Urban transport: eliminating blind spots and missing links in the era of the fourth industrial (r)evolution

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Abstract

The transport sector, especially in growing cities, faces challenges relating to the climate, local environment, congestion, funding and equality, and uncertainties over political leadership, self-driving vehicles, citizens' reactions, and how the system is understood. Despite ambitious goals and investments, problems escalate via motoring's self-supporting processes: more cars, more roads, longer journeys, urban sprawl, more cars ... . Neither technical streamlining nor investing in public transport and attractive urban environments can trump the process. This paper examines whether we can use the methods of the fourth industrial (r)evolution to transform the urban-transport system. Starting points are: the role of transport in creating accessibility; the sector's inherent logic and vast unused capacity, particularly in infrastructure; and the methods and business models of the rapidly expanding digital-platform monopolies.

A feasible future is described, its basis a digital multimodal urban-transport platform for information and payment, founded on the sector's base services: room on the streets, roads, rails, car parks and public transport. The technology exists but institutional problems abound. Radical public-sector service innovations are required. The paper identifies opportunities and obstacles. It concludes by evaluating the potential to realize these ambitious goals, looking at public transport's role in a reorganized system of this kind.

1. Introduction

Many remedies have been suggested to solve the growing transport problems that cities, mainly in the West, are facing (Santos et al. 2010a, b) – hugely expensive economic problems and frightening inefficiency; major congestion and a lack of predictability; ecological problems resulting in climatic effects that are hard to address, damage to local environments through noise pollution, barriers, exhaust gases and particle emissions, and the use of valuable urban space; and social problems such as inequality in illness and death, and in access to necessities such as work and amenities such as shopping and recreation (Niedzielski & Boschmann 2014). The problems are so great, and ambitions so high, especially in terms of the climate, that small gradual changes are insufficient, if they cannot quickly overcome the resilience of the current transport system.

Numerous proposals aim to increase capacity, build more roads, more efficient engines, or develop more eco-friendly fuel, measures that have failed to show any radical transformative power. Any improvements are consumed, wholly or partly, by increased consumption, larger vehicles and longer journeys. Life-cycle perspectives are routinely overlooked: the fact that manufacture, maintenance and eventual disposal of vehicles, fuel and infrastructure have a significant environmental impact. Major investment in public transport, cycling initiatives and courses to wean motorists off cars yield only marginal benefits, if these carrots are not used alongside sticks.

Keywords: digital platform; business model; dynamic pricing; complex system; multimodal integration; climate change. *Classification codes*: H540, O350, O380, R410, R420, R530.

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Recently many have put their hope, in vain, in sharing services such as the commercial Uber, charitable ride-sharing, or the group of transport services packaged as Mobility as a Service (MaaS. Kamargianni et al. 2016). Nor has the proposal of more data and increased 'smartness' led to ideas with game-changing potential, despite many years of supporting Intelligent Transportation Systems (ITS – not a transport system but a movement strongly focused on IT). Improved services for traffic information, travel planning and navigation are also included in the comprehensive arsenal of measures that raise exaggerated hopes. The situation with demand-related congestion charges and parking fees is different. Although these have real potential, focus is often lost because prices are seldom adjusted and the income generated is used as just another form of taxation.

Many of these services, which are good in themselves but insufficiently transformative, will be indispensable parts of a future climate-adapted transport system. The reason for their limited success can be found in the way the transport system works. In cities with congestion problems there is also latent demand (Downs 1962). If pressure on a particular road declines, when motorists transfer to public transport, others road users will take their place. This, surprisingly, is a blind spot common to virtually all the above proposals.

The fact that the transport sector as a whole presides over a vast unused capacity is often overlooked too – another blind spot. The sector is one of the most inefficient in terms of the relationship between the work it carries out and the available capacity, which, in common with latent demand, is because 'in no other major area are pricing practices so irrational, so out of date, and so conductive to waste as in urban transportation' (Vickrey 1963:452). For the same reasons, the century-old strategy of predict and provide (Owens 1995) failed to solve problems by increasing capacity at times and places of peak demand. Given that the road network regularly grinds to a halt when it attracts more traffic, the flow of traffic is lowest when demand is highest.

The idea of pricing in relation to demand has met with stiff resistance. Where it has been introduced, though, the correlation between price and demand is weak and the effects are therefore limited, albeit clear. Thanks to IT – the third industrial revolution – the means of introducing flexible dynamic-pricing systems have successively increased (the same is true of parking), although without making any great breakthrough.

