



Trends in Mobility **2018**

From continued development to moving differently



Dear reader,

It is with great pleasure that we present to you the Capgemini report Trends in Mobility 2018. This report provides you with interesting insights into new technologies and services, which will be of great influence on congestion in the Netherlands. Key comments associated with mobility policy in the coming years are: cohesion, autonomy, shared economy, horizontal and vertical movement and self-learning systems.

On March 18th, 2018 we presented the first edition of this report to Cora van Nieuwenhuizen, minister of Infrastructure and Water Management of the Netherlands.

With kind regards,
Capgemini Netherlands B.V.



March 2018

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Mark my words: A combination of airplane and motorcar is coming. You may smile, but it will come."

Henry Ford, 1940.

Preface

With the 2018 Trends in Mobility "From continued development to moving differently", Capgemini once again starts with the publication of trend reports concerning the topic of mobility in the Netherlands. An important reason for this is that we note an acceleration of the implications of new technologies and services for mobility; we also note an acceleration of other uses of existing technologies and services, in new combinations.

In our first trend report in 2007, we concluded that our infrastructure (roadways, railways and waterways) could be better used. Everyone wants to travel at the same time – during rush hour – which results in huge peak loads. Surely there's an easier and more intelligent way to do things? As an initial exercise for a joint framework, Capgemini launched the concept of Gross National Transport Capacity (Dutch acronym: BNV), expressed as a function of travelers' mileage. After extensive calculation, it turned out that only 1.2% of the total transport capacity was used and that the greatest bottlenecks arose from well-worn habits.

The second Trends in Mobility "Beyond the Conurbation" followed in the second year. The conclusions in this edition were that the fragmented mobility policy that the Netherlands had relied on since the 1960s had resulted in accessibility problems and that there was no coherent, planned approach to traffic issues.

In 2009, Trends in Mobility published "Focused on survival: a view from the eye of the hurricane". The economic crisis had hit the Netherlands hard and congestion on our roadways decreased temporarily. That edition focused on the cohesion between the physical and non-physical (i.e. digital) infrastructures. Avoiding rush-hour, more working



from home: various reasons no longer to use the car for the daily commute to and from our work locations.

Still, there is rush-hour traffic every day. Will this continue to characterize our country? Or will there be a substantial change? We suspect the latter – partly from the influence of new technological developments combined with services, possibly provided by means of intelligent and handy apps. Beyond this, sufficient investment in physical infrastructure remains essential.

This report came about partly on the basis of interviews with stakeholders in the field and from our own desk research. For the creation of this trend report, we asked those interviewed an ambitious question: "How do we (the market and the government) make sure that we can achieve a country that is either low in congestion or, wherever possible, congestion-free in 2027?" We can conclude that we're all taking a journey together and that it is difficult to predict how and when we will achieve the ambitions. Developments and combinations of technologies and services to be applied and that are difficult to predict will have a huge influence on the pace and on the result.

As mentioned in the final chapter of this trend report, Frits Lang, a prominent film director in the era of black and white film, presented his famous film "Metropolis" in 1927. That film included flying manned objects in urban areas. 100 years later, in 2027, such images are likely to be commonplace in many cities worldwide and beyond. Autonomous drones suitable for personal transportation are already flying in Dubai. In the Netherlands, drones are steadily becoming commonplace – first for hobbyists and now for professionals. Consider such experiments as pizza delivery or the deployment of emergency services, for example. It's interesting to consider

the influence this will have on congestion in our current infrastructure if all of these developments continue. It's also a hefty administrative challenge to make the proper preconditions available on time.

Just as with other developments in society, it will come down to the idea that seeing, doing, learning and repeating - in whatever manner - are needed in order to deploy the combination of new technologies and services effectively. Capgemini is glad to make its Applied Innovation Exchange (AIE) innovation center available for this. The AIE is intended for companies and governments that wish to experiment together with us on new technology and services in order to achieve practical and effective application opportunities for the mobility objectives.



Zsolt Szabo
Capgemini Nederland B.V.

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Management Summary

Since the publication of the last Trends in Mobility report, many new technologies and services have been developed that contribute to solutions to many of the mobility challenges facing the Netherlands. This year, we first look back at previous editions to look at lessons we have learned in previous years, followed by a look forward into the future. We look at the developments that may provide breakthroughs for allowing us to move about in low levels of congestion in 2027 and what will have to happen in order to have this succeed. In addition, we project these developments onto the coherent objectives that the Netherlands is striving toward in the area of mobility.

In order to draw up the 2018 Trends in Mobility "From continued development to moving differently", we performed a survey of the literature and held interviews with representatives of bodies representing a huge variety of modalities and with those fulfilling a guiding role in this. The main question posed of the respondents was: "how do we (the market and the government) make sure that we can achieve a country that is either low in congestion or, wherever possible, congestion-free in 2027?"

The most important findings from these discussions can be found in Chapter 2.

The following general conclusions can be drawn:

- We may stand at the forefront of the biggest changes ever in the domain of mobility. Combinations of new technologies and services, from autonomous transport to shared modalities and drone travel, can have a huge impact on congestion in the coming years.
- Initiatives to decrease congestion that have been launched in the last 10 years have had some results but, in many cases, not yet to a degree sufficient to have the forecast growth in mobility take place at low levels of congestion.
- In certain cases, there was an issue of suboptimal cooperation resulting from existing settlement mechanisms and local optimization criteria.
- Mobility objectives are quite diverse and the organizations involved – each with its own objectives – are just as

diverse. More horizontal cooperation is desired.

- Companies in the mobility domain – from vehicle manufacturers to application builders to consumers – increasingly dictate the way in which transport is done.
- Trends concerning big data and analysis, along with self-learning systems, will lead to (nearly) real-time applications in the flow of traffic.
- Government, under the influence of new developments in the domain of mobility, will focus more on managing uncertainties than on creating certainties. Existing laws and regulations will have to be made "future-proof" and possibly integrated into a single mobility law in the longer term. Market forces and increased transparency in the form of user assessments are increasingly forming the new quality safeguards, so this needs to be safeguarded less in laws and regulations, allowing more latitude for innovation.
- In addition to experimenting, there is also a need for deployment. In other words: gaining experience with the existing infrastructure.
- Key comments associated with mobility policy in the coming years are: cohesion, autonomy, shared economy, horizontal and vertical movement and self-learning systems.

So the large changes we face in the coming years will have to be recognized and managed in a timely manner. These days, the introductions of technological innovations and associated services conflict with various obstacles. Because of this, technological innovation cannot yet be implemented at the level at which it can be useful. Is this a new phenomenon? Not at all. Why aren't all of our cars already completely electric and/or hybrid? The first electric car was already available in 1890 and there was a hybrid vehicle just after the first world war! We see the same phenomenon today, but in a different light. One example of the introduction of a new transport modality and new services: laws and regulations are still under development for the use of autonomous drones and flying cars for both personal transport and freight, while these vehicles are already commercially available in the market. In the Netherlands, AVY and Pal-V are enterprises that are already making inroads. However, such large companies as Airbus and Kitty Hawk, that have cooperated with Google founder Larry Page, are also launching aircraft for commercial use. Cora, Kitty Hawk's aircraft, which will function as a taxi, is currently being tested and made ready for deployment in New Zealand.

Consumers, in turn, get more choice. In the coming years,

consumers will be increasingly assertive, wanting to be able to book a flight with an autonomously flying drone from their easy chairs. Then link these developments to innovations in adjacent domains via blockchain. This creates marketplaces with transport service apps for consumers in which the processing of the services takes place via smart contracts. Using these services, consumers can easily rent, park and charge a combination of transport resources. What is the influence of mobility on all this (including the associated financial transaction models) and, consequently, on laws and regulations and fiscal policy? Topics related to the ownership of all the data generated, and where that data is located and its impact on privacy can also be added to the complexity that we will encounter in the coming years in this domain and with this example.

The example shows that the world around us is changing rapidly and, as indicated in the conclusions, we are at the dawn of huge changes in the domain of mobility. The impact of new technologies linked to new services is increasing at an accelerating pace. Companies are increasingly 'in the lead' when it comes to which products and services are brought to market, how soon and in which manner. At the same time, consumers are increasingly taking the wheel when it comes to determining which products or services they buy and when. It will be a challenge to government to facilitate this paradigm shift. The consequences for the government are difficult to predict. The emphasis will therefore lie increasingly on managing the uncertainties that arise for us, instead of on creating certainties. This is possible by approaching the issue of congestion integrally and by following and coordinating relevant developments concerning new and existing technologies and services efficiently in order to achieve a system optimum. Daily experimentation in both cohesive and sometimes differing compositions will be an important success factor in achieving the mobility objectives and, with these, bringing about low levels of congestion in the Netherlands in 2027 and thereafter. At the same time, suppliers demand deployment in addition to experimenting opportunities, i.e. gaining experience on the existing infrastructure. This is truly a challenge when it comes to introducing new mobility applications successfully.

In conclusion

Capgemini's intention with this trend report is not to provide a scientific report. The observations and estimates are ours – concerning the question of who among the providers of transport modalities will be tomorrow's winners, for example: those building a transportation resource around computers, or those building computers into transportation resources, or entirely new parties who are yet unknown. More than enough questions to conclude that this trend report will be the first in a new series.



At this point, man is the integrator of all decisions for choosing a modality. But soon, the system will take care of this."

**Ab van Ravestein,
Managing Director of RDW**

We wish to offer a special word of thanks to those people we interviewed, who made their insights and time available to contribute to this new "Trends in Mobility".

