

ADOLF MALIĆ, D.Sc.
Fakultet prometnih znanosti
Zagreb, Vukelićeva 4
DAVOR BRČIĆ, D.Sc.
DAVOR KRASIĆ, D.Sc.
Gradsko vijeće Zagreba,
Zagreb, Trg Stjepana Radića 1

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PARKING MEASURES IN TRAVEL DEMAND MANAGEMENT

ABSTRACT

The ever-increasing use of private cars is a consequence of the improving standards of town-residents, availability of passenger vehicles and their needs and experiences of the freedom of movement. Traffic planners today are faced with the need to meet the numerous needs for mobility by town-residents and the available traffic infrastructure, with the aim of sustainable living in urban agglomerations. Since one of the basic aims of the overall traffic policy is the downsizing of the volume of passenger vehicle travelling to an acceptable and tolerable measure, the parking measures and strategies are used more and more frequently as a means of achieving this goal.

This is proved by the applied experiences of the cities in the developed countries, and by the growing number of research and analyses of the parking policy influence on the traffic regulation in town agglomerations. The first results provide encouragement for planners and strategists to continue designing strategies and parking policy measures dependent on the transport demand management in big cities.

KEY WORDS

travel demand management, parking demand, parking supply, parking policy

1. INTRODUCTION

Urban agglomerations, especially their centres, are experiencing concentration of traffic flows, particularly regarding private cars that result from the improving standard of the town-residents, availability of passenger vehicles and the experience of mobility.

Traffic planners are faced by a demanding task to make a compromise between numerous town-residents' demands for mobility and the available use of traffic infrastructure with the purpose of achieving sustainable, high-quality and tolerable life in the urban agglomerations.

Bringing the town-residents' mobility and its negative effects into balance, that is the aim of the majority of cities faced by everyday traffic congestion, demand-

ing financial investments into traffic infrastructure and environmental pollution in its widest sense (noise, air pollution, environmental pollution, land use, etc.).

Traffic demand is substantially growing in almost all parts of the world, and it has been realised that the "build-as-much-traffic-infrastructure-as-possible" approach is not a solution that would solve the issue of increased demand. New infrastructure induces new transport demand, which results in the following disproportion between demand and supply.

2. TRAVEL DEMAND MANAGEMENT

Travel demand management is part of the transport system management (TSM). Essentially, transport demand management is a series of strategies used by experts to try and model transport demand, in order to meet the town-residents' needs for mobility and to provide the desired lifestyle and development of the town itself.

In the early 80s travel demand management in the cities appeared first in the US, as a response to the culmination of the problems with traffic congestion and the negative effects generated by traffic (air pollution, irrational use of traffic infrastructure, time loss, increased number of traffic accidents, etc.). The term "travel demand management" originated in 1985 in South California. In the mid-80s the travel demand management approach began to be implemented in Europe as well. First articles on travel demand management were published in professional journals at the beginning of the 90s.

The report entitled "Overview of Travel Demand Management Measures: Final Report", written for the US Department of Transportation, Federal Highway Administration and Federal Transit Administration, defined travel demand management as: "a programme designed to maximise the possibilities of movement of people through the traffic system by increasing the number of passengers in a vehicle or by

influencing the time of travelling or the travelling needs.”

The following definition is given by the experts of the study group that studied the technologies for travel demand management ordered by OECD: “wide application of technology, as well as implementation of economic and administrative measures in road and other traffic.”

On the other hand, in his work “A Brief History of Travel Demand Management” Eric Ferguson defined

the travel demand management as: “an art of modelling the behaviour of those who travel, basically avoiding the expensive expansion of the travelling system.”

Basically, the diversity of definitions has the same goal – to regulate urban traffic in a way that does not restrict the mobility of town residents, with rational use of the traffic system, minimising the overall cost, and focusing on environmental protection.