The fourth industrial revolution (some talk of evolution) has introduced major changes in many branches and sectors of society. These include radical innovations with completely new patterns of behaviour, ways of meeting existing needs, and amazing possibilities for coordinating and streamlining. So far the transport sector has seen only modest change because its infrastructure is not yet involved (Paaswell 2014). What is lacking is a firm, comprehensive grip on the entire transport sector, together with a consistent, radical focus on users (Gullberg 2012a, b; 2015a). This allows us to imagine an urban world without congestion; with room for children to play on the street without fear of lethal air pollution or being run over; with good, cheap public transport and help available for everyone to find their way; where traffic information is reliable and where we can arrive on time; and where an ecosystem of transport and other services allows companies supplying geographically defined services to develop their innovations and businesses.

The article is arranged as follows. Part 2 describes the transport sector's accessibility services and how increased mobility came to replace proximity in order to create accessibility. Part 3 details the sector's unused capacity, inherent logic and complex nature. Part 4 describes the methods and business models of digital-platform companies. Part 5 defines the characteristics of good-quality services, the foundation for the services provided by the proposed digital platform. These sections form the basis for Part 6, which outlines a conceivable future with a digital-transport platform and adapted business models, and how the transport sector's missing links can be bridged and its blind spots filled. Thereafter Part 7 examines obstacles and opportunities for introducing such a platform. In conclusion, Part 8 evaluates the platform's potential to fulfil the ambitious expectations directed at the sector and the role of public transport in a future of this kind. The fourth industrial revolution provides the opportunity to replace increased mobility with a restrained orchestration of proximity and mobility as a means of creating accessibility. However, urban development with increased mobility seems most likely, given the major investments in developing autonomous vehicles.

2. Accessibility services of the transport sector

'People [just like other animals are] destined to move … to find food and satisfy other material and social needs. … This principle does not change because we … delegate transport to others who carry it out by machine' (Hägerstrand 2009:202).

The main role of the transport sector, to create accessibility by moving people and goods, has long been obvious to scholars without making a significant impact on transport policy. Accessibility enables people to benefit from goods, services and activities (Litman 2015), but it also provides the opportunity, for example at a regional level, to unite in time and space the necessary skills and resources for various types of societal activities and processes (and to remove waste and exclude other obstructing elements).

The point is not transport itself but the opportunities it provides. Demand is derived; benefits arise in the sectors being served because geographic distances are bridged between supply and demand in its widest sense.

Yet the actual transportation between O(rigin) and D(estination) is not of sole importance. Accessibility too, in other words the opportunities available to carry out transport, to reach resources and amenities, represents a significant option value (Litman 2015:11).

Transport cannot be "stored" and nor can its production be moved elsewhere (Owen Jansson 2006:72). When people are transported, as with other people-related services, the person using the service must be present, which is not the case with goods traffic. As a minimum, people must physically take part, contribute their time, perhaps pay, and maybe suffer discomfort, unpunctuality, stress, the risk of injury or death, and the loss of their sense of control and their privacy. The transport economy treats these sacrifices as part of the function of production, in other words necessary trade-offs that allow the service to be produced (Small and Verhoef 2007). Conversely, travel time may sometimes be a bonus: a chance to listen to music in the car, or an opportunity, otherwise unavailable, to socialize. Some forms of transportation are made for their own sake, with no destination: a drive in the car, a Sunday stroll. In addition, transporting people always entails extra-instrumental aspects, given that they take place, to varying degrees, in public space, under the gaze of others, providing people with a longed-for, or awkward, opportunity to present themselves (Goffman 1956). The composition of the car park is a clear example of this phenomenon, cars being typical positional goods (Hirsch 1977; Veblen 1899), valued in terms of their status in relation to other cars.

Before motorization, transport was both laborious and expensive. The dominant principle for creating and maintaining accessibility was to limit distances travelled via co- and close-locating. In terms of cities, the first industrial revolution made little change here. But steamships and railways made long-distance transport much more efficient, which quickened urbanization and increased city density. Things were different in the second industrial revolution with the electric motor, internal combustion engine and very cheap energy.

Constantly increasing mobility became the dominant formula for maintaining and preferably increasing accessibility, and in consequence cities became progressively dispersed, daily journeys ever longer. The transportation of people and goods has grown enormously. Information technology: the third industrial revolution, which offers more opportunities for coordination, control, and payment for services, has not altered the main thrust of current development.

3. Unused capacity, inherent logic and complexity of the transport sector

The transport sector's method of creating accessibility by increasing mobility is partly self-destructive. Simpler, cheaper and quicker forms of transportation contribute to more dispersed localization with reduced accessibility as a result. Conversely, co- and close-locating of homes, workplaces and businesses tends to increase accessibility and reduce the demand for transportation. The inhabitants of a typical US city cover twice the distance as those in an equivalent European city to reach the same range of services (Owen Jansson 1996:38). The interaction between transportation and localization is a classic research theme, without making a significant impact on transport policy.

The production of availability is further complicated by the fact that mobility occurs via several modes of transport, separated in terms of organization and operation from one another, and varying greatly in capacity and environmental and distributional effects, at the same time as they influence each other, often in contra-intuitive, overlooked ways: in a complementary fashion, linking into a single journey; and when competing for transport users, funding, and for room in the city and its shared infrastructure.