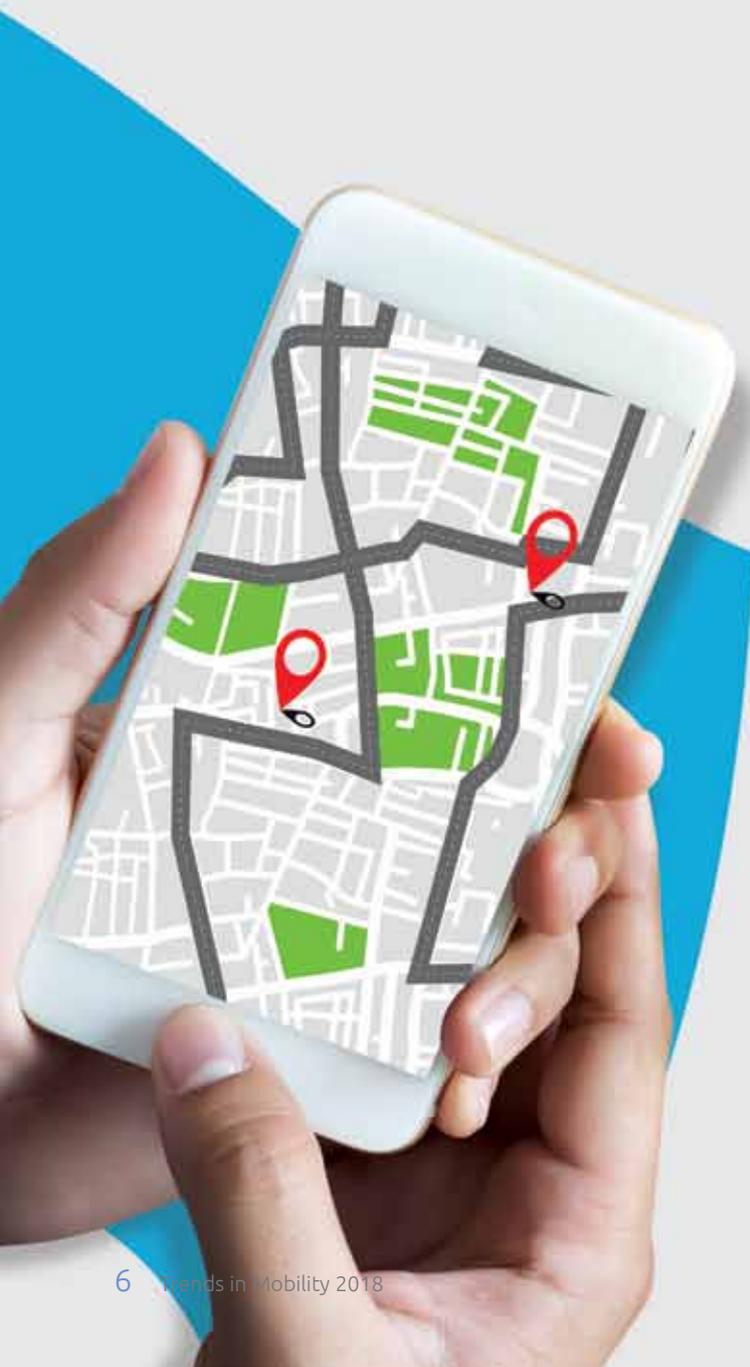
01 Introduction: a cohesive approach

In 2007, the idea was that there was too little line and cohesion in all sorts of measures, investments and policy. Capgemini is of the opinion that, with a uniform context and unambiguous definitions, more of an effect can be achieved to the benefit of better mobility, logistics and transportation. In addition, the presumption was that technology (in a broad sense, but indeed including IT) can be particularly helpful in the efforts toward better mobility for people and goods.

As an initial exercise for a joint framework, Capgemini launched the concept of Gross National Transport Capacity (Dutch acronym: BNV), expressed as a function of travelers' mileage. The working area included all federal highways, all railways and all primary waterways in the Netherlands. We calculated what the capacity would be if all transportation channels were used to their maximum capacity day and night. To do this, we presumed that all transportation resources were maximally used – i.e., that all of the seats and standing places were occupied and that maximum cargo capacities were transported.

The BNV provided a framework within which all of the measures, disruptions, improvements and programs could show their effects on the entirety. So the measures were comparable in terms of effectiveness and benefit. Driving at night, shorter distances between trains, flex working, carpooling, working from home, transporting more cargo on each boat, fuller trains, more asphalt and smaller cars – all of these factors could be viewed in cohesion.

After extensive calculations, it turned out that only 1.2% of the total transport capacity was used (in 2007) and that the greatest bottlenecks arise from well-worn habits. An important finding was that the various groups in the domain of mobility recognized no links with each other. Those groups that dealt primarily with persons on the road focused on the number of cars and not on the capacity in terms of the numbers of persons. The fact that each personal vehicle in traffic jams during the week is 80% empty was not included in the scenarios. That also applied to the comparisons of waterways, public transport and asphalt. The number of cars was a given and the departure point for the calculations. The conclusion was that the problem was not capacity, but indeed the utilization and distribution over the modalities. Utilization has not changed significantly since 2007 despite all of the developments.



In 2007, there was already a discussion about financial incentives and a policy of disincentives. Road pricing was a hot item. The idea to use technology to contribute to the improvement of mobility in the Netherlands had not yet gained traction.

The economic crisis of 2008 made the problem of traffic jams less prominent. The idea was that many people sat at home or could not afford their own cars. The reasoning that populations were aging and that the number of cars would decrease in the longer term has also turned out not to be true to date. We have already pointed out a number of factors for this. The first factor was the vital or better off senior citizens with slightly larger cars. The higher level of health, increased recreational traffic and the delay of retirement age all contributed to unabated growth in the need for transport. This still has more of an effect than young people who make greater average (continued) use of public transport.

The examples from previous reports and the big picture are still up-to-date. The liberalization of the market for packet transport has decreased prices, but has also decreased quality and profit. The transport companies that supply stores encounter only downward price pressure and still drive around with their large trucks into inner cities in many cases. Due to local pricing battles, interior waterway ships are becoming larger on average and are consequently becoming less of a serious alternative to trucks on the road. Except for a few quirky customers such as the beer brewer Heineken, which has set up transport by ship to Rotterdam, there are very few projects or initiatives that transcend the boundaries of transport modalities and policy areas. Recent smart shipping initiatives are promising, but must be developed further. And even the idea that one should no longer be able to fly from Schiphol to Brussels or Paris (since the train can offer a better alternative from a social standpoint) conflicts with the local interests of the various parties. From the standpoint of cohesion, the local measures have a relatively low yield, high costs and they still represent only a drop in the bucket. Cooperation contributes to the solution, but is hindered by the settlement mechanisms and local optimization.

In the later reports, we predicted that the Dutch conurbation could develop into a city with public transport. In reality, nearly all of the bottlenecks are in the large cities. Local administrators keep cars out of the inner-city due to environmental considerations, but without providing a true transport alternative. Keeping cars out of cities is not an integral part of the transport plan for the Netherlands. These are independent measures. This also applies to the transport needs of large industry and the harbors, for example. The Eemshaven Harbor is growing like wildfire but is, in principle, not part of an overarching mobility plan for the Netherlands. Lelystad Airport will attract extra traffic as a boarding place for passengers

and, who knows, possibly as a complete replacement for Schiphol Airport. But this is not yet combined with a long-term plan to facilitate that traffic in the region.

Since 2007, the potential presented by technology that can be used to the benefit of transport capacity has taken huge steps forward. Everyone is aware that communication technology and structure (focused on persons and on the transport resource) will make significant contributions to better utilization of transport capacity. This also goes for the technology in and around the transport resources themselves, such as cars. A mid-market German passenger car now contains between 600 and 1000 sensors that can be used increasingly for the car's transport task. At first, the technology focused on the proper/safe operation of the car from a technical perspective. But the self-driving car is now on the horizon and the technology also focuses on the most intelligent routing and the best transport model.

A large portion of the main streams of modern informatics (including such topics as Artificial Intelligence, the Internet of Things and Data Analytics) can and shall play an important role in improving mobility. But then, the various forces in the field must have a (type of) similar objective. Considerable technology is now available, but it is used only to a relatively small degree to coordinate the need for capacity.

One interesting example: the discussion about the role of sensors in the road in relation to the intelligent/communicating car. Within the proper administrative framework, today's technology makes it simple to have cars on the road negotiate with each other as entities without having guidance be necessary from a central point. We then use the vehicles' Situational Awareness and must intervene only in the event of emergencies. In aviation and at the Defense Department, these technologies are taking over and that results in better utilization of the assets and more rapid and adequate control. To do this, the government of a country, the suppliers of the vehicles and the users must first agree to the policy frameworks and the optimization criteria: with today's technology, it's not too difficult to have an ambulance communicate with the cars around it, without the intermediation of people, in order to provide optimum passage. It is socially accepted and the technology is ready. It's slightly more difficult if this involves an animal ambulance or a car from the city street cleaners. In aviation, with limited space and noise regulations, there is nearly no latitude for people's interpretation. The aircrafts respond to each other and the role of the traffic controller will change quickly.

One example of where a cohesive approach is required is a situation in which the government, the business community and consumers demand an answer to the question concerning a continuous system optimum – in other words, the demand for a cohesive approach.



Laws and regulations must depend less on technology and must be written with more of a focus on objectives."

Bart de Liefde, previously at Uber

Striving toward the system optimum; a thought exercise

The mobility issue is a system in which every mobile party is an actor following his/her own strategy. In a car, you optimize your routes according to your own strategy, e.g.: the fastest route. An inland waterway ship optimizes its cargo load factor, for example. A train optimizes travel time. Game Theory provides insight into the behavior of systems with multiple actors, each of whom follow their own strategy. This theory can be used to understand and to optimize mobility. One example of this is the Braess Paradox.