Travel demand management is possible by modelling the measures that influence the travel demand or

Table T – 2.1 – Classification of travel demand management measures

Field of application	Type of strategy	Measure
Travel demand	Land use and zoning	Land allocation policy, Site amenities and design
	Communication substitutes	Telecommunications, Teleconferencing, Teleshopping
	Traveller information services	Pre-travel information, Regional rideshare matching
	Economic measures	Congestion pricing, Parking pricing, Transport allowances, Economic incentives for rideshare, Public transport priority, Changes in financing
	Administrative measures	Rideshare, Travel reduction measures, Alternative travelling, Car restricted zones, Parking management
Travel supply	Traffic operative measures	Ramp controls, Information system, Traffic signs, Traffic management, Incident management, Traffic control at construction sites
	Preferential treatment	Carpool and vanpool lanes, bus lanes, Bicycle and pedestrian facilities, Traffic signal pre-emption for certain vehicle categories
	Public transport	Express bus services, Park & Ride, Service improvements, Public transport advertising, High capacity public transport vehicles
	Freight transport	Urban goods movement, Inter-city goods movement

Source: Strickland S.G., Berman W., Congestion Control and Demand Management, Internet 11/98

Table T – 2.2 Travel demand management measures

Strategy class	Measure	Town	Peak	Off-peak
Land use and zoning	Land use policy	YES	YES	Y/N
	Site amenities and design	YES	YES	Y/N
Communication substitutes	Telecommunications	YES	YES	-
	Teleconferencing	Y/N	Y/N	Y/N
	Teleshopping	Y/N	Y/N	Y/N
Traveller information	Pre-travel information	YES	YES	Y/N
	Regional rideshare matching	YES	YES	-
Economic measures	Congestion pricing	YES	YES	Y/N
	Parking pricing	YES	YES	Y/N
	Transport allowances	YES	YES	-
	Rideshare and public transport	YES	YES	Y/N
	Financial initiatives	-	-	-
	Public transport incentives	YES	YES	-
	Innovations in financing	YES	YES	Y/N
Administrative measures	Rideshare	YES	YES	-
	Trip destination reductions and regulations	YES	YES	-
	Alternative work schedules	YES	YES	-
	Car restricted zones	YES	YES	YES
	Parking management	YES	YES	YES

Source: Strickland S.G., Berman W., Congestion Control and Demand Management, Internet 11/98

Index: YES – significant application
 Y/N – some application
 - – no application

Table T – 2.3 Travel demand management measures

Strategy class	Measure	Town	Peak	Off-peak
Traffic operative measures	Entrance ramp controls	YES	YES	Y/N
	Traveller information system	YES	YES	Y/N
	Traffic signalisation control	YES	YES	YES
	Motorway traffic management	YES	YES	Y/N
	Incident management	YES	YES	YES
	Temporary regulations	YES	YES	YES
Preferential treatment	Bus lanes	YES	YES	YES
	Carpool lanes	YES	YES	Y/N
	Bicycle and pedestrian facilities	YES	Y/N	Y/N
	Traffic signal pre-emption	YES	YES	Y/N
Public transport operative measures	Express bus services	YES	YES	Y/N
	Park & Ride	YES	YES	Y/N
	Service improvements	YES	YES	YES
	Public transport image improvement	YES	YES	Y/N
	Public transport HOV	YES	YES	Y/N
Operative – traffic supply measures	Urban goods movement	YES	YES	YES
	Inter-city goods movement	Y/N	YES	YES

Source: Strickland S.G., Berman W., Congestion Control and Demand Management, Internet 11/98

Index: YES – significant application
 Y/N – some application
 - – no application

that influence the travel supply. Therefore, travel demand management measures can be divided into measures that influence the travel demand and those that influence the travel supply.

Measures that influence the travel demand tend to reduce the demand of using private cars in such a way as to promote the use of other travelling modes such as public transport, increase of car occupancy, reduction of the travelling needs to certain destinations and/or reduction of the travelling needs in peak periods.

Measures that influence the travel supply have the basic goal of insuring greater capacities and attraction of the traffic infrastructure of all transport modes, i.e. to influence the modal split by modelling the travel supply measures.

Table T-2.1 shows the classification of travel demand management measures. It may be noted that about 40 conventional and innovation travel demand management measures have been defined between these two management modes, and that these are further divided into nine strategic classes. In Table T-2.1, the measures related to parking are specially marked.

The analysis of travel demand management measures has resulted in the evaluation of availability of each single measure for the urban area, peak and off-peak periods, which is shown in Tables T – 2.2 and T – 2.3. Table T – 2.2 shows the applicability evaluation of the measures related to travel demand, whereas Table T – 2.3 indicates the applicable measures related to travel supply.