The movement of people and goods is dependent on infrastructure, within which vehicles move with their loads. Three predominant forms of production differ from one another in terms of the relationships between end users, vehicles and infrastructure.

Self-service: private vehicles using someone else's infrastructure – primarily the street and road network. This dominates the transport sector in the form of motoring, the main feature of the self-service economy (Gershuny 1978). Passenger transport: walking (no vehicle!), cycle, car, other types of motor vehicle and boat. Goods are conveyed in personal lorries, vans and cars.

Public transport: nowadays mainly passenger traffic; a seat in someone else's vehicle according to a fixed tariff, usually according to a timetable and travelling along a fixed route on shared or reserved infrastructure: tram and bus on the street and road network, trains, the metro; aerial lifts; Bus Rapid Transit (BRT); additionally a hybrid comprising reserved-lane buses using lanes not completely separated from the street and road network; and boats.

Hire vehicles: Booking a seat in someone else's vehicle, according to agreement, via third-party infrastructure. Passenger transport: taxi and similar services and shipped goods. Hybrids exist and are evolving. A fourth form of production comprises the pipes and cables that transport energy, heating, cooling, water and sewage, and the airwaves that spread information. These are important for cities as they relieve the street and road network. In most cities the lion's share of the infrastructure – rail and street and road networks – are in public ownership, the latter in the public domain, accessible to all citizens. Networks are strongly inclined to be natural monopolies and morphologically the entire section must be available, which can be facilitated if public bodies ensure the right of way (Millward 2005:17).

Along with space on the streets, roads and parking spaces, local public transport is one of the base services of urban transport, on which all travel and transport depends. Here the public sector often enjoys a monopoly. Local public transport is normally partly financed by the taxpayer (Small and Verhoef 2007:159, Dienel 2009:275), which is often motivated by its social importance, sometimes for its mitigating influence on congestion (Schrank et al. 2015).

3.1 Unused capacity and differences between the modes of transport

In a region such as Stockholm, a decade or so ago only a few percent of the overall street and road network was affected by congestion, and then only at limited times of the day, week and year. Yet it is still worth drawing attention to this phenomenon. First, a far greater proportion of road users are affected by congestion-related delays and unpunctuality. Second, current congestion tends to set the dimensions for future expansion of the street and road network.

Unused network capacity is considerable and can be further increased, without new investment, by changing the way vehicles are used. In the average car, during the 5 per cent of the time it is actually used, only 25 per cent of the seats are occupied (which is the same degree of coverage for parking spaces. Shoup 2011; Hagman et al. 2007). If this figure were doubled, then all rush-hour passengers on Stockholm's public transport, which is well known for its large market share, could be accommodated in the cars then on the road, albeit not all to the same destination. This is a calculation, not a proposal (Lundin & Gullberg 2011:92). Buses, as well as bicycles, on city streets in mixed traffic can carry seven times as many passengers as cars, whereas pedestrian traffic is capable of conveying 15 times as many people per width metre and unit of time. A tram can carry between ten and twenty times as many passengers per unit of time, and its passengers take up only a twentieth of the urban space of car passengers. In a reserved bus lane, the number of travellers can increase by a factor of 15. The metro can accommodate 25 times more passengers than cars on city streets, and over six times more than on urban motorways (Gullberg 2015b).
Capacity differences can also be expressed in terms of surface use. To replace a metro train with an equivalent-capacity urban motorway would require seven lanes in each direction, or 17 in the case of a city street. A commuter who changes their mode of transport from rail to car increases their surface usage by a factor of 60 for the journey time alone, or by a factor of 850 if eight-hour car parking is included (Vuchic 1999).

3.2 The street and road network as a commons

The street and road network is a human-created commons, used for the public good and open to all three forms of production. A large proportion is prioritized or fully reserved for motor traffic (motor-dominated street and road network: reserved for a "club" of licence holders with access to vehicles who are "sharing … an excludable (rivalrous) public good that is a club good" (Cornes and Sandler 2007:347). The network may be used on demand, requiring neither agreement – with the road owner nor consultation with other users. The system is loosely connected; the relationship between the infrastructure and its use/users is weak. Usually traffic flows unhindered, but with too many users at any one time, using the same routes, the service deteriorates for everyone and ends in queues. The network is susceptible to congestion, flow decreases and capacity reaches its lowest point when demand is greatest.
A social dilemma has arisen: everyone loses by doing what is best for them. Traffic jams would not occur if vehicle flow was slower when capacity was about to reach its limit. This

would allow more cars to reach their destination during this otherwise congested time period, and they would arrive much sooner too. This means those setting off later would still arrive sooner. Relatively small changes have major consequences. For example, on Sweden's busiest road a reduction of 500 vehicles just before congestion occurs could accommodate an additional 8 000 vehicles during the eliminated congestion period (Gullberg 2015b). In other overload-sensitive network systems such as power, telecommunications and data, huge efforts are made to avoid a collapse of this kind.

