Foresight in ICT innovation: driving the new policy mix

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Theme 3: FTA in Research and Innovation

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ICT has become increasingly important in information society (IST) policy and innovation policy at European and national levels, as ICT has become deeply interwoven with many social and economic activities. However, IST and innovation policy have become increasingly complex, involving many different actors, stakeholders and domains. Key policy challenges are therefore the selection of instruments, establishing cooperation across policy domains, policy coherence and impact assessment (Poel and Kool, 2008). The objective of this paper is to explore how foresight exercises can support policy makers in defining the appropriate selection of policy instruments, i.e. the policy mix, in different societal domains. We propose to use a holistic approach in which prospective methods are combined with impact assessment in order to improve the policy mix.

1. Introduction
The enabling characteristics of Information and Communication Technologies (ICTs) become ever more visible in the various domains in which ICT is implemented. ICTs continue to impact upon various societal domains and contribute to sometimes rather radical changes in the internal dynamics of these domains. ICTs themselves are subject to turbulent changes as well. The basic physical component of ICTs being the chip, ICTs today relate to complicated systems and infrastructures, that can have physical, informational and virtual components and refer to hardware, software and orgware alike. From the old main frames, realised fifty years ago, ICTs now move in the direction of ambient, wireless, intelligent technologies and start
increasingly to converge with biotechnology, nanotechnology and cognitive systems\(^1\). These developments are science and technology driven and they will foster tomorrow's systems. Looking at the societal and business implications of ICT today, one can perceive major disruptions in several domains as well, be it the development of mobile technologies or the emergence of decentralized intelligent energy systems. Though these disruptions seem to emerge from the technology base of ICT it is argued that it are especially the disruptive consequences of ICT on business models and innovation processes which turn ICT in a technology to be aware of (Christensen, 2003). Getting an early view on potential disruptive innovations may contribute to the realisation of the promises of the so-called 'second' phase of the ICT paradigm we experience today (Perez, 2002). Carlota Perez identified this present, second phase of ICT as the potential 'golden' phase in which the economy and the society can profit in unforeseen ways of the new opportunities offered by ICT. These new opportunities do not arise from new technological developments but are the result of a purposeful and well-thought implementation of ICT in existing structures, cultures and institutions in various domains (health, education, energy, transport.). This requires a process of 'creative destruction' of old institutions and a process of societal engineering.

ICT has as such created many challenges for firms, citizens and governments. Examples of such challenges are globalisation, international competition, privacy, changes in skills and in labour markets, and reliability on ICT and energy resources (Poel and Kool, 2008). At the same time, ICT can be used to address societal challenges, e.g. in mobility, energy efficiency and education. Governments can influence this process with a number of policy instruments. Policy is one element of the socio-institutional framework that interacts with the new techno-economic context (Poel and Kool, 2008). However, to be able to (re)design policy instruments requires a deep understanding of societal challenges, causes, mechanisms, drivers and barriers. Furthermore, societal challenges, innovation and ICT cut across many different societal domains. This complicates matters for policy makers, as they are traditionally organised in different ministries, each with a demarcated domain in which it can act (silos). This results in often compartmentalized policy actions, which sometimes overlap, and sometimes even hinder each other. In this paper, we argue for a holistic approach to overcome

this problem, in which prospective methods and impact assessments methods are combined in order to improve the policy mix.

Both foresight and impact assessment have become ‘mainstream’ in policy making, both within Europe and nationally. Impact assessment is seen as an instrument to increase the understanding about developments taking place and as an opportunity to better attune a broad range of policy instruments to the desired policy objectives. The focus is on the impact of policy. Getting a better understanding of these developments, their future consequences and to prioritise policy actions also requires the use of prospective instruments. These come in many forms and shapes as well.\(^2\) The focus is on the impact of (new) technologies and societal trends. The forward looking approach may help to identify weak signals that over time could turn into developments with profound consequences for existing market structures and societal uses of ICT (and other technologies). For a proper identification of such developments one needs a clear view on developments related to ICT and on the internal dynamics of the domain under study (health, education, mobility, etc.)

