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Authors: J. de Haan, J.L.M. Vrancken, Z. Lukszo

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WHY IS INTELLIGENT TECHNOLOGY ALONE NOT AN INTELLIGENT SOLUTION?

J. de Haan[1], J.L.M. Vrancken[2] and Z. Lukszo[3]

[1] Corresponding author
Centre for Water Sensitive Cities
Monash University
Building 11, Clayton Campus
Clayton (VIC)
Melbourne, Australia
j.dehaan@monash.edu
T: +61(0)399052616
F: +61(0)399052948

[2] Delft University of Technology
Faculty of Technology, Policy, and Management
Section of Information & Communication Technology
Jaffalaan 5, PO Box 5015
2600 GA Delft
the Netherlands
j.l.m.vrancken@tudelft.nl
T: +31(0)152781566
F: +31(0)152783741

[3] Delft University of Technology
Faculty of Technology, Policy, and Management
Section Energy & Industry
Jaffalaan 5, PO Box 5015
2600 GA Delft
the Netherlands
z.lukszo@tudelft.nl
T: +31(0)152781147
F: +31(0)152783422

Abstract

This article investigates how *intelligence* can contribute to the flexibility of infrastructures. Intelligent solutions, here, are ways to optimise the capacity, efficiency, safety, sustainability &tcetera. of an infrastructure system, typically by means of ICT-based information processing. For this, three cases are presented of implementations of intelligent solutions. Viewing the infrastructure as part of a constellation, serving to fulfil a societal need, the problems encountered in these cases are found to be of a similar nature. It is found that intelligent technology in itself is not enough for an intelligent solution, the users and operators need to be involved in a learning process, and the institutions will need to be changed as well. Consequently, the design should not focus on the intelligent infrastructure alone, not only on the end goal, but rather the transition phase itself should be designed carefully, with much attention for intermediate and hybrid stages where sometimes the flexibility gained from the intelligent solution can already be put to use.

1. Introduction: Flexibility and Intelligence

If flexibility is some ability of an infrastructure to move along with changing circumstances or demands, couldn't flexibility be gained when the infrastructure knows better what the circumstances are and could act smartly accordingly? In other words, would adding intelligence to them, make infrastructures more flexible and thus more future proof?

Some scholars argue that information processing might only optimise the functioning of current infrastructures [1], and therefore potentially lock-in the current persistent problems further, others plead that ICT might lead to a greater sense of well being in urban environments [2]. In fact this debate could easily be transposed to all approaches that would make an infrastructure or otherwise technological solution more flexible.

Although it is important to consider the dangers of potential lock-in into an intrinsically unsustainable infrastructure, it is at the same time worthwhile to investigate the opportunities intelligent solutions could offer to existing infrastructures in making them more flexible. This is what is done in the remainder of this article and especially the implementation phase is addressed with the aim to draw lessons for future implementations. However, first some matters of definition and framing are discussed.

1.1 Flexibility

Flexibility is understood in this article as the *intrinsic* ability of an infrastructure-constellation to change its functioning when the circumstances deem necessary. *Intrinsic* means here that the system does not require significant alterations of its architecture to be able to continue satisfying a societal need. The notion of flexibility refers also to the ability to deal with *unknown* changes in circumstances. That is, flexibility can be seen as an ability to deal with uncertainty. In other words, flexibility is a *property* of an infrastructure constellation and not a *solution* to a problem in itself. This in turn implies, that several types of solutions can exist that contribute to the flexibility of a system.

- Over dimensioning, multi functionality, &cetera. See for the conceptual distinction between these robustness-like solutions and flexibility [3].
- Real options, for instance in building new infrastructures building it such that it is prepared for future expansions, that not necessarily will take place. See, for example [4].
- Modularity, for example the introduction of standardised dimensions so that components can be used in different countries, and expansions can easily be realised. See [5] for more on standards.
- Intelligence.

1.2 Intelligence

In this article, the focus will be on *intelligent* solutions for the flexibility of infrastructures. What intelligence *is*, when referring to infrastructures, is not immediately clear. In this article, when is spoken of an intelligence in the context of infrastructures, roughly the conception of Lukszo and Weijnen [6] is intended. They speak of "(...)methods and tools for the operation of existing infrastructures, deploying advanced information, communication and control technologies and systems."