3.3 When overload threatens

The means to exclude or otherwise influence the use of the motor-dominated street and road network when it is threatened by overload is crucial for managing the social dilemma described in the preceding paragraph. For a resource to be excludable would depend on social convention and cost as well as technical means (Cornes & Sandler 1996:9f). There are five ways to deal with the problem of the commons or social dilemma, of which the first three depend on the influence of influx (Gullberg & Isaksson 2009:34f).

1 Hierarchy/regulation. Means of rationing are readily available: restricting the number of vehicles, prohibiting driving licences or registration plates that end with certain numbers on certain days of the week, but difficult to adapt to the wide variations in demand over time and space. Rationing of slip roads at known congestion blackspots (ramp metering) has better accuracy but insufficient power.

2 Market/price. Congestion charging so far correlates only weakly to actual demand in time and space. Comprehensive charging for road use, especially 'with the actual crowding experienced ... usually does not [happen], since such efficient schemes are difficult and costly to institute' (Cornes and Sandler 2007:411). Yet technical breakthroughs have meant that costs, both transactional and purely economic, have declined considerably, which is also true of parking. Nevertheless, real-time dynamic pricing exists only on limited stretches of road in private projects. The resistance of popular opinion appears to remain strong.

3 Co-operation/agreements. Opportunities to develop trust and shared norms among drivers who are about to create congestion are small, which impedes collective solutions (Ostrom 2003:257). Digital car-sharing services increase contact opportunities, but not enough. Any alleviation is undermined by rebound effects (see next paragraph).

4 Increased capacity with new or widened roads where congestion is greatest. So far this has failed to solve gridlock problems. In the short term increased capacity quickly attracts more traffic; in the long term it stimulates decentralization, increased traffic and congestion. Induced traffic of between 0.2 and 0.8 has been measured for limited projects – 20 to 80 percent of traffic on the new road can be attributed to its construction – the so-called rebound effect. (Small and Verhoef 2007:174). Viewed over a longer period of time, and a larger part of the motor-dominated street and road network, the effect may probably exceed 1, the so-called backfire effect (Gullberg 2015b).

Alternatively if public transport, using a dedicated network, is built parallel to the congested road the effect is different. If motorists transfer to public transport, which is likely in the case of heavy congestion, then this would strengthen the basis and thus the possibility of improving public transport with a more frequent timetable and/or lower prices. The more people travel, the better transport can become (the Mohring effect, see below in section 3.4). However, the positive effect of reduced congestion declines when the roads attract more cars. On the other hand a new road, in unfortunate cases, can even lead to a worsened traffic situation, yet another example of how when everyone does what is best for them,

everyone loses. Conversely, closing a road can lead to improved traffic conditions (the Braess paradox, Small and Verhoef 2007:95).
5 Taking no action would likely lead to increased congestion for cities with growing populations and economies. Increasing congestion is used as an (irrational) rationing method.

3.4 Rail and other forms of public transport
Public transport, especially on reserved lines/lanes, is far superior to the other forms of production in terms of capacity, surface efficiency and the environment. Although for many this is the only option, in its conventional form it faces difficulties in providing traffic at times and places when demand density is low. With a separate infrastructure, public transport avoids the kinds of congestion that afflicts the motor-dominated street and road network, because coordination between infrastructure and vehicles/rolling stock is strong and regulated in closely controlled systems of this kind. In heavy traffic, delays and capacity deterioration may occur when public-transport columns form because of delays in boarding and exiting. Public transport on the street and road network is also affected by the social dilemma (described in section 3.2). Public-transport passengers have a potentially positive effect on each other. The more people travel, the better the basis and possibility for a more frequent timetable and/or lower prices (Mohring effect, Mohring 1972). Conversely, motorists on the motor-dominated street and road network hinder each other in congestion, but support each other by increasing political pressure for more roads.

3.5 Business models of production
End-user transport costs vary according to the form of production. In self-service, marginal costs apply, whereas in public transport (minus tax subsidies) and vehicle hire, average costs apply (Cornes & Sandler 1996:524). For self-service, no payroll costs are involved (unless the end-user is a company employing a driver), whereas vehicle hire and public transport are imposed with salaries and taxes. A common factor to all forms of production using the street and road network is that the costs incurred for its use do not reflect demand and negative external effects. An important component of self-service motoring is parking, where financial demands on property developers to provide high standards are passed directly to the population as a whole. This is in clear contrast to a business model where car ownership would require the funding and operation of parking spaces.
The ability of transport users to exploit their consumer power varies between the different forms of production. In public transport, opinion forming and pressure on politicians applies. In the self-service sector, people express themselves through the choice of vehicles they buy, even though political pressure may still be necessary in terms of the street and road network (Gullberg 1989). Motoring’s self-service nature requires far greater effort from road users and households than other forms of production. As co-producers motorists are responsible for driving and maintenance, and in economic terms a car-owning household usually spends far more of its income on transportation than a non-car household. This increases the road user’s personal involvement in motoring, far beyond that required by its position as a dominant status symbol.
Business-model variations between the forms of production can produce unintuitive results, for example that the *widening* of a road that runs parallel to a dedicated public-transport line leads to a *deterioration* of both forms of production where latent demand prevails, according to the Downs-Thomson paradox (Owen Jansson 1996:97f; Small & Verhoef 2007:95).