Foresight thus almost always considers a multidisciplinary approach in which a combined perspective on ICT developments and domain specific developments is needed. This multidisciplinary approach is visible in a multi-year project we are running at present within TNO. The project is labelled the Innovation Outlook, and it should help us in identifying weak signals of developments that might have sincere consequences within a number of years in terms of societal, economic and sustainability impact.

During 2007 we have developed an on-line Delphi instrument as part of the final toolbox for the Innovation Outlook. We have elaborated and tested the Delphi instrument in a specific case, namely in studying the impact of ICT on mobility patterns of people and goods. ICT is both a driver for new mobility patterns, for instance because virtual contacts lead to the desire for physical contacts as well, and a means to lower mobility needs, for instance by using videoconferencing as substitute for physical meetings. It is also a driver for changing existing mobility patterns, for instance in case of teleshopping where ICT help to virtually buy goods while the delivery process is transformed as well (instead of individuals carrying their goods homewards logistic centres take care of the distribution of goods to households).

This paper focuses on the results of the case study we have performed on ICT and mobility. We will elaborate our findings by discussing the policy implications of the results we have found. What policy mix should be considered in order to mitigate negative consequences of the results we found and to foster positive consequences? What issues fall outside the scope of policy makers today due to a limited understanding of the role and effects of specific policy instruments?

We will start with a presentation of the main findings of the Foresight study on ICT and mobility (Section 2 and 3). In Section 4 we will outline the elements of the holistic approach to improve the appropriate policy mix and discuss how Foresight research and impact assessment can mutually benefit from each other, and how a specific combination should – in this case – lead to a more inclusive, sustainable Information Society (Section 4). In Section 5 we will illustrate our approach by presenting the main findings of a study we did on improving the policy mix for sustainable mobility in the Netherlands. We will highlight those elements that are important for an understanding of the use of policy instruments in furthering sustainable ICT related transport.

2. ICT and mobility

Physical mobility increasingly poses problems to modern societies. Auto-mobility more and more becomes the dominant form of transport, notwithstanding the attempts of governments to promote alternative modes of transport such as trains, buses and bikes. Within the EU-27 passenger transport has grown less than GDP over the years 1995-2006 (1.7% viz. 2.4% annually) while in the same period good transport exceeds GDP growth (2.8% annually).\(^3\) Relative growth in public transport (bus, metro, train) has been substantially less than growth in passenger-kilometers by car over the same period (1.5% for car versus 0.3% for buses and coaches, 1.0% for trains and 1.4% for metro and tram), while in absolute terms transport by car is by far the most important contributor (4,602 billion passenger-kilometer for car in 2006 compared to 523 billion p-k for buses and coaches, 384 billion p-k for trains and only 84 billion p-k for metro and trams).\(^4\) The contribution of the transport sector to total CO2 emissions within the EU-27 is 21% (ranks second after energy sector with a contribution of

but while the energy sector has been able to cut down its total emissions by 47% over the period 1996-2006 the road transport sector has only been able to cut it down by a mere 3.7% (which should of course be compared with the total growth of 17.6% of road transport during the same period).

