# Mobility Oriented Development (MOD): Public-Private Partnership in Urban Parking and Traffic Management with the Use of Autonomous Automobiles, Car-Sharing, Ridesharing Modes of Transport and Mobility as a Service (MaaS)

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**Abstract** The focus of the following research are relations between mobility technologies and metropolitan (urban and suburban) spatial structures. In this paper the author discusses various urban modes of transport (e.g. automobile, mass transit) in the context of emerging technical (autonomous vehicles, self-driving cars and driverless shuttles) and organizational (carpooling, ridesharing, car-sharing, on-demand mobility) solutions for the mobility as a service (MaaS). The author presents assumptions (chances and threats) and solutions for a scenario for better transportation-related city management proposing Mobility Oriented Development (MOD).

**Keywords** Car-sharing · Mobility as a service (MaaS) · Mobility oriented development (MOD) · Parking · Real estate developer · Selfdriving cars · Traffic · Urban development

## 1 Introduction

I wish to forewarn the reader of potential significant side-effects of the emerging mobility as a service (MaaS) solutions basing on historical and contemporary evidence from the field of transportation. In general MaaS intends to give the possibility of traveling without the need of self-owning any mode of transport (neither bike nor car). The chapter will present how mismanaged MaaS may badly

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affect both environment (built and natural) and people. Thus, I present assumptions based on known facts and logical thinking.

My interest in mobility came from architecture and urban design studies, which I finished with my hometown redevelopment concept, designing awarded mixed-use compact district with bike- and walkability approach [55]. Afterwards, during my Ph.D. studies I focused on the correlation between accelerating diffusion of innovations and increasing number and range of their spatial side effects. I assumed that both aspects' correlation are determined by causation, thus I begun to investigate their relations. My chosen subjects were emerging technical and organizational solutions in personal mobility. It appears to me that in many cases creating solutions, which solve particular problems, may generate additional problems, which demand the creation of other solutions etc. [57], as presented on Fig. 1. This observation goes along with conclusion of emergence of an unbound circle. It reflects the theory of induced demand and Jevons' paradox of efficiency [26], also known as rebound effect—in transportation e.g. Downs-Thomson paradox [for more information, see the recent complex study: 67] and Lewis-Mogridge law [36, 48].

The objectives of the following study are both to describe the relations and to evaluate the impacts between technological diffusion and spatial structures understood as physical, functional, social and economic aspects of space. The aim of this paper is also to emphasize the mistakes caused by blinded trust in data. Quantitative data research is mostly correct for a narrow scope of studied area, however it may lack a holistic approach to the problem, for instance due to the lack of: research time, funds, and text volume to present wider scope of results. As a consequence, the implementation of such data may induce unexpected results including side effects (for example improving street capacity may result—e.g. due to avoidance of crossing to the opposite site—in mental separation of neighbourhoods).

This chapter results from logical thinking method based on literature review of historical and contemporary diffusion of emerging urban modes of transport. Thus, it presents analogical assumptions for the near future based on historical facts. The presented impacts may occur physically in the built environment as well as in the

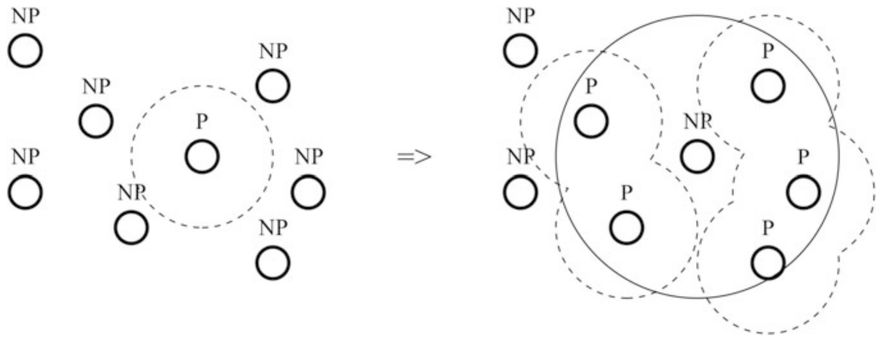



**Fig. 1** Spatial problem generation: after solving the problem (P) of particular location the side effects spread to previously non-problematic areas (NP). *Source* Author

quality of citizens' life. The study scope of a metropolis includes both urbanized and rural areas. I focus on negative impacts, although each technology solves, as mentioned before, particular problems. Ultimately I propose short- and long term mobility-related solutions for enhanced urban development, and thus higher quality of urban life.