1.3 Circumstances

Flexible to what? An intelligent solution to what problems? To adequately discus flexibility and intelligence of infrastructures, both need to be studied as part of a broader societal constellation. An infrastructure is the tangible aspect of a constellation that serves to fulfil some societal need, like energy, transportation, etc. To this end an infrastructure is complemented by an institutional structure arranging the way the infrastructure is operated, controlled, and functioning (see [7] for more on constellations).

Assuming that an infrastructure functions well, that is, it meets the societal needs to a satisfactory extent, what are circumstances that might necessitate flexibility? Since it is all about meeting the societal need, two directions appear possible whence such change might come.

1. The societal need might change. For example, demand increases or preferences change.

2. The environment, enveloping the constellation, might change. E.g. resources become depleted or the international setting imposes limitations.

In the first case it is also important to realise that meeting a societal need also entails perception. Not only does it matter if the infrastructure has the demanded capacity, e.g. can enough people travel at the same time, or is the energy supply constantly secured, also it matters whether the infrastructure has legitimacy, e.g. in the sense that it is a sustainable form of transport or that the energy supply does not come with a dependency on foreign countries.

2. Further conceptualisation and intelligent solutions

As mentioned before, infrastructures will be considered here as part of a larger constellation, serving to fulfil some societal need. This implies that the physical networks, the nuts and bolts, so to speak, are only part of the story. The physical infrastructure needs people to operate it and this entails that there is also an institutional structure in play [8]. The constellation therefore, consists of the infrastructure, complemented with the institutional structure. The constellation can then be said, not only to function, but also to *have* a societal functioning, see Figure 1.

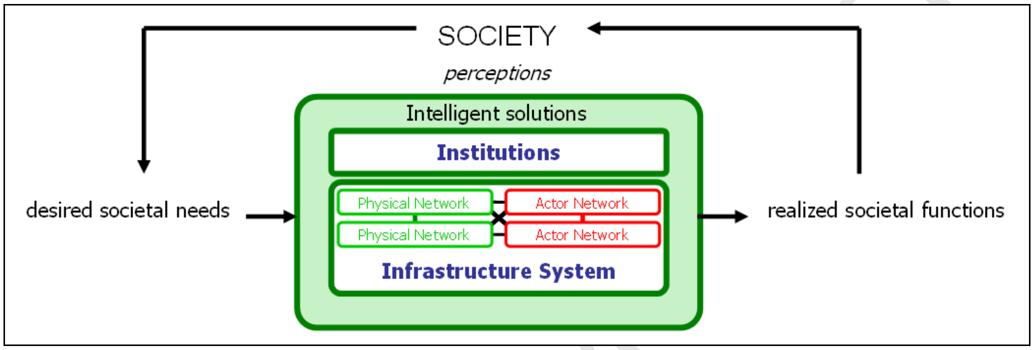

Figure 1: Infrastructure system for realization of societal needs

As the conception of infrastructure intelligence in Lukszo and Weijnen's [6] definition already suggests with their speaking of "for (...) *existing* infrastructures," (emphasis added) the intelligent solutions is an addition to the infrastructure constellation. In Figure 1, the addition that an intelligent solution entails, would shift the balance between the *functioning* of the system, the *societal need*, and the *environment*. Obviously, when the intelligent solution is any good, the new balance is more desirable than the old one, for example by being more *flexible*.

2.1 Intelligent solutions

Typically, an intelligent solution is a technical one. The physical infrastructure is supplemented with a facility that allows it, for example, to tune its capacity to the demand, or dynamically take safety measures when a dangerous situation arises. Such facilities can consist of ingenuous mechanical structures or advanced ICT control. In this way intelligent solutions can add to the flexibility of infrastructures, they allow them to alter their 'mode of operation', while operating.