The Braess Paradox shows that these road users' strategies result in a sub-optimal user's optimum. This takes place on a large scale in traffic, but also in many other areas. Often, a system optimum exists that is much better. Alignment of the individual strategies into a collective strategy is necessary for this.

A simple example demonstrates this effect. See:

https://en.wikipedia.org/wiki/Braess%27s_paradox#Example

It can be proven mathematically that a maximum improvement of decreasing travel time by half could be possible. This represents huge potential savings that far exceed what can be achieved with any other resource whatsoever. So this is an important direction in which to search for solutions.

There are multiple ways to arrive closer to a users' optimum. For road traffic, an analysis is performed of three classes of strategies:

1. Individualistic
2. Centrally controlled
3. Democratic

The individualistic class of strategies basically comes down to what we now do as individual users of transport. We inform ourselves as well as possible about the current utilization of the infrastructure. We know where the traffic jams are and which roads are closed. We base ourselves on the various parties that report the current traffic situation, helped in this by various governmental institutions that share their current information and commercial parties that enrich it. We use our experience from other times that we were on the road. On the basis of this, we select our strategy for finding the best route. This class of strategies provides us with the user's optimum. Which is, in fact, not optimal at all.

The centrally controlled class of strategies boils down to having a central body (the network manager) that decides for us whether and when we can travel and, possibly, how. The railroad is a fine example of a centrally controlled strategy. The train schedule is established completely beforehand and one optimizes the system that includes passenger trains, freight trains, working trains and shunting activities. The schedule is able to arrive precisely at the system optimum. So it's perfect. Translated into terms of road traffic, you then end up with strategies such as "slot management", which is now used in aviation. Road users indicate that they want to go from A to B. The central body makes a deliberation among the various interests. For example: ambulance with haste, quickly perishable goods, business traffic and recreational traffic. The moment that the journey can begin is determined on the basis of this. The central body can go even further and even dictate the route and the driving speed. So using collective interests, the network manager can determine how the infrastructure is used and how much congestion is permitted. The great disadvantage of these strategies lies in the fact that they are contrary to our sense of freedom of movement.

The democratic class of strategies tries to find middle ground. A network manager is required to represent the collective interests. As the Braess Paradox shows, the network manager can exercise influence by intervening in the infrastructure by means of traffic measures. In the Braess Paradox example, by closing a road. Additional traffic measures can be deployed in a practical network: reducing/increasing maximum speeds, opening/closing rush-hour lanes, increasing/lowering the capacity of urban routes, etc. The road user has every freedom to choose his own route: whether, when and which route optimization. However, this does not generate a system optimum if the strategies of the network manager and the road user are not coordinated. In order to align the strategies of both actors, another ingredient is required. All road users must notify the network manager beforehand of their intention: I am at A, want to go to B, am leaving at T, so optimize for the fastest/shortest route. The network manager can then start calculating using the expected traffic in the network. The network manager can then optimize the network by deploying traffic measures. After this, the network manager shares the traffic measures deployed with all of the road users. But what's more: the effect on the allocation of traffic on the network. If each road user keeps to his intention, then the road user will get the best possible route and that is better than when the intention is not reported beforehand. And all of the road users together arrive at their destinations more quickly. The network manager is capable of representing collective interests. If a residential neighborhood's livability is negatively impacted by traffic, then traffic measures can be deployed to limit traffic in the neighborhood. Sometimes, this can be done by making other routes attractive – by making

more capacity available. For example: staggered green lights on through routes. But this can also be done by implementing traffic-limiting measures at the location. For example: speed limits or bans on through traffic. When compared to the individual strategies, this is a limitation of the freedom of choice. With respect to the centrally controlled strategies, there is complete freedom to choose a route within the context of the traffic measures. The network manager represents the interest of the collective by optimizing a collective goal. Therefore, the network manager must be designated by the people and must be given the collective goal. This is the essence of a democracy and it explains the name of this class of strategies. The network manager must obtain his objectives from a democratic process and that is a role that fits with the country's government.

So the application of game theory to the problem of traffic management shows that the current situation makes sub-optimal use of the available roadway infrastructure. It shows that there are multiple strategies that can further optimize use. And that a central body is required to align the strategies with each other and to optimize further.

This analysis is not an attempt to demonstrate that a democratic strategy is better than the other strategies. It shows that conscious choices must be made in order to align the strategies of all those involved with each other. For only then do we have the opportunity to utilize the available infrastructure optimally. We must make that choice anew for each modality. And even for the entire transport system as a combination of various modalities, we must determine the strategies that help us to optimize the entire system. With the necessary consequence that a central body is required to enable this across the entire system.

Have we reached our goal then with a strategy for the transport system?

Unfortunately, no: this is just part of the story. The analysis above deals with network management: how can we allocate supply and demand intelligently across the network? If we continue with the example of road traffic for a moment, then the question is obvious: what do we do with autonomous cars and how can we combat phantom traffic jams? The answer to this is that you can think about road traffic as a series of different but linked problems in various timescales: seconds, minutes, hours. In ICT terms, we would call this a multiple-layer system. The various layers (seconds, minutes, hours) each have their own problems and solutions. Together, the layers have a limited degree of joint dependency. For road traffic, you can consider a three-layer system:

1. Network management: the hours
2. Flow management: the minutes
3. Survival: the seconds

Network management is described above. It describes how road capacity is allocated and how vehicles then determine their route through this. Flow management deals with multiple vehicles in a driving lane that want to move as efficiently as possible over that lane. Survival concerns the vehicle that moves among the other vehicles on the infrastructure and that wants to do so safely.

Flow management presents challenges such as traffic that enters and exits driving lanes, traffic jams and obstacles such as stranded vehicles or loads that have fallen off. There are now very many technologies under development and already in use in this domain. Consider, for example, adaptive cruise control, cooperative vehicles, shockwave absorption and therefore autonomous vehicles as well. And then there are the classic dynamic traffic measures such as traffic signals, traffic jam warnings, on-ramp stoplights and traffic regulation equipment. The limitation of a road lane's capacity is used to make course corrections in the flow management layer, but it never resolves congestion in the network. That can be done only in the network management layer.

With survival, you encounter such challenges as: choosing a position in the driving lane that is safe. Here, the choice of lane and distance to those vehicles behind you and in front of you plays an important role. Technologies here include ABS, automatic braking and automatic acceleration systems. This layer is the most mature and is characterized by the least development. One does however see development taking place between this layer and the flow management layer. Adaptive cruise control is a fine example of this. Automatic acceleration and automatic braking are used to secure a safe position on the road. Autonomous vehicles will also be able to be used from flow management to properly substantiate network management. An autonomous vehicle can (and shall) comply more consistently with the optimum recommendation for the choice of route from the network management layer. Based on these three layers for road traffic, we have shown that resolving the need for mobility in road traffic is possible with a reasonably complex model. When you also consider the other modalities, then comparable layer models arise for each modality. Beyond this, there is also control and optimization among the transport modalities. In short, much work still needs to be done to think up a good model that gives us a grip on complete mobility in its entirety.

The highest layer of this traffic model is network management. But it is quite likely that a couple of higher layers will be necessary to respond to the developments that are currently underway. What do we think of the choice among road traffic,

inland waterways, aviation and rail? What do we think of unlimited use of infrastructure for all sorts of purposes: from the fire department to the recreational user? How will we then allocate this fairly if (electric) transport is largely free? Or, at yet a higher level: what do we think of the space that infrastructure takes up? How will we build more houses or an airport and how will we deal with the extra need for mobility associated with these?

This raises the question: which (hierarchical) goals do we set for ourselves? Once answers can be found to these questions, then the necessary layers will follow to achieve those goals and to create strategies to keep the Netherlands livable and safe. The technology involved in vehicles, infrastructure, goods and people has sufficient potential to make huge leaps forward in more intelligent use of the infrastructure. But this also requires a system architecture that establishes the technologies that must exist, the control mechanism (will we encourage, discourage, forbid, punish or facilitate; will we use market principles or will mobility require rigid intervention?).

In any case, all of the tools for analysis, prediction, explaining behavior and communicating/moving autonomously are present at their core. The question is then how we can utilize this to advance mobility.

02 Mobility objectives

To create this trend report, we spoke with a number of leading persons in the world of mobility. The questions posed were: "How do we (the market and the government) make sure that we can achieve a country that is either low in congestion or, wherever possible, congestion free in 2027?" and "Which cohesive mobility objectives must the Netherlands have to achieve a low level of congestion in 2027?"

In summary, four primary overarching objectives can be formulated:

- **Safety:** generally mentioned as the primary driver for many mobility applications. Once a development can contribute to the improvement of safety and can therefore contribute to fewer accidents and (traffic) casualties, this development quickly becomes interesting.
- **Accessibility:** developments are attractive if they contribute to the improvement of traffic flow (rapidity), to an increase in the reliability of expected travel times and to the possibility of getting where you want to go.
- **Livability:** sustainability is an increasingly important driver for mobility developments. In particular, the Netherlands' ratification of the Paris climate agreements will result in the government encouraging smart mobility in the built environment even more than now in order to improve the sustainability of the Netherlands. But livability comprises more than just sustainability. For example, livability can also be expanded by making efforts toward more social inclusion. As an example of this: people who have difficulty getting around can nonetheless be helped to reach their destinations by such developments as Mobility-as-a-Service (MaaS).
- **Competitive position:** the Netherlands is considered a good testbed for new technologies; the idea is that if it works here, it will also work elsewhere in Europe. If you can get approval here for a self-steering car, for example, then that should also apply to other countries. By staying ahead of the pack in innovative thinking and acting, the Netherlands remains an attractive country for investment, knowledge development, skills, products and services – which, in turn, is important to the competitive position of the Netherlands.