3.6 Mobility, accessibility and complexity

The combined transport sector, as we have seen, consists of several subsystems with very different characteristics. They are managed separately in terms of politics, administration and economy (missing links), despite strong interactions between them often being overlooked. This makes the sector a complex system (Macário 2011), amplified by loose links within the street and road network and the journeys that take place on it. Because of the intricate interaction of the sector as a whole with localization in the common production of accessibility, complexity is further increased. This produces difficulties in predicting the consequences of subsystem changes for other subsystems and for the transport sector as a whole.

At the same time, and in some ways a contradiction, great stability has prevailed since the early 20th century via the dominance of the private car, whose logic, formal political backing and support by influential lobby groups, all based on a broad, positive public opinion, has transformed urban regions, at the same time as the radical consequences of motoring have been overlooked, becoming blind spots. This may be explained in terms of the system's strong resilience to internal and external change. To transform this situation, in which the least energy- and surface-efficient means of transport dominates, requires reduced complexity, which would allow the system to be more easily managed and the various subsystems to interact according to more uniform principles.

One way to reduce complexity is the use of dynamic pricing, to more closely connect the street and road network with vehicles, an idea first proposed in the 1840s (and after that by Smeed in 1964 among many others. Balwani & Singh 2009) that has still to make any real impact (Gullberg & Isaksson 2009). Theoretical progress has been summarized by Tsekeris & Voß (2009), including the possibility for price variation according to user, vehicle and road, taking into account social and spatial equality, and interaction with other parts of the transport system and beyond.

In the 1990s, an IT development called telematics encouraged the idea of combining dynamic pricing with all modes of transport (Höjer 1997; Yaro 2003). But neither the transport sector nor the IT sector were ready for this kind of new thinking. Several features have seen further development, by among other Tsekeris & Voß (2009), albeit focused on road pricing. After the major breakthrough for platform companies and ubiquitous mobile computing in around 2010, several applications and concepts have seen the light of day, but nothing as comprehensive as that in the 1990s, even taking the latest IT developments into account (see however Gullberg 2012a, b, 2015a).

If we can learn from this development to reduce the complexity of the transport sector, and thus contribute to its transformation, the assertion by Brutton (2015:4, 44) that ‘a general logic of platforms [is] a fundamental principle for the design and coordination of complex systems’ provides good reason for further investigation.

4. Platform companies: methods and business models

Over the last decade, major social changes have taken place with the IT industry at the epicentre. Five platform companies have topped the list of the world’s highest valued businesses. Aided by new technology and digital-platform logic, everything has been remodelled, from warfare to news reporting to how our identities are created. This phenomenon has been described as the fourth industrial revolution, although some prefer the word evolution. Whatever the term, very obviously the playing field for many businesses has changed fundamentally.

Digital platforms interact with numerous other IT-related phenomena such as the internet of people and things (ubiquitous mobile computing), big data, artificial intelligence/deep learning and the cloud. A platform is a form of digital infrastructure where two or more groups can meet, an intermediary located between users. Its digital nature (platforms are no new phenomenon: older examples include streets and squares etc.) puts it an excellent position for gathering vast amounts of data, and also encourages users to commit to the platform and contribute to its development. A platform expands with the help of double or multiple network effects: the more groups and people who use it, the more valuable it becomes, which creates an inherent tendency to monopolize. Rapid growth also stems from the economy of scale: the greater the number of users, the lower the cost of accommodating each newcomer. The platform owner decides the rules of the game, which yield considerable power if the platform has grown large. Platform companies, via the vast amounts of data they collect, can coordinate, optimize, and flexibly develop and control their processes (Srnicek 2017).

A platform is an institutional logic, neither a state nor a market, 'a standards-based technical-economic system that simultaneously distributes interfaces through their remote coordination and centralizes their integrated control through that same coordination' (Bratton 2015:42). They provide users with great freedom, often with the ability to create, gamify and constantly remain on the platform, at the same time as the owner exerts control over them, not according to a predetermined masterplan but by having 'set the stage for actions' (Ibid.:47). With online ubiquitous mobile computing and continually updated customized information, users can instantly retrieve, and be reached by, offers whenever and wherever their need or desire is greatest, or when they are most susceptible (Ng 2014). New technology allows and/or demands new business models (Tongur & Engwall 2014). The great value of personal data means that new, online services can be offered apparently free of charge in exchange for user data, sometimes as a freemium service, a paid-for alternative with enhanced features. This too has contributed to the exponential growth of these companies.