Whether an intelligent solution is a *good* solution, that is to say, whether it is truly an intelligent solution, is another matter. Apparently, if the intelligence is a solution, then there was a situation where there was a problem. This could be that the societal demand was not met, or not in sufficient extent. It could also be that the environment suffered from the functioning of the infrastructure, where environment is to be taken in the broad sense as all that is not part of the infrastructure constellation or those making use of it. It can also be that the societal demand is met in an objective, measurable sense, but doing so in a way that is not condoned by society. For example by making it dependent on certain foreign nations, finite resources, or in that it induces some social injustice. It might also be the case that the solution functions well but is perceived as dangerous or that the solution is undesired because the there was no way to influence its choice or implementation. Matters of legitimacy, public values, and perception.

2.2 Outline of this article

In the following, a number of cases will be presented where an intelligent solution has been implemented for infrastructure flexibility. These cases will be described in terms of the conceptualisation put forward in the previous by addressing the societal needs and how the solution was implemented in the infrastructure constellation and how that impacted the physical networks, as well as the actors and the institutions involved. After the cases, a discussion will follow on:

- Whether and how intelligent solutions contribute to infrastructure flexibility
- Wherein the typical difficulties lie when implementing and intelligent solution

This discussion is subsequently cast in the form of recommendations for the implementation and the transition phase towards an intelligent infrastructure. These recommendations are illustrated with a case of an ambitious intelligent solution to be implemented in the Dutch road-transport system: dynamical road-uses charging.

3. CASES

3.1 Case 1: ERTMS - the European Rail Traffic Management System

Infrastructure constellation	European rail transport system.	
Societal need	Transport of people and good in and among European countries.	
Problem addressed	Incompatible safety systems strongly limiting the flexibility of trains regarding international movements.	
Intelligent solution	A European safety standard with various levels depending on the actual technical implementations of the standard.	
	Description	*Changes through implementation*
Physical network	Trains, tracks, signals, GSM-R (GSM for trains)	Communication system among the trains
Actor network	European member states, railway companies, ground personnel, engine drivers	New actors: producers of technical components, EU.
Institutions	Incumbent safety systems, “block-based” safety.	ERTMS, “block” as well as communication based safety.

Table 1: The ERTMS case

Currently, train safety systems are country-specific, with some countries having even more than one system [9]. This causes a tremendous technical and logistical complexity. Trains can drive only on lines for which they happen to have the right system on board. Engine drivers can drive only on line for which they know and have enough experience with the pertinent safety system. For instance, the Thalys has no less than seven different safety systems on board, in order to be able to drive in 5 countries. With the advent of high speed trains that are intended for longer distances through more than one country, the need for a unified European safety system became more urgent. Around 1998, it was decided to develop a new safety standard, called ERTMS. This process still continues. Gradually, the system is being adopted by various countries, among which The Netherlands, France, Spain and Switzerland, especially on new lines.

The train safety system serves the purpose of preventing trains to come too close to each other, with the risk of collisions. The systems consist of a procedural and a technical component. Both components show great variability, but this was not successful and has been abandoned for the time being. It was then decided to develop a technical component capable of supporting most of the current procedural practices, hoping that in the long term, procedural practices would converge on a common, harmonised set. The extra complexity through this requirement was accepted and considered more feasible than first harmonizing procedures, which would anyway also require a harmonised technical component.

Development of the standard started, by a consortium of the train manufacturers, the companies that would also be the future implementers of the new standard. Development, however, suffered serious drawbacks because two factors had been underestimated [10-12]:

- the development of the standard was strongly dependent on the development and actual use of products implementing the standard. To further develop and improve the standard, practical experience with it was crucial, which could only be achieved by the lengthy process of implementing, installing, testing and using products based on the standard. Especially testing is usually a very time consuming process in the railway industry. Some countries, for instance, require testing during all 4 seasons, which means that the testing phase takes at least a year.
- the compatibility between different products implementing standard was not guaranteed by the standard alone, especially not if the products were made by different manufacturers. The compatibility could only be achieved by additional testing against products of other manufacturers. This means that compatibility is essentially an emerging property.

Because of the interdependence between the standard development and product development and use, a proliferation of different versions of the standard, as implemented in products has resulted. The official standard being immature and incomplete, one has to make decisions for the missing parts when developing a product. It is then not possible to wait till the decision is adopted and incorporated by the official standard that would take way too long. Only some of these decisions, which in different projects are often taken differently, will end up in the standard. In the long term, all these products will converge, as products are regularly updated and then follow the official standard as far possible, but this is a lengthy process.