“ *This mainly concerns safety, accessibility and, increasingly, livability. This last objective in particular just might be a better motivation than "not wanting to sit in traffic any longer". Because we often opt for that ourselves. The trick is to find out what moves people and to capitalize on this.* **”**

**Marja van Strien, Connecting Mobility
Program Director**

2.1 Hierarchical objectives

However, the list of objectives above is not the starting point for a cohesive choice for tomorrow's direction. The starting point is a cohesive overview of all of the objectives and their mutual interrelationships. The stated objectives are often not elementary objectives. For example: a competitive position is not an ultimate goal in and of itself. It is a means to a higher objective such as prosperity. On the one hand, the challenge is to clarify the cohesion of hierarchical objectives and, on the other, to be able to balance their relative importance. For example: an ultimate consequence of livability is that we no longer move about and therefore do not consume energy. The ultimate consequence of accessibility is that we can move about in an unlimited and unhindered fashion. Sometimes, objectives are compatible and can be united. In this case, by means of movement using renewable, zero-emission movement. And sometimes objectives are

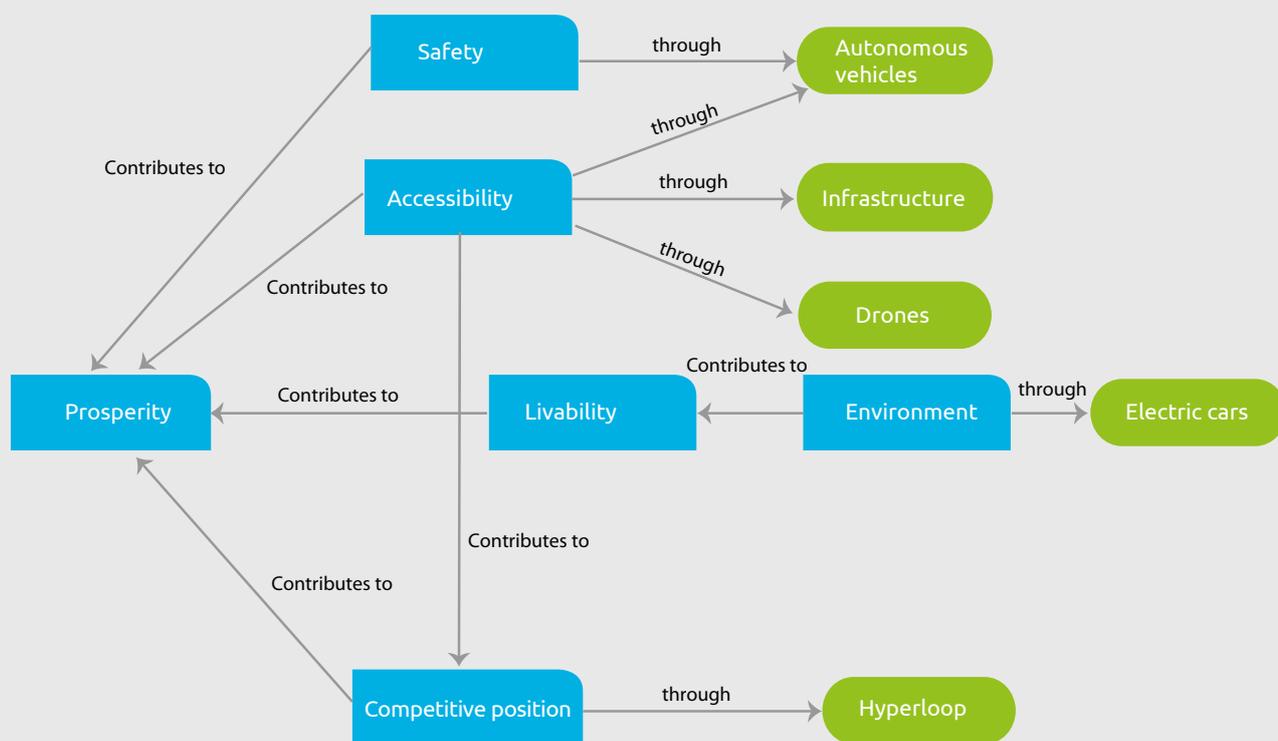
incompatible. In this example, the space taken up by the required infrastructure for accessibility flies in the face of space for recreation for livability. One current example is the shifting of flights from Schiphol Airport to Lelystad Airport. The wider region around Lelystad will encounter limitations to livability, while this nonetheless contributes to accessibility for consumers. Apparently, a coherent choice for the various objectives can be made here.

complex. The illustration also indicates the resources that contribute to objectives, in advance of the rest of this report.

Sensible choices about the relative importance of the objectives and the subsequent choices of the various associated resources can only be made once there is a clear picture of the coherent entirety of objectives.

The illustration below provides an example of the cohesive objectives. True and complete coherence will be much more

Figure 1: Cohesive objectives





2.2 The effects of developments

All sorts of initiatives are started and resources are developed that contribute in a particular way to achieving the aforementioned goals. All of these developments provide resources that aim toward the achievement of one or more goals. Sometimes this goes other than was expected. Below, we sketch a picture of how a few resources contribute to the objectives.

Autonomous cars

Autonomous cars certainly contribute to safety. They are developed to prevent accidents flawlessly and soon they will be able to do that better than people can. They provide for an objectification of safety. They force us to make choices: should the car run into a tree or into a mother with a stroller? Autonomous cars will also contribute to accessibility because they can quickly obviate phantom traffic jams and can make merging lanes much more efficient.

Assisted Adaptive Cruise Control (AACC)

AACC is a technology in which multiple cars in sequence communicate respectively with each other to keep the distance between them safe. It makes largely the same contribution to the objectives as autonomous cars, but then only for those cars driving in sequence. It is simple technology and would appear to be a logical predecessor to autonomous cars as a resource that will be deployed on a large scale. But perhaps this step can also be skipped if autonomous cars make a quicker entrance.

Electric cars

On railways, the idea that electric travel had benefits came about much earlier, even though the electric car existed already in 1890. Trolley buses have already tried it, but that turned out to be feasible only to a limited extent.

This is now happening for cars on the roadways. The last word has not been said about the form in which we will store electrical energy in the car. This will be determined by a combination of the research and development of various forms of storage such as hydrogen, formic acid or batteries. But it will also be determined by the logistics and infrastructure that these require. Energy is expected soon to become completely renewable and possibly free. This will soon allow unhindered growth in transport. So it may just be that this resource contributes to livability, but indeed works against accessibility. So which objective do we now find more important? How do we guide the developments properly?

Drones

Drones have the capability of delivering door to door – both persons and cargo. They represent rapid transport and they use three dimensions, so they're not bothered by congestion. With this, they contribute to accessibility. They work

“The transformation of vehicles continues. The development of vehicles toward a more hybrid condition of driving and flying would now appear to be advancing at the same rate as the self-driving and self-learning vehicle.”

Gerard Doll, Vehicle Division Manager for Regulation & Admission at RDW

autonomously and can therefore also contribute to safety. But if drones are flying around everywhere in residential areas, their contribution to livability is an open question. But perhaps this resource can be made practical for the "last mile" of transport. We then may have congestion around the P+R lots or at train or bus stations where everyone transfers to the drones. Does the drone then contribute sufficiently to the objectives to be developed further as a personal means of transport? Or should drones be deployed for freight transport in residential areas and commercial areas in order to get rid of the polluting buses? Regardless of the possible uses, the first experiments with autonomous drones for personal and freight transport have now been successfully completed. In the coming years, drones could come to dominate the street and air scene as a new transport modality, presuming the implementation of timely and suitable (non-hindering) laws and regulations. In any case, it is no longer a question of generations, but years. To an important degree, drones can also resolve part of the demand for mobility in a chain of autonomous vehicles that offer mobility as a service. One benefit of drones is that they require hardly any infrastructure. It would also decrease the need for the expensive infrastructure required to pass by natural obstacles such as rivers or protected objects such as the Stelling van Amsterdam (historical line of defense). The commissioning of drones may be the final step in achieving a low level of congestion in the Netherlands.

Autonomous trains

Careful experimentation is now being done with autonomous trains. The Dutch railway system also has a mature safety system (ATB, combined with ATB-VV) that already accommodates considerable human failure. With a new train safety system, trains can run closer to each other, allowing more trains to travel on the network without the need for expensive adaptations to the infrastructure. Naturally, the implementation of a modern train safety system is a huge investment in the infrastructure.

Hyperloop

One new star in the constellation of innovations is a take on the age-old tube mail... but then slightly different. The promise is one of high transport speed and therefore a contribution to our competitive position. The development of the hyperloop is in full swing. Considerable innovation is needed to make this system inherently safe. How the hyperloop will relate to other transport modalities must also become clear. Will it replace the use of existing modalities or is it an "add-on"? So experimentation is important, not just in Nevada but also in the Netherlands. There are already plans on the table for a circuit of large cities/airports and the Netherlands is already viewed as a possible experimenting country. By the way, with respect to the objective of livability, there's a question here of whether the system of tubes must be installed above ground or below ground.