Environmental impacts of transportation is the wide topic avoided in this chapter in purpose, just to mention products life cycle (vehicles and infrastructure), including resources mining and their transportation, production and transportation of: materials and their later reuse (such as aluminium); parts needed for each technological stage, and the final product; as much as the need of resourses (materials, energy, costs) for everyday use, maintenance and service.

## 2 Urban Mobility in History

Many authors referred to the diffusion of technologies, including mobility innovations, when studying cities. Historically spatial development of cities and their population growth (except from few examples) were limited by the availability of resources in their closest surrounding—outreach of everyday travels to and from their agricultural hinterland. Only few had their own horses—mostly farmers for supporting food produce and delivery [5, 19, 40, 56]. Cities and countryside were walkable [60] until the 19th century, when railways started to conquer traditional urban and rural space, as much as sprawling the city for the distances unreachable by walking—thus inducing demand for more railways and popularizing other modes of transport [50]. Henry David Thoreau wrote about rail: "a few are riding, but the rest are run over", thus "we do not ride on the railroad; it rides upon us" [64]. Since then, the cheapest mode of transport—that facilitated passing distances between "neighbours" or to work—was a bicycle [11].

In 1831 the first horse-drawn omnibuses appeared, which one year later were put on railways as horse-drawn trams [4]. In the U.S. in 1887 first electric trolleys opened, which turned into transit lines connecting shoppers with commercial centres [52]. Every single innovation that helped to reduce the time needed for traveling any distances, enabled and justified the growth of suburbanization, peri-urbanization, urbanization of rural areas (rurbanization) and separation of functions. The vicious cycle of unbridled spatial development has begun.

At the same time an essential, yet vertical mobility innovation appeared, and had a great impact on cities—the elevator. Elisha Otis presented his invention of a safe elevator during the New York Crystal Palace exposition of 1853-54; in 1889 he co-worked in constructing lifts for Eiffel Tower [23]. Elevator along with other building technologies allowed the construction of the highest buildings of those times: from the 1902 twenty-one-story Flatiron Building, to the 1913 fifty-seven-story Woolworth Building, to the 1930 seventy-seven-story Chrysler Building [47] and the like. Later in 1933 the idea of high-rise buildings was used by modernists in Athens Charter, and the concept of multifamily flats spread around the world. In 1972 the St. Louis Housing Authority began demolishing infamous Pruitt-Igoe high-rise district, due to social problems [39]—casting light on the unexpected side effects of modernism. Elevators allowed to use taller (and sometimes over-scaled) housing buildings which in many cases resulted in intertwining negative consequences: neighbours turned out to be anonymous (meeting in silence inside lifts), thus safety declined; streetscape disappeared (conditioned by bigger distances between taller buildings); greenery overgrew (due to insufficient time and funds for maintenance of over-scaled areas); housing was separated from services (justifying automobile use) and the like. Thus, the impact of the invention of the elevator stretched much further than the form of particular buildings: to the neighbourhoods, downtowns, not to mention global scale. Lewis Mumford and other scientists consider the invention of the elevator as the example of vertical mobility technique that changed the city shape as much as the automobile, exaggerating negative spatial consequences [13, 20, 40, 42].