The introduction of ICT in traffic and transport and broader societal areas has various consequences on traffic and transport issues. Mobility patterns may change due to direct consequences of ICT (for instance: sensing systems in and around the car) and due to indirect consequences (for instance: travel information systems). Systems that do not relate to mobility as such may impact as well (indirectly) because they change the need for mobility (substitution or shift in modes and times of travel, such as e-shopping, telework and teleservices). The literature review points in the direction of a major impact of ICT in the traffic and transport system itself, especially by adding intelligence to the traffic and transport system. This enables systems to take over part of planning in advance of the trip, and coordination and control during the trip. It impacts on the driver as well as on the driver-vehicle system. Important issues to address are the reliability of the systems to be developed, the complexity of the traffic and transport system, the adoption by users of systems which take over control, and rebound effects that might reduce or annihilate the impact of introducing ICT to promote safer, more efficient and less polluting traffic and transport. The literature also points in the direction of a major indirect impact of ICT innovations on the traffic and transport system, by the on-going virtualisation of daily life, such as the substitution of traditional shopping by virtual shopping, traditional working by teleworking, traditional production facilities by virtual production and traditional leisure activities by virtual leisure activities. Hardly any human activity does not have a relationship with the need for mobility, be it physically or virtually. The direction of the impact is the summation of various impacts which point in various directions, sometimes improving the safety, efficiency and sustainability of the transport system, while in other situations deteriorating these.

We have organised the ‘spheres of influence’ in Figure 1. At the kernel of the figure the Intelligent Vehicle Highway Systems are situated. They encapsulate Advanced Driver Assistance Systems, Travel Information Systems, On Board Navigation Systems, In-car sensor technology, Infrastructure-Vehicle Communication. In the inner sphere, encompassing

this kernel, three traffic and transport related ICT-innovations can be found: logistics (Multimodal transport, Just in Time delivery and the role of RFID), ICT based services (traffic information systems and location based services) and policy issues (road pricing, sustainability/pollution, carsharing). The primary sphere is in turn encompassed by a circle of ICT technologies, especially broadband and the internet of things. The outer sphere comprises three perspectives as well, of which each perspective overlaps with two of the inner sphere perspectives. The three perspectives are: e-services which is by far the biggest of the perspective, encompassing milestones such as 3D body scanners, e-shopping, e-identification and profiling systems, teleservices, 3D printing and remote assistance services; the workplace, such as mobile teleworking, small office home office, and collaborative work systems; socio-economic developments, encompassing milestones such as 24/7 economy, locally produced goods and conversion of products to digital services.

Figure 1: Milestones defined for ICT and mobility
3. The Delphi study

The Delphi-study followed the methodology as elaborated by Linstone and Turoff (2002), Popper (2006) and Loveridge (2006). The on-line version introduces the opportunity to have several rounds of reflection by the experts in which experts may revise their statements, due to the presentation of the average scores per item which may show to deviate from their own findings. The evaluation showed that this aspect of Delphi has hardly been used. People showed not to re-evaluate their responses, even when invited to do so some weeks after their initial response. We invited over 400 persons to participate. The response was relatively low (35 persons, 8.7%). Though we did not survey the motives for non-participation, ex post evaluation showed the workload for the questionnaire to be considerably higher than we had expected at beforehand. This might explain the relatively low level of response. About half of the response came from Dutch respondents, the other half from international respondents outside the Netherlands. Due to the low number of respondents we can use the outcomes only as illustrations of trends. We checked the consistency of questions as well. Where appropriate, we will reflect upon this.

3.1 Results of the Delphi study

The issues that have been identified in section 2 have been elaborated in statements on each of 31 formulated milestones. Figure 2 presents an overview of the response on the different milestones, grouped along time of realisation and likeliness of realisation. The shaded blocks indicate the milestones which are considered to have high impact as well. These three dimensions (time of realisation, likeliness of realisation and expected impact) are the basic dimensions on which the milestones have been scored. At first glance one notices that most statements cluster along the 2014-2016 timeline, with most milestones around 2016. Only one milestone is considered to be realised already (on-board navigation system) and one milestone is considered to be realised in the long term (3D printing). With regard to 3D-printing, it is interesting to note that – notwithstanding the rather imaginative appeal of the technology – already today indications of this new technology pop up.5 This is, of course, far from 3D printing being commonplace in households for the acquisition of appliances, but it indicates that some technological innovations may come rather unforeseen and fast.

http://technology.newscientist.com/channel/tech/dn13207?promcode=nletter&DCMP=NLC-nletter&nsref=dn13207
Likelihood of appearance

Some other issues are considered to be rather unlikely, such as the 3D body-scanner, locally produced goods, e-ID for all online transactions, e-shopping profiles, and self-employment (the SOHO concept – small office-home office). The last three induce organisational and institutional innovations more than technological ones.

