ICT'S CHANGE TRANSPORT AND MOBILITY. MIND THE POLICY GAP!

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1. INTRODUCTION

Developments in information and communication technologies (ICT's) are changing our demand for mobility, and the opportunities and tools available to meet this demand. ICT's have influenced our transport modes, our infrastructure, available transport services, our destinations and through that, our behaviour. In this paper we discuss the main features of these changes. In many ways, our transport system and our travel experiences improve through these innovations. However, some of the developments can potentially compromise public values relevant in the transport debate and lead to new policy challenges.

This paper is structured as follows. First we sketch an overview of what changes are happening in transport through ICT's or are expected to happen in the near future. Seven major changes are discussed. Then we discuss how these developments relate to relevant public values like accessibility, availability, (financial) efficiency and acceptability. They reflect a wide range of issues, not rarely in conflict with each other, as transport comes with benefits and burdens and often an unequal distribution of both. Moreover, there are tensions between the short and long term, public and private interests and between efficiency and equity. Finally, we identify some new challenges for transport policy.

This paper is based on a recent study on how ICT's impact the infrastructure for transport and electricity in the Netherlands (PBL 2016).The focus is on passenger transport.

2. MAJOR CHANGES IN TRANSPORT

ICT's influence transport and traffic in several different ways, impacting both the physical structures, the organisation of transport services and the demand and preferences for travel. Based on a review of literature (e.g. Aguiléra et al. 2012; KiM 2013; KiM 2014; Litman 2014; Mokhtarian 2009; Van de Weijer 2015, Townsend 2013, Townsend 2014), insights from the 2015 Disrupting Mobility Conference (MIT, Cambridge MA, November 2015) and a number of interviews with experts in the field we identified seven major changes with a variety of effects on activity patterns, travel behaviour and traffic flows.

2.1. More and more informed

ICT's make us more and more informed, since they provide us with a deluge of information on travel options and (unexpected) changes in traffic conditions and transport services. Moreover, the available information on potential destinations (also further afield) has exploded. Individuals and businesses are therefore in a position to make different choices, sometimes leading to new trips, different mode choice or new destinations. We now know about that amazing new club, the convention of fans of our favourite tv show and that wonderful glamping destination in rural France. We can also adapt our time of day for a trip, our mode choice and route, based on (multimodal) travel information apps. More information leads to more optimal choices, lower travel resistance and, likely, to more kilometres travelled.

The availability of more and better quality information also improves traffic management and efficient use of road space and travel time. This information is used in technologies such as satnav systems, information services (lane advice, real time traffic information, parking guidance, multimodal travel planners etcetera), dynamic controlled access to motorways, smart traffic lights, communication between vehicles and infrastructure (for example busses communicating with traffic lights) or between vehicles (to prevent shock wave congestion) or driving assist / task automation in vehicles. These ICT's help make the most of currently available road space and potentially reduce or delay the need for new investments. They can also help reduce congestion, increase safety and make trips more comfortable (less stress, avoiding detours and search traffic).

2.2. The range of transport options increases

ICT's enables the arrival of new transport options. This includes services such as car sharing, bike sharing, taxi(like) services and new (self-driving) transport modes. The new buzz in mobility is that 'access will trump ownership'. After all, if a made-to-measure transport solution is available at your call, why own a vehicle with all the hassle that comes with it (parking, maintenance, taxes, insurance etcetera). The ease of car sharing has been improved enormously by web applications showing you where cars are available and at what price. It takes only a few clicks to order a Uber taxi (if you live in the right area) and through Blabla-car you can even find a ride with someone who fits your personality.

The advent of ever improving made-to-measure transport services can potentially lead to a world with substantially less privately owned vehicles. The

traditional divide between private and public transport (services) may become obsolete. This will strongly depend on the quality mobility services will manage to provide: will they resemble the ease and access that private vehicles offer or remain stuck at a level that is merely a quality upgrade from what we know now as public transport. The arrival of autonomous vehicles (see section 2.7) could enhance this process because they take away some of the current impediments for car sharing (the car comes to you in stead of you picking it up somewhere).

