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# THE NEED OF PUBLIC PASSENGER TRANSPORT INTEGRATION

*The paper deals with the issue of supporting public passenger transport and integration in order to ensure the sustainable mobility of population. It highlights the importance of public passenger transport and the reasons why the population prefers cars. The objective of the paper is to analyse public passenger transport without mutual integration of individual transport systems resulting in the fact that it is not sufficiently able to compete with individual automobile transport. It is suggested the process of public passenger transport integration as well as the design of key elements in order to increase road safety. In addition, the paper confirms the hypothesis that by supporting of public passenger transport and increasing the number of individuals transported by public passenger transport, road safety increase can be achieved.*

**Keywords:** *transport, behaviour, road safety, process, integration*

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## 1. Introduction

EU transport strategy prefers the transport of passengers by public passenger transport to the individual transport because the use of public passenger transport results in meeting all the goals of the EU strategy in the field of road safety. It relates mainly to the stabilisation of the increased road transport claims on infrastructure whose expansion is problematic especially in built-up areas. Construction of a new expressway infrastructure caused by increasing transport operation is a long-standing problem due to the ageing of the population in the EU. The support of public passenger transport brings lower fuel consumption. This is the way how to attain another objective of the EU strategy in the field of transport that is the reduction of the EU's dependence on crude oil as a raw material that needs to be imported into the EU. Emission of air pollutants is another strategic goal that is fulfilled due to less diesel fuel consumption (Konečný at al, 2016). Based on the above considerations it has been concluded that the strategic objectives of the EU transport policy are achieved when population uses the public passenger transport. In this regard it has to be noted that it is necessary to support the public passenger transport and its competitiveness in relation to the individual automobile transport (Poliak, 2013). The aim of this paper is to identify the importance of public passenger transport and to define the effective method of creating the integrated transport systems. The article also tries to confirm the hypothesis by integrating mass passenger transport and achieving greater use of mass passenger transport by the population can contribute to enhancing road safety. It is completely impossible to eliminate accident in practice and dangers arising on the road due to a human factor, but if at least it can contribute to mitigating the danger emerging on communications so it's just a properly secure integration by public transport.

## 2. The importance and problems of public transport

"Transportation is often referred to as the lifeblood of cities and regions because it provides the essential link of constantly moving population in this area, thereby helping to shape the region (Vuchic, 1999)". To support the sustainable and livable urban environmnents, private, public and non-motorised transport must functionally complement each other by forming balanced integrated systems. However, in many cities today, transportation is characterised by the dominance of the cars, it means that there is a high auto-dependence in travel (Klotildi, 2014). As long as there is sufficient infrastructure available (road and parking), the cars offer convenience of travel to travellers. The increase of individual automobile transport in towns causes a decrease in travel speed, irregularity of public transport operation and it has also an impact on passengers in public transport. There is also congestion that prevents the accessibility to the destination points, especially those that are located in the city centre (Rajsman at al, 2014). The increase of individual automobile transport causes other problems such as decreasing road safety, increasing air pollution, traffic noise and global warming (Banister, 2005), (Nedeliakova at al, 2016).

While providers of public passenger transport operate only the key areas and places in certain territories, the car users benefit from a high quality of transportation in terms of availability and time. Car users usually do not consider the use of land and emission produced by road transport as a problem. However, individual transport causes static problems, too. Parked vehicles are often obstacles for pedestrians, cyclists and the disabled. Concerning these problems, the key issue is to cause a change in people´s mobility behaviour towards lower car usage and to encourage them to travel using public means of transport, use more bikes and walk (Nosal a Starowicz, 2010).

