Leading Innovation Timeline as an Enabler for Traffic Management Roadmaps

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Abstract

Traffic management is changing fast. In order to make the right choices concerning smart mobility, it is important for road operators to monitor ITS developments relevant for traffic management. Dutch road operator Rijkswaterstaat developed a so-called Leading Innovation Timeline (LIT) to deal with this. It is a tool to visualize future innovation, more in particular changes in IT systems which are expected to have an impact on traffic management. The LIT helps create awareness of what is happening around us and how fast it will influence traffic management. When relying on the LIT, investments can be made in a timely manner. It also allows road operators to better assess risks of new innovations. The new LIT will be a European timeline. However, broadening the timeline involves some challenges as the speed at which an innovation is implemented or accepted differs per country and depends on the systems already in place.

Keywords:

Traffic management, innovation, roadmap

Trends and developments

Technology

Traffic management is changing fast. The future is 'connected systems' and 'connected people':

- Connected: around 2020 all new vehicles will be equipped with wifi-p;
- Autonomous: most likely a reasonable amount of SAE-level 3/4 vehicles will be on the road in 2019 (20-40.000 vehicles in the Netherlands);
- Big data: Increasing amount of data available, also from vehicles;
- Artificial Intelligence: more and better insight in traffic as a system;
- Sensoring: new smart and cheap methods to collect data;
- Automation/robotisation: possibility to have processes without human intervention.

This is facilitated through an increasing cooperation between public and private actors. The glue between these systems is the sensor data coming from all vehicles (floating vehicle data) and the distribution of public and private data to the end-users. The result is one integrated transport system with smart infrastructure and smart vehicles. This change will not happen overnight. It is not clear what will change, when it will happen and how it will impact traffic management. Uncertainty about these changes makes it difficult for road operators to anticipate on these changes.

Society

Smart mobility is defined as the (combination of) innovations which will make the organization of mobility better and cheaper. It is seen as an important means to cope with a series of societal developments:

- Economic growth and continuing urbanisation are expected to lead to more congestion within and around cities. In a densely populated country as the Netherlands, expanding the infrastructure is not (always) possible.
- After years of improved road safety, since 2015/2016 the number of people killed or injured has increased sharply.
- The climate goals from the Paris Climate Agreement request the reduction of CO2, also from mobility.
- At this moment, not all urban areas fulfil the requirements concerning air quality. A better mix of the various transport modes would increase the liveability of cities.
- The costs of maintaining, replacement and renovation are increasing. The means however are limited, which makes it more important to control these costs.
- Smart mobility is seen as a means to contribute significantly to achieve the societal goals in the domain of liveability, safety and congestion (Rijkswaterstaat, 2017). At the same time, it could bring down the public expenditure for the current systems.

Monitoring ITS developments

In order to make the right choices concerning smart mobility, it is important for road operators to monitor the (expected) ITS developments relevant for the management of the road network. Not only for the short term, but also for the medium and longer term.

Innovations and S-curves

The long-term goals give direction to road operators. At the same time, it is also important to be flexible, since it is unknown how fast developments will go. However, based on current knowledge it is possible to distinguish three phases:

- Start-up phase: Until 2020 it is about learning by doing, to prepare for the large transitions and in particular to realize quick-wins for the short-term in accessibility and safety.
- Scaling-up phase: From 2020 to approx. 2025 it is all about market introduction of autonomous driving and connected services.
- Transition phase: After 2025 until approximately 2040 autonomous vehicles and connected services will change mobility in such a way that new technologies will start to replace old working methods.

A long transition period is ahead of us, in which changes will happen gradually. This means that at this moment road operators have to shape the future, whereas at the same time they have to do the daily operation of traffic management for a long period. The combination of connected and not-connected, autonomous and not-autonomous vehicles, will lead to increased complexity in traffic, certainly until 2030. The risk exists that this will negatively influence safety and congestion. Road operators have to prepare themselves for this. Flexibility means that road operators will have to take into account the possibility that some developments will go faster, others might be delayed, and new innovations will appear. In practice, this means that road operators will have to do two things:

1. The innovation process: strengthening the professional innovation chain through cooperation with, among others, the automotive sector, license agency, research institutes.
2. Monitoring: intensifying the monitoring of the "S-curves" and tipping points. Typically, questions to be answered are:
    a. Which technology is the 'winning' technology?
    b. What does the S-curve look like, in which year will the impact on traffic management occur?
    c. Which roles/actions come with it for road operators?