2.3. The need to travel decreases

ICT's also help reduce the need to travel. We can work from home, shop on the web and communicate and interact with others through all sorts of virtual channels, making it less necessary to meet face-to-face. The time saved can be used differently: spend more time with the kids, work longer hours, take a bath. Or we trade in a night at the pub for a night of online gaming. However, the available time, money and effort can – in combination with the increased availability of information (see section 2.1) – just as easily be filled with extra travel since there appears to be a constant amount of time traveled (known as Marchetti's law or – in the Netherlands – as the Brever law, also see Metz 2008). Our travel behavior tends to adapt to the available options: we travel less kilometres when it takes more time or effort, we travel further if travel is made easier. The measure in which we adapt also differs by motive: it is much easier to make different choices in our leisure travel than for commuting.

2.4. Travel time isn't what it used to be

Through ICT's, the perception of travel time may change. More and more we are able to use our time productively or pleasantly while traveling. We can work, watch movies, browse the internet, communicate etcetera, while on our way. These developments (partly) explain why the value of time as increased less then expected in recent years. The autonomous car may accelerate this process. It may even impact the total amount of time we travel. As a result, the amount of time and distance travelled could increase.

2.5. The geography of destinations changes

ICT's change our geography. For example: e-commerce leads to shops closing, resulting in a reduced physical availability of these facilities. On average, people will need to travel further for a real life store. Moreover, ICT's change the importance of traditional location characteristics. When the internet becomes your shop window, being located along a busy route for visibility purposes is less relevant. This results in (specialty) shops and trendy

clubs locating at unexpected locations and in the decline of 'target audience' facilities (for example: online apps have swept away gay bars). And ICT's make it much easier to stay in contact with distant friends and relatives. These virtual contacts, sooner or later, usually leed to real life encounters, travelling over longer distances.

2.6. Increased complexity of the mobility system

Along with all the changes described above, the mobility system is becoming increasingly complex and detached. 'In the old days' you could walk, ride your bike, take the car or travel by public transport. On a very special occasion you might even call a taxi. At the train station you bought a ticket from a real person at the ticket office. Now, they have been replaced by machines and chipcards. You are expected to get your travel information from the internet and your ticket is now called a 'travel product'. There are shared bikes, shared cars and new transport services like Uber to choose from. And for all of them you need a membership, a card and/or a password. Train services are run by different companies, sometimes requiring you to check in and out with your chipcard, several times along the way. Our cars increasingly act autonomously, sometimes unexpected. Our satnav tells us where to go and we follow, without any clue where we are. And when it fails, we are completely lost in more than one meaning of the word. So while ICT's bring lots of improvements to our transport system, making it more efficient, complete and usefull for most, let us not forget that there is a large group of people that have difficulties coping with all these changes.

2.7. The advent of the autonomous vehicle

Our discussion above has already mentioned an important new development several times: the autonomous vehicle. It is, without doubt, currently the most discussed technological innovation in transport (KiM 2015, Milakis et al 2015, Smetsers 2016, Townsend 2014, Burns 2013, recent statements from the Dutch minister of transport, and many articles in newspapers and professional media). The arrival of the autonomous car may have a major impact on transport and traffic. It is likely to change our travel experience, since car drivers will no longer have to pay attention to traffic and vehicle control. Time spent in the car can be used as pleased: working, chatting with friends, watching a movie or reading a book (see also section 2.4). A fully autonomous car can, theoretically, take any passenger, irrespective of age or capabilities, safely to any destination. This can greatly increase the independent mobility of young people and the mobility impaired. All of this could very well lead to more car travel, not in the least because there will be empty cars driving

around. After all, parking will no longer be needed close to destinations when cars can independently find a spot elsewhere (or go on and pick up a new passenger). Safety could improve immensely, maybe even up to a point where maximum speeds can be increased. And autonomous vehicles are said to contribute to more efficient use of road space.