Note: For clarity reasons and because of the nature of this paper dealing with parking, a part of authentic data in Tables T- 2.2 and T – 2.3 were left out as being of minor importance.

The aim of travel demand management is to achieve a number of goals, that can be achieved individually or several at a time, depending on the applied measures. The basic aims include:

- to reduce the need to make a trip,
- to reduce the length of a trip,
- to promote non-motorised transport,
- to promote public transport,
- to promote car-pooling, van-pooling,
- to shift peak-hour travel to off-peak hour travel,
- to shift travel from congested locations,
- to reduce traffic delays.

The analysis of implementing the travel demand management measures with the aim of reducing travelling by means of private cars and of increasing the use of alternative travelling modes, developed for the metropolitan area of Phoenix, USA, for the application period between 1989 and 1996, resulted in the following conclusions:

- Use of alternative commuting modes during the week have increased by 65% (from 20% in 1989 to 33% in 1996);
- The total number of trips by means of traditional alternative modes (carpool, bus, bicycle or walking) increased by 71% (from 14% in 1989 to 24% in 1996);
- It is estimated that 19% less mile-vehicles daily were travelled out of the possible total (in 1996), due to the usage of alternative commuting modes;
- About half of the employed who travelled to work on their own, where carpooling is the most frequent mode of alternative travelling for the ex-solo drivers (35%);

Analysis of the Tables T – 2.2 and T – 2.3 in the parking context, shows that it is possible to manage travel demand by economic and administrative measures in cities both for peak and off-peak hours. On the supply side, parking represents a measure only in the strategy class of operative measures for the public transport of passengers as Park & Ride measure.

It should be noted that what is also missing in the table in the strategy class of preferences is the measure of managing parking supply, as providing parking at parking spaces for certain categories of users. Although this measure could be classified as administrative type of strategy on the demand side, it belongs to the measures related to supply. At non-residential parking lots, namely, in the town centre (US cities), the application of this measure with the aim of stimulating van-pooling and car-pooling has given certain results.

Careful analysis of causes and consequences of the traffic specifics of the urban area, and the application of the group of measures from the series of strategies in travel demand management may result in the reduction of traffic congestion and also in the reduction of travel demand, especially by private cars, to a level that may be tolerable for the town life. The results of analyses done in the US cities that had a travel demand management programme, confirm the thesis of the possibility of managing travel demand in the cities.

Since theoretical theses do exist, as well as the results of study of practical implementation of parking as a significant mechanism which allows travel demand management, the attention further in the text will be oriented towards parking policy, its measures and strategies depending on the travel demand management in the cities.

3. PARKING DEPENDING ON TRAVEL DEMAND MANAGEMENT

Parking management is becoming today an increasingly significant measure in travel demand man-

agement strategies. The availability of parking spaces, parking prices and other conditions related to parking are decisive in passengers' decision about the way of travelling.

In considering the interactive influence of parking on the overall travel demand, the parking demand and supply need to be analysed, i.e. mechanisms that allow efficient management of travel demand. This statement is important for two reasons:

- a) in order to allow application of parking policy measures within the overall traffic policy of a certain area in the context of determining short-term traffic policy;
- b) in order to allow that long-term traffic policy may be planned on the basis of the pattern in the relations between the travel demand and the parking policy measures.

3.1 Parking demand management

Based on the knowledge that when there are changes in the parking policy, changes occur in the travel demand, i.e. in the behaviour of private car drivers who travel and then at the end park their car at the desired destination, forming thus the parking demand, it may be concluded that this relation needs to be analysed in more detail.

As a rule, drivers of passenger cars when travelling and looking for the parking space behave in a foreseeable pattern. Studies carried out in order to analyse "parking demand strategies", aiming at more detailed analysis of the factors that influence the parking de-

mand, have resulted in the data presented in Table T – 3.1.1, and that refer to two British cities.

The drivers' decision "I drive always to the same parking space" and "I drive to the parking lot nearest to my destination" prevail and cover over a half of the surveyed group. This knowledge allows us to conclude that the majority of drivers, when using passenger cars, drive to the known parking lot, i.e. that one of the significant factors in the travelling mode is the information about the place and the availability of the parking place, influencing the mechanisms of the overall travel demand.

Therefore, we may conclude that parking has two basic functions within travel demand:

- strong compulsion, i.e. restriction; through the information on parking space availability;
- the factor of cost.