While operators serve key origins and destinations, it is too costly for them to provide direct service between all points and it is essential to coordinate different modes of transport in order to ensure smooth, convenient transport services involved in the transfer of passengers (Rivasplata, 2003). To minimise the public passenger transport time, which is greatly influenced by passenger transfer, the integration of public passenger transport aimed at coordinating and promoting the continuous passenger transportation and providing high quality services is required. Generally speaking, many definitions of public passenger transport integration can be found in literature, e.g. Hine (2000), Ibrahim (2003), Dydkowski (2005), Hull (2005), Preston (2010), but the most popular are those formulated by Nosal and Solecka (2014):

- integration is the organisational process, in which the elements of public transport system (network and infrastructure, fares and tickets, information and marketing, etc.) served by various operators, who use different modes of transport, interact more efficiently and closely. This results in general improvement in travel conditions and quality of service (NEA, OGM a TSU, 2003),
- integration is the way in which the individual elements of public transport are embedded in the chain of movement (QUATTRO, 1997).

Commonly, in the urban public transport services, the word 'integration'is used for solutions that guarantee a continuity of a "door to door" services (Janic a Reggiani, 2001). Urban transport is to provide attractive chain of services in the relationship "door to door", making integration to be defined as the combination of (Nosal and Solecka, 2014):

- different means of public transport,
- public and individual transport,
- transport policy with other policies concerning the spatial planning or investment in infrastructure.

Speaking of the public transport integration, we can take into consideration the Mohring effect that was defined in 1972: "If more passengers use public transport, the costs per passenger are lower. It means better transport services with shorter waiting time, denser network of routes and bus stops and shortening of walking time. Due to more passengers it is allowed to plan express links in order to reduce the distance travelled by a vehicle" (Mohring, 1972). At present the most significant factors in supporting the integration of public transport are road safety and the impact of transport on the environment.

The integration of public transport is the latest trend in Western Europe that assumes the increase of attractiveness of public passenger transport (Klotildi, 2014) and the quality of public transport services. On the basis of public passenger transport integration, it is possible to develop a unified system that provides passengers with compatible timetables for different modes of transport. The integration also plays an important role in social policy. According to Nielsen (2005) the importance of transport integration creates an efficient transport system that leads to the reduction of traffic congestion and contributes to the protection of the environment. In practice, especially in Eastern Europe, it is often about the integration of fares, services and providing information (Poliak at al, 2015). According to Preston (2010) this kind of integration represents only the first level of the following ones:

- integration of fares, services, terminals/bus stops and information on the public transport;
- provision of infrastructure integration, management, public and private transport pricing;
- integration of passenger and freight transport;
- integration with transport authorities;
- integration of transport measures with policy of land use planning;
- integration of general transport policy with transport education, health and social policy;
- integration of transport policy with other policies.

In practice, it is necessary to apply a more strategic form of integration that is directly relevant to strategy formulation: the integration of individual policy instuments achieves greater performance from the overall strategy (May at al, 2006). This integration can occur in four general ways:

(1) Integration between policy instruments involving different types of these instruments;

(2) Integration between policy instruments including the use of infrastructure, management, information and price;

(3) Integration between transport measures and land use planning measures;

(4) Integration with other policy areas such as health and education.

For optimal traffic system setup is necessary interconnection of integration. Integration of types (1) – (3) draws on the wide range of different types of transport and land use policy instrument currently available. In addition, it is necessary to point out that the combination of policy instruments is likely to perform differently against a given objective from applying the individual instruments alone.

Dealing with the transport integration, it is inevitable to define basic features such as: number of journeys, lines, and the share of transport modes and daily system operation. Some instruments will also change the supply of transport, and thus the costs to users. The costs of implementation and operation and revenues generated will also have an impact on instruments, alone and in combination. Each of them will affect the scale and intensity, that is used as a policy instrument; fare changes, for example, can vary in magnitude by time of day and potentially by route and area. The number of possible policy combinations is very extensive. A carefully designed integrated strategy, particularly of types (1) – (3) should be able to achieve the objectives set for one or more adopted policy instruments. Some of the integrations outlined above may prompt a wider set of objectives; for example integration of transport and land (type 3) can well raise the set of development objectives (Jones at al, 2003). With any strategy, it is important to clarify the objectives before the strategy is developed, because the combination of suitable policy instruments, for example for the pursuit of economic development will differ from those which best meet environmental and health targets.

