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Impacts of ICTs on Transport and Mobility (ICTRANS)

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Impacts of ICTs on Transport and Mobility (ICTRANS)

Petra Wagner (ARC Seibersdorf research), David Banister (UCL), Karl Dreborg (FOI), E. Anders Eriksson (FOI), Dominic Stead (UCL), K. Matthias Weber (ARC Seibersdorf research)

Based on contributions by
Peter Zoche, Bernd Beckert, Martina Joisten (ISI-FhG),
Anique Hommels, René Kemp, Peter Peters, Theo Dunnewijk (MERIT)
Lucien Dantuma, Richard Hawkins, Carlos Montalvo (TNO-STB)

IPTS contributors:
Jean-Claude Burgelman, Panayotis Christidis, Paul Desruelle and Anto Geyer

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Technical Report EUR 21058 EN

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Background

Over the last years, high expectations have been expressed regarding the potential benefits that the widespread use of information and communication technologies (ICT) could have for reducing the growth in demand for transport and mobility services. Frequently, these expectations have had consequences for policymaking and priority setting, both in the transport and the information society technologies (IST) areas. Specifically in transport policy, the objective of achieving a decoupling of transport demand growth from economic growth has stimulated the interest in the potential of ICTs. Therefore, the potential of ICTs in relation to mobility is seen in its ability to curb the growth in transport demand.

The potential impact of ICTs can be twofold. First, ICTs can be used in transport in order to optimise and improve transport operations. Second, the widespread use of ICTs can exert an influence on the demand for transport and mobility, both in terms of the volume and the spatial and temporal distribution. More so with respect to the impact on transport demand, there is little systematic and structured evidence available that could be used to justify either optimistic or pessimistic expectations. The contribution of the project "Impact of ICT on Transport (ICTRANS)" needs to be placed within this context.

The objectives

- To improve the understanding of impact loops and chains affecting the demand for transport, which in turn are driven by new opportunities of ICT applications in conjunction with emerging trends and trend breaks in the social and organizational practices.
- To develop and formulate a set of scenarios for "e-society" to frame the exploration of possible future impacts that ICT applications may have on transport and mobility.
- To assess the impacts with suitable indicators and investigate possible substitution or rebound effects, modifications of travel behavior, or the case of stimulation of additional transport demand.
- To analyze and suggest options for robust and adaptive policies and policy portfolios that would allow future mobility paths influence developing in a sustainable direction and prevent major negative side effects.
- To identify major areas where additional research work is needed to consolidate our understanding of the causal relationships between ICTs applications and transport / mobility behavior.

Approach and methodology

In order to systematize our current knowledge of impacts, the three socio-economic spheres of Living, Working and Producing have been delimited in which ICTs are supposed to have a major influence on mobility patterns and mobility demand. These three spheres cover the following application areas of ICTs: logistics services, manufacturing systems, customised services, retailing and distribution, tele-shopping, distance working and self-employment.

In order to explore future issues for European policy-making, a scenario methodology has been chosen. The scenarios are intended span a wide range of possible futures as frames for thinking about the range of policy options that may have to be taken into consideration. By looking across the different scenarios, the intention is to derive "robust" and "adaptive" policy options. Robust options promise to have a beneficial impact on the transport demand in all scenarios under consideration, whereas adaptive options aim to be able to react swiftly to situations of opportunity or crisis that may emerge in individual scenarios.

On that basis a number of key issues can be identified that will determine the extent to which ICTs can be expected to exert a beneficial impact on transport under the conditions of the different scenarios. These issues then also point to possible inroads for policy.

The limits of current knowledge

The project has also covered the field of current relationships between ICTs and transport in the search for direct empirical evidence of the impacts of ICT-based activity on transport activity. The critical survey of the existing literature shows a highly complex set of interdependencies that is still far from being understood and disentangled. The available evidence shows there is still need for a concise analytical framework to be developed. Moreover, it has become evident that the transport and mobility impacts of ICT tend to be overestimated, partly because the role of ICT in society has been assessed too optimistically and partly also because second-order effects tend to be neglected in the existing estimates of transport impacts. One of the main findings in all the state-of-the-art reviews is that the ICT-mobility nexus has been insufficiently researched in order to draw any firm conclusions.

