relative probability (log-odds) is represented as a linear function of independent variables (McFadden, 1974), (2):

$$log(OR) = B_0 + B_1x_1 + \ldots + B_kx_k \quad (2)$$

where, B_0 is the constant, x_k are k explanatory variables, B_k is the parameter related to x_k (which can take binary, categorical, ordinal or continuous values). Therefore, the OR, considering exponentiated parameters, can be expressed as follows:

$$OR = e^{B_0 + B_1x_1 + \ldots + B_kx_k} \quad (3)$$

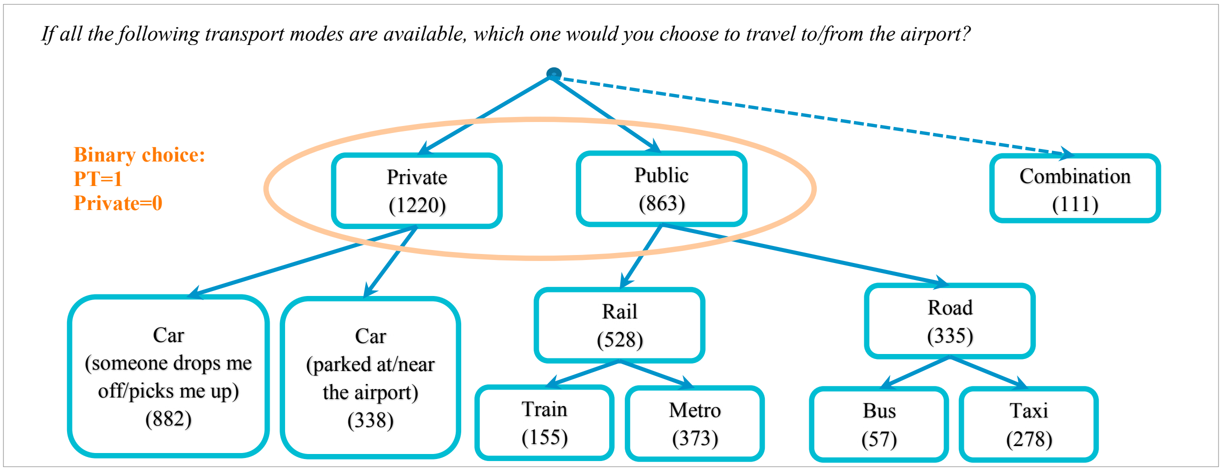

Fig. 1. Binary choice related to public and private modes

According to (2) OR, i.e., $OR = Exp(B)$, is equal to 1 for null values. In the case when OR>1 the result indicates positive effect, while OR<1 for negative one. Focusing on the probability, the model becomes:

$$p = \frac{e^{(\sum_i B_i x_i)}}{1+e^{(\sum_i B_i x_i)}} = \frac{1}{1+e^{-(\sum_i B_i x_i)}} \qquad \forall\, i \in [1, k] \quad (4)$$

The maximum likelihood method was used to estimate the model's parameters. The interpretation of parameters consists of the change of the log-odds considering a unit change in the related predictor, maintaining unchanged the others. In general, at first, the selection approach of the independent variables considers the Eq. (3) with only constant parameter B_0. Secondly, the independent variables x_k, with the largest increase of performance are included in Eq. (3). This process is repeated as long as adding the variables does not improve the model. The variables are included if their significance value is lower than a chosen threshold (here, p-value ≤ 0.05 for all variables, except for reliability which was not significant on 5% level, but proved significant with p-value ≤ 0.1).

All attributes that are not correlated with the transport mode choice have been excluded and analysis has been repeated for those which are significantly correlated. Based on binary logistic regression analysis of data, the mode choice model has been derived and attributes of reliability, travel purpose, gender, age, income and vehicle ownership were found statistically correlated to the mode choice of transport in the countries covered by the survey. Explanatory variables are given in Table 1, as well as the corresponding *OR* related to the use of PT such as: the importance of reliability in the choice of the transport mode (*OR*=1.089), business purpose of travel (*OR*=1.458), male gender

(*OR*=1.705), age from 50 to 65 (*OR*=1.560), high income (*OR*=1.882) and non-possession of cars (*OR*=2.437). Therefore, these predictors have a positive effect towards the choice of public modes (*B*>0, or *OR*=*Exp(B)*>1).