Most approaches to the implementation of strategic integration focus on one of two types of principle: the pursuit of synergy (May a Roberts, 1995) and the removal of barriers (May at al, 2005). The pursuit of synergy involves finding pairs or groups of policy instrument that reinforce one another in achieving changes in the transport system. The examples are particularly obvious when using park and ride system to reinforce rail or bus transport. The example of synergy tested by Wegener (2004) is illustrated in Table 1. He tested the synergy between increased car operating costs, public passenger transport time and fares.

*Table 1*

EVIDENCE OF SYNERGY BETWEEN INCREASED CAR OPERATING COSTS, FASTER PUBLIC TRANSPORT SERVICES AND LOWER FARES FOR DORTMUND

| **Strategy tested** | **Difference from reference scenario in 2021 (%)** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Trips** | **Mean trip length** | **Percentage of public transport trips** | **Percentage of car trips** | **Car-km/ per capita** | **Car owner-ship** | **$CO_2$ emission per capita** |
| A Car operation costs + 75% | -2.78 | -14.77 | +6.49 | -3.61 | -20.98 | -6.24 | -18.89 |
| B Public transport times – 5% | 0.00 | +0.02 | +1.15 | -0.06 | -0.12 | -0.05 | -0.04 |
| C Public transport fares – 50 % | +0.75 | +2.49 | +11.84 | -0.42 | -0.68 | +1.95 | +1.62 |
| Total | -2.03 | -12.26 | +19.48 | -4.09 | -21.78 | -4.34 | -17.31 |
| D Combined (A+B+C) | -2.00 | -11.35 | +26.68 | -4.93 | -23.03 | -3.88 | -17.43 |

Source: WEGENER, 2004

The combination illustrated in Table 1 involves increases in car operating costs by 75%, potentially through fuel and lubricants taxes or distance-based charges, reducing public transport journey times by 5% and similar measures; such as public transport fares. It shows a significant synergy in its ability to attract passengers using public transport, with an increase 35% higher than that from the sum of the basic elements. Moreover, there is not clear evidence of synergy for total car operating costs per 1 km. As a result, there is a modest indication of synergy for $CO_2$ emissions, with the combined reduction just under 1% greater than that for the sum of the basic elements. The question that arises is whether synergy should appear in elements of the total travel fares, but only to a very limited extent in performance against aggregate policy indicators such as $CO_2$. One possible answer is that these synergistic changes, for example the use of public transport, are balanced by changes in other modes and elements of travel within stable aggregate value, such as travel time.

The removal of barriers implies identifying factors that prevent the implementation of otherwise desirable policy intruments, and using other instruments to overcome them. Key barriers to any strategy are often finance, public acceptability and concerns that some members of society will be adversely affected. Integration can contribute to the removal of barriers in three ways (May at al, 2006):

- it can involve measures that make other elements of the strategy financially feasible. The increase of parking charges, fares or road tolls may all be seen as the way of financing a new infrastructure.
- Integration can contain a package of measures that are less acceptable on their own with ones that show a clear benefit. Once again, an example is to be found in road pricing. Attitudinal research shows that it will be likely much more acceptable if the revenue is used to invest in public transport (Jones, 1998).
- Integration can involve measures that cause adverse effects. For example, road pricing could lead to higher traffic outside the charged areas.

## 3. The process of public passenger transport integration

According to Vuchic (1999) the most important element of the decline in the number of passengers in public passenger transport is to increase the quality of service. It is required when multiple transfers and the coexistence of more than one operator lead to the necessity of coordination, cooperation and interaction among them to ensure the image of one unified system without confusing the potential users or allowing them to notice the interruption in the offered services. To define the integration of public transport it is necessary to divide it into three levels: organisational, operational and physical integration must be achieved (see Table 2).