A broad class of innovations is considered to be rather likely (levels 4 and 5 in the figure). These innovations are a mix of technology based innovations (sensing infrastructures, new services in traffic information, internet of things), complemented with institutional and organisational innovation (shared transport means, road pricing, night delivery, 24/7 society).

The innovations most likely to be realised (the milestones in the upper part of the figure) have a sound technological basis. On board navigation systems have been successfully rolled out
since they could be bought as separate devices, not attached to the car itself. Travel
information systems, RFID, new services in traffic information, Location Based Services and
Advanced Driving Assistance Systems are in different stages of realisation but they share that
the underlying concepts are either studied in research activities and test pilots (ADAS, LBS)
or are already in some form available.

**Impact**

Seven milestones have an impact which is considerable (4.5 or higher on a seven point scale):
(Mobile) teleworking, Location Based Services, Road Pricing, High Speed fixed Internet
(Broadband), Multimodal transport, Sensor network infrastructure and self-employment
(SOHO). The impact need not be unidirectional which for instance the case of teleworking
shows. Rebound effects (such as home mates using the car instead of the original commuter)
may annihilate part of the positive contribution of teleworking to reducing congestion.
Nevertheless, the impact is considered high, just as with Self-employment. People working
from their own location have more flexibility in the choice when to travel. They can avoid the
daily rush hours. As such, widespread diffusion of SOHO-practices can contribute to a change
in mobility patterns.

Multimodal transport is another innovation which requires institutional and organisational
reforms. In the Delphi-survey, multimodal transport has been presented from the perspective
of the UN in which multimodal transport is carried out by one transport operator. Multimodal
transport requires the timing of different transport modalities (over water, rail or road) which
adds complexity to the logistic processes. Multimodal transport essentially means that freight
transport by road is transferred to another modality (rail or water). In combination with
improved eServices, the efficiency and quality of transport services may be improved, while
being more sustainable (rail and water instead of road transport). Though the impact may be
high, additional measures are needed to realise the full potential of Multimodal Transport.

Road pricing is expected to change mobility patterns. Confronted with time-space oriented
road pricing (different tariffs during the day, and depending on the roads taken), people will
start to calculate their best options. Lowering the number of cars on a road with a modest
percentage (10-15%) may have severe consequences on the removal of congestion. The
technological system behind road pricing has changed considerably over the past ten years,
from road-fixed towards GPS-based systems today. When the technology and the political
will to introduce road pricing will both stable enough, it has great potential in influencing mobility.

The consequences of Location Based Services are difficult to predict. One would expect LBS to have a mobility enhancing effect. By offering local information one can lower the threshold of driving into less known environments such as city centres. In combination with on-board navigation systems and traffic information services LBS enables a more efficient use of road infrastructure. While today's LBS do not sufficiently take into account issues such as road safety (having trucks move again through vulnerable small streets and kernels of small villages) negotiations between government and LBS manufacturers might improve this situation in the longer term.

Another milestone which is considered to have high impact is the availability of fixed high speed internet infrastructure. The Netherlands score high on the Eurobarometer concerning availability of high speed infrastructure, competition on the infrastructure and competitive prices per bandwidth offered. The availability of high speed internet enables the use of sophisticated equipment for online videoconferencing and meeting each other without the need to travel to far away places for a business meeting of a few hours. The technology behind video conferencing has been improved considerably over the past few years, such that it becomes attractive for firms to use it instead of travelling. Other eServices will be enabled as well.