Before the invention of Ford Model T most of the people could not afford mechanized travel and their mobility had not changed much [43]. Henry Ford simplified the automobile structure, thus made it cheaper in the time when cars became complicated and more expensive [41]. Soon automobile owners and producers begun new movement of anti-pedestrian propaganda called Motordom [39]. The General Motors' Highways and Horizons pavilion opened during the New York 1939 World's Fair, presenting the Futurama exhibition—which contained dioramas and a propaganda film To New Horizons about the future motorized world of 1960s—begun a new era of automobile-addicted people and -dependent spatial structures [39, 65]. Personal vehicles created a vast problem of resources and energy use. Until now car weight has tripled, besides less than one percent of energy is used for moving the weight of human body, since most of the time there is only the driver alone in a car with four, five or seven seats [after: 24]. Automakers and researchers invent new types of individual transportation mitigating their footprint and use of resources—the example is the folding MIT car [35]. Nevertheless, improving the idea of automobile is already outdated [30]. Emerging IT solutions enable mobility as a service (MaaS) instead of individually owned vehicles.

Prior to automobile everyday travels were reduced to walking or riding emerging mobility services (omnibus, trolley, tram, rail). Comparing to transit the self-owned car became more comfortable way of everyday travels across and between newly sprawled towns and cities. Moreover, adjustment of space to automobile (roads, highway, parking) in many cases finished with reaching places in walkable scope by automobile [33]. Transportation planning and urban planning has a lot in common, and therefore cannot be considered separately [34]. There are numerous possibilities of mobility needs mitigation [31, 56, 61]. New Urbanists claim that shaping urban form has the impact on mode of transport preferred—the more compact and full of local services, the more non-motorized and non-individual modes of travels are chosen [8]. Thus, examples of so-called compact cities are strongly related with sustainable mobility [62]. Besides, since there is no space in cities for every individual with a car, municipalities sustain urban mobility by investing in public transit, which may easily generate growth but is as easy potent for cancellation due to economic reasons [12]. Yet, there is still place for private operators of mass transport, such as jitneys, private buses, taxi companies, car renting [45] etc.

Numerous lessons can be brought from the history, just to mention three of them: (1) Overcalling road infrastructure is expensive, does not solve the problem, rather induce demand and borrows from the future like in the Ponzi scheme [33]; (2) Infrastructure is not shaping our cities, rather urban design and legislation is determining necessity of implementing particular infrastructure (new roads, lanes, parking); (3) Changing behaviours is relatively cheap potential for refining cities and infrastructure efficiency, but we have to keep in mind Lesson's 1 paradox of induced demand. Thus, at present we are ready to discuss managing MaaS with the use of contemporary emerging technical and organizational solutions in mobility.

## 3 Nowadays MaaS

We are in transition of the second century of developing urban transit systems around the world [44] and we are still, if not more, facing emerging urban mobility problems, regardless the infrastructure we built. Part of the solution, if correctly used, may be information and communication technologies (ICT), such as intelligent transportation systems (ITS), and mobile ICTs [38]. Emerging nowadays the new mobility paradigm is based on Internet applications [46] abstracting physicality [32]. Since this decade numerous of mobile apps has appeared offering different solutions for trips [53]. For instance, the Citymapper mobile and web application offers—along with comparing time of different modes of travel (including car-sharing) from point A to B and finding optimal route—counting calories burned by walking and cycling; money spent by driving a car; proposing the most comfortable section of train; and more [9].

Besides, using existing transportation systems cities are managing in real time our moves using ITS with, or without our acceptance or even consciousness [6], while these new technologies operate seamlessly [20]. In contrast, along with ICT implementations, the congestion problems are getting worse [37]. Moreover, Adam Greenfield says that smartphone killed the city [21], but Janette Sadik-Khan adds: it's not what we have in our smartphones but what we have on our streets [51].

A part of the new paradigm (which is actually the evolution of pre-automobile paradigm) is so called shared mobility. Its name comes from sharing economy, which historically was (and still is) stimulated by spatial density [3] but today has few in common with its origin, due to commercialization and anonymity [27]. Recent times the diffusion of shared mobility modes are accelerating, as for example bike- and car-sharing, ride-sharing, carpooling, on-demand ride services (ride-sourcing and e-hail), alternative transit services (ATS, such as micro-transit and paratransit) [53]. Figure 2 illustrates sample relations between urban modes of transport, including shared mobility.