Framework scenarios for "e-society"

A small set of framework scenarios has been developed to provide alternative, qualitatively different futures for "e-society" in the timeframe 2010/2015. Each of the three scenarios provided a different social, cultural and political context against which ICT may impact transport and mobility in the future "e-society":

- The New New Economy scenario corresponds to a situation where e-society is driven by open source technology and networking culture, enabling widespread substitution of physical transport by electronic interactions.
- The Big Business as Usual scenario corresponds to the situation where economic efficiency is the main driver for the economy and society and the transport system remains car-dependent.
- The Smart Social Policies scenario assumes that social issues will have a main role in defining ICT-enabled mobility priorities with a strong focus on cluster-based initiatives.

Future transport and mobility impacts of ICT

To identify the various effects of ICT on mobility in the three different scenarios, a systematic analysis of transport impacts has been carried out along four main types of impacts that represent the linkages between ICT use and transport: frequency of travel, travel distances, travel mode and the ratio between freight and passenger transport. Further details can be identified by looking at three socio-economic spheres Living, Working and Producing within each of the scenarios.

A critical assessment of the evidence shows that the best one can hope for in response to a more widespread use of ICT is a slightly slower growth in the overall transport volume than otherwise projected, but the overall effect is likely to be minor. A more significant impact is likely to be expected on the spatial and temporal distribution of transport flows, which might contribute to breaking traffic peaks if flexible IST concepts for working, living and producing are adopted.

Key issues

Several key issues have been identified that will determine to which extent ICTs may have a significant impact on transport:

- The co-ordination of manufacturing, logistics and distribution
- Making distance-working reduce transport demand

- Matching customized mobility services with diversified lifestyles and attitudes
- Avoiding digital divides that limit the potential positive impact of ICT on transport
- Turning relative cost increases in transport into a benefit
- Lock-in and how to overcome it

Policy conclusions

One of the main conclusions of the ICTRANS project is that different kinds of mobility impacts are possible in different scenarios. This is particularly so because the potential impact of ICT on transport depends, to a significant extent, on non-transport and non-ICT policies as well as on complementary policies at national and regional level.

Or to put it different, if the policy goal is to reduce negative effects of growing transport demand, a comprehensive transition strategy, encompassing IST and non IST measures as well as dedicated transport measures, is needed.

The implications for current policy in the areas of information society technologies (IST) and transport and transport technology are as follows:

- Two main directions where IST policy could be reinforced to ensure a wider uptake of ICTs to reduce growth in transport demand. Firstly, stronger attention on users and user needs; secondly, targeted initiatives to develop ICTs for niche applications with major relevance for mobility.
- Three main directions for action can be distinguished as far as transport policy is concerned: co-ordination along the transport chain, but also with ICT-systems, pricing policies, and the development of customized mobility service concepts geared to user needs.

Areas for future research

In order to move beyond current speculation on ICT impacts on transport and mobility, a number of areas of research have been identified to fill the existing knowledge gaps

- the lack of sound, systematic conceptual frameworks for analysing ICT impacts on transport
- empirical studies on specific linkages, to study at least selected second-order impacts
- empirical studies on agglomerations to capture the interaction between effects, allowing in particular to highlight the spatial dimension
- linking transport indicators with indicators on living, working and producing
- modelling of the complex interactions at play that determine the effects of ICT on transport and mobility demand

1 INTRODUCTION

1.1 Background

Information and communication technologies (ICTs) are considered a major influence on present and future mobility. In technological terms, ICT applications such as wireless technologies can be available to users as electronic infrastructure when they move between regions and states. ICTs also influence the actual movement of goods and people, thus adding a direct, physical dimension to the mobility question in the form of transport and logistics. And ICTs are important enablers of changes in social and organisational practices, thus affecting the demand for transport in spatial and temporal terms.

These issues are of major importance to EU policies in the fields of ICTs and transport. The recent EU White Paper on Transport Policy has underlined the need to achieve a decoupling of economic growth and transport growth (CEC 2001). Otherwise, major transport bottlenecks and associated negative external costs are to be expected in Europe's agglomerations. The e-Europe Action Plan (CEC 2002) contains specific chapters on transport as well as on e-working, which aim to foster the integration of ICTs in transport.