This future with autonomous vehicles looks bright: safer, more comfortable, more efficient, providing better accessibility for all, opening up space in urban areas. Who would not want all of that? However, there are still some issues to resolve. Experts strongly disagree about the level of autonomy that is feasible, and when full or partial automation will be mainstream in the car fleet. They do seem to agree that it will be a incremental development: step by step tasks now performed by the driver will be taken over by the car. Many new car models are fitted with lights and wipers that switch on automatically or with lane departure warning. Some cars are able to park themselves, provided that there is a clearly marked parking space available. These features will slowly become standard on most models. The most recent development are the Tesla's; they were uploaded with an autopilot function overnight and can perform more difficult tasks autonomously. However, these systems have growing pains. At the press presentation of a self-parking Volvo, it very awkwardly (and fortunately slowly) ran into a group of watching journalists. More recently, the first casualty of the Tesla auto pilot appeared in the statistics. A Tesla-enthusiast trusted his car too much, took his hands of the wheel and (allegedly) watched a movie. However, the car could not discern the white truck from the white sky and crashed into it. These incidents are, although very serious, probably just start-up issues that will be solved shortly. However, we need to be aware of the fact that many of the blessings attributed to autonomous vehicles, can only be delivered when these vehicles are fully automated, are past their teething troubles and make up a relatively large share of the car fleet. Only then they will substantially impact our travel patterns, our traffic flows and our cities.

Acceptance and adoption of these new vehicles, crucial for reaching a substantial share of them in the car fleet, is not a matter of course. Accidents, as the one with the Tesla, will impact this process, as will the public opinion on the (moral) choices programmed into the software and the way liability issues are handled. Even then, in a world with fully automated vehicles, the path to the future can take quite diverse directions. Autonomous vehicles can give an enormous boost to car sharing (see section 2.2). It is also imaginable that car manufacturers will take on a completely different role in the sector: not just as a supplier of vehicles, but also of mobility services and maybe even as

owner/manager of infrastructure, changing the organisational landscape of our mobility system. And finally, autonomous vehicles can change our cities in many ways, ranging from substantial suburbanisation to extreme concentration (Townsend 2014).

3. IMPACT ON PUBLIC VALUES

The major changes in the transport field, as discussed in section 2, show us that ICT's can improve our transport system. They can help ease our busy lives and provide us with many benefits: more efficient and reliable traffic flows, less congestion, improved road safety, lower need for investment in infrastructure, better transport services, more flexible travel options, better accessibility, to name a few. They can lead to less travel, yet also to more travel. And maybe even more important than the plus or minus question, is the fact that they alter our travel and our lives.

These technological innovations, and the social innovations that accompany them, also create new challenges for policy and politics. Securing public values is a classic task of government, translating these values in rules and regulations, taxes, permits, supervision etcetera (WRR 2012, 2013). In our research we found that it was repeated questioned whether or not the current legal and policy frameworks still fit the technological and social dynamics brought about by ICT's. Can our physical infrastructure, our system of rules and regulations and our organisation for governing society adapt in a timely manner? To quote one of our interviewees: 'How to connect our 19th century infrastructure to the 21th century dynamics of the network society using 20th century governance'.

To explore these issues we started at the basis: what is the impact of ICT's in transport on the public values we traditionally hold dear in transport policy? We analysed the impact of the changes happening or being expected on the values accessibility, availability, efficiency and acceptability. From experience we know that the government is typically held accountable for securing these values. Please note that our list of potential impacts and public values is not intended to be exhaustive.

3.1. Accessibility

Accessibility - the measure to which people have access to transport options and destinations as a means to participate in society - is an important public value in transport policy. Traditionally, many rules and regulations in the

transport sector have the purpose of securing access for all. ICT's can impact accessibility in many different ways. We discuss the main issues.

In general, ICT's improve accessibility: new transport options and more information on existing options become available. However, for the time being, these improvements are often reserved for a limited part of the population. One needs a certain level of income, sort of job, a more luxurious type of car and, above all, the digital and mental capabilities to make use of all of this information. Moreover, it is certainly not self-evident that this divide will disappear on its own as time passes. There are actually good reasons to assume that the gap between those who have access to and capabilities to use these opportunities, and those who don't, will even increase (see for example the work of professor van Dijk from Twente University on the 'digital divide'). And if, in the meantime, our cities and our socio-economic system adapt to these technologies, social inequity will increase. For example, when road side information is removed and replaced by in-car systems, people without access to these more expensive systems will be deprived of relevant information.