Different scenarios of car-sharing diffusion and its impacts can be considered, including full private services with potential negative spatial consequences, public-private partnership (PPP) services with controlled spatial impacts and public services with limited scope focused on urban renewal [58]. Many examples from the past has shown that diffusion of new technologies along with solving particular problems is followed by side effects, and it speeded up nowadays when new solutions are introduced without reflection [57]. Unfortunately owning a vehicle depends not only of mobility needs but also for bragging owner's wealth [10, 56]. Thus, car-sharing may potentially replace merely small part of automobiles, and complement to the much bigger amount to the car share in traffic, as shown in Fig. 3. Only few, if any may use alternative mobility modes, including walkig—and some may use both their self-owned cars and car-sharing during their everyday travels.

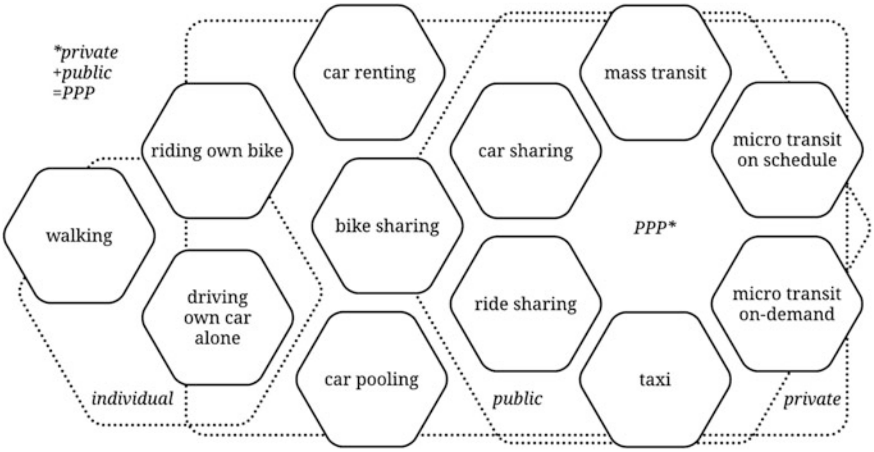



**Fig. 2** Sample urban mobility modes diagram. *Source* Author

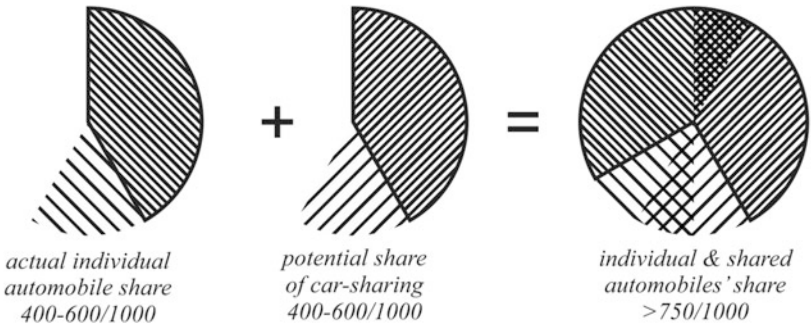



**Fig. 3** Potential results in general car share of complementing individual automobile use with car-sharing—in some cases both self-owned automobile use and car-sharing may be used for everyday travells (overlapped). *Source* Author