High, yet uncertain expectations are attached to the role of ICTs to alleviate transport problems. First of all, ICTs are increasingly used in optimising transport operations, for instance for travel information systems, road pricing or safety applications. This type of impact on transport operations has been studied quite extensively over the past years. Secondly, ICTs are expected to exert a major influence *on* transport demand by allowing changes in mobility behaviour to emerge, such as distance work, teleshopping, business-to-business electronic commerce, integrated manufacturing systems, etc. This demand impact of ICTs seems to be an area where speculation still prevails over understanding. This is not surprising given the fast pace of technological change in ICTs and the necessity to assess the co-evolution of technological changes and general socio-economic trends in lifestyles, territorial developments or economic systems.

1.2 Challenges

The interplay of ICTs and transport is obviously a complex one to address. The limited scope of this study only allows us to focus on identifying those issues where ICTs will impact on transport demand to induce significant changes in future mobility behaviour and the different policy-making arenas involved.

Many studies in the past have tended to concentrate on the direct impacts of ICTs on transport only. This has been, for instance, a major flaw of assessments of the transport impacts of teleworking, where indirect effects such as the complementary car-use by other family members or longer travel distances for each individual commuter trip were not considered, leading to an over-optimistic assessment of the transport demand impacts of teleworking.

By overlooking the interactions of societal factors - such as new patterns of living and working - with the possibilities offered by ICTs, misleading assessments have frequently been made. Several such contextual factors are currently undergoing significant changes in themselves (e.g. lifestyles, labour regulations, etc.), whereas others are changing in interaction with the widespread use of ICTs. In fact, most of the path-breaking changes expected from ICT applications are only possible in conjunction with changes in socio-economic practices. As a consequence, many of the more radical changes on mobility behaviour can be expected to result from the changes in e-society. This argument reflects insights from technology studies regarding the embedding of new technologies in social, organisational and institutional contexts.

The radicalism of the transformation process possibly ahead of us can only be captured by a comprehensive framework that takes into account the many new linkages that may emerge between the technologies for mobility and the social, economic and organisational factors that together shape future mobility demand. This explains also the difficulties in applying conventional models of transport demand modelling to the issue of ICT impacts on transport because they cannot capture the new kinds of linkages between transport and socio-economic practices emerging in the e-society. What is urgently needed is therefore a better grasp of the underlying relationships that link different ways of using ICTs to direct and indirect impacts on transport demand, but set in a context that captures the breadth of possible developmental paths of the e-society ("impact chains and loops"). From a policy perspective, this implies that we need to devise ways to cope with a situation that is characterised by a high degree of uncertainty.

This ESTO study has been given the task to explore in particular the less well-understood dimension of ICT impacts on transport. Our field of investigation is the dynamic relationship between information and communication technologies (ICTs) and transport demand with the years 2010/2015 as the time horizon, set in a context of changes in wider social, organisational and economic practices. We will concentrate on implications for information society technologies (IST) policies and transport policies, in particular with respect to the impacts on transport intensity and/or transport demand. Thus, we will employ a broad concept and understanding of transport in the sense of mobility.

The study will analyse a number of alternative development paths that may be driven by either specific *policy measures* (such as the *Lisbon strategy* for a "Competitive and Knowledge-based Society"), or *external socio-economic factors* (e.g. demographic trends, changes in consumer preferences, etc.). In order to capture the breadth of future developments in the e-society, the development of framework scenarios of the potential changes in transport-related ICTs suggests itself as a useful methodology.[1] A small set of scenarios will be constructed such that they capture the uncertainties most significant to the most salient strategic choices. They will serve as a basis to investigate possible impacts on passenger and freight transport.

When it comes to thinking about possible policy issues in a scenario context, two types of policy options are of particular interest. Robust policies are those that would allow to improve the situation across a wide range of possible scenarios, and hence the most attractive. However, normally it is not possible to identify robust policies that allow effective coping with all negative side impacts and the risk elements attached to all scenarios. Therefore it is also useful to operate with a portfolio of policy options that pave the way for policy measures that are useful in some scenarios but not in others. This latter idea is referred to as adaptive strategy.

1.3 Objectives

The overarching aim of this ESTO study is to improve our limited understanding of the impacts of ICT on transport and mobility and make the first steps towards the development of elements for adequate policy strategies to contribute to a reduction of overall transport demand.

The objectives

More specifically, ICTRANS aims to address the following objectives:

- Improve the understanding of impact chains and loops affecting the demand for transport, which in turn are driven by new opportunities of ICT applications in conjunction with emerging trends and trend breaks in the social and organisational practices.