In a world where mobility services play an increasingly bigger part in the whole transport system, a larger supply and greater diversity of these services will increase access and opportunities for many people. This could improve the situation for example for the mobility impaired or for those people who cannot afford a private car, but would be able to afford a certain level of services. However, accessibility-for-all may be at stake when public transport services are more and more replaced by on demand services, often supplied by (new) commercial parties. It is not unthinkable that certain groups in the population or certain parts of the city will be deprived of these services. The price may be too high or providers could consciously decide not to service certain areas for economic reasons. However, lack of accessibility may also be an (unintentional) side-effect of self-learning algorithms. In order for your transport demand to be visible in the system, you first of all need to exist in the data, which is not self-evident for many (groups of) people.

With the onset of autonomous cars, an important accessibility issue can arise when (in time) parts of the road network will be exclusive to autonomous vehicles. For safety reasons, this might be a necessary step to take. However, for those who cannot afford these – most likely relatively expensive – vehicles, accessibility can be strongly reduced.

3.2. Availability

Since transport is considered crucial for economic performance and social interaction, the availability of a reliable transport system is very important. At present, ICT's already assist in keeping traffic flowing. On the longer term, the impact of ICT's on availability is less straightforward. The traditional system, based on privately owned vehicles in combination with a public transport system (usually based on longer term concessions), is relatively stable from an availability point of view. A more fluid system based on transport services is more vulnerable. The services offered today, may be gone tomorrow, especially since these services are increasingly offered by actors that do not actually own any infrastructure or even vehicles (e.g. Uber, Blabla car and other 'sharing' based services). In a world where transport service supply is organised differently, we may need different ways of securing availability, not only from today to tomorrow, but also spatially distributed, serving both rich and poor and the urban and the rural.

Availability of the 'right' sort of infrastructure might also become an issue, with an increasing diversity of transport modes and services making up our transport system. For example: autonomous vehicles may, depending on choices made by the automotive industry, require 'smart' infrastructure. If this is the case, the issue arises who is responsible for providing, managing and maintaining this ICT-technology in infrastructure (see also section 3.3).

Finally, ICT's are prone to be 'buggy, brittle and bugged' (Townsend 2013), making systems that heavily depend on them, vulnerable to failure and fall out. Since the transport system is considered crucial for our economy and for our social interactions, it is risky to take this characteristic lightly. As the responsibilities for the transport system as a whole are so huge, it is important to secure them. Simply referring that responsibility to the market, may not suffice from a public value point of view.

3.3. (Financial) efficiency

Central and local governments are expected to spend their money wisely: the costs need to be proportionate to the gains society derives from a project. ICT's have the potential to reduce costs. For example: more efficient traffic management may reduce the need for new infrastructure investments. On the other hand, increased flexibility in use of networks, in sort of services demanding network capacity and faster changes in our travel patterns make it more and more difficult to determine which long term investments are sensible and which are not. Even in a highly digital society, we still need physical

infrastructures to move people and goods around. These infrastructures require large investments with a long payback period. They are by definition large scale (it is no use building 1 kilometre of motorway), drawing board planned, decided on after long deliberation, supply based, 'one-size-fits-all' and are usually provided by a few dominant (public) actors. Its long lifespan creates strong path dependencies.

There is another form of tension between low and high dynamics, further complicating spending decisions in transport planning. Technological innovation can go very fast, while infrastructure changes slowly. When government invests in new technology, there is always the risk of spending money on things that are soon out-dated or betting on the wrong horse. For example: many municipal governments invest in charging points for electric vehicles. These may prove to be disinvestments when market parties prove to be better at this (placing more or faster options) or when swift technological developments make them out of date prematurely. Governments also invest in innovation in the transport system. For example: the Dutch government aims to support innovations in self-driving cars. However, as different manufacturers still see very different development paths as the way forward, the choice which developments to support with public money, can implicitly lead to path dependencies and impact return on investment. Another issue with regard to efficiency of government spending is whether 'smartness' should be incorporated in the (collective) infrastructure, or in the (vehicles of) users of the infrastructure. Will we have smart cars on stupid roads? Or do we need smart roads too? And who is the one making this decision and paying for its consequences: governments or the automotive industry?

3.4. Acceptability

The fourth public value is related to the acceptability of what is happening. Acceptability is a broad category, including issues with regard to justice and solidarity, mental capabilities of people, the impact on safety and other external effects, the impact on the market playing field and respect for privacy. We discuss some examples of issues that arise as a result of ICT-developments.