According to the results in Table 1 a unit increase of importance for the Reliability factor (measured by Likert scale), would result in a positive effect on the probability of choosing public modes. A delay (unreliability) would, therefore, lead to a modal shift from public to private transport alternative. However, the factor reliability appears to be less significant than other variables, but since it is important for this analysis, we included it in predicting the use of public modes versus private ones. On the other hand, the OR value of the binary variable related to the business purpose of travel shows that business travellers are about 1.46 more likely to choose the PT than other travellers. A similar interpretation is shown for the rest of the OR values for binary variables (male gender, age from 50 to 65, high income and non-ownership of cars).

Table 1. Variables in the equation: binary logistic regression, public vs private transport.

Variables in the Equation	B	$S.E.^a$ of B	Wald	df^b	$Sig.^c$	$OR = Exp(B)$	95% $C.I.^d$ for $Exp(B)$	
							Lower	Upper
Q17c_Reliability	0.085	0.051	2.768	1	0.096*	1.089	1.001**	1.184**
Q2_bin_business	0.377	0.105	12.809	1	<0.001	1.458	1.186	1.793
Q19_Male	0.534	0.099	28.920	1	<0.001	1.705	1.404	2.072
Age_50_65	0.445	0.126	12.453	1	<0.001	1.560	1.219	1.997
Q23_High income	0.632	0.117	29.306	1	<0.001	1.882	1.497	2.366
Q25_0 cars	0.891	0.140	40.434	1	<0.001	2.437	1.852	3.207
Constant B_0	-1.370	0.220	38.786	1	<0.001	0.254		

$Sig.^c$ reports the significance level for the Wald statistic based on its chi-square distribution, where the Wald statistic (considering variables having a single degree of freedom df^b) is the squared ratio of B and its standard error $S.E.^a$ The reported $Sig.^c$ are for values minor than 0.05; $Exp(B)$ can take the values between the lower and upper limits considering the confidence level $C.I.^d$ of 95%.

a. Standard Error; b. Degree of freedom; c. Significance level; d. Confidence Interval; *. $Sig.^c \leq$ 0.1; **. 90% C. I. for Exp(B)

The accuracy of the derived model is one of the logistic regression analysis outcomes which is showing the number and percentages of correct predictions and false predictions for each option as well as the overall accuracy as shown in Table 2. It can be noted (Table 2)Table that model predicts the values of the dependent variable (the use of public modes versus private ones) with the variance scores (R^2), 7.7% and 10.4%. More precisely, the proportion of the variance in the dependent variable is explained by the independent variables. These variance scores are defined by Cox & Snell and Nagelkerke respectively, and for the logistic regression these values are much lower than in the case of linear regression. Moreover, the independent variables (i.e., the importance of reliability in the choice of the transport mode, business purpose of travel, male gender, age from 50 to 65, high income and non-ownership of cars) are able to correctly predict 62.7% of the cases. In particular, the proposed model is much more accurate for those who preferred private transport mode (82.5%), than for those who have chosen public modes (34.8%), Table 2.

Table 2. Performance: binary logistic regression public vs private.

Predicted		Predicted (%)		Percentage of total prediction (%)	% R^2	
Public	Private	Public	Private	62.7	Cox & Snell.	Nagelkerke
300	1006	34.8	82.5		7.7	10.4

6. Conclusion and future works

The results presented in this paper are expected to help in planning and estimating the effects of introducing the new multimodal D2D service. The framework developed in this study precisely aims at tackling the challenges addressed from the transport operator's perspective, as well as from passenger perspective. The motives for collaboration of transport operators could be found in the fact that revenue increase is expected, as well as increase in the volume of passengers. The most challenging task is to convince transport operators to enter the collaboration and share the data among each other. The requirements concerning current challenges in terms of necessity for creating a good policy framework, as well as diversity parameters and features all over the Europe (e.g., social habits, purchasing power, transport features, etc.), are pointed out.

On the other hand, the proposed model reveals the importance for policy makers and transport operators serving the airport to address the access time reliability by carefully considering the passengers' preferences in terms of their needs and age. The increase of transport service reliability should result in the higher probability for choosing the public transport. The derived model is considered as reasonable based on overall accuracy of 62.7%.

Several areas for further research were identified in terms of developing multimodal transport system such as: What are the environmental impacts of multimodal transportation systems? Is the multimodal system implemented in particular country (city) transferable to other locations in Europe? etc. Bearing in mind all mentioned, the issue of developing a multimodal transport system is complex problem, but its positive effect on society will be very important.

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