Sensor network infrastructures will have as a side-effect that they enable interaction with drivers in situations which are considered difficult by these drivers. Examples relate to driving under difficult weather circumstances (fog, heavy rain fall, snow, strong winds), and driving in congested areas where information can be provided on desirable speed of driving or even taking over control on driving. In combination with intelligent Human Machine interfaces and Advanced Drivers Assistant Systems it will become possible to take over control from the driver and assist the driver in difficult traffic situations (crowded roads, difficult road turns, difficult to judge traffic situations, etc.). The prospects are that it will remain possible to participate to the road traffic even when your driving skills are not optimal anymore, for instance due to ageing. Technological advances are meant to improve safety, comfort and

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efficiency of driving, not to enforce a modal split (people taking the bus or the train instead of
the car, or using the rail for transport of goods).

3.2 Conclusions
From the perspective of policy (see next section) a number of issues are interesting to note.
First, technological progress is probably still the most reliable predictor of changes taking
place. That is to say, thinking about future applications based on technology is less difficult
than considering institutional or organisational innovations as well. The 'soft' side of
innovation may induce larger problems. Governments may play a role in this.

Second, though we did not deliberately intended to do so, much of the innovation actions
relate to car mobility. In itself it is not a strange situation given the predominance of the car in
today's mobility system. Some elements in the innovation scheme are more overarching
(travel information systems) or do not specifically address a mode of transport (eServices,
telework). But we did not isolate innovations which are specific for other than car modalities.
The institutional structure around the car-industry is however far less government oriented
than the other modalities. This poses interesting challenges for policy as well.

Third, to really arrive at reliable predictions, more flesh should be put to the bone of the
milestones than we have been possible to do in this illustrative Delphi example. As such, this
Delphi only paves the way for a better and more in-depth approach. The results can however
be used for the check with the kind of policy interventions that should be most fruitful.

4. Policy Mix: research approach

4.1 Introduction
The Delphi exercise aimed to examine the future impact of ICT innovations on sustainable
mobility patterns. The important findings of the Delphi are that the ‘soft side’ of ICT
innovations might induce large challenges for policy makers. ICT innovations with an indirect
effect on traffic and transport – such as new ways of working or e-shopping – do play an
important role in restructuring traffic and transport, just as the ICT innovations which are
directly related to traffic and transport (such as travel information systems or in-car
technology). However, most of the (European and national) attention in transport and ICT
policy is predominantly focused on direct impacts. For example, there is little attention for the
liberalization of opening hours of shops or extending possibilities for child care with respect to the mobility debate, although these will impact mobility patterns as well. It is therefore important that the focus of policy makers will shift to include the indirect impacts of ICT innovations – and subsequently – to include different issues, different actors, stakeholders in their policy making process and to adjust their policy instruments to these indirect impacts.

Furthermore, the scope of policy makers needs to be broadened to include policies that are not directly related to the traditional traffic and transport domain, but include policy instruments from the environmental, societal, economic, ICT and innovation policy domains. Such an approach requires increased cooperation between different ministries and coordination between policy making processes in different ministries, and the accompanying different political priorities (which might in some cases conflict with each other). A holistic impact assessment approach can help to identify which policy instruments in specific policy areas constitute the appropriate policy mix to address future challenges for a specific problem, in this case sustainable mobility, and show how the policy mix contributes to the political priorities of different policy domains involved. More specifically, the impact assessment identifies what challenges can be addressed by the responsible ministry itself, what challenges are influenced more directly by other ministries and for which is a need for cooperation. The research approach will be introduced below. Section 5 will present the results for the mobility case.

4.2 Research approach

The policy conclusions that are mentioned above – on the soft side of ICT innovation, the indirect impact of policy and the need for policy coordination – can be complemented by more detailed conclusions. To this end, the foresight exercise is linked to impact assessment. We have used five steps in what can be labelled an expert based case study method. This impact assessment method allows for an analysis of the policy mix rather than a single policy area (e.g. mobility policy) or a single policy instrument (e.g. a research programme or regulation). Furthermore, the method allows for exploring the mechanisms via which policy can have an impact on developments and actors, e.g. by reducing existing barriers and increasing existing drivers.