These insights will be leading for the speed and direction of smart mobility projects to be carried out by road operators. With the S-curve for innovation the development of the innovation over time is linked to the penetration ratio. It helps road operators to assess when an innovation will actually enter the market and when it will have an impact on traffic management. At a specific point in time the impact becomes such that a tipping point develops where the innovation will start to replace existing

systems. To monitor the (changes in) S-curves is very important. Example: Such a tipping point is already almost there for Variable Message Signs, since the majority of road users already has an in-car navigation system.

To tackle these fast approaching changes and developments, Rijkswaterstaat, the road operator of the national road network in the Netherlands, has developed a so-called Leading Innovation Timeline (LIT).

Leading Innovation Timeline

The Leading Innovation Timeline (LIT) is a tool to visualize future innovation, more in particular changes in IT systems which are expected to have an impact on traffic management. On the basis of literature research and meetings with experts of Rijkswaterstaat and external experts, technological innovations relevant for traffic management are mapped on a timeline until 2035. It not only shows the year when the innovation will become commercially available on the market, but also the year in which the first serious impact on traffic is expected.

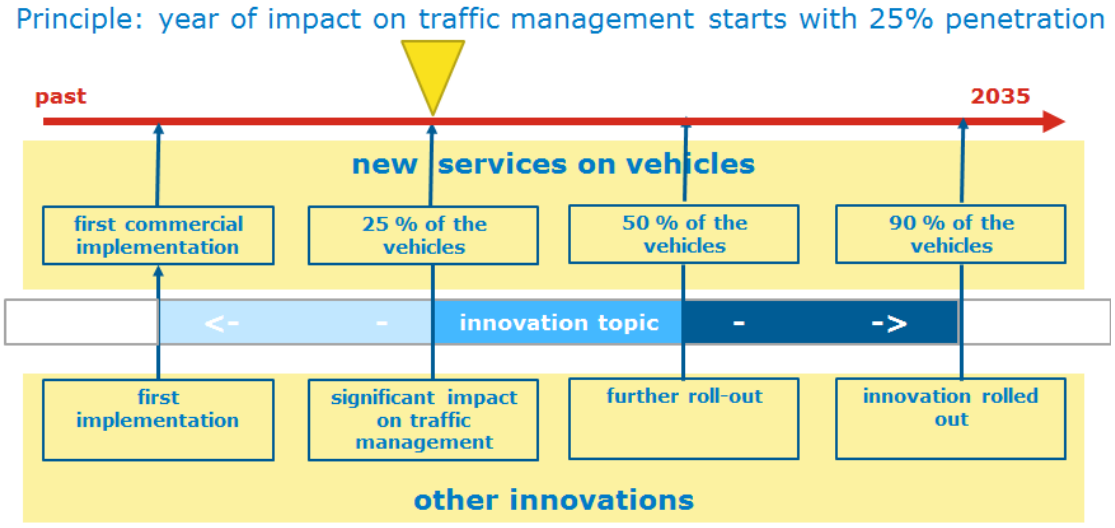

Figure 1 – New technologies and penetration ratio

When all innovations are thus plotted on the timeline, it serves as a very good input for discussion on the effects and timing of the technological innovations, the role of Rijkswaterstaat as a road operator and the tasks of its personnel (knowledge) with respect to traffic management.

The Leading Innovation Timeline distinguishes 10 categories of ICT developments:

- Autonomous vehicle level
- Vehicle – Vehicle level (V2V)
- Infrastructure – Vehicle level (I2V)
- Infrastructure level
- Data transmission

- Data services
- Other

Apart from the developments mentioned above, the LIT also contains a number of services:

- C-ITS day 1.0 services
- C-ITS day 1.5 services
- SAE levels for automated driving

The first Leading Innovation Timeline was published by Rijkswaterstaat in 2015. It gave great support to enlarge awareness about what was happing regarding innovations. In 2016 the Timeline was updated and the new version showed that the installed base for traffic Management would be needed much longer then was foreseen at first sight. In 2016 also C-ITS was added to the timeline as it became clear (by the EC report) what was really meant by this term C-ITS. In 2017 and 2018 the Timeline was introduced and incorporated into to the European ITS Platform and will be updated again.