Notwithstanding the underestimated difficulties in developing such a standard, the advantages are obvious, to the extent that many countries have railway projects based on ertms, even outside of Europe. Actually, China is currently the country with the highest ertms-adoption rate. The advantages are not only in compatibility and the more flexible use of rolling stock and lines, but also in improved safety and in higher line usage and train frequencies, not to mention the reduced complexity and the economies of scale that in the future will apply to ertms based lines and vehicles [13].

One distinct advantage of ERTMS is that evolution is built into the standard. To that end, the standard distinguishes three levels, which in the future may be extended to further levels. Level 1 is most similar to the traditional safety systems, with components in the line and signals outside, along the line. In level 2 the signals are moved into the cockpit and the operation becomes automatic, especially in emergency situations. Still the line is divided into fixed length blocks, with the rule that two trains are not allowed in adjacent blocks. In level 3 the fixed blocks are abandoned. The blocks are train-bound and speed dependent. This allows the most frequent and the densest traffic, while not jeopardizing safety. A procedure has been defined how a line and the trains on it can switch from one level to the next.

It should be stressed that intelligent solutions not only concern changes in the physical system but also changes in the actor network and adjustments in the institutions. Engine drivers, ground staff as well as control-room operators have to work differently. Moreover, institutional harmonization of the safety standards should be realized, too. This shows that many factors, both technical and socio-institutional in nature should be combined to turn a serious challenge of one European train safety system into a great success satisfying social needs of lower costs, better utilization of an infrastructure and less complex logistics. Especially at level 3, it becomes clear that the intelligent, software-based solution offers more flexibility than the largely mechanical safety systems currently in use and allows a very gradual transition from the traditional systems to ERTMS level 3 and beyond. In the long run, the system may have fundamental institutional consequences, as a Europe-wide harmonized system (technically and procedurally) allows train management at a European level.

3.2 Case 2: Truck tolling in Germany, the LKW-Maut system

Infrastructure constellation	German goods road transport system.
Societal need	Transport of goods by trucks in Germany.
Problem addressed	Toll system without regard to actual road use.
Intelligent solution	IT and GPS-based system, monitoring the amount and region of driving done.

	Description	*Changes through implementation*
Physical network	Roads, trucks.	Communication system among the trains
Actor network	Truck drivers, German state.	New actors: manufacturers of the OBU's.
Institutions	Regulations concerning the Eurovignet.	New use-based tariffs.

Table 2: The truck tolling in Germany case

Truck tolling has been introduced in a number of European countries, among which Germany, during the nineties. It consists of a paper document that should always be present in a truck heavier than 12 tones using motorways. Obviously this system is not very flexible, in that it does not take the amount of driving in a certain country into account, or the routes a truck takes. In 2001, Germany decided to replace the system by an IT and GPS-based system [14, 15].

The development was a near disaster, for various reasons. After the failure of the first attempt at introduction in August 2003, the system had to be redeveloped, to be finally taken into operation in 2005 in a stepwise fashion and with several additional measures to make the transition easier. However, the old system had been abolished at the first unsuccessful introduction, so Germany missed some 3,5 billion euro's in toll income, causing a serious problem for the financing of road maintenance and extension in Germany. Causes of the initial failure included a lack of even very basic systems engineering knowledge with the governmental commissioners. Elementary mistakes, such as abolishing the old system before the introduction of the new system, and not paying adequate attention to the transition, were the result of this. On the other hand, the selected consortium failed to inform the commissioners in time of the problems they faced, most likely out of fear of losing the assignment or of other legal consequences.

The new system measures, by means of GPS in an OBU (on board unit) the actual distance a truck covers in a given time period. In this way, the amount of toll to be paid, depends directly on the actual use of the motorway network and can be further differentiated for heavily congested areas or areas where truck traffic has an extra negative effect on liveability for the local population. It is obvious that the flexibility of this system is of a totally different order than the paper-based Eurovignet.