“ *There's never a single solution. It's the combination of solutions that allows us to achieve the objectives; we need multiple answers.* ”

Mark Frequin, Director General for Accessibility at the Ministry of Infrastructure and Water Management

It's no small feat to maintain an overview of the coherence of these developments, effects and objectives in order then to be able to prioritize properly and, especially, to learn from other initiatives and build further on these without constantly reinventing the wheel. So it all comes down to the fact that seeing, doing and learning – and then repeating this – will be necessary to achieve the mobility objectives.

2.3 Progress enablers

In addition to the goals and technical resources for achieving those objectives, other "enablers" are needed: the necessary preconditions. The following necessary enablers are now recognized.

- Improving cooperation
- Changing users' behavior
- Data availability and data quality
- Modernization of legislation and regulations

2.3.1 Improving cooperation

The mobility challenge is so large that it must be substantiated across the entire breadth of society. The discussions showed a clear realization that dealing with mobility intelligently is not something that should be approached solo, from the perspective of one's own island. This involves a cross-boundary interplay of all technologies and partners, both public and private. Finding good forms of collaboration and instruments to guide innovation and to achieve actual implementation constitutes a goal in and of itself for the coming years.

“ *Nobody has the silver bullet, but together we have the golden bullet.* ”

Nico Anten, Managing Director of Connekt

Streamlined cooperation is required among the government, business community, knowledge institutes and end-users. More horizontal cooperation is important in order to make innovation successful, not only on the basis of experiments, but also in deploying existing infrastructure.



“ We must create multidisciplinary communities and not simply link up all the existing islands hopefully. By focusing on that higher goal, you then naturally exceed the grasp of all those separate institutes. You can start with this today.”

**Dirk-Jan de Bruijn,
Director of Innovatiecentrale**

Mobility developments break down the traditional walls between auto manufacturers, traffic control centers, telecom providers and payment systems, for example.

Government may be expected to perform a driver function and to hold parties accountable for their responsibility. Government can then make innovations with considerable

(proven) potential attractive so that the market can then deal with them sensibly.

Parties will also find each other in this regard. A good example of this is the Mobility Alliance (Dutch: Mobiliteitsalliantie) – a broad coalition of parties in the Dutch world of cars, bicycles, road transport and public transport. The member parties wish to represent the interests of travelers and of freight transport. The Mobiliteitsalliantie also points out the importance of the government in driving cooperation.

“ Mobility: you go on the journey together.”

**Steven van Eijck, General Chairman of the
RAI Vereniging**

One project that provided considerable learnings about working from a joint perspective and with concrete objectives was the experiment with truck platooning performed in 2016. With truck platooning, trucks are linked to each other electronically, so that the foremost truck determines the speed and the route. The other trucks follow automatically without requiring the help of the driver. Truck platooning is intended to provide more room on the road and, in this manner, a better flow of traffic. By having trucks drive closer to each other, fuel savings – and CO₂ reductions – of 10% are possible. This is good not only for reducing CO₂ emissions, but it also generates interesting savings for the business community. Truck platooning also ensures safer road transport, according to the conviction of the initiators. The European project concerning truck platooning, encouraged primarily by the Dutch government, was a huge success and was an important milestone in the history of truck transport. It requires discipline to advance the initiative further – within both the business community and government. So this demands continuous attention to the political agenda.

It is important to realize that the entire traffic system is much more complex than many of the experiments and pilots



As roadway manager, Rijkswaterstaat faces the challenge of discovering how both groups – autonomous traffic and traditional traffic – must be served on the road. And we must certainly not underestimate how long this dual situation will last.”

Eric Verroen, Top specialist at RWS in network development and traffic resources

that are now conducted under controlled conditions. It's even quite possible that developments in mobility may first result in a period of (temporary) deterioration in terms of congestion and that the investment pays for itself only later. Consider, for example, the implementation of autonomous vehicles. At first, greater safety margins will be used since a large proportion of less predictable, traditional transport will still have to be taken into account.

With this in mind, joint investments must be made in innovation, possibly with money borrowed from the future. In order to achieve the benefits in the future, investments must be made now in developments with which those benefits can actually be achieved. For this, it is important to have a clear picture of the effects (benefits) that can be achieved, how these relate to each other and how they should develop over time. These effects should also be clarified concretely in order to legitimate and substantiate investments in development. Providing concrete and explicit insight into the effects achieved also contributes to better understanding and awareness of each of the parties' effects on mobility – an important condition for arriving at insights into improvements and new innovations.

2.3.2 Changing users' behavior

Many of the mobility developments relate to the implementation of so-called ADAS systems (advanced driver assistance systems). These are systems aimed at offering driving support to drivers – a development that will ultimately result in completely autonomous vehicles.

One positive effect from the use of ADAS systems is expected from the increasing number of electric cars. In addition to the emissions advantages, the Netherlands will increasingly come into contact with "automatic driving". The majority of the Dutch still drive stick-shift cars and don't want to give this up. Since electric driving is driving with an automatic transmission by definition, you must teach the Dutchman to give up a bit of control today in order to make it easier to get used to all of the supplemental driving support systems tomorrow.

For this reason, in recent years, several useful initiatives have been started by the government, business community and knowledge institutes in the area of Smart Mobility linked to Smart City initiatives, Connecting Mobility, innovations in mobility and Better Utilization. These are initiatives that have often had measurable results but that were not always structured or implemented in optimum coherence with each other. Therefore, the next round of consolidation would appear logical. Here, we can consider the mobility objectives that could be safeguarded most efficiently, the instruments that could be deployed for this, the laws and regulations (or reduction in these) that must be brought about, the required expertise and the concrete linking initiatives that must be implemented. This is truly an effort that can be brought about only with coherent cooperation and concrete direction based on the principle: managing uncertainties and no longer simply creating certainties. The transitions from the here and now toward new milestones (from "continued development to moving differently") will become increasingly important in the coming years. To achieve the objectives, the following keywords of support can be nailed to the wall: cohesion, autonomy, shared economy, horizontal and vertical movement and self-learning systems.

“ *Technology alone will not solve the mobility issue. It is also necessary to achieve behavior change on the part of the road user.* ”

**Kai Feldkamp, Smart Mobility Program
Director at Rijkswaterstaat**



2.3.3 Data quality and data availability

In our current phase in the area of mobility, having sufficient good-quality data available in a timely manner is a hugely important topic. Road managers, road users (partially via messaging on social media) and sensors in vehicles and infrastructure objects generate huge amounts of data with which all sorts of clever things can then be done in the context of smart mobility. The availability and the exchange of good data is a crucial common thread throughout all of the various mobility innovations.

Various categories of data can be peeled from this, allowing for various assessments. For example, you'll deal very differently with data that guarantees the safety of other road users from the way you'll deal with data that provides information about traffic intensity.

More investment could be made in big data analysis for purposes of better data quality and data availability. Now, for example, all information from road managers and roadwork activities is recorded explicitly in accordance with specific process agreements in which the parties involved must place all sorts of checkmarks at the right moments – when work activities start or finish, for example. However, this represents a considerable hassle, with the risk of its being forgotten. A lot can be done automatically, precisely by means of big data analysis (possibly with Robotic Process Automation – RPA), e.g., detecting traffic jams resulting from the roadwork activities. This is also what the users want: not the knowledge that there are roadwork activities, but that they may be delayed as a result of the traffic jam that this creates. When considering big data, think of the enormous potential from the use of sensor data from vehicles, for example. What does it mean if cars suddenly turn on their fog lights or windshield wipers at a particular location, for example.

2.3.4 Modernization of legislation and regulations

It is important to realize that the technological developments are occurring faster than getting all of the preconditions up to snuff. In 2020/2021, all of the technology will be ready and we will have to prevent laws and regulations from being the biggest bottleneck to actually deploying these applications effectively and efficiently. The government can encourage innovation by removing limitations to innovation. It is vital for the Netherlands that we continue to lead in innovation.

In principle, current laws and regulations are not made for the more intelligent solutions offered by new technology. A lot is hard-coded in laws and regulations, presuming traditional mobility solutions organized for each modality. Consider all

kinds of specific requirements with respect to taxi transport, for example – consisting of mandatory courses, specific requirements for equipment and even clothing, etc. Or consider the legal obligation to have a driver's-side wing mirror and a rearview mirror in new cars. What does this mean for the autonomous cars coming to market?

Market forces and increased transparency in the form of user evaluation also form the new quality safeguards, creating a situation in which less has to be anchored in laws and regulations and in which more flexibility arises for innovations. It could be viewed more as an opportunity that (mobility) companies start performing ancillary activities, for example: bus companies can transport packages and other companies can transport more people. For this reason, laws and regulations could be written to be less dependent on technology and modality and to focus more on objectives.

In summary, dealing effectively with the combination of objectives linked to proper substantiation of the required preconditions will have to make it possible to tackle congestion reduction efficiently in the coming years.



The success of our products depends on good coordination and collaboration. Wherever possible, the legal partitions between cars, buses, bicycles, metros and trains must disappear. Simple and flexible regulations improve the quality of the travel and offer more latitude for continued innovation. Extremely important and essential for our sector.”

Roger van Boxtel,
President of the Nederlandse Spoorwegen

Causes of congestion with respect to road traffic

Before we address the impact of the new products and services that have been developed in recent years, we must first look at the causes of congestion. This will make it clear what the main causes are, what bothers us most as users, and we can then determine which developments will have the most impact. It will also then become clear whether there are causes to which no single development makes a contribution,

while that is indeed desirable. In looking at the causes of congestion, road traffic has been studied the most. This modality consists primarily of individually controlled vehicles, where no traffic control is present to resolve problems quickly – in contrast to aviation and the railway, for example. In addition, road traffic and the associated congestion are among the greatest challenges to increasing the aspects of safety and livability.