Platforms have huge potential not only to streamline, reduce transaction costs, and make the best use of available resources, but also to greatly increase and control consumption as a whole. They achieve this, in among other ways, by being proactive, anticipating actions, demands and dreams that are about to arise, or could conceivably do so. Some of these are then selected for cultivation. It is this eminent ability to coordinate heterogeneous users and products that makes platforms an excellent tool for minimizing uncertainty and improving the manageability of complex systems.

The transport sector too has felt the effects of this new technology in terms of connected vehicles, automatic traffic control, platforms for guidance, real-time information, and the ability to book Uber or Mobility as a Service. These and other services allow individual transport users to make better-informed choices, at the same time as *the traffic situation as a whole remains unaffected*. Changes to the transport sector have so far been modest, because the sector's base services have yet to adopt the new opportunities for coordination, efficiency, product development and user-adaptation.

5. Platform service quality and content

The services provided in urban transport are generally of poor quality. Travellers cannot even reliably know when, or with what form of comfort, they will reach their destination (Gullberg 2012b). Reliability is poor, in striking contrast to other branches where 'it has become the common goal ... to satisfy … customers' (Dabestani et al. 2015).

Services can be evaluated using three parameters: 1. technical/instrumental or outcome – what. 2. functional/interactional or process – how. 3. image (Grönroos 1982). The technical aspects of transport services concern what movements are feasible and, of these, which are actualized (FitzPatrick et al. 2015). Functional aspects involve ‘the interactive nature of services and refers to the two-way flow that occurs between the customer and the service provider … including both automated and animated interactions’ before, during and after transport, and in many cases permanently (Kang & James 2004:267). Image applies to the service provider's reputation, but may also relate to the choice of car brand, or the status of transport alternatives, which might persuade motorists to stop commuting by car (Redman et al. 2013). Common values in terms of level of service (LOS) focus primarily on technical quality, but as Litman (2015:13) has shown, information has a great bearing on accessibility.

Technical quality (Kang & James 2004; Schiefelbusch et al. 2009; Macário 2011):
Scope/range – feasible movements of people and goods; availability – distance to public transport stops, car parking, and other obstacles; time taken, punctuality, price, comfort, safety, positive/negative social contacts; journey completed without problems; environmental impact.
Interactive quality (Kang & James 2004; Schiefelbusch et al. 2009; Meier 2009; Egol et al. 2014):

- Information/interaction – easy to understand, customized, reliable, continually updated and manageable; transport alternatives/product information; contract/guarantee; booking; payment; user guides; disruption notification and support for making alternative travel plans.
- User options to choose interaction channels and interaction intensity: from no contact; to personal initiative, open to receiving reminders and suggestions; to being constantly logged onto the platform, giving feedback, co-producing, creating and sharing experiences and material – acting as a traffic watchdog in other words.
- Access to extra material: sightseeing, augmented reality, third-party offers, vendor ecosystems.
- Follow-up (Kang & James 2004): reliability: provided as promised; responsiveness: keeping customers informed and readiness to respond to requests; assurance: making customers feel safe, providing knowledgeable answers; empathy: individual attention to customers, understanding their needs; tangibles: appealing facilities and materials.

Transport services have drawn-out processes with several critical points where opportunities for interaction with the supplier are particularly important. There is, from the point of view of options, a continually ongoing delivery – a steady flow of opportunities (Cornes & Sanders 1996:55). In the fourth industrial revolution, there is an increasing tendency for technical and interactive aspects to blend together, to such a degree that it is true that mobility is becoming ubiquitous (Tuominen & Ahlqvist 2010; Conti et al. 2012).

5.1 Contents of the proposed platform service

Interactive quality
The digital platform would provide:

Choice of service level and terms of use of personal data (search results, choices and itinerary, subject to informed consent):
No interaction, travel/transport the same as today (uncertainty about dynamic pricing is managed using a maximum price); interaction only by user initiative; some/all types of deals are desirable; premium users: co-producers, third parties.