Therefore, the system addresses adequately the societal needs of a fairer way of paying tax that is, paying in proportion to the amount of use. Examples of other needs, some of which became more urgent after the introduction of the system, are that trucks can be charged more if they pollute more, and routes with a liveability penalty can be made more expensive.

It is obvious that, in this case, the flexibility that the system in principle offers could have easily been applied for the transition problem. The paper system and the new system could easily have coexisted. Pricing could have made the electronic system more attractive for part of the target group, making it possible to test the system in real life on a small group, without the risk of tax income deficit.

3.3 Case 3: The OV-chipkaart

Infrastructure constellation	Dutch public transport system.	
Societal need	Public transportation in the Netherlands.	
Problem addressed	Simplification of payment for transport. Reduction of fare dodging. Paying for distance travelled, rather than number of 'zones' traversed. Synchronising payment system for rail travel with other public transportation.	
Intelligent solution	Traveller uses an RFID card which, through checking in and out, keeps track of the trip made. The card is also a debit card of sorts, and upon checking out the appropriate amount is subtracted unless the card has been 'charged' with a season ticket.	
	Description	*Changes through implementation*
Physical network	The public transportation network itself, trams, busses, metro's, trains, & cetera.	Installation of access ports, card readers, machines for recharging the cards.
Actor network	Public transportation companies, travellers.	New actors: TLS (Trans Link Systems), union of most public transportation companies dedicated to the implementation of the card; East-West E-ticketing B.V., consortium serving as the contractor for the central system.
Institutions	Use of the paper *strippenkaart*, season tickets, and train tickets. Payment often per *zone*.	Payment (excepting season tickets, and such) on the basis of distance travelled.

Table 3: The OV-chipkaart case

The OV-chipkaart is the Dutch name for a Public Transport electronic card. Currently, the Netherlands is in the middle of the process of gradually introducing the card [16].

The idea behind the card is that paying for your trip in public transport (PT) is greatly simplified, while the tariffs applied are far more flexible and can depend on time, place and mode and quality of transport. The PT system is considered as a whole in which trips can be made using a variety of transport modes such as train, bus, tram, and metro. A traveller checks in entering the PT system and checks out upon leaving it. Travellers do not need to buy separate tickets for the different modes of PT they use during a trip. This wasn't necessary within the old system either, except for train travels. Actually, they do not need to buy tickets at all. The system is implemented with an RFID-based card, the MIFARE card, already in use in several countries as a payment system for PT and for controlling access to buildings.

The system is implemented by Trans Link Systems, a union of most public transportation companies, especially created for this. East-West E-ticketing B.V., consortium serves as the contractor for the central system. The card can be charged with a certain amount of money, which is decreased with the trip fare at the end of each trip, or with a season ticket. Checking in and checking out is done by holding the card before a reader.

Current perception of the card is rather positive. The public is gradually getting used to it and appreciates the ease of use. Nevertheless the introduction of the card is an exceedingly complex and risky process, for a number of reasons.

First of the all, the payment system that it replaces is very complex, and in principle, the card is supposed to offer the same or more functionality, such as reduction for season tickets, groups, trips avoiding rush hours, the elderly, children, etc.

Secondly, the introduction is necessarily very gradual, both for the transport systems and for the passengers. Not all transport modes already support the card and those that do support it, have to continue to support the old payment systems for a while as well. Often, the card requires extensive infrastructural measures, such as card controlled access gates, to make it usable. This makes that currently the ideal of checking in and checking out once per trip is still the exception rather than the rule when a traveller uses more than one transport system.

A third major problem with the card is the security and privacy [17]. In principle, the security system of the card has been broken and travelling for free is possible. To what extent this will take place in the future is hard to say, but it is a very serious risk. Apart from breaking the security of the card, there are also ways to avoid paying or to pay less by using several cards per traveller. In addition to avoiding payments, the privacy of travellers is at risk. It is possible to tamper with card readers and get access to data on cards of passengers checking in or out. It is possible to find out who is travelling where by people who are in no way entitled to know this. The security and privacy issue may necessitate a major technical overhaul of the system, which may be a very expensive operation. On the other hand, it should be observed that the public, on average, has a positive perception of the card, even though at this stage only part of the advantages has been realized. The concept behind the card can be considered as sound, the biggest hurdle, achieving a positive perception of the card by the public, has more or less been cleared. It is just the complexity of the transition that causes most of the current transitory problems with the card.