Figure 2: Traffic jam causes

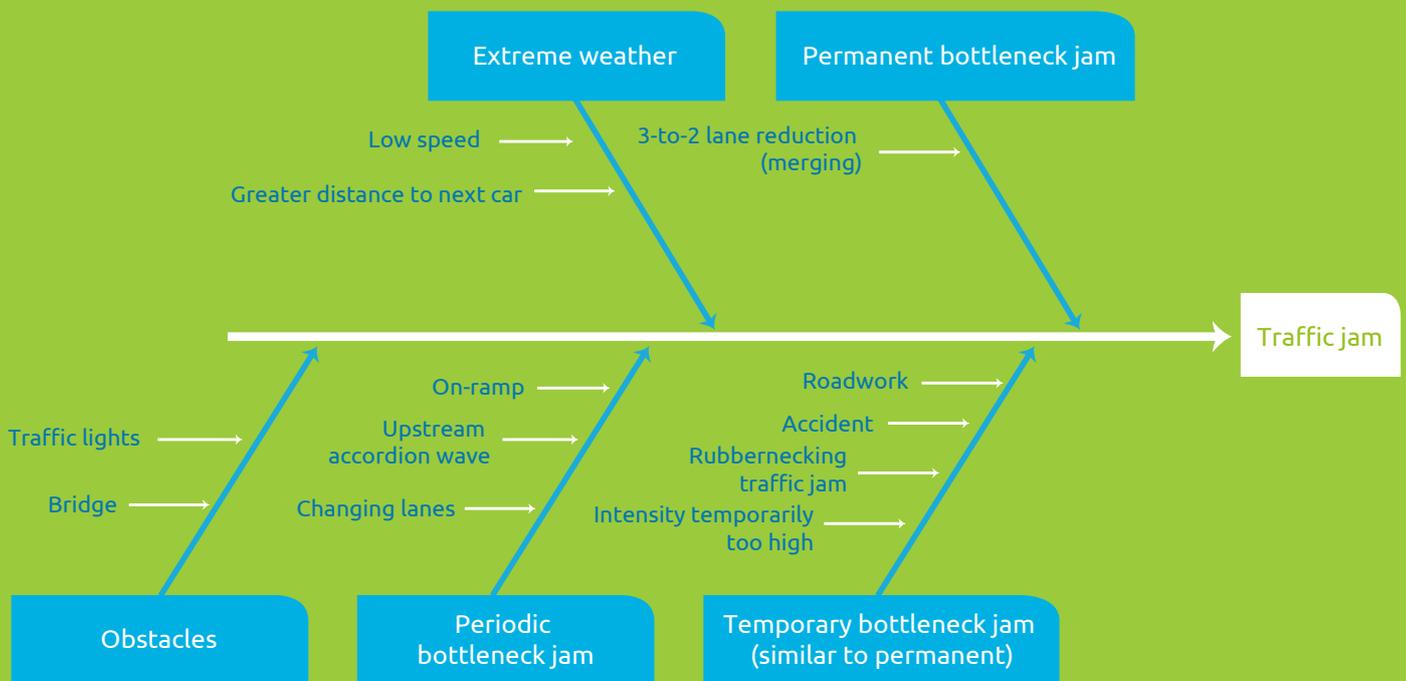


Figure 2 illustrates the most prevalent causes of road congestion in a cause-and-effect diagram. In essence, both the permanent and the temporary bottleneck jam look a lot alike. A bottleneck is present on the roadway, one that is perhaps not always present. One example is a limitation of the number of driving lanes, which causes the road users to have to merge lanes. This contributes to a bottleneck in two ways: the same number of road users must now use less space on the road and the reallocation (merging lanes) also takes up capacity. Once the traffic is reallocated and everyone has found his place on the road once again, traffic normally flows through fine. The same goes for a temporary bottleneck, only then it is caused by an accident or by roadwork, for example. Lanes need not be closed off in that case, a rubbernecking traffic

jam gives the same effect. Once the temporary bottleneck has disappeared, the traffic jam in this case will also dissolve very quickly (a couple of miles of traffic jam can be resolved in 10 to 15 minutes). Traffic jams caused by permanent or temporary bottlenecks have a clear head and tail. A periodic bottleneck jam can be said to exist when you need to take your foot off the gas or even brake within a couple seconds. One example is the inflow of traffic on a highway on-ramp. The highway is already at a high-capacity level and there is not enough space right away for the added flow of road users who may have been given the green light on the underlying road network. This causes a decrease in speed that forces

road users to slow down. It starts with a bit of braking, the road user at the rear brakes slightly harder, the road users behind him even harder, and so on until traffic is ultimately forced to stop. When the cars at the front of the traffic jam can move once again, this wave of stopped cars keeps moving upstream like an accordion. If additional traffic enters into the flow, a new wave is formed. As a road user, you experience these waves whenever you are able to drive forward a few feet after having stopped and then must stop once again suddenly. These types of traffic jams often cause considerable delay despite their relatively short length. Another cause of this type of accordion traffic jam is antisocial driving behavior like tailgating, changing lanes often, staying in the left lane and speeding. This sort of behavior often causes other road users to use their brakes, causing an accordion traffic jam to cause in this way, particularly if it's already busy on the road.

For traffic jams caused by an obstacle, a clear cause can be pointed out such as a bridge that is open, a stopped vehicle on the road or a red light. During extreme weather conditions, more careful driving behavior causes people to drive slower and the distance between cars is increased: fewer cars can use the driving lanes than is normally the case. Furthermore, accidents are more prevalent, so a periodic bottleneck jam forms quickly.



03 Impact of new developments

3.1 Introduction

Since the last Trends in Mobility was published in 2009, many new and different developments have been added to the list of "potential solutions for congestion". For many of these developments, we couldn't have predicted in 2009 that they would result in usable products and services in a relatively short time period. This is mainly due to the fact that those products were introduced only after 2009. In order to

investigate which of these may make the difference in making the Netherlands safer, more accessible, more livable and more competitive, we take a look in this chapter at the most important developments; we describe what these mean and how they may contribute to safety, accessibility, livability and a good competitive position.



3.1.1 Developmental playing field

Figure 3: Developmental playing field



In recent years, a plethora of various applications has been introduced in the domain of mobility. These are in various stages of development: some may already have been available for a few years, while others are still in the experimental phase. A few familiar examples include Uber, ParkMobile, combating phantom traffic jams, the rollout of autonomous vehicles (e.g. the Tesla Autopilot), WE Pods and, recently, autonomous drones for personal transport. Figure 3 shows a non-exhaustive summary of a large number of familiar applications in various phases of development, distributed across two axes. The vertical axis describes the layer on which the application is active (hardware, communication or services layer) and the horizontal axis subdivides these into type, such that respectively different aspects of sharing vehicles, rides or parking places is paramount; it also shows the use of multiple modalities in which the car is but one component of the entire trip and shows automatic driving by means of cooperative, linked vehicles.

The large number of applications active in the Netherlands is remarkable: initiatives come from both the public and the private market. Vertical integration is often present here: for example, a project that focuses on offering a service (such as Flitsmeister) also involves itself with the underlying systems that are the source of this data. At this moment, horizontal integration is less developed, although extremely useful applications can arise from this. Consider navigation systems, for example, that can show the suitable connection to a train on the basis of the predicted traffic intensity so that the traveler can arrive more quickly at his/her destination.

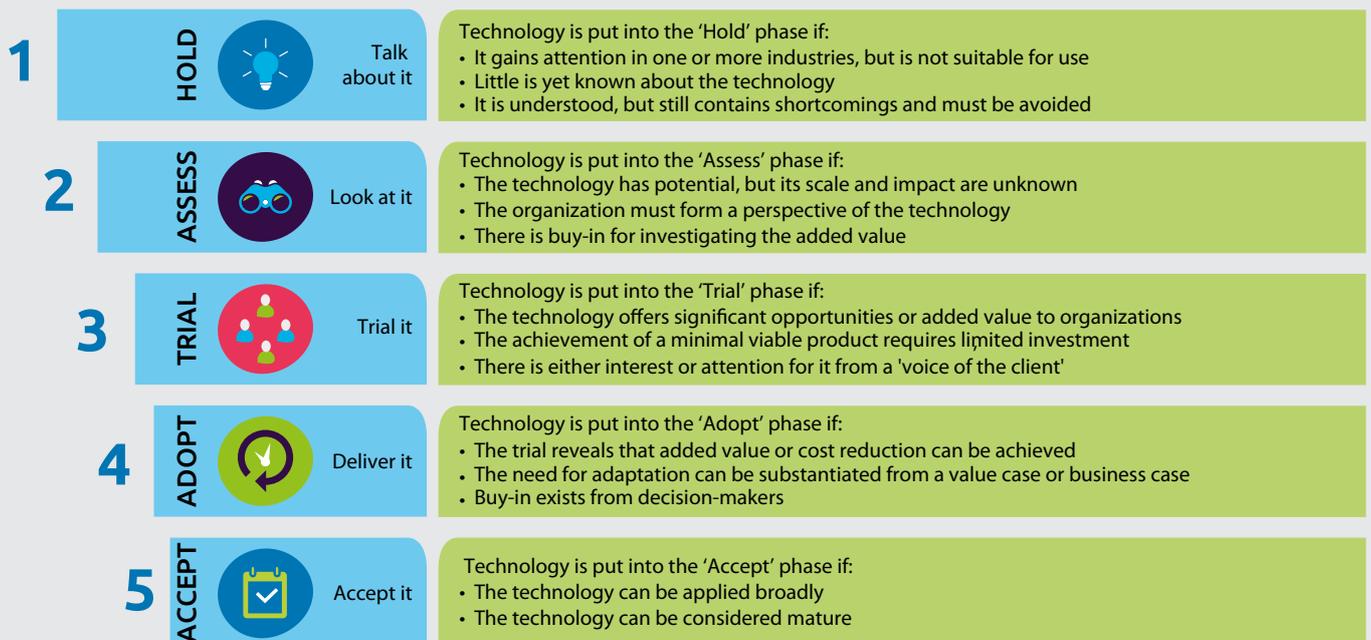
Overviews such as figure 3 show that the playing field for all these applications is extremely diverse. The interviews that we held revealed that cooperation can be improved. Knowledge and experience are indeed exchanged, but the various projects don't actively search for each other in order to learn from each other during the execution of these projects and in order possibly to affect each other. This means that we are dealing with a relatively fragmented landscape in the mobility sector, which may have consequences for achieving the desired effects and objectives. The consequences of insufficient cohesion are already visible in multiple policy

areas in the Netherlands such as in the area of Smart Cities, or concerning startups. So the time is right for the directed composition of a sustainably coherent bouquet instead of having 1000 flowers bloom separately and then having them wither without having enjoyed all of the beauty that a bouquet offers.