When an the increasing number of transport services access the market and the infrastructure, some sort of management may be required: who gets access when and how do we divide responsibilities? Since transport infrastructure is an important part of our public space in towns in cities, managing the use of that infrastructure is almost per definition a public issue. Especially with regard to autonomous vehicles, the distribution of public space

can become an important problem (see sections 2.7 and 3.1). Time will tell whether or not autonomous cars can use road space simultaneously with other users (pedestrians, cyclists, conventional cars etcetera), without compromising safety, traffic flow and use of public space as a place to spend time in. Maybe, autonomous cars will need 'robot proof' infrastructure, requiring exclusive road space. That can have substantial impacts on the appearance of our towns and cities.

Acceptability is also a major subject when it comes to liability issues with regard to autonomous cars and the choices programmers built into their systems with regard to emergency situations. A recent study (Bonnefon et al 2016) showed a classic social dilemma: the respondents expressed the opinion that autonomous cars should make ethical decisions, aiming at minimising the number of victims. However, they also indicated that, when buying an autonomous car, they would choose the car that, above all, protects its passengers over a car that responds 'ethically'.

The changes in the transport world, as a result of ICT's, lead to all kinds of new players in the field. It becomes more difficult to define 'the transport sector'. In this process, several risks arise. As with many ICT-driven developments, one or a few large players may become dominant (*winner takes all*), eliminating real competition. We have seen this with Google, AirBnB and Facebook, to name a few. In transport, this could happen with Uber. However, economic markets only exist by the grace of market rules, set by governments. There are many ways the public sector can influence this, for example by making (government) data available, by assisting in developing standards, by offering room for experiments and in choosing how to deal with (emerging) monopolies.

ICT's also come with questions regarding data and privacy. The ubiquitous availability of data and processing power brings many benefits such as providing more information on traffic situations to enhance safety and better plan for maintenance. However, the fact that ICT's - in theory - provide us with much more data and monitoring options than ever before, does not mean this data is always used effectively and appropriately. For example: do we want to allow car manufacturers or travel service providers to collect, use or even sell personal data of their users, for purposes way beyond the improvement of their transport service? A potential conflict might also arise when market parties refuse to share their data on transport services delivered or transport needs detected, although they may hold crucial policy information to base infrastructure investment decisions upon. An interesting example of this is the

Dutch OV-chipkaart. All public transport travel using this smart card is registered. However, since both the public transport services as well as the administration of the smart card are privatised, the government has no access to these data, even though these private companies are heavily subsidised.

A different sort of acceptability issue

Many of the benefits that ICT's could bring to transport, depend on the ability and willingness of people to change their travel behaviour. Transport choices are strongly based on habits. Frequently, they are far from rational, at least not when rational is defined as 'sensibly weighing up factors like time and money'. Many more arguments play a role in our transport choices: comfort, familiarity, laziness (being able to leave your stuff in the car), exclusive availability, to name a few. Time will tell if we will trade in our largely habitual travel for transport services that may be more efficient, sustainable or cheaper, yet that require us to give up on some comfort aspects. Maybe the most important factor inhibiting acceptability will be the need to make conscience decisions again and again. After all, from a psychological point of view, there are very good reasons why travel is largely habitual. It eases the strain on our brains, a very relevant factor in our high-demand society. On the other hand, maybe we will delighted, wondering what ever possessed us in the first place to take on the responsibility of a private vehicle and driving it ourselves.

4. CONCLUSIONS: MIND THE POLICY GAP!

In this paper we have sketched an overview of some of the major impacts ICT's can have on traffic and transport and how this may affect public values that are relevant in for transport policy. On the basis of this discussion and the examples provided, we conclude that some of these values may be compromised, without appropriate action being taken towards adapting policies, rules and regulations to the new reality. We see four major challenges.