Lacking parking supply or supply restricted to a certain group of users influences strongly the travel and parking demand, and the first one is the compulsion – i.e. restriction. The person, namely, who has to travel appreciates when choosing the travelling mode the information on the availability of parking spaces in the destination zone. The second modality of compulsion results from the lack of information whether there is available parking supply in the destination zone, of what type and to what extent, which is directly connected to the process of looking for the available parking supply.

Research carried out by Axhausen confirms that it is possible to convert the process of looking for a park-

Table 3.-1.-1 Behaviour of drivers when travelling by passenger vehicles

Way of behaviour	Kingston	Birmingham
"I always go to the same parking space"	39%	33%
"I have a private or reserved parking place"	3%	16%
"I drive to the destination and then start looking for a place"	18%	18%
"I drive to the parking lot nearest to my destination"	26%	18%
"I drive around the streets looking for an empty parking space"	11%	8%
Other solutions	3%	8%
Size of the sample	624	147

Source: Axhausen, K. Ax., Parking Demand and its Characteristics, University of London, Centre for Transport Studies

Table T – 3.1.1 Impact of parking cost on the flexibility of travel demand

Distance from the destination	Flexibility		
	Price	Time	Total cost
< 1 block	-0.24	-0.53	-0.75
< 2 blocks	-0.35	-0.44	-0.75
< 3 blocks	-0.41	-0.38	-0.80

Source: Axhausen, K. Ax., Parking Demand and its Characteristics, University of London, Centre for Transport Studies

ing space and the uncertainty of finding or waiting for a free parking space into a measurable cost element, which is necessary in analysing the influence of parking on the citizens' behaviour pattern, i.e. the total travel demand. He came to a conclusion that the drivers prefer the strategy of looking for a reliably free parking space, but, in the absence of the first behaviour strategy, they would apply others as well.

It was also found out that the introduction of the information management system about the parking spaces and parking lots has a significant influence on the reduction of travel demand and parking demand. Having the information about parking places, the drivers do not have to drive around in order to find a free parking place. The experiences of other researchers have also confirmed this.

Another characteristic of parking is the parking price. Logically, parking cost influences the driver's decision whether to use a private car and where to park. In his research, Axhausen analyses the influence of the parking price on the flexibility of travel demand. The results are presented in Table T – 3.1.1.

The presented data determine the relation of the flexibility of destination distance from the parking place to the parking price, walking distance, and the total parking cost. The changes in the flexibility show that the parking price and walking distance are inter-related. The price flexibility increases with the increase in distance, since time flexibility falls with the increase of distance. The total cost flexibility is stable around the value of -0.78 and certainly higher than the flexibility determined in other researches.

Research confirms that the parking supply users, who generate the parking demand, are very sensitive to the parking price, i.e. they are prepared to walk longer from the parking place to their destination provided the parking price is lower. Users who park their cars on the outskirts are more sensitive to the parking price than those who park in the central zones.

This knowledge has to be taken into consideration when designing the parking policy for a certain area, since there is real danger when introducing new parking policy, that a number of measures ranging from restriction to charging may shift a part of the parking demand to a neighbouring area that has no complementary parking policy.

The research results indicate that costs outside the vehicle expressed in time or money are actually more important in making the decision about the travelling mode. This proves that parking policy measures are relatively more important than other travel demand management measures, and they strongly influence the choice of travelling mode. The influence of the parking price has stronger implications on the travel mode than the impact of the public transit fare or fuel price.

The study of introducing parking charge regime, although only for one group of drivers, who travel to work in their own cars, is very indicative. Table T – 3.1.2 shows the results of two studies.

Table T – 3.1.2 The impact of introducing parking charge regime for the employed

MODE	Canadian study		Los Angeles study	
	Before %	After %	Before %	After %
Solo driver	35	28	55	30
Carpooling	11	10	13	45
Public transit	42	49	29	22
Other	12	13	3	3
Total	100	100	100	100

Source: Feeney B. P., "A review of the impact of Parking Policy Measures on Travel Demand", *Transportation Planning and Technology*, 1989, Vol. 13, pp. 229-244

It is evident that the structure of the way of travelling to work changes after parking fees have been introduced. The percentage of those who travel alone to work falls significantly. Whereas in the Canadian urban centres the percentage of public transit increased substantially, the Los Angeles study shows a great increase in carpooling, even at the expense of public transit.