*Table 2*

THREE LEVELS OF TRANSIT INTERMODAL INTEGRATION

| Organisational integration | Operational integration | Physical integration |
|---|---|---|
| Arrangements between operators | Network layout | Access to facilities |
| Existence of an independent authority | Plan of transport serviceability | Location of stations |
| | Transport timetables | Design of stations |
| | Transmission of information | Control of vehicle movement |
| | Travel tickets | |

Source: KLOTILDI, 2014

### *3.1 Organisational integration*

One of the conditions necesssary for the development of a well-integrated public transport system is that a responsible authority must be given the power to organise the integration of transport service standards (Poliak at al, 2014). The established authority is necessary due to the fact that there are several public authorities responsible for transport services in an operating area. Urban transport serviceability is commonly provided by municipal authorities while regional transport serviceability is provided by regional authorities. For instance, in the Slovak Republic the regional bus transport is provided by the Office of self-government region – regional authority and regional rail transport is operated by the Central Government – Ministry of Transport. The concept of transport serviceability was originated in Hamburg, Germany in 1960.

Originating in Hamburg, the concept of an integrated organisation was established as a reaction to the declining role of transport in the city’s modal split. The concept of an integrated organisation still serves as a public authority that fully coordinates transport services in the region while preserving the individual entities of the component companies which are the ones actually responsible for supplying the services (Pucher and Kurth, 1996). Unorganised transport serviceability can result in its significant reduction as shown by the cases from Great Britain (Schöller-Schwedes, 2010). Market liberalisation in Great Britain in the 1980s led to the fragmentation of public passenger transport (Preston, 2010) which caused the reduction of public transport serviceability. Table 3 demonstrates municipalities with population of more than 1,000 people that do not have daily regular transport services.

Moreover, organisational integration defines the contracts between the stakeholders ensuring their interest and commitment to the performace of public transport integration system. The established authority must take into account the expectations of public transport passengers; however, according to Rivasplata (2008) the authority must also consider the commercial interests of the operators in order to identify the clear objectives of integration.

*Table 3*

TRANSPORT SERVICEABILITY IN GREAT BRITAIN

| **Town/Village (outside Moray)** | **Population** | **Buses per day: Monday-Friday** | **Buses per day: Saturday** | **Buses per day: Sunday** |
|---|---|---|---|---|
| (Aberdeen) | (220,420) | - | - | - |
| Aberlour | 785 | 2 (+1 Thursday) | 0 | 0 |
| Burghead | 1,640 | 15 | 14 | 0 |
| Carron | <1000 | 1 | 0 | 0 |
| Cullen | 1,327 | 2 | 1 | 0 |
| Dufftown | 1,454 | 15 | 14 | 0 |
| Elgin | 25,678 | - | - | - |
| Forres | 9,174 | 15 | 12 | 0 |
| (Inverness) | (51,832) | - | - | - |
| Keith | 4,470 | 9 (+1 Tuesday) | 7 | 0 |
| Lossiemouth | 6,803 | 39 | 36 | 8 |
| Milltown of Rothiemay | <1000 | 1 Tuesday | 0 | 0 |
| Tomintoul | 332; 363 | 1 (+1 Tuesday and Thursday) | 0 | 0 |

Source: statistical data from GB

### *3.2 Operational integration*

Operational integration refers to the coordination and planning of the transport system with minimum interruption in space and time in order to satisfy the passengers' expectations. It consists of an integrated network layout, synchronized schedules between different modes and routes of direct transport, integrated information about all services, common fares and convenient ticketing system (Yiu Kwok Kin, 2005). Greiving and Wegener (2003) also highlighted the importance of transport planning. Layout intergration refers to the planning of the network without spatial discontinuities so that all routes, lines and modes are connected and coordinated in the most efficient way, allowing for convenient passengers' transfer. A clear hierarchy and structure of the system are required in combination with defined roles for each mode. Hierarchy promotes services that are easily remembered, uncomplicated, with direct routes when possible, and an efficient coverage of reliable travel routes (Klotildi, 2014). Once the network has been harmonised, the optimisation of the system's operation requires the integration of schedules: the coordination and synchronisation of arrival and departure times of the involved lines and modes. The aim is to reduce waiting, dwell-time, transfers and total travelling times.

Within the operational integration it is necessary to communicate with passengers (Poliak, 2011). The traditional view of transport integration is that travellers perceive transfers as negative experience due to the time, costs and uncertainty (S. Kingham, 2001). That is the reason why the integrated information system is needed. All necessary information about the entire transport system must be provided, regardless of the mode used and operator responsible for the service. The way in which the network is presented to the public can significantly affect the effectiveness of the public transport system (Nielsen, 2005).