This timeline is accompanied by a text document called 'Central Document': Leading Innovation Timeline For Traffic Management – version 20161. This document briefly describes all topics and indicates for each topic the impact on road safety, traffic flow and environment. Distinction between passenger and/or freight traffic is indicated as well (where applicable). Each topic shows a list of relevant background documents, so a list of literature for those interested in more in-depth information is available.

So far almost a hundred experts have given their judgement on which topic should be included and in which year the first impact (25% penetration) is expected. It appears that this timeline is a good tool for discussions to gain better insight on what will/could happen and to improve the timeline.

In general, services are the result of a combination of technological innovations. One single innovation often has no impact on traffic or traffic management, but a combination of technological innovations (a service) does. The development of a service is dependent on the development of a number of technological innovations. By mapping these innovations, these can be visualized as well as the impact it can have on traffic and traffic management.

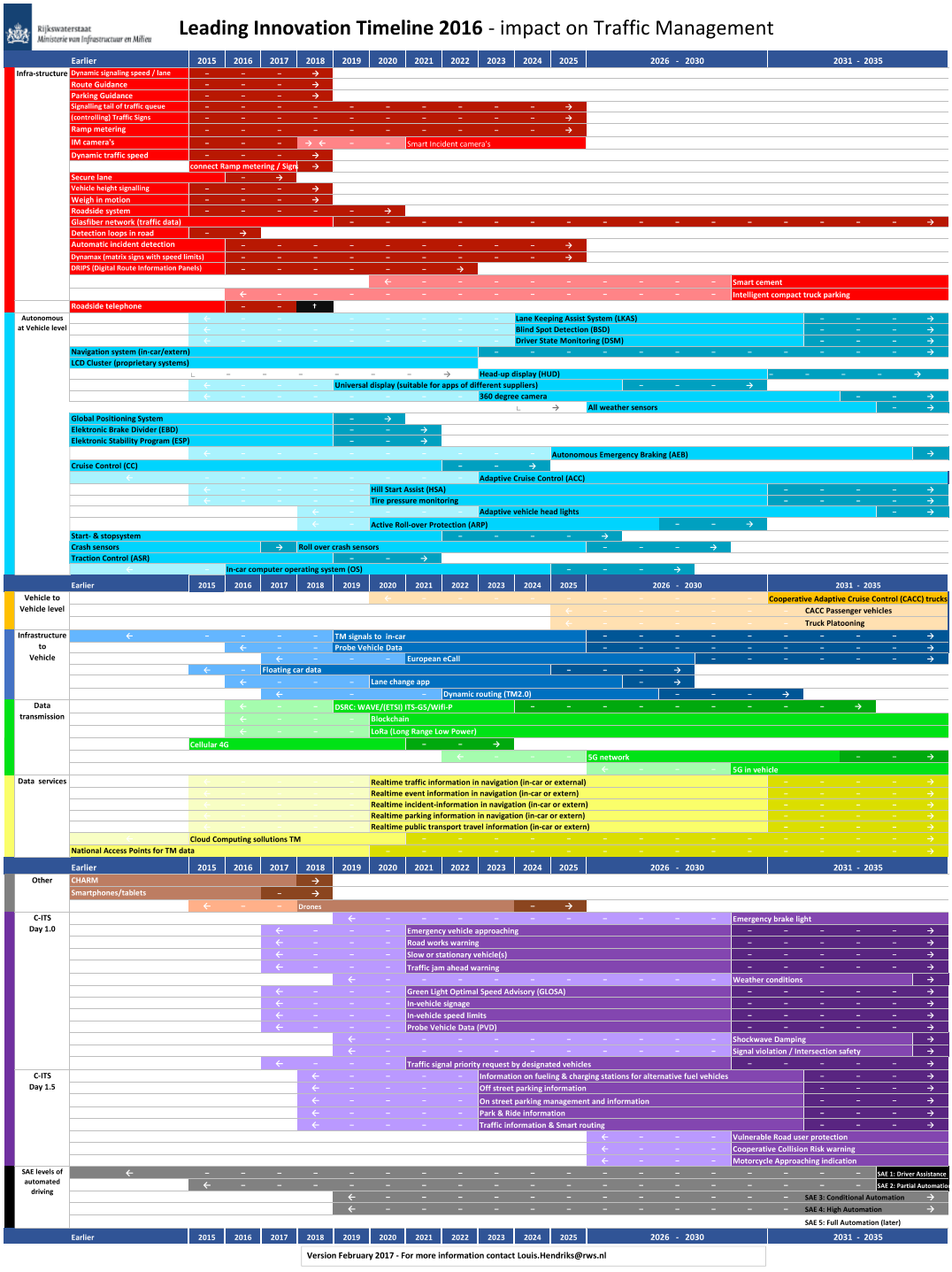

Figure 2 – Leading Innovation Timeline (Rijkswaterstaat, 2016)

Once these expected developments are known, Rijkswaterstaat can identify the urgency to take action. Innovations with a relatively high impact in the short term require instant action (research, pilot, new strategy), whereas innovations on the long term and/or with little impact does not (yet) require action. However, in all cases the innovations need to be monitored constantly.

LIT as input for European road operators' policy

Increasing mobility in the Netherlands is exacerbating traffic congestion on the Dutch motorway network and the number of accidents is rising dramatically. At the same time, due to developments such as smart electric cars for example, the composition of traffic is changing, data streams are growing, there are a multitude of technical innovations and road users are changing their behaviour. The Traffic Management Roadmap 2022 gives this transition substance (Rijkswaterstaat, 2018). It defines ambitions for road traffic management, describes how Rijkswaterstaat can adapt to continue adding as much societal value as possible to traffic management in the future, introduces seven network services that make up road traffic management and discusses improvement and renewal of these network services:

- Object Control
- Incident Management
- Road Works
- De-Icing
- Enforcement
- Network Optimisation
- Travel and Route Information

The renewal/transition of traffic management is based on four themes or tracks:

- Exchanging and Using Data (e.g. data from others);
- Developing Assets (e.g. smarter roadside systems);
- Influencing the behavior of road users;
- Cooperating with partners.