3.1.2 Trend radar

With respect to new technology, overarching thinking is recommended concerning data analytics, RPA, self-learning systems, blockchain, geographic information systems, virtual reality and censoring. Each of these involve technological developments that can have a huge influence on the domain of mobility. This report looks primarily at a combination of the use of these technologies and derived applications in the attempt to achieve a low-congestion Netherlands in 2027. A combination of the technology trends that are relevant and that can contribute in the longer-term to this objective are visualized in a "trend radar". This plots the relevant technologies that influence the clusters mentioned above into various phases of maturity.

Figure 4: Maturity phases for technologies



The summary is a first attempt and certainly not exhaustive and will be supplemented in the coming time (after the publication of this report), partially based on new insights.

The trend radar is divided into five clusters that contain the technological developments:

Vehicles

In recent years, there have been multiple technological developments related to the type of vehicles on our waterways, airways, railways and roadways. Autonomous and linked vehicles and drones, in particular, have made their way onto the stage.

Infrastructure

Our infrastructure is undergoing continuous development and is becoming increasingly intelligent. Use, monitoring and maintenance are more easily schedulable – by means of sensors, for example.

Behavior

Humans are an important factor in mobility. The question is: how can we influence ourselves to make the proper choices in order to reduce congestion?

Mobility as a Service

Possessing a car is no longer a status symbol. More and more services focus on offering mobility as an on-call service. This presents opportunities for more efficient allocation of vehicles on the road, on the water and in the air.

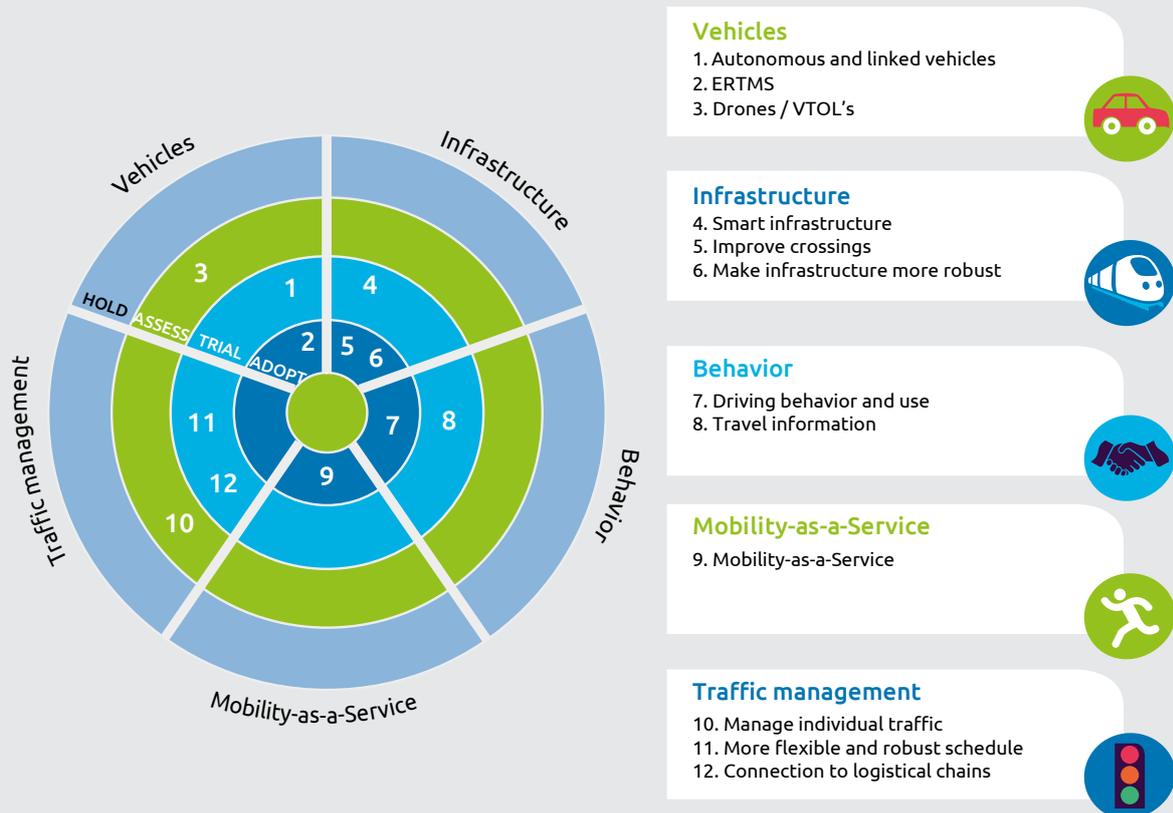
Traffic management

In order to make the right choice for both machines and for humans, the right information at the right moment is crucial.

“If there is space on the road, it gets filled.”

**Ab van Ravestein,
Managing Director of RDW**

Figure 5: Trend radar





3.2 An observation

Many new technologies and services have come about in recent years that can contribute to reducing congestion and to increasing sustainability and livability. Not every solution makes an equal contribution to these objectives and there is certainly no single technology or service that solves everything. One thing that has become clear while making this Trends in Mobility, however, is that a number of new technologies and services have arisen that will make a significant contribution to reducing congestion, and that these must be combined and deployed flexibly in order to solve the problems of increasing mobility. It is clear that a combination of several technologies and services will have the greatest significant impact on our use of transport.

First, Mobility-as-a-Service (MaaS), as part of the emerging sharing economy, is an oft-mentioned way of reducing car ownership. Cars can easily be shared – for the same trip, for example – making cities quieter and cleaner and with fewer cars on the road. Car ownership is becoming less and less important (particularly among young people) and services offering flexible car rental or on-call transport are becoming increasingly popular. In order to expand such services with more providers, it is important that they are provided latitude by the various levels of government. One expansion of this is to bring together all modalities (own cars, shared cars, bicycles, trains, etc.) by means of an (eco) system that determines the ideal transport for each traveler on the basis of the demand at that moment. Since the system determines the best way of transport for each traveler, the congestion can be distributed.

This brings us to autonomous and linked vehicles. This technology is now emerging and increasing numbers of manufacturers are introducing ways in which cars drive themselves. At this point, that's still on the highway, such that the driver's hands still have to remain on the steering wheel. In the foreseeable future, such systems will be far more advanced, so that drivers no longer need to drive the cars themselves. Such systems (in combination with vehicles that communicate with each other) will already be able to

snuff out periodic bottleneck traffic jams in the near term and to ensure constantly flowing traffic. And certainly because a 100% penetration rate is not required for this: noticeable improvements already arise from an estimated 10% share of autonomous and communicative vehicles on the road. This also applies to the non-completely autonomous vehicles, but also to ADAS systems (Advanced Driver Assistance Systems) such as adaptive cruise control combined with lane keeping. So it's vitally important to implement these types of systems in cars as quickly as possible and to encourage their use.

A crucial aspect of technologies and services that contribute to a low-congestion society is their adoption. If a large portion of the vehicles are equipped with ADAS systems or can be equipped with these systems, for example, but no drivers

“Digital information – personal and custom-made – during travel is becoming an increasingly important factor. It provides increasing levels of comfort. Consequently, any delay may come to be experienced as less problematic.”

Jan-Bert Dijkstra, Director of the Better Utilization program at the Ministry of Infrastructure and Water Management

purchase them or use them, then they still don't contribute to reducing congestion. Therefore, the behavior of end-users and companies must also be influenced in order to achieve the desired mobility objectives.

As far as railway congestion is concerned, benefits can be achieved by having trains travel as metros do: all trains travel at the same speed over a rail, so there's no difference between inter-cities, express trains and sprinters. Should there be a need for differentiation in speed, then they could be allocated to separate tracks. Until that time, traveling without a train schedule can help somewhat.

Waterways still have considerable underutilized capacity. It is a modality with reliable and predictable travel times and is therefore extremely suited to freight transport. Speed is often less relevant for this. By moving freight traffic from the railway or roadway to the waterway, based on smart shipping among other methods, more space is created for personal transport (that does benefit from speed).

The autonomous drones mentioned earlier are also making their appearance as cargo and personal transporters. This will substantially reduce the pressure on the existing infrastructure.

Finally, we must not be beguiled by technological possibilities

and use these simply because they are promising and fun. It is vitally important to think even further and to place the technology in a greater mobility perspective. Consider its functional model: what does this technology actually do? How can it cooperate with all of the other possibilities? And are we really solving problems with this? Nearly all of the technological resources are already present. Nonetheless, new solutions still get thought up for each new problem. It is important to have a look at all of the existing solutions and current mobility experiments to see whether these can also be used for new problems and challenges involving low-congestion mobility. Learn from each other and work together. For it's only in this manner that we can approach the mobility problem together, with experiments being an important link, along with learning via deployment on the existing infrastructure.