Information immediate, updated, reliable and proactive about all available (for transport users – customized) travel and transport options (including ride sharing paid for via the road owner), services replacing or reducing physical movement, combination/intermodality (door-to-door), parking, dynamic pricing, travel times, comfort.
Agreement/payment option to book/order/subscribe and ease of payment for the option selected, whereby an individual, specified, easily monitored agreement is created.
Guarantees, automatic compensation guaranteed arrival at the agreed time, automatic follow-up and compensation for delays and other errors.
Directions for use guidance/navigation throughout the journey for all modes of transport, including walking, cycling, public transport and goods transport.
Notification of potential or actual disruption/deviation Notification of changes to expected travel times or to travel or transport costs that are subscribed to/normally chosen, along with proposed alternatives; decision-making support/suggestions of alternative modes of transport and routes, deployment of replacement transport if a journey in progress is disrupted.
Invitation to co-production and involvement by third-party companies car sharing, exchange of ideas, watchdogs, injury reporting, sharing of experiences. Motorists/freight companies are invited to be co-producers (prosumers), with compensation by the road authority. Platform open to transport sharing, links to social media and groups of like-minded people (communities). Additional services such as reserved seats on public transport, priority motorway lanes, extra insurance in case of delays, and environmental competition between commuters from different suburbs and between companies. The possibilities are endless.

Technical quality
With appropriate balances, the platform has the potential to provide dramatically improved accessibility; an increased range of mobility services; shorter travel times; greatly reduced congestion; more choice/less compulsion to use cars; more use of carpools, rental cars, taxis, walking and cycling; transport and car sharing, even in taxis and community transport; more public transport with the choice of uncongested times/carriages; and increased intermodality and accessibility without physical movement. Spare capacity would be used instead of investing in infrastructure, vehicles and rolling stock, at the same time as operating and maintenance costs would be reduced.

6. The platform’s backstage

In many respects the urban-transport sector, so burdened by problems, has features that make it particularly suitable to be remodelled using the streamlining methods that successful platform companies employ. The sector's base services have yet to be optimized either collectively (at a system level) or individually. This means that a considerable unused capacity is available, that major differences between modes of transport can be exploited, and that small changes will produce large effects on congestion. Moreover, the impact will probably be great, given that all residents and businesses in an urban region are affected. The necessary features already exist but need to be developed and combined: information, pricing, dimensioning and operation. These relate to 1. Public transport. 2. The street and road network. 3. Parking spaces. Addition features are 4. A multimodal travel planner based on traffic information and short-term forecasts. 5. A traffic and transport control centre covering all modes of transport.
Through a combination of this kind, in proactive real-time (looming traffic problems can be predicted) on the digital platform, the range of base services can be dynamically, uniformly

and coherently developed using algorithms optimized for goals such as efficiency, climate and environmental considerations, and equality. This takes the form of individualized responses in the platform's travel-planning function and notified changes to subscribed transport. The now-altered decision-making situations of transport users, if enough people respond, lead to reduced or eliminated congestion. Gradually their choices and the whole transport system will shift in line with the platform's algorithms.

Large amounts of traffic data are used as raw material: historical data; real-time data from cameras, sensors and smartphones in motion; data scraping; weather forecasts etc. Personal data from the platform may also be used: search results, and agreements and routes, if informed consent is given.

Data analysis produces output, not only to users but also to suppliers of base services and hire-vehicles, and to the next stage of analysis. Continual reiteration of this kind gradually improves the accuracy and services of the platform, the more it is used.

The complexity of the transport system decreases when previously absent links between the modes of transport, and between the street network and vehicles, are established via the platform. Various components no longer counteract one another. Many repressed areas or blind spots of transport policy will become apparent: the importance of the sector for equality (Macário 2014:112); vast unused capacity of the street and road network and its almost infinite value; strong structural effects of the motoring system; the presence of latent demand; public-sector innovation; close ties between the transport sector on the one hand and property values/localization on the other (Macário 2014:109); and the importance of accessibility rather than mobility (Sclar et al. 2016).

Because the platform service will be highly valued, anyone demanding and/or offering spatially defined services will have the opportunity to attract numerous types of producers and consumers/users. It will therefore develop into a vigorous ecosystem for innovation by involving third-party developers. Clear agreements between producers and transport users will pave the way for product differentiation and user-driven innovation.

The proposed platform, and business models, would simultaneously use all the five methods in section 3.3 to deal with the social dilemmas that easily arise in overload-sensitive systems. Hierarchy: deciding the rules of the game. Market: individual transport-user choices. Cooperation: enabling parties to establish contact and work together. Expansion: increasing road-network capacity when congestion looms. Inaction: leaving the physical infrastructure unaltered (or reduced).

The platform will offer a collection of services whose value increases by being brought together. Srnicke (2017:49) calls this ‘an on-demand platform of product type’ citing the example of the Spotify music service.

7. Platform reform: obstacles and opportunities

Many interests and types of circumstance have chained urban transport to its current car-friendly path of development, although other perspectives are now beginning to emerge. Despite this, comprehensive change faces strong resistance.