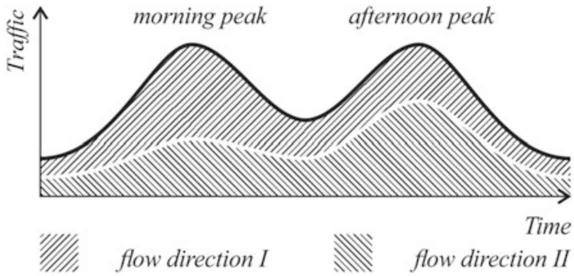
Another example of the emerging technology is an artificial intelligence allowing the automation or robotizing of transport modes. The automated mobility exists in cities around the world since the beginning of 21st century, yet its operations were mostly restricted to the closed port areas [28]. Nowadays, the automotive and IT industries introduce this technology into the urban public spaces [59]. There are different names with intertwining meanings, and therefore with diverse impacts on spatial structures, depending of the pursued or emerged scenario, for instance: autonomous- or automated automobiles (AAs), driverless cars, self-driving vehicles [59]. Due to the automation the second major automobile expansion with all its "devastating consequences" may occur [17]. Replacing individual automobiles with autonomous taxis fleet could generate additional traffic [7], as it occurred analogically in the New York with emerging car-sharing services [16]. In recent survey up to 54 percent of respondents would not wish to replace their favoured mode of transport [18]. Yet, congestion from seeking parking place is estimated to 30 percent of traffic flow [54], thus autonomous fleet, if managed well, could reduce this number. If mismanaged could work opposite—adding additional vehicles (shared) to the already existing (self-owned and self-used). Unfortunately, as another recent research has found, most of the cities and regions are not mentioning mobility automation in their development strategy documents [22]. Moreover, municipal and regional governments are rarely investing on technology supporting individual transport. For instance, electric vehicles (EVs) which might be charged wirelessly both on parking places and riding on the road [15]. However, we have to be aware that vehicle automation technology (and other mobility inventions) could get obsolete every few years—demanding replacement [52], and thus generating repetitive costs. These costs could be taken by private sector, as the 'mobility' developer which is proposed later in this chapter.

It has to be mentioned that driverless cars ease travelling to any destination at any time, thus making vehicles ubiquitous everywhere (perhaps complementing the traditional automobile)—and they may be in almost constant move (occupied or empty), instead of short moments of letting passengers in or out. On the other hand, the liveable urban streets invite primarily the people (understood also as the commuters), not the vehicles (nor adjacent to them infrastructure). Therefore, to avoid analogical mistakes to those done for the period of automobile emergence the municipalities must pay more attention to pedestrian-friendly (accessible, inclusive) spatial structures (including road infrastructure, especially the so called complete streets [29]).

## 4 Managing Mobility Behaviours

Worldwide city urban form follows more or less the radial model of connections between the city centre and its surrounding. This spatial model generates traffic flows with the two peaks. Yet in most cases congestion emerges in particular directions: morning into the city and afternoon outside. Thus, the road infrastructure

**Fig. 4** Sum of two traffic flow directions. *Source* Author




is used inefficiently—lanes in one direction are congested, when second direction may be underused. Figure 4 presents the theoretical graph of traffic flow as the sum of two flows in opposite directions. Just to mention, occurring of such ineffective and inefficient traffic problem would be primarily solved in the private sector.

Presented in the previous module examples show how increasing capacity of road infrastructure may have opposite results due to promotion of more intensive use—induced demand [36]. User behaviours influence how infrastructure is used, thus changing human actions seems to be important part of mobility management. This module will discuss the possibilities of reshaping the theoretical model of existing urban traffic situation with proposals of changing user behaviours—in contrary to investing in road infrastructure. Moreover, proposed solutions could solve problems in both short- and long-term.

Some municipalities manage traffic by charging drivers, e.g. for entering city core or parking places, but in many places it may be difficult political decision due to the accuse that drivers are charged in particular reason—to heal local budget. Nowadays gamification appears as the new way of mobility management. The Fun Theory initiative, which states that fun can change behaviour for the better, brings some brilliant examples: (1) The Speed Camera Lottery—the camera photographs all drivers, speeders are fined and money gathered goes through the lottery to those who drives under speed limits; (2) Piano Staircase promotes stair use instead of escalator by turning steps into playing piano keyboard [66]. A different example of mobility management is the Project Interzone which provides idea of three time zones inside the city for every user to choose: −2 h, standard time and +2 h—thus, traffic from peaks stretch for longer period, as shown at Fig. 5 [49].