[1] See for instance earlier scenario-based work on transport or information society issues, such as the STEEDS, SCENARIOS or FANTASIE projects in FP4 or the more recent ISTAG ambient intelligence scenarios.

- Develop and formulate a set of scenarios for "e-society" to frame the exploration of possible future impacts that ICT applications may have on transport and mobility.
- Assess the impacts with suitable indicators and investigate possible substitution or rebound effects, modifications of travel behaviour, or the case of stimulation of additional transport demand.
- Analyze and suggest options for robust and adaptive policies and policy portfolios that would allow to influence future mobility paths to develop in a sustainable direction and prevent major negative side effects.
- Identify major areas where additional research work is needed to consolidate our understanding of the causal relationships between ICTs applications and transport/mobility behaviour.

Focus on socio-economic spheres and application areas

The project focuses on key application areas where ICTs are expected to have major consequences on mobility and transport, and by giving a first qualitative assessment of major questions and challenges in selected fields. These application areas include

- *retailing and distribution*, where ICT applications and e-commerce can help to optimize transport operations at a firm level and may influence the location decisions for distribution centres. Transport intensity and modal split could be affected as a result.
- *tele-shopping* in certain market segments of e-commerce such as books, software, music, food and groceries, travel and electronics. This may reduce individual shopping trips, but may lead to a significant increase in trips for delivery of tangible goods, and raise new requirements for freight transport, especially in urban areas.
- *logistics services*, which are supposed to undergo a major transformation towards inter-modal logistic chains as part of extended production systems.
- *manufacturing systems*, where ICT applications may influence the distribution of manufacturing activities at a European level: ICTs may stimulate the development of small and micro production units that serve local demand or, on the other extreme, facilitate the development of large clusters of competence (e.g. industrial districts).
- *customised services*, that can favour the matching of dispersed demand (e.g. micro-niches, individual/mass-customised markets) with dispersed offers (e.g. making possible the "personal factory" phenomena, or "*holonic* manufacturing").
- *distance-working*, which is expected to be adopted more widely in the future, leading to changes in mobility patterns, choices of residence and possibly the generation of additional leisure traffic.
- *self-employment*, which is facilitated by e-society concepts and triggers similar changes in mobility patterns as telecommuting.

In order to structure the work on these frequently overlapping key application areas our subsequent work was organised into the three socio-economic spheres: Producing, Living and Working. Producing focuses on manufacturing, logistics services, customised services, retailing and distribution. Living concentrates on tele-shopping and customised services. Working addresses distance-working and self-employment (cf. Figure 1).

Figure 1: Mapping application areas onto socio-economic spheres

Key application area →	Socio-economic domain
Logistics services	Producing
Manufacturing systems	Producing
Customised services	Living
Retailing and distribution	Living
Teleshopping	Working
Distance working	Working
Self-employment	Working

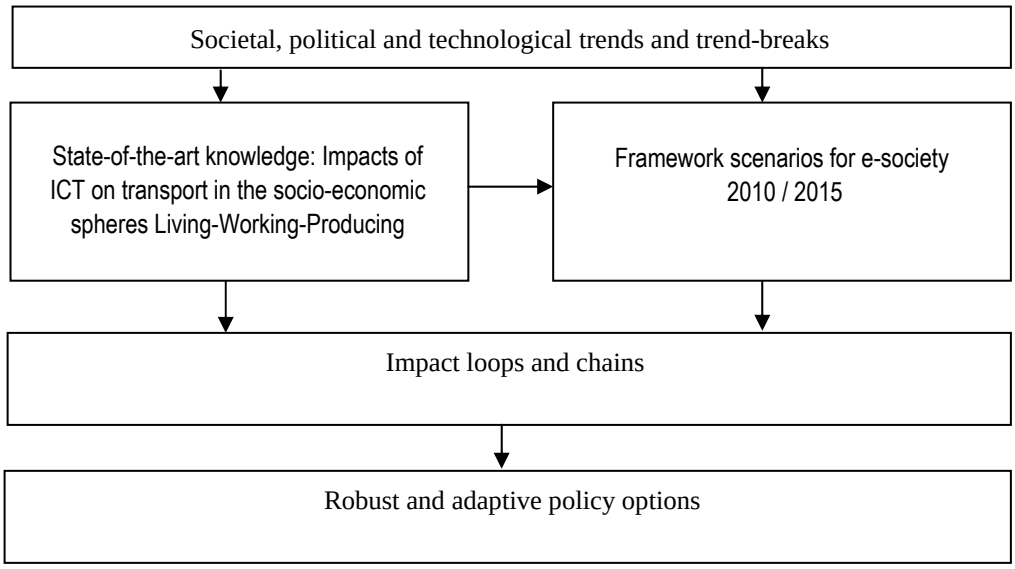
1.4 Approach and methodology

To adequately address the research issues outlined above, a future oriented and policy strategy oriented approach is needed. In the ICTRANS project we address these requirements by setting up an interdisciplinary project team (plus external experts) to adequately investigate the transport impacts of ICT in the various socio-economic spheres and key application areas with an adequate methodological mix.