A fourth issue is that of the one-use tickets that also contain an RFID chip that is, with the ticket, thrown away after use, which is a waste of material. A not entirely negligible problem, considering the number of one-use ticket that are used each day and the increasing scarcity of rare-earth metals in the chips.

The card serves the need of ease of use and less waiting time for passengers. For the PT operators, it will, when fully introduced, replace the current expensive machinery and organization to sell tickets, and it will collect data about travelling patterns. It will be, and already is fairly effective against fare dodging. In addition, changes in the tariff system will be far easier to introduce. The flexibility of this intelligent system has been applied to some extent to the transition problem. There are cases where the access gates, that are supposed to be operated with the card, could also be operated with the *strippenkaart*.

However, despite the advantages of the system of Public Transport electronic cards, there exists a number of serious issues which still needs to be addressed in the transition period in order to achieve desired final system goals related to privacy, security, and sustainability.

4. Findings and recommendations

In this article the implementation of intelligent solutions in infrastructure constellations was studied on three cases using the simple framework of Figure 1. Although flexibility is a highly desirable quality for an infrastructure, it is often not the reason an intelligent solution is implemented. Often, reasons of efficient use of capacity or additional functionality is the main reason to add intelligence. This might be the reason why the flexibility that an infrastructure gains from intelligence is not used to overcome the problems that accompany these apparently nontrivial implementations – more on this later.

The framework of Figure 1 viewed infrastructures necessarily as part of a constellation fulfilling a societal need. This involved taking into account that an infrastructure is accompanied by actors using and operating it, and an institutional setting that sets the rules of the game. None of the implementations discussed in the cases were without problems, and with a constellation view on infrastructures one could readily see that the problems had the same traits. In short, an intelligent solution was viewed as the implementation of intelligent technology. Implementation of technology is not often a trivial matter, especially when intelligence is involved. Necessarily the users and the operators of the infrastructure need go through a process of learning and getting-used-to. Moreover, the intelligent infrastructure is in some respects a *new* infrastructure which implies that the accompanying institutional setting needs to be renewed as well. That this takes time, more time than the deployment of the new apparatuses alone, might seem the all-too-simple conclusion, it is nevertheless the relevant one. For these cases and this article this boils down to these two interrelated points:

- Intelligent technology in itself is not enough for an intelligent solution, the users and operators need to be involved in a learning process, and the institutions will need to be changed as well.
- The design should not focus on the intelligent infrastructure alone, not only on the end goal, but rather the transition phase itself should be designed carefully, with much attention for intermediate and hybrid stages where the flexibility gained from the intelligent solution could already be put to use.

In the remainder of this article these findings will be elaborated more into recommendations, illustrated with a case of intelligence still to be implemented.

4.1 Elaboration of findings, and recommendations

Intelligent solutions offer fundamentally greater flexibility: information in an IT-environment is essentially easier to change, to produce in large numbers and to distribute than paper-based or mechanical components. This intrinsic ability to change and thereby to better respond to unforeseen changes in societal needs or changes in the environment is what makes intelligent components in infrastructures highly attractive. However, as mentioned, the introduction of intelligent components comes with a number of typical challenges that one should be sharply aware of and which have to be given adequate attention in the process of development and deployment:

- The proper level of ambition: an intelligent solution is necessarily a big and ambitious step forward. The risks of too low a level of ambition are that the solution will fall short of the users' and the public's expectations, that one will get out of sync with technology and developments in the environment, that it creates a vulnerability to competing, more innovative, solutions and that one will miss out on potential benefits and cost reductions. On the other hand, an adequate level of ambition implies a step into uncharted territory, with undeniably serious levels of risk.
- The shift towards intelligence still requires the deployment of physical components. So an intelligent solution is not entirely immune to the disadvantages of physical components. The difference is just that such components can, in principle, be far more generally applicable than paper or mechanical components.
- Because an intelligent solution is a big step forward, there is a big transition problem, which in practice is often aggravated by being underestimated. The transition period is often the most complex phase of the development and introduction of an intelligent solution as typically one has to cope with two systems, the old one and the new one, and with the interactions between the two. The tendency to give it inadequate attention stems from the fact that transitions are, by definition, temporary. Any investment of time and resources in the transition will be profitable only for a limited period. As a rule, the human actors involved constitute the biggest challenge in the transition: users have to get acquainted with the new system, operators have to learn to apply and manage the new system, policy makers have to get used to the policy implications of the new system, which after roll-out will often be different, to some extent, from the intended implications during design.
- Intelligent solutions require specialized knowledge. The multi-disciplinarity of an infrastructure project that aims at an intelligent solution, is a bigger challenge than in the case of traditional solutions. The knowledge problem is a major driver behind PPP-approaches in intelligent solutions.
- Intelligent solutions are less transparent for users. They can collect and transmit data about users silently and without users or operators noticing this. Privacy and security are harder to handle in an intelligent solution, and especially, it is harder to make these properties transparent to users.

The main recommendation here is that one should harness the flexibility of the envisaged intelligent solution to meet these challenges. Practice shows that this is still often under-utilised and that transitions are not handled adequately. Humanity is still in the middle of the learning process of applying intelligent solutions. More specifically, the following recommendations may be relevant:

- Make the new solution compatible with the old one. Make sure that the two, if not fully interoperable, can at least exist and be used simultaneously.
- Stepwise introductions are often easier and less risky than big-bang, full-scale, all-at-once introductions. There are many ways to make the introduction a stepwise process: in functionality, in geographic coverage, in target groups, etc. Stepwise may seem to entail more overhead, but in practice, this is little in comparison with the overhead caused by a failure in a big-bang introduction. A distinct advantage of stepwise introduction is that it leads to a smoother, more gradual learning process for all parties involved. This holds in particular for the citizens, if they are involved.
- A practical way to address the problem of finding the proper level of ambition, is to be found in the design of a stepwise introduction. Such an introduction also offers a way to find out what level of ambition is feasible. Each further step is also a step in ambition. So start with a pretty high level of ambition, as final goal to be achieved years into the future, but spend adequate time on the design of the transition phase, i.e. on the stepwise introduction of the envisaged solution, such that the proper level of ambition is an automatic outcome of the process.

These recommendations will now be illustrated with the case of the Dutch system for Road-User Charging.

4.2 Road-User Charging in the Netherlands

Infrastructure constellation	Dutch road transport system.	
Societal need	Road transport in the Netherlands	
Problem addressed	Congestion problems, need for different taxation system in general.	
Intelligent solution	OBU's monitoring and registering via GPS the actual road use. Taxation accordingly.	
	Description	*Changes through implementation*
Physical network	Road network, cars.	OBU's in the cars, the GPS.
Actor network	Drivers, the Ministry of Transport, Public Works and Water Management.	New actors: certified car-service stations (to install the OBU's).
Institutions	Rules and regulations for road use taxation per vehicle, according to its weight and age.	New taxation based on road use, new institutions processing the information gathered by the OBU's.

Table 4: The road-user charging in the Netherlands case

Since 1988, some five attempts have been made in the Netherlands towards the introduction of some form of road user charging [18]. Each attempt saw an increase in level of ambition and sophistication, both technically and organizationally, but as yet none of these attempts got beyond the planning or early testing phase. Currently, the sixth attempt is under way, with deployment being projected somewhere in the period 2012 through 2016. This time the plan is to make all drivers in the Netherlands pay per kilometre on all roads, by means of an OBU (on-board unit) that registers road type and distance covered using GPS positioning. Tariffs can be differentiated for the level of congestion of a road, time of day, rate of pollution of the vehicle and possibly other factors. The main goal of the system is twofold: a fairer way of paying road-related taxes (pay in proportion to use of the road) and reducing congestion by reducing demand for road capacity and by spreading demand over the day and over the network. Although many different systems of Road User Charging are in operation in many countries, the scale and sophistication of the Dutch envisaged system is unsurpassed. So, internationally, there is a great deal of attention for the Dutch endeavour.