1. My first proposal is to combine ideas of gamification and ITS mobility management. Since the congestion appears mostly on the lanes in particular direction drivers can be charged when using more congested lane, and collected money can be transferred to those driving in opposite direction. This will make congestion-makers yet more envy of people travelling opposite direction, who sustain traffic flow. In long-term period it may promote housing location in the city centre and spread the businesses across the city until it will reach the level near balance. Thus, it could convince people (in general) to choose urban core

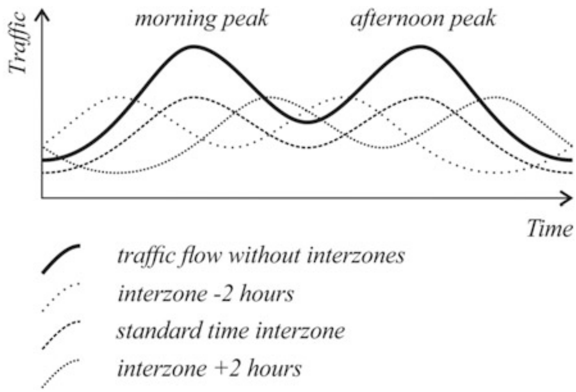



**Fig. 5** Traffic flows before and after introducing interzones. *Source* Adopted from [49]

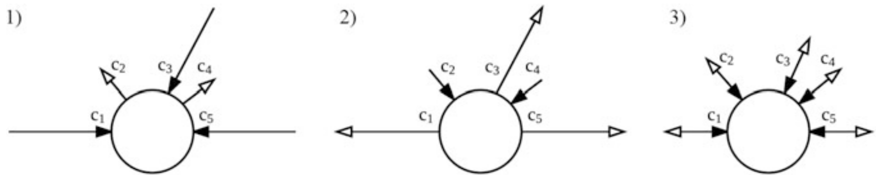



**Fig. 6** Theoretical models of traffic flows on five different roads ($c_1$–$c_5$) to the city centre: **1** morning, **2** afternoon, and **3** sustained (expected). *Source* Author

for living and using no-central areas for the work-place. This behaviour changing model may have two major big impacts. In short term, it may reduce car use in the most congested directions, when promoting use of underused infrastructure, as shown in Fig. 6—making it more cost-efficient investment. In long term it may change the urban form for the better by promoting mixed-use —instead of modernist-like single-function districts which generate peak congestion. The idea is even more possible nowadays with flexible transit based on MaaS, due to the possibility of introducing adaptable pricing.

2. Thus, I propose second solution, which should be excluded from above drivers' charging. The idea is to adapt prices e.g. for sharing a car or a ride, dependent on direction travelled. This solution requires private-public partnership (PPP) for providing transit, due to the needs of non-market operations and private capital.

Since above proposal supports sustainable urban development it cannot be considered without other parties, for instance developers. Traditional developer faces the problem of parking requirements, which not only reduce the scale of potential development but also impacts negatively on costs, aesthetics, and users' behaviours and their quality of life. Moreover, researchers estimate that in average 30% of urban traffic in high density structures is actually generated by drivers looking for parking place [54]. A part of the problem solution is the Transit

Oriented Development (TOD), which emerges as the cooperation between private (developer) and public (municipality) investors [25] or Transit Adjacent Development (TAD) [1].

3. Thus the third proposal is the Mobility Oriented Development (MOD) approach, which focus on delivering MaaS included in development. That means developer organizes mobility (e.g. vehicle sharing included in development) instead of the place for it (single-use functions such as garages, parkings and inner streets).

Audi at Home is an example of cooperation between developers and automotive company, allowing residents to use the car implemented to the real estate [2]. Yet, it allows to use one car by many users, the car is unavailable when parked outside of the property. Thus, acceptance of autonomous vehicles on streets will allow developers to introduce their own fleets. One can say that Lyft, Uber, ZipCar and similar companies give the solution in global scale. However, there are many car owners, who won't give up their own cars until they will feel their property fleet belongs to them [10] (similarly, the jet planes are shared by businessman). These cars will be considered as cleaner and safer, since they will be shared within neighbours, besides supporting social interactions in neighbourhood. For instance, neighbours could schedule their home-work-home travels in advance through the application and travel together if suitable and invite their trustworthy friends to the system.