Thus, due to the complex nature of the interrelationships between ICTs and transport and mobility, the project is based on a scenario development process to identify alternative development paths of the e-society. The scenarios frame the exploratory work on transport and mobility impacts. This exercise is underpinned by review work on the state-of-the-art knowledge of the impacts of ICTs on transport and mobility in the socio-economic spheres. On this basis, causal relationships and impact loops are worked out, taking into account the role of second-order effects as far as possible. In particular we would also like to know, in how far such causal relationships might differ across the scenarios, even if such statements may be attached with some degree of speculation. The cross-scenario analysis is further deepened when it comes to tackling policy issues, i.e. robust and adaptive policy options.

The overall structure of the work and the main building blocks of our approach are outlined in Figure 1 and described in more detail below.

Figure 1: The main building blocks of the ICTRANS project



State-of-the-art knowledge: Transport impacts of ICT in the socio-economic spheres Living, Working and Producing

A review of recent research findings covering the socio-economic spheres Living, Working and Producing provides a major knowledge base of the project. Its aim is to consolidate how much - or actually how little quantifiable – knowledge we have about the mobility impacts of ICTs in terms of direct and indirect effects. The three reviews are available as separate papers in the annex to this report.

'E-society' scenarios 2010 / 2015: Framing future development paths

The framework scenarios within the ICTRANS project represent alternative, qualitatively and structurally different futures of what the emerging 'e-society' might look like in 2010 to 2015. Their purpose is to provide relevant, plausible, and at the same time challenging contexts for analysing and assessing the transport impacts of ICTs and their interactions with social and economic trends. They take into account a broad range of perspectives on 'e-society', reflecting different - and possibly opposed - sets of values, governance approaches, market rules and institutional patterns. Experience from recent decades indicates that this is reasonable, even within such a relatively narrow time horizon as 2010 to 2015.

Scenarios were developed in a series of expert workshops that involved both project partners and external experts around the focal issue: "What socio-economic impacts could ICT have for transport and mobility in an enlarged Europe in the timeframe of 2010/2015, and what challenges for policy would that bring about?"

The scenario development process was based on a bottom-up, storyline-based methodology (Ericsson 2003). Key factors supposed to exert a major influence the ICT-mobility nexus are generated in a brainstorming session and then prioritised. By linking key factors together into storylines, rich material is generated, which is subsequently grouped into internally consistent clusters. The clusters are then incorporated as key statements to characterise each scenario. The final scenarios (abstract and description) are elaborated in terms of a common pattern to address key dimensions such as technologies, actors, infrastructures policies, etc.

Impacts chains and loops: Deriving transport implications for 'e-society' scenarios

The scenarios represent different pictures of what e-society might look like 10 or 15 years from now. They provide contexts for studying different living, working and production patterns and how they might affect transport and mobility. The current state-of-the-art knowledge on the three socio-economic spheres was fed into the impact chain analysis in order to capture both direct and indirect, i.e. second-order effects. Such second-order effects include feedback effects (rebound effects) as e.g. in the case of distance working.

In order to identify possible impacts on transport, four key indicators were used to structure the analysis. These indicators allow connecting ICT developments related to the spheres of living, working and producing to transport demand issues. The four indicators are trip frequency, trip distance, contribution to modal shift (modality), and impact on the passenger/freight ratio. The rigorous implementation of this approach in a quantitative sense was not feasible due to the absence of appropriate data, but it was used as an analytical framework to qualitatively discuss impact chains and loops.