In transport-sector organization, the production of base services is strictly divided, in various public hands and monopolistic forms. This provides protection against competition and impulses for change. A strong emphasis on production focuses on creating and managing infrastructures at the expense of users and service. A lack of understanding of how the transport system works as a whole does not improve the situation. Many reform ideas are limited to only one mode of transport. The ‘predict and provide’ principle is still applied with

no understanding of its nature as a self-fulfilling prophecy. There is a prevailing inability to imagine the sector working any differently than it already does (Enoch 2015).
Public-sector organizations and the powerful motor-industrial complex (one of the most successful lobby groups of the 20th century, comprising the automotive, construction and oil industries) guard their interests. Strong support is drawn from a significant motoring movement, anchored in people's identity and lifestyle. We can also add the major financial commitments of car-owning households. The urban structure, with a thin suburban population, makes the car a compulsory part of everyday life.
At the same time, this grip is being challenged, not least in cities, by the problems described in section 1. Yet hopes have been raised that new fuels and so-called eco-friendly cars and/or self-driving vehicles can solve these problems, or at least contain them using geoengineering or terraforming.
Increasing knowledge about the nature of the transport sector, and awareness of a growing crisis, suggest a platform solution might find support. Commitments within COP21, with its firm focus on the transport sector, may have a bearing in this context.
Successful internet companies can serve as models and inspiration. Here we can learn that major, rapid adaption is possible with the help of interactive, personalized and attractive offers to users via platforms. Spreading insight about these opportunities increases the chance of reform, especially if motorists see the point in paying to avoid congestion.
Reformed urban transport would also bring benefits for other areas of policy: the local environment, noise and air pollution, aesthetics, street life, health, social contacts, equality, safety and property development. Limited public resources are a strong motivator for change, and here the proposed model has huge potential, which may prove useful when fuel tax revenues start running out.
Although the transport sector is not exposed to competition, cities do compete through city branding where transport and the environment are major components. Industrious and visionary mayors can push forward new traffic solutions: Ken Livingstone, Enrique Peñalosa and Anne Hidalgo. The fact that cities can thus be niches (according to transition theory) for new solutions increases the chances of a breakthrough for platforms. If some cities lead the way others will follow, as with congestion charging (Gullberg and Isaksson 2009). Many factors point to the platform being publicly owned. The basis of the available services derives mainly from this sector. Privatizing motorways has proved problematic, being described as at 'a very early stage ... with a large number of project failures' (Beria et al. 2015: 31). Privatization, as a rule, is a slow route to efficiency (Molander 2017), which provides another argument for public ownership, especially as urban transport has many different goals to achieve. Privatizing the entire street network may be possible, but not without its problems.
Despite the obvious benefits that a digital transport platform with new business models would bring about, it is far from certain that they will be realized. Other, more conventional, solutions may be chosen such as driverless vehicles. Radical reforms emanating from the public sector demand strong political leadership and thorough crisis awareness. A platform solution might suffer the same fate that Borins (1988) predicted for electronic road pricing: '[a]n idea whose time may never come'.

8. Conclusion

To face the major challenges in urban transport and to live up to our high ambitions, at the same time maintaining or increasing availability, radical changes are needed in transport systems and locational dynamics alike. Two possible lines of development can be identified – one is car- and mobility-oriented with autonomous vehicles; the other focuses on systems

and accessibility – which is the digital-transport platform presented here. Investments in the former are massive; the latter has yet to find a place on any agenda.
A transport platform would allow better control of how infrastructure is used, which will be important when vehicles of varying autonomy begin using the motor-dominated street and road network. We would thus avoid being at a loss when faced with the distribution of private and collectively owned vehicles, parked and circulating cars, and permanent and mobile housing, all of which will be significant for the climate, local environment and equality in the future.
Here the allocation between private motorists and public transport is also important. The latter, especially using dedicated lanes or lines, has a huge advantage in terms of capacity, performance and equality, and must therefore form the basis of any future adapted urban-transport system. Public transport also contributes to another, more spatially concentrated, form of localization. The opportunities to gradually strengthen public transport, while improving conditions for private motorists in important areas such as reduced congestion, make the platform a feasible unifying instrument for future reform.
Major platform companies have been hugely successful in swiftly changing people's habits and behavior. Evidence suggests the same would be true of the transport sector, which opens the door for realizing very ambitious goals. Yet the problems may be reversed, the methods so effective that far too much power would fall into the hands of the individuals or companies who might seize control of the transport platform.
The fourth industrial (r)evolution can, strangely enough, enable us to create a wider market, by way of greater government control or hierarchy, empowering citizens to make informed transport choices with known outcomes.
The second industrial revolution replaced proximity with increased mobility as a means to create accessibility. With the fourth industrial revolution it is possible to replace this unbridled quest for mobility with coordinated localization and transport of people and goods. Such a restrained orchestration of proximity and mobility may prove to be the future method to create accessibility. But whether this opportunity is discovered and embraced, before the mighty vehicle-focused strategy shuts the door to the alternatives, remains highly uncertain.

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