This is clearly an intelligent solution for the management of the road network infrastructure. It is information based and flexible because new versions of the software and new data (such as new tariffs) can be distributed to the OBU's easily and regularly. But it also faces a number of the challenges often seen in intelligent solutions:

- There is uncertainty about the effectiveness for the congestion reduction goal. For this goal, the system is certainly the first attempt at this scale, so there is simply no prior experience with price-based traffic management at this scale. There is a risk that the traffic demand will continue to grow and, after a while, will annihilate any initial reduction of congestion by the system. Tariffs cannot be increased indefinitely, because of political constraints on the system (see below).
- There is much political attention for the system, as it will affect nearly every citizen (even those without a car), but certainly no stable, unanimous support for it. Actually, the system is regularly an object in political negotiations between parties. The uncertainties in the system are often politically countered by making support dependent on requirements of which the feasibility is far from clear, such as: exploitation costs may not go beyond 5 % of the total income of the system, or: tariffs should be such that revenues from the system do no exceed current revenues from road- and vehicle-related taxes.
- The logistics of installing the OBU's in some 9 million vehicles, by certified car service stations (in order to comply with security requirements) is an as yet unsolved problem.
- When in operation, the burden of complaints about the system on the legal institutions, is considered a very serious risk.
- The technical complexity of the system, especially the OBU's, may seem limited, as similar OBU's are already in operation elsewhere, but still, the process of development and deployment has to be guided by a ministry which has no track record in this kind of systems, apart from the above-mentioned previous

unsuccessful attempts. PPP (public private partnerships) will be necessary for development, deployment and exploitation, for various reasons, among other things, for supplementing the necessary technological and logistical knowledge required in the project. The ministry then has to safeguard the state's and the citizen's interests while having serious knowledge arrears on technological and logistical matters.

- The different components of the system and its users (boxes, law, organizations, citizens) have different rates of change. Technological components can change relatively quickly, while law components change far slower. This makes it hard to keep all components and users in sync.
- The European embedding of the Dutch system is both challenging and necessary. Dutch cars go abroad and foreign cars enter the Netherlands. When other European countries introduce similar systems, it would be nice if one needs only one OBU in order to be able to drive in all those countries. The ERTMS case showed that interoperability requires a standard, whose development however depends on live products. On the other hand, the standard will not guarantee interoperability, which can only be achieved as the result of testing existing products. This means that there will be a proliferation of different OBU's in different countries. The outcome of this lengthy process may very well be that the ultimate European standard will be based on some other (read: bigger) country's system, making the Dutch system short lived.
- Finally, various other developments in road traffic may have adverse consequences. Currently, road traffic is in the middle of a transition from a shortage of information to an overload of information. The large scale deployment of navigators in vehicles and PDA's in the driver's pockets, together with broadband, wireless communications (such as UMTS and its successors) will have far reaching consequences for traffic, as companies, such as Google, Apple, Nokia and TomTom consider the road user as an important target group and they do have a track record in successful, often worldwide, changes in relatively short periods of time. The exact consequences of this development for road traffic and the congestion problem are as yet unknown but they may very well be adverse for the envisaged RUC system. For instance, the congestion problem, as it is today, may very well disappear or change in character (become far less predictable and dispersed differently over the network) when travellers receive adequate information before and during their trip and their information processing platforms can apply sophisticated algorithms for congestion avoidance.

In the approach followed until now by the Dutch ministry, some of the recommendations given above, can be recognized. But especially the possibilities for gradual introduction still seem to be underutilized [19]. This system's introduction can be done stepwise in various aspects: functionality, geographic coverage, at first voluntary, target groups, and so on. Starting with voluntary introduction is a way to make old and new coexist. The stepwise introduction offers a solution, or at least greatly alleviates, the logistics, the knowledge and the different rates of change problem. It reduces uncertainty about the effectiveness and the European embedding. And this way of introduction buys time, while still making progress, for the uncertainties about the ultimate European standard, the political positions of parties and the changes in traffic characteristics caused by consumer electronics. It is essentially different from simply waiting, as just waiting has no learning effect and does not strengthen one's position in the European debate about road pricing. Still, with the gradual stepwise introduction, the investments and possible losses remain limited.

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