Robust and adaptive policies and policy portfolios: Coping with uncertainty

Beyond their function of think tools for exploring impacts of ICT on transport, the scenarios have an important role to play with respect to policy strategy analysis. Policy is essentially about shaping the future in a socially benign way. It requires combining the feasible with the desirable under conditions of uncertainty with respect to technological development as well as with respect to the behaviour and the preferences of citizens, businesses and other key players. Scenarios are therefore a means to describe the space of possibilities to which policy may have to adapt, but which – at least partly – can also be shaped by policy. In other words, they can be

used as a basis for exploring combinations of adaptive and pro-active policy actions. If different future developmental paths are possible, policy needs to be prepared to cope with all of them, i.e. it needs to have options available to counteract the most negative impacts that may occur as well as to exploit the opportunities offered.

This understanding of policy strategy underpins the use we intend to make of the scenarios, namely to give some preliminary indications of robust policy options (i.e. of options that would be beneficial and advisable under all or most possible future developments) and policy portfolios (i.e. sets of options that would allow to prevent or effectively counteract negative developments or exploit positive developments that may occur only in some of the possible futures).

1.5 Structure of the report

The report starts with a view to the contextual developments that provide the frame for analysing the impact of ICTs on transport (chapter 2). We dedicate a section to the current social and technological trends that make up the notion of e-society, before presenting the three main scenarios that were elaborated in the course of this project. Thereafter we concentrate on the analysis of impacts on transport and mobility, based mainly on the state-of-the-art review work (see Annex), but complemented by initial thoughts on where the scenarios could make a difference (chapter 3). In the course of the project work, the lack of knowledge and understanding of impacts and – first- as well as second-order – effects turned out to be one of the key issues to be raised for research and research policy. The identification of knowledge gaps and areas for additional research work concludes this chapter. Chapter 4 focuses on a comparative analysis across the scenarios, and the issues of major relevance to future policy strategy in terms key issues/challenges, robust and adaptive policy options. Emphasis is put on IST and transport policy, but other relevant policy areas are also touched upon. In the final chapter, the main conclusions for policy in terms of portfolios of options are drawn (chapter 5).

2 TRANSPORT AND MOBILITY IMPACTS OF ICT: THE CURRENT KNOWLEDGE

A major task of the ICTRANS project is to collect and systematise our current knowledge on impacts of ICTs on transport and mobility. A digest on the state-of-the-art knowledge within the socio-economic spheres Living, Working and Producing of the transport and mobility impacts will be presented below. The detailed results of a literature review are published as separate background papers in an annex to this report.

In the introduction to this chapter, traditional views on ICT impacts on transport and mobility that promoted a highly optimistic view of technological futures are critically presented (ch. 2.1). More recent approaches, however, stress the complex interrelations between societal and technological evolutions and put impacts in a much more realistic perspective (ch. 2.2). In the following sections, the three socio-economic spheres Living, Working and Producing are investigated in terms of the direct impacts and the indirect, or second-order impacts (ch. 2.3 to 2.5). Examples are given of impact chains, trying to draw out the linkages and interaction effects. When possible, the potential scale of impact (substantive / marginal / no effects) and the distinction between freight transport and passenger travel is assessed and actual evidence cited. In the final part, unresolved research issues will be highlighted (ch. 2.6)

2.1 Traditional views

Technology in a variety of forms has been a central concern in much of the debate over solutions to the transport problem (Banister, 2002). Three basic arguments have been used. Technology is seen to

- stimulate more travel as new opportunities become available,
- substitute for travel as activities can now be carried out remotely rather than by travel,
- modify travel as the two elements combine to change the ways in which activities are carried out.

This rather simplistic conceptualisation has been widely criticised in literature (e.g. Lyons, 2002) as it doesn't attempt to understand how technology develops and shapes society. Early studies all seemed to suggest a huge potential for change, but in reality the changes made seemed to be far less obvious and subtler. The reasons for this may relate to the quality of the technology (including its reliability), the ease of use and the cost. It also needed to be embedded in the wider changes taking place in society, both in transport and more generally. Even if there are reductions in one set of transport-related activities (e.g. the journey to work), there may be compensating increases elsewhere as the car is now available during the day for other uses (e.g. for shopping and social activities) or users. The net effects of change may conceal quite large variations in individual behaviour.

More generally, cities are spreading as decentralisation takes place. ICT innovation, like transport, may be one important factor in facilitating this process. The net effect may be that fewer journeys to work take place each week, but these journeys may be much longer and so the total distance has increased. This is an example of substitution and stimulation effects taking place simultaneously.