The application could be introduced by the metropolitan municipality which should promote MODs by giving them construction permissions conditioned by including mobility service instead of automobile infrastructure. This will promote the system due to common tool for users and vast savings for investors. Moreover, the municipality will liberate of creating its own mobility fleet moving costs to the private sector, including costs of every-few-year updates due to the predicted fast obsolescence of automation technology. And the last but not least, the application should complement with public transport system and follow presented earlier in this chapter adaptive pricing for sustaining traffic (for instance in some conditions the joined trip of car-sharing and transit could be priced the same as transit-only trip to convince possible drivers for using the MaaS[1]).

There are several benefits of this solution: (1) MOD generates vast savings by reducing costs of building underground parking (although he may for sure hide these costs in property prices, rents etc.) as well as revenues from additional floor area for filling it instead of outdoor parking or landscaping this area which will at the same time flourish urban streetscape, generate profits from local services (including car-sharing service), as shown on Fig. 7; (2) *property's residents* generates savings from not owning a car, which include: car costs and amortization,

[1]According to 17 Aug 2016 Lyft Blog post—after the submission of this chapter manuscript for peer review—Lyft introduced free rides to the nearest light rail stop in the City of Centennial, CO, USA.

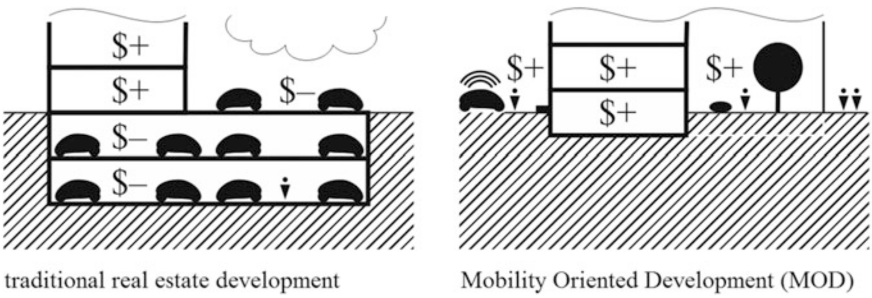



**Fig. 7** Theoretical example models of traditional real estate developer and the Mobility Oriented Development (MOD). *Source* Author

maintenance, repairs, insurances, and addiction of on-every-occasion car use; users socialize by sharing common cars and rides with their neighbours (3) *neighbourhood inhabitants* receive profits from not as much of car-dominated streetscapes (less parked vehicles and reduced congestion, and extra greenery and multi-services structures), together with the opportunity of joining development (or developer's) car-sharing system; (4) *municipality's* reimbursements remain from reduced congestion due to less frequent use of individual transportation, which comes from greater use of public transport, due to the complementarity of sharing mobility with nearby transit stops.

## 5 Conclusions

Historical evidence proves that investing in the transport infrastructure capacity turns into the rebound effect which forces next investments (e.g. Downs-Thomson paradox, Lewis-Mogridge law) [14, 36, 63]. Similarly results the enhancing of automobile (eco-)efficiency, which turns into more sales and higher usage of the car [after: 48]. Its grounded in the focus on the objects (infrastructure capacity and accessibility, vehicles efficiency) instead of the subjects who are the commuters. Therefore, I foreworn from repeating the mistakes from the past during today's implementation of MaaS. The way to take advantage of rebound effect with positive results is managing mobility behaviours of people. It can be occurred with the use of existing infrastructure and with building-up new mixed-use structures with less physical and more organizational solutions included, such as the presented MOD solution which should complement in partnership the existing public services.

The future research is required to evaluate the public acceptance of the proposed solutions, as much as the commercial analysis are necessary to calculate the costs of investments and possible profits. Concluding, the proposed *Mobility Oriented Development (MOD)* is the solution for both short- and long-term problems creating the positive rebound effect of sustaining the actual parking and traffic as much as the future urban development.

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