While the roadmap mainly describes why certain choices are made and what ambitions Rijkswaterstaat is aiming towards, the "how" will need to be determined in the coming period.

The Dutch Traffic Management Roadmap 2022 is a great example of how the LIT helps provide input for policy and decision makers to define the next steps in traffic management. The LIT helps create awareness of what is happening around us and how fast / when it will influence traffic management. From the perspective of a road operator, those innovations that are expected to have an effect on road management within a relatively short period (±5 years) are more relevant than innovations that are to happen at a later stage and are still unclear. This means that while the roadmap does include "Object Control", "Incident Management" and "Road Works" as network services, it does not include "Automated driving" as this development is still too far away, too general and not yet useable in day-to-day operations. The LIT supports the process of defining what innovations will affect traffic management and therefore helps define what a road operator should focus on in the coming years.

The LIT also helps Rijkswaterstaat gain more knowledge of innovations in traffic management. This knowledge is necessary when such innovations start affecting traffic management and the road operator's organization has to change to keep up with new methods and systems. For example, when Floating Car Data was introduced, public private partnerships were set up to be able to purchase and collect FCD instead of gathering data via loops. As the LIT allows road operators to be better informed of upcoming innovations that will affect traffic management, investments can be made in a timely manner. It also allows road operators to better assess risks that come with new innovations.

Below, two considerations are given with respect to expected developments that will influence the way road operators should maintain existing and at the same time invest in new ITS systems and services, to further showcase the usefulness of the LIT in policy and decision making.

Mixed fleet

Even though the speed of technological development goes fast, the impact on traffic is largely dependent on de penetration of the technology in the vehicles. Connected and autonomous vehicles are developing fast, but due to the long lifespan of cars, changes on the street will go much slower. This is an important observation, which will impact the way road operators will have to ensure road safety and efficient traffic flow. For example, the characteristics of the car fleet will partly block a fast and disruptive change:

- There are (approximately) 8 million vehicles in the Netherlands;
- Every year approximately 400.000 new vehicles are being sold;
- The average car is over 9 years old;
- Because of the high quality of new cars, it is expected that these cars will even last longer;
- Given the above, it will take approximately 20 years to replace almost the complete car fleet.