3.2. Parking supply management

Parking supply management is related interactively with parking demand management, i.e. with overall transport demand. For parking supply management various strategies are usually mentioned, but the analysis shows that there are six basic ones:

1. stimulating priority of parking,
2. reducing minimal parking requirements applied to new constructions,
3. maximum parking needs applied to new constructions,
4. control of overall parking supply,
5. parking time restrictions,
6. park and ride system (peripheral parking, combined with public transport).

Stimulating priority of parking is a strategy tending to increase the occupancy rate in passenger cars, especially during peak hours. Parking lots are located near the central city core – zone of attraction, for minibuses, single-volume vehicles and clean vehicles. The modality of on-street and off-street parking is used, under the responsibility of the local authorities. It is better applicable to the areas where public transport is not very well developed (areas of low residential density). The parking lots should be supervised, with good parking standards (lighting, roofing, etc.). It is often applied in the USA for the parking of the employed, at

private non-residential parking lots and public off-street parking lots.

Reducing minimal parking requirements applied to new constructions is a strategy which allows private non-residential parking to be restricted, i.e. to reduce the parking supply in certain areas. It is applied in a way so as to reduce the number of minimal places ensured by the investor for a building which generates a great number of parking places for the employed. This strategy is usually related to paying the means into the city budget, which are directed to subsidising public city transport and constructing parking supply in areas that are included in the traffic and parking policy of the whole urban unit (e.g. Park&Ride). The examples of frequent application of this strategy speak of its successfulness, but it must be noted that the local authorities have to ensure efficient and effective program for investing the special purpose-funds from the budget into the planned facilities. The example of Calgary, a town in Canada, illustrates how this strategy may be unaccepted, because of the slowness and inefficiency of re-investing by the local authorities into the traffic infrastructure.

Maximum parking needs applied to new constructions represents a strategy whose aim is to ensure (using construction regulations) huge parking supply. It may be applied to areas of low build-up density, where public transport is poor or insufficient. Maximum parking places represents the bottom limit in ensuring the parking supply, and helps the investors to evaluate the necessary supply. The implementation of this strategy, although theoretically possible, in central city zones, represents a risk of the increase in the private non-residential parking supply, outside the adequate responsibility of the local authorities, so that it is possible that this fact results in lower feasibility or unfeasibility of the overall parking and traffic policy.

Control of overall parking supply is a strategy that can be implemented by the local authorities in order to perform efficient parking policy in travel demand management. By using this strategy, the local authorities can control the whole available parking supply, by prohibiting the construction of detached garages and surface parking places, and stipulate the construction of new facilities without parking spaces, and revise the prices for buildings for public purposes. This strategy is suitable for long-term implementation. The majority of parking lots is controlled, so that there is a minimum number of places outside control. It is feasible for high-density built-up areas, provided the public transport supply capacity is satisfactory. This long-term strategy can achieve satisfactory transport demand control, and lead an efficient parking policy and overall traffic policy.

Parking time restrictions is a strategy that is most often implemented for a certain type of parking lots,

usually for public on-street parking lots, but this strategy may also be implemented to off-street public parking lots. It is implemented to prohibit access to the area, i.e. long-term parking, to certain categories of users. It is usually applied together with other strategies, but on the selective types of parking supply. For example, if the off-street parking supply uses the "minimum" and "maximum" strategy, the public on-street parking lots apply the strategy of parking time restrictions. This strategy has to be combined with an efficient penalty system for the breach of the regulations and good control of complying with these strategy measures. Very often wheel-clamping (Amsterdam) is used to enforce the compliance with the regulative measures of this strategy, or the vehicles get towed away. The condition for implementing this strategy is that there is no major supply of street parking places that are not supervised nor covered by the strategy measures.

Park and ride system (peripheral parking combined with public transport) is a strategy whose aim is to reduce travel demand by passenger vehicles into certain areas (most frequently central city zones) and shift in modal split in favour of public transport. The success of this strategy depends on the sufficient capacities and attraction of the public transport. The implementation of this strategy also depends highly on the careful parking service pricing that can be solved through a unique tariff system of the public transport. It is applicable to peripheral areas of the central city zone or a zone of high built-up density served by good public transport, whereas the zone itself is usually of low built-up density.