Another key issue within the operational integration is convenient ticketing system. The integrated system can increase convenience by eliminating the need to purchase a ticket for each trip. Tickets and fares establish a common integration system for the involved operators and contribute to the improvement of transport convenience allowing passengers to travel between lines by purchasing a ticket for the entire service only once. Fares have an impact on both passengers and operators. By introducing a common fare system, competition between operators can be avoided and the collected revenue can be distributed according to the signed agreements.

Some authors, e.g. Wesolowski (2008), Solecka (2013), de Ona at al (2015) separate the infrastructure integration from the operational integration and consider it as an individual element of integration.

The infrastructure integration consists of an arranged combination of elements that make up the integrity of transport network. It relates to, first and foremost, all such elements as: location of bus stops, stations and interchange junctions for convenient changing of means of transport.

### *3.3 Physical integration*

According to M. Miller (2004) physical or infrastructure integration relates to physical changes such as integration of new routes and reorganization of transfers points. It refers to the planning of bus stops, stations and transfer centres, their location and facilities, as well as their design. It also involves the coordination of vehicle movements for transfers to be safe, without any conflicts between pedestrians and moving vehicles. Physical integration aims at planning the system carefully through good station designs, convenient walking paths and station amenities in order to speed up and secure transfers, improve accessibility towards and inside the intermodal transport system for all traveller groups, facilitate the users' movement and minimize the discontinuities inside the system.

### *3.4 Barriers of integration*

Speaking of the integration of public transport it is necessary to take into consideration some barriers. A barrier is an obstacle which prevents a given policy instrument from being implemented, or limits the way in which it can be implemented. In the extreme, such barriers may be overlooked and the resulting strategy may be much less effective. Barriers can be grouped into four main categories (May at al, 2005):

- Legal and institutional barriers – these include lack of legal powers to implement a particular instrument,
- Financial barriers – these include budget restrictions limiting the overall expenditure on the strategy, financial restrictions on specific instruments, and limitations on the flexibility with which revenues can be used to finance the full range of instruments.
- Political and cultural barriers – these involve lack of political or public acceptance of an instrument, restrictions imposed by pressure groups which influence the effectiveness of instruments.

- Practical and technological barriers – while cities view legal, financial and political barriers as the most serious which they face in implementing land use and transport policy instruments, there may also be practical limitations. For expansion of public transport infrastructure, engineering designs may limit progress.

Integrated strategies are particularly effective in overcoming the second and third of these types of barrier and integration between authorities may help reduce institutional barriers as well. It is usually harder to overcome legal, institutional and technological barriers in the short term. It is often difficult to overcome a barrier without to some extent reducing the performance of the overall strategy. The pursuit of synergy and the resolution of barriers are thus to some extent in conflict with the design of integrated strategies.

In order to achieve the best integration of public transport, by which potential barriers are quickly identified, it should be chosen the following procedure (Solecka, 2013):

- Stage 1: Diagnosis and assessment of the current status of the public transport system.
- Stage 2: Formulation of the concept of ISUPT evaluation as multi-criteria problem of ranking of given variants.
- Stage 3: Review and evaluation of methods for multi-criteria ranking of given options.
- Stage 4: Conducting computational technique using selected methods of options ranking.
- Stage 5: Summary of computational experiments.

## 4. Relation of public passenger transport integration to road safety performance

The most important benefit of public passenger transport integration focuses on road safety and sustainable mobility, particularly in urban areas. By supporting public passenger transport integration and transferring passengers to public transport, the density of traffic flow, which is expressed in number of vehicles per one kilometre of infrastructure, reduces (Poliak a Konečný, 2008). We assume that passengers do not use rail transport but they use bus service on the same road, and the density of traffic flow expressed in number of vehicles per one kilometre of distance in the current period changes from $H_A$ to $H_B$ according to Fig 1. The intensity of traffic flow is a function of the density that is:

$$M = f(H)$$

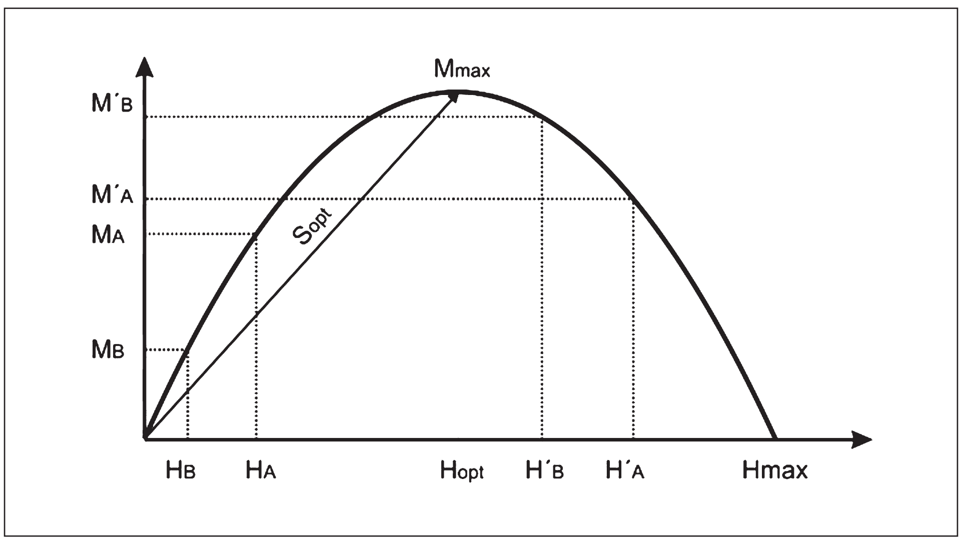
By changing the density of traffic flow it is possible to achieve a decrease in the intensity of traffic flow:

$$\Delta M = f(HA\text{-}HB);\ \text{under condition}\ HA \leq Hopt$$

In case that $H_A > H_{opt}$, congestions arise on infrastructure and by transferring passengers to the public passenger transport, decrease in the density of traffic flow would release congestions and the intensity of traffic flow would increase. Figure 1 depicts the state of change in the density of traffic flow from $H'_A$ to $H'_B$. The figure also illustrates speed $S_{opt}$ which can be achieved at maximum intensity of traffic flow. Exceeding this intensity, the speed of traffic flow decreases. Therefore, zero speed and zero intensity of traffic flow is achieved at maximum density of traffic flow ($H_{max}$).

*Figure 1*

CHANGE OF TRAFFIC FLOW INTENSITY
WHILE CHANGING THE DENSITY OF TRAFFIC FLOW
UNDER THE SUPPORT OF BUS SERVICE




Source: Yannis, G., 2013

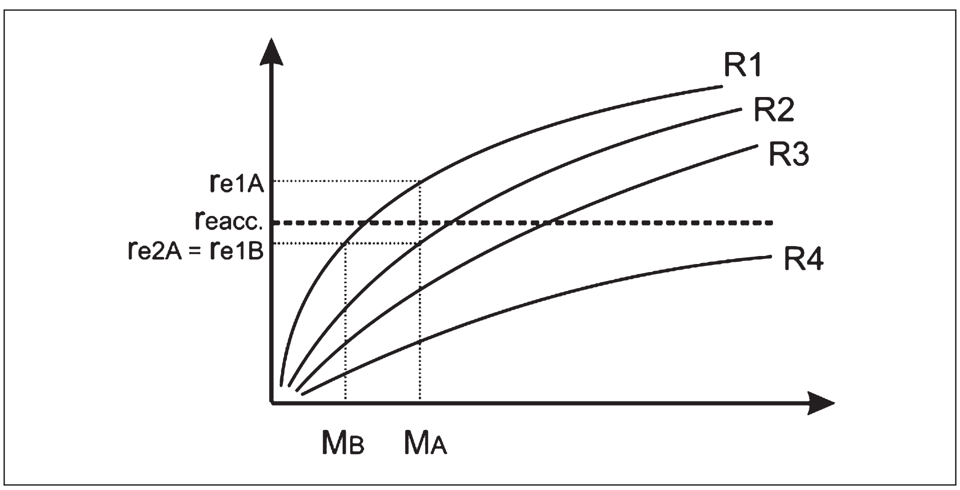
Yannis, G. et al (2013) defined the relationship between the probability of an accident and the intensity of the traffic flow. Yannis, G. et al. (2013) characterised the probability of an accident as a function of the intensity of traffic flow where a course of the function is dependent on the category of the road network. Courses of dependence are presented in Figure 2, which includes four categories of roads (R1 the lowest category, R4 the highest category). The following relationship can be stated for a particular category of roads:

$$re = f(M)$$

We assume that a particular road of R1 category has the intensity of traffic flow $M_A$, the probability of an accident $r_{e1A}$ which exceeds the acceptable value of the accident probability $r_{eacc}$. In practice, such a road is usually adjusted to a higher category R2, which leads to decreasing the accident probability from $r_{e1A}$ to $r_{e2A}$. Within urban areas, this solution is not always possible and the decrease of accident probability can be also achieved by reducing the intensity of the traffic flow from $M_A$ to $M_B$.

*Figure 2*

RELATIONHIP BETWEEN THE ACCIDENT PROBABILITY
AND THE INTENSITY OF TRAFFIC FLOW




Source: Yannis, G., 2013

It means that the result of the support of public passenger transport, through which the density of traffic flow would be decreased, can be expected in reduction of the risk of an accident, because the following applies:

$$\Delta re = f(MA\text{-}MB) = f(\Delta M)$$

*under condition HA ≤ Hopt further applies*

$$\Delta re = f(f(HA\text{-}HB))$$

Based on above equation, it can be concluded that the density of traffic flow decreases through the support of public passenger transport integration, even if passengers would use bus service. The reason is that there are less transport means on roads which results in increasing road safety.

## 5. Conclusion

In modern cities, individual transport leads to serious problems related to: congestion on roads and environmental pollution. With increasing performances in road transport within the insufficient capacity of road network, the possibility of traffic accident is increasing and the road safety is decreasing. Therefore, it is extremely important to strive to change people's travel behaviour towards the use of more sustainable means of transport: public transport, bicycles, walks, car sharing and carpooling. It can be achieved by using the concept of the transport demand management. The aim is to support the city inhabitants to use public means of transport. The experience gained abroad show the importance of integrated transport. The liberalised operation of public passenger transport in Great Britain led to the reduction of regional transport serviceability. Reduction of transport serviceability has caused the transfer of travellers to individual transport. The transport integration is not a simple process as indicated in this article. The article confirmed the assumption, by increasing the number of users mass passenger transport the density of the transport stream will be reduced on a particular road. It is possible to assume, that would have the effect also to increase road safety. It is necessary to proceed also from the assumption, that the occurrence of a traffic accident strongly depends on the human factor, which means that not even by promoting mass passenger transport and moving passengers from individual motorism for mass passenger transport it is not possible to completely eliminate the risk occurrence of a traffic accident.

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# POTREBA INTEGRIRANJA JAVNOG PUTNIČKOG PROMETA

Sažetak

Ovaj rad se bavi problematikom potpore javnog prijevoza kao  i njegovom integracijom da bi se osigurala održiva mobilnost populacije. Ističe se značaj javnog prijevoza te se navode razlozi zašto generalna populacija preferira automobilski prijevoz. Cilj rada je analizirati javni putnički prijevoz izuzevši individualne načine prijevoza te se zaključuje da se javni ne može mjeriti sa individualnim automobilskim transportom (po broju putnika). U radu se predlaže način integracije javnog putničkog prijevoza i ističe ključne elemente za povećanje sigurnosti na cestama. Dodatno, ovo istraživanje potvrđuje hipotezu da se poboljšanjem javnog prijevoza kao i povećanim brojem korisnika istog povećava sigurnost na cestama.

Ključne riječi: promet, ponašanje, sigurnost na cestama, proces, integracija