4.1. The dance of the elephant and the mice

The behavioural patterns in space and time become more and more whimsical and less predictable while infrastructure such as road or rail is inherently robust, inert and takes a long time to plan and build. We need to find ways to connect the physical infrastructure, where clock time rules, with the globalised and sometimes seemingly timeless digital world. Somehow, the

mice (our fast changing behavioural patterns) and the elephant (our slow changing physical infrastructure) will have to (learn to) dance together. Governments will need to make robust choices and prevent disinvestments while still keeping our infrastructure up to date. On the other hand, users of the infrastructure (the public and the transport service providers) need to recognise that path dependency is an inevitable consequence of physical infrastructure with a long lifespan. Patterns of use will always change faster than the networks upon which they take shape. Adapting the networks to every change in usage is most likely a very inefficient way of dealing with the situation. So we both need an elephant with a basic sense of rhythm and mice that are willing to improvise on that. It is a game of give and take, not aiming for optimal networks but for satisfactory networks. After all, there also is an important advantage of a highly flexible, digitally driven world. Not only make ICT's our activity and travel patterns more complex and unpredictable, they also increase our opportunities to deal with less than perfectly matched infrastructure available. They are therefore problem and solution in one.

4.2. Access for all

Social equity is a major concern when accessibility becomes more and more dependent on privately run platforms and transport service providers using unknown algorithms. Access can be limited in multiple ways. Physical access can be an issue (for example, service providers may shun certain neighbourhoods). Transport may become too expensive for larger groups of people, especially when public transport service levels decrease as a result of increased competition by private services. And finally, accessibility is becoming more and more a matter of skills and psychological flexibility to keep up with new things (for example smart ticketing in public transport or using apps for travel information). Not everyone can cope with that. The challenge for policy makers and politicians is to develop a view on what minimum levels of accessibility we, as a society, want to provide for all and then to assess what type of rules and regulations are necessary to secure those levels and provide people with the necessary skills to take full advantage from them.

4.3. Private wealth, public poverty

In the ICT-sector we find a strong 'winner-takes-it-all' tendency. Tech companies can become rich, powerful and unassailable, sometimes riding on the back of collectively financed infrastructure. Uber does not pay for the roads their cars drive on and TomTom makes good money from the existence of the publicly financed GPS-system. The costs for development,

maintenance, education, safety, long term availability etcetera, or the protection of 'soft values' such as liveability, sustainability and equity, are left to the public domain, as are the consequences of monopolisation, unfair competition and loss of innovation power. While it is a good thing for policy to facilitate economic opportunities and growth, the challenge for transport policy is to balance this with a wide array of other interests in a fast changing world. This may also include charging a fair price for use of publicly financed infrastructure, setting boundaries for use of personal data obtained through service provision and holding companies accountable for the actions of their algorithms (see section 4.4.).

4.4. Policy making for robots and algorithms

The final challenge we derive from our explorative study into the impact of ICT's on transport is that we urgently are in need of rules and regulations for robots, algorithms and computer systems, maybe even as separate legal entities. The rules and regulations that are in place now, are relatively clear on what we expect of individual traffic participants and our basic requirements for vehicles. However, it is far from clear whether or not these rules and regulations are fit for and applicable to software, especially when this software is self-learning, making it almost impossible to keep track of the rules the system adheres to. Vehicles, transport service platforms and management systems are increasingly autonomous, making decisions which lead to actions in the real word, making them some sort of independent actors. This demands new ways of designing regulations and of supervision/enforcement.

The speedy developments in autonomous driving make this an urgent issue. Not only do we need requirements for software quality and ways to hold service providers and manufacturers accountable for the actions of their systems, we also need policies and guidelines with regard to the difficult choices these robots inevitable will have to make (see section 3.4) and clear rules on who (or what?) is held accountable in case of failure or accidents. And finally, we also need to decide if we want real people, on real roads in real cities to test and propel our innovations (as Tesla is doing with by updating their software and letting it learn from experiences), or if we prefer to demand other ways of testing.

4.5. Final remarks: from reactive to proactive

ICT's change our lives and the way we travel: more options, more comfortable travel, more efficient use of infrastructure. These changes alter the transport planners' task. We find that the current debate is mainly on how policy can

respond to technological development. However, for transport planners and decision makers to move beyond reactive policy making, we need a good understanding of the real changes technology is causing in our transport system and our society, and a public and political debate that is not fixated technological solutionism. We think that approaching the issue from the public values traditionally relevant for transport policy, can broaden our view and make a shift to a more proactive approach. It helps us to think about what we want technology to do for us - and what not - and start creating the framework that ensures we do justice to all of the values we hold dear. Lets bridge the policy gap.

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