The first step is to describe the developments (or milestones) that have been identified as having the strongest impact: economic, social and/or environmental. What is causing these
developments, what are related developments (trends that reinforce one another), what are the drivers and barriers? This analysis can be based on the information that is gathered in the foresight exercise. The analysis can be done for high impact developments that are likely to appear. The analysis may also be done for high impact developments with that are less likely to appear. This depends on political priorities and practical considerations. For instance, a country or region may try to push very hard to stimulate developments that are not likely but that will have substantial positive impact.

The second step is to focus on drivers and barriers - e.g. technology trends, market failures and system failures - and to link the drivers and barriers to the existing policy mix. This can be done for each of the high impact developments. Expert based methods are most suited to link a specific driver or barrier to a policy area and existing policy instruments. Do existing policy instruments increase or reduce drivers and barriers? Note that the impact can be positive or negative (and small or substantial). A policy area refers to mobility policy, information society policy, innovation policy, energy policy, etc. Policy instruments refer to real interventions. In a previous study we have identified five types of policy instruments and a number of subtypes that are relevant for ICT related innovations (Table 1). A typology of policy instruments - especially if existing policy instruments are mentioned - can assist experts in linking drivers and barriers to policy instruments. Which existing instruments are most relevant? The analysis can be done for one policy level, e.g. national. To include different policy levels increases both the workload and the quality of the analysis, depending on the topic.

Table 1  Typology of policy instruments for ICT innovation (Poel and Kool, 2008)

<table>
<thead>
<tr>
<th>Government Provision</th>
<th>Financial instruments</th>
<th>Regulation</th>
<th>Information</th>
<th>Demand by public organisations</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1  By government institutes</td>
<td>F1  Tax incentives</td>
<td>R1  Laws and regulations</td>
<td>C1  Foresight and priority setting</td>
<td>D1  Demand aggregation for public organisations</td>
</tr>
<tr>
<td>G2  Dedicated public organisation</td>
<td>F2  Subsidies and grants</td>
<td>R2  Specific decisions, e.g. frequency allocation</td>
<td>C2  Provision of data and information, e.g. market data and best practices</td>
<td>D2  Procurement</td>
</tr>
<tr>
<td>G3  Public infrastructures and facilities</td>
<td>F3  Guarantees and loans</td>
<td>R3  Co-regulation</td>
<td>C3  Networks and platforms for information exchange and consensus building</td>
<td>D3  Other</td>
</tr>
<tr>
<td>G4  Public-private</td>
<td>F4  Investments,</td>
<td>R4  Self-regulation</td>
<td>C4  Advice</td>
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The third step is to discuss existing policy instruments that have been identified as having a negative impact, by means of increasing barriers or reducing drivers. How can the design and implementation of these policy instruments be improved? Or should they be replaced by new policy instruments? Or should they just be removed?

The fourth step is quite similar. Here, the focus is on drivers and barriers - for high impact developments - that are not yet influenced by policy. It can be explored whether (and which) policy instruments can add value - e.g. by reducing barriers - or whether government failures are more likely.

The fifth and final step is ‘embedded’ in each of the four other steps. Policy coordination is crucial. Different ministries or different Directorate Generals may have different pieces of the puzzle. Each of them can reinforce a number of drivers and reduce a number of barriers. Involvement in the entire process is crucial to agree on ambitions, actions to be taken and additional policy analysis to be launched.

The next Section will provide the results for ICT and mobility. To a large extent, the results are based on the foresight exercise. To some extent, experts at TNO made additional assessments, e.g. linking the main drivers and barriers to the existing policy mix.

5. How to improve the policy mix for sustainable mobility?

[This is a draft paper. The fifth and final Chapter will be available before the conference]
**Literature**