This means that, assuming a positive growth of autonomous vehicles (level 4) starting from 2020, in 2040 approximately 30 to 50% of the car fleet will be more or less autonomous. This implies that manufacturer-based innovations of in-car systems will lead to a long transition phase with a mixed fleet. A nearly permanent situation will arise in which increasingly smart, autonomous vehicles will mix with largely conventional vehicles. This will lead to unexpected effects, also with impact on safety and congestion. For Rijkswaterstaat this means that conventional safety and traffic management measures will have to be maintained, while at the same time developing new measures.

Investment bump

In a wider perspective, other innovations like mobility services such as Uber and Snappcar2[1] can have a much faster growth and thus also its impact on mobility behaviour. Also, one can imagine that

[1] Snappcar is a company that provides a rental service of privately owned cars in The Netherlands, Denmark, Germany and Sweden.

autonomous or driving task supporting systems will see a fast growth in leased cars. The gain in safety and productivity of employees will lead to a positive business case, even if the initial costs are high. Smart mobility services via smart phones (with a safe interface) can assist drivers in making better choices, even when the car is not 'connected'. It is unlikely that more advanced systems (autonomous, ADAS) can be retrofitted cheaply and safely in existing fleets. It is also not very likely that all applications will improve safety and reduce congestion. Possible negative impacts (e.g. distraction of drivers, bigger distance between autonomous vehicles) need to be pre-empted.

The challenge of road operators is to facilitate the ingrowth of smart mobility with all possible support, while at the same time facilitating conventional traffic with the same safety level. In the long term, smart mobility will lead to a reduction of costs (through phasing out of current technologies). This transition period will lead to a 'bump' in costs, because on the one hand 'current' systems will have to be maintained, while on the other hand new systems will be developed and implemented.
For example, Rijkswaterstaat expects that road side systems will be required for the years to come. For cooperative and autonomous functionalities, the road side systems will be replaced by road side systems 'light'. Rijkswaterstaat expects that promotion of good individual navigation will lead to a better follow-up of route advices and thus to a reduction in congestion and higher driver satisfaction. Navigation systems will be able to take over the role of Variable Message Signs, certainly for regular and planned situations (door to door, tailor-made message for individual users).

Working towards a European Leading Innovation Timeline

The Leading Innovation Timeline is a useful instrument to monitor the expected technological developments from the perspective of the road traffic manager. It shows the expected timeline of technological developments as well as the expected impact of these technologies on traffic. It thus forms a good basis for road operators like Rijkswaterstaat to develop a long-term strategy for traffic management in The Netherlands.

Where the LIT 2015 and LIT 2016 were mainly based on inputs from the Netherlands, the new LIT will be a European timeline. This broadened perspective can be achieved because the LIT is now part of the European ITS Platform (www.its-platform.eu). The European ITS Platform, or EU EIP, is a group of (mainly) European road authorities and road operators aiming at the harmonized implementation of ITS on the main European motorways in Europe. It therefore is the perfect body to collect input and feedback on the expected impact of new technological developments, as well as to verify the LIT via experts in the field of traffic management.

However, broadening the timeline to the European perspective involves a number of challenges. While innovations are not country specific, the speed with which an innovation is implemented and accepted by road users or road operators differs per country. One could for example distinguish between early adopters and followers. How should these differences be incorporated in a European timeline? The

rate at which countries can implement new innovations also depends on the type of technologies that are currently implemented and when these need to be renewed. Implementing a new technology when the legacy systems have to be replaced anyway is relatively easy and cheap. However, a road operator may think twice about implementing a new system when the currently implemented system is relatively new still.

In the coming year the EU EIP team working on the LIT will work on how to address these challenges so that a European LIT can be developed that can help facilitate discussions, provide support for policy and decision makers and can be used as input for other European traffic management road maps. The Leading Innovation Timeline will be publicly accessible via the EU ITS Platform website[2]. Practitioners and academics from across Europe are welcome to use the LIT and/or to provide feedback. People interested to organise a workshop on this subject are welcome to contact the authors of this paper.

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[2] This document will be available at the European ITS Platform (EU EIP) website: https://www.its-platform.eu