4. CONCLUSION

Generally speaking, there are numerous measures and strategies for successful travel demand management through systemic measures and consistent policy of parking. This has been confirmed by a whole series of performed practical research studies and all the more frequent implementation of the parking policy depending on the overall travel demand management, both short- and long-term.

Since some of the parking policy measures are complementary, and others supplementary, determining the parking policy and the overall traffic policy, and often more than one of the mentioned measures are applied, requires good analysis of the mechanisms of each and every one of them, so as to estimate the feasibility of the set objectives.

The implementation of parking policy within the designed frames, either the existing or the future ones, forms the basis for success in parking policy. Well designed policy with poor implementation will fail to

give the expected results. Therefore, the conclusion follows: parking policy is good to the extent of how well and consistently it is implemented in everyday practice. It is often the case that traffic policy in a certain area can be improved by consistent implementation of the existing parking policy. The implementation of parking policy measures should be oriented to the parking service user, in order to enable consistent implementation of the measures, or to those providing parking supply, with the aim of keeping the supply within the frame of set limits, and to use it in the planned way.

Modelling of the accessibility of the available parking supply can be provided so as to limit the number of parking places to a certain building or area, restricting the overall supply in an absolute way. The restriction can be carried out also in a way so as to limit the parking time for a certain type or in a certain area of parking places. In this way, a certain category of users cannot access a part of parking supply (e.g. commuting by private cars). The exception from this restriction, i.e. permits may be issued exclusively to a certain group of users, exempted from time-restrictions or charging. Residents are, for example, issued with permits for on-street parking, free of charge or at a symbolic fee.

Modelling of the parking pricing system, as mentioned above, is a strong mechanism for limiting the parking demand. Comprehensively designed, and systematically and consistently implemented, the parking pricing system can strongly reduce the parking demand. Therefore, it is necessary in the central city zones, that mark the highest misbalance between parking supply and demand, to introduce the parking charge regime, on the widest possible basis of supply. Parking prices play a twofold role. On the one hand, they force the parking service user to behave rationally and economically by its function of cost. The other role is in accordance with the principle of fairness, to financially charge the service user who actually consumes this service.

For a short-term, the most successful and the most adequate are the methods of consistent implementation of the existing parking policy and ways of modelling the parking prices. For a mid- and long-term, the method of modelling the parking supply availability is adequate. This can be concluded from the fact that the modelling of parking supply availability requires a number of steps that affect the administrative regulative measures, and the effects of this method have to be monitored over longer periods.

Finally, it should be stated that the parking policy with its measures and strategies is a very good means for travel demand management, both for short-term, with the aim of traffic therapy, and in achieving the long-term objectives of the overall traffic policy. The proof lies in the ever-increasing implementation of

parking policy depending on travel demand management in the cities. Parking policy is gaining greater significance in reducing the traffic volume, restrictions in travel demand of private cars, and in stimulating shift in modal split in favour of public transport. The final aim of travel demand management is to provide tolerable urban living and working conditions for all the city residents.

SAŽETAK

MJERE PARKIRANJA U UPRAVLJANJU PRIJEVOZOM POTRAŽNJOM

Učestalo korištenje osobnih automobila produkt je sve većeg standarda stanovnika gradova, dostupnosti osobnog vozila te njihovih potreba i doživljaja slobode kretanja. Prometni su planeri danas suočeni s potrebom podmirenja mnogobrojnih potreba za kretanjem stanovnika gradova i raspoložive prometne infrastrukture, u cilju održivog života u gradskim aglomeracijama. Kako je jedan od temeljnih ciljeva ukupne prometne politike dimenzioniranje količine putovanja osobnim vozilom na prihvatljivu i podnošljivu mjeru, to se sve učestalije koriste strategije i mjere parkiranja kao način za ostvarivanje tog cilja.

Dokaz tome su primijenjena iskustva gradova razvijenih zemalja, te sve brojnija istraživanja i analize utjecaja politike parkiranja na reguliranje prometa u gradskim aglomeracijama. Prvi rezultati daju ohrabrenje planerima i stratezima nastavku osmišljavanja strategija i mjera politike parkiranja u funkciji upravljanja prijevoznom potražnjom u gradovima

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