04 In conclusion: from continued development to moving differently

Concluding with a look forward to 2027 and in connection with the previous chapter, a number of topics remain to be defined that are relevant to reducing congestion:

1. Reducing or making physical transport superfluous.
2. Adding flexibility/customization within/among transport modalities.
3. Changing within the modalities.

4.1 Reducing or making physical transport superfluous

The best way to ensure a reduction in congestion is to reduce the demand for transport. For personal transport, the greatest potential lies in working from home by using modern communication resources. Due to the increasingly international nature of our activities and the increase in complexity of international travel, there is a need for better communication. In 2027, we will communicate in a more lifelike fashion and with more feeling, including the support of multi-medial knowledge systems. The phenomenon of "the office", with its predominantly administrative functions, will be subject to change. The number of administrative functions will decrease autonomously. Call centers and service centers will be decentralized. Because of the explosion in the number of projects/initiatives concerning RPA (the automation of administrative processes), the reduction of administrative work will accelerate even further.

One particular category of persons that now uses primarily roadways includes service technicians, inspectors and instructors. Consider the people who repair and maintain heating systems, machines, access systems and coffee machines, for example. An increasingly large share of these devices is now equipped with software for control and repair and backup systems are built in by default. With the Internet of Things (IoT), many more things will be done remotely. On-site personnel are no longer needed, so travel by technicians, for example, will reduce considerably.



Much more will be done with our knowledge of transport demand. Principles such as those underlying Uber will increase the degree of cargo utilization for taxi and package transport and are expected to reduce congestion on both the roads and the rails. The basic principle is that we talk less about cars, trucks, ships and trains with cargo, and more about cargo in a transport resource. Models that we know already from container transport at sea (following an individual container) will find their way to rail transport and road transport, and even to drones.

The technology for making goods "intelligent" down to the lowest level will help us not only to perform the operation more intelligently in the near-term, but will also help us increasingly in designing systems and structures. At that point, it will turn out that there is indeed a market for smaller, more maneuverable ships and for flexible cargo transport using small vehicles on the road and in the air. Flexibility, speed and maneuverability will play a clearer role in addition to traditional profit (more cargo capacity, larger units such as ships and vehicles).

4.2 Adding flexibility/customization within/among transport modalities

40 years ago, employers created commuting traffic. In harbors, in the process industry and in heavy industry, employers provided bus transportation to and from work. There was even a company bus standing at the ready for shift workers. With increasing levels of prosperity, car ownership increased. The car became a symbol of prosperity. Company transport became pointless since many people drove to work in their own cars. Forms of corporate transport are still visible here and there (e.g. bus transport for people who work at Schiphol Airport), but today's employer presumes that personnel can find their way themselves.

Car ownership is expected to decrease significantly by 2027; at the same time, the use of "public" transport will increase. These two (most important) forms of transport are merging with each other in terms of features and use.

The phenomenon of an employer providing a company car will no longer be the standard in 2027. We already have the concept of a mobility budget today, with more responsibility being placed on employees. Intelligence in the car allows us to view driving behavior and bonus/malus schemes exist. Those who drive economically, who make few personal trips and/or who buy cheap fuel get money back. Some employers have already introduced the weekend car. During the week, a small car is sufficient, but very different patterns arise in the weekends and these require a different car. In addition, many

employers provide their employees with a public transport card in addition to a company car. From there, it's just a small step to such constructs as private lease, monthly lease or mileage lease. In 2027, car ownership will have decreased considerably and people will require transport availability, partly due to the availability of autonomous transport resources. Custom transport with payment per performance. Self-driving cars, along with autonomous drones with a taxi-app control system that offer custom-made transport of goods and people according to a schedule and on-call may not be completely ready in 2027, but the movement is underway.

Public transport will have to manifest itself more clearly as a combination of transport types that provide end-to-end services. In 2027, transport in general will focus primarily on the person/freight to be transported. The type of transport is subordinate to this. Transport resources will become smaller scale (also in shipping) and will become more autonomous/intelligent. Trends concerning big data and analysis, along with self-learning systems, will result in (nearly) real-time applications in the flow of traffic.

4.3 Changing within the modalities

There is already a careful trend toward letting go of the rail schedule. The public transport systems on smart phones are shifting from displaying the railway schedule toward indicating direct and personal transport possibilities. The next step is that the system actually reserves for you and that the rail schedule is only an indication of the frequency. This can work in practice only if the transport units are small-scale (and unmanned). Just as cars are personal, this will also make public transport for more personal and more focused on the individual person/cargo. In practice, the smart phone/watch will control transport planning and demand on the basis of artificial intelligence and it will serve as a navigation system in order to fit into the transport system. There is a similar trend for freight (piece goods). We are already seeing this in aviation. First at the container level, but later for individual items as well. The technology for building traceable/communicating tags into goods is becoming cheaper and more advanced. In combination with the transport systems we sketched, goods can "ask" to be transported. This can be done quickly and expensively, intelligently, reliably or cheaply (off-hours).

As mentioned, car (ownership) is also shifting: from ownership/possession to an on-call transport possibility. In this manner, the types of transport grow toward each other. The functions of information technology in cars are shifting from motor management and entertainment to

communication and navigation. The self-steering car and active navigation are components of intelligent transport. In 2027, these components will be so far developed that these systems enable scheduled transport. Systems for actually reserving space on the road will then be available. In civilian aviation, however, this is already daily reality. Pilots submit their flight plans and all bottlenecks (from the start "slot" to the corridor to the US) are scheduled according to the agreed conventions – including safety, fuel consumption, weather and travel time. This would also appear to set the tone for transport over water and roads.

“ It is important to realize that the technological developments are occurring faster than getting all of the preconditions up to snuff. In 2020/2021, all of the smart mobility technology will be ready.”

**Dirk-Jan de Bruijn,
Director of Innovatiecentrale**

4.4 In conclusion

In 2027, the contours of these forms of transport will have taken shape. There will also be solutions for specific target groups.

In any case, it will be much clearer in 10 years (and in far more detail) which types of traffic flow exist and what their behavior is. This provides a basis for seeing how behavior can be adapted and where control and course corrections make sense. How mobility relates to other aspects such as livability, accessibility, safety and the economy will become clear – moreso than to date. This insight is a natural byproduct of the huge number of intelligent devices within the transport flows of people and goods. In 2027, simulation of the effective measures and more thorough business cases will be actual tools. At this point already (2018), far deeper analysis is possible than could be done 5 to 10 years ago. The big data projects concerning the connected car (from the large auto manufacturers) will form the basis of a general picture that is also relevant to other types of transport.

Societal implications, legislation, tax consequences and the role of the various organizations occupied directly or indirectly with mobility will change drastically, particularly due to information technology. Information technology that cannot be captured in existing organizational or administrative structures and that demands to be followed. Since we don't inhabit an island, the advance of this technology is autonomous and unstoppable. In order to gain and/or use influence in this, a clear and broad and primarily practical image of mobility is required – an image that extends far beyond the horizon of the current administrative structure within the domain of mobility.

In conclusion: as we approach a low-congestion Netherlands, here are a few words about the emergence of autonomous





drones for both personal and freight transport. In 1927, Frits Lang released *Metropolis*, his famous black and white film. This film included flying and manned objects in cities. 100 years later, in 2027, these images will likely be commonplace in multiple cities throughout the world and beyond. The experiments with autonomous drones (a less complex transport modality than an autonomous car, by the way) in locations including Dubai, the new *Metropolis* of this era, are very promising. And in our country as well, drones are becoming commonplace step-by-step. Experiments with pizza delivery and freight transport are now in full swing. In 2027, we will evaluate whether these disruptive mobility modalities have been accepted and successfully implemented and whether they will provide for a low-congestion Netherlands. It's an interesting administrative challenge to satisfy the preconditions. Looking at and evaluating this sort of disruptive technological developments from a new perspective also provides the opportunity to highlight the current developments such as the ones described in this trend report. Are we involved with system optimization based on current premises or does it still come down to the transition of "continued development toward moving differently" in which all modalities still bring about a low-congestion Netherlands coherently, taking the current objectives into account?

“*Increased autonomy. Ultimately, everything will be autonomous. It's not a question of whether, but of when. Adapt your policy to this.*”

Patrique Zaman, Director of Avy

05 Discussion partners and experts

Discussion partners and experts

This publication would not have been possible without contributions from a number of persons. In the working field, we interviewed the following people:

- Nico Anten (Managing Director of Connekt)
- Roger van Boxtel (President of the Nederlandse Spoorwegen)
- Dirk-Jan de Bruijn (Director of Innovatiecentrale)
- Jan Bert Dijkstra (Director of the Better Utilization program at the Ministry of Infrastructure and Water Management)
- Gerard Doll (Division Manager for Vehicles, Regulation & Admission at RDW)
- Steven van Eijck (General Chairman of the RAI Vereniging)
- Kai Feldkamp (Smart Mobility Program Director at Rijkswaterstaat)
- Mark Frequin (Director General for Accessibility at the Ministry of Infrastructure and Water Management)
- Bart de Liefde (previously at Uber)
- Ab van Ravestein (Managing Director of RDW)
- Marja van Strien (Connecting Mobility Program Director)
- Erik Verroen (Top specialist, Rijkswaterstaat)
- Patrique Zaman (Director of Avy)

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07 Colophon

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