2.2 New interpretations

Towards the end of the 1990s, it was realized that the linkages between ICT and transport were much more subtle and the opportunities created were used in different ways, thus making analysis much harder, for example, the logic that teleconferencing substitutes for business travel

was based on the assumption of a fixed number of social contacts. "The possibility that teleconferencing might add an extra mode of social contact that would increase the total number of contacts was not considered." (Geels and Smit, 2000, 873). Similar examples can be given of all expected changes brought about through ICT innovations.

Current thinking has moved away from simple cause-and-effect type relationships towards co-existence and complementarity between old and new technologies. Internet shopping provides a good example of this new complementarity and a break with the conventional approach that treats shopping solely as a functional activity. Although certain goods can be purchased via the Internet from home, there are still the "fresh" goods that need to be seen before purchase. Other aspects of shopping include its social function as a place to meet people and to satisfy the need to get out of the home. All of these processes take time in having an impact as new patterns of activities become established. Apart from the problems with the system being established, for example whether Internet shopping is done through the local supermarket outlet or through the regional distribution centre, there is the user interface and the delivery window problem, and the acceptance of the basic concept.

There are also strong complementarities due to second-order effects (see also HOP 2002). An example of how working and living jointly impact linked trips is that ICT at the workplace not only enables a higher flexibility of working hours, but it also drives up growth in female employment. At the same time, we can see a trend towards the deregulation of shopping hours. Overall, the gain in flexibility allows linked trips to be made more easily, where children can be dropped off at school before doing the shopping in one of the malls on the way to work. This flexibility is also one of the drivers of urban sprawl, and the latter is enabled by deregulation of planning procedures. The use of ICT at the workplace offers also possibilities to submit e-shopping orders which can either be picked up on the way home or brought by a delivery service.

There is thus a need to move away from the primary concern over technologically led futures to one that places a much greater emphasis on the social and cultural context within which change takes place (Geels and Smit, 2000). As can be seen from this summary of both the general trends and the more traditional interpretations of the impacts of ICT on transport, the actual effects are more varied and complex. They require an understanding of the context within which change takes places (see section 3.1).

Table 1: Key features that shape the future role of new technologies

Feature	Impact on technological change
Contemporary concerns and hopes	Perceptions of the future are shaped and coloured by current problems and aspirations resulting in optimistic rather than plausible scenarios
New technological trajectories	The pathway of technological innovation and product development may significantly change, introducing new possibilities and expectations concerning the role in and impacts on society (not clear what is intended)
New for old substitution	The role of a new technology is often phrased in terms of replacing or substituting the old technology, whilst in reality old and new technologies often co-exist, serving different markets, circumstances or purposes
Social practices neutral	It is often wrongly assumed that the pool of social practices and needs remains unchanged; thereby implying that new technology will (only) substitute certain social practices. In reality, the pool of social practices can increase
Narrow functional thinking	Through only functional thinking, new technologies can be judged capable of enabling the purpose of an activity to be fulfilled. This neglects the consideration of other social and psychological aspects of an activity

Feature	Impact on technological change
Societal embedding	The process of societal embedding of new technologies can be viewed as unproblematic, when in practice many social and institutional adjustment processes have to take place, which may not be straightforward and can take some time to achieve
Hope monstrosities	Promoters of an emerging technology can voice unrealistically high expectations. This may create a "breathing space" for investment and development to continue. It may also be a consequence of neglecting the co-evolution of technology and society, and the understanding of the practical difficulties and resulting slowness in the processes of societal embedding of technology

Source: Lyons (2002)

2.3 Impacts of ICT on Transport and Mobility in the sphere "Living"

The main impacts of ICTs in the socio-economic sphere of living can again be divided into three main groups. Public transport and private transport planning relate to the impacts in transport operations than on transport. In both cases, the intention is to increase the reliability of the system. For public transport, this is particularly important, as the system needs to be seen as an integrated set of multi-modal alternatives with easy transfer between the different forms of transport. This requirement covers not just the services provided, but information, timetables and ticketing. Technology permits the provision of a "seamless" transport system provided that the user interface covered here is combined with other actions to give public transport priority within the system.

ICTs are applied in implementing policies aimed at reducing travel demand, for example through road pricing, and other policies aimed at making more efficient use of the available capacity, for example through control technology. Clearly, these two types of interventions are quite different from those discussed here in terms of their impacts on travel demand, but this table gives some indication of the interactions between ICT on transport and for transport systems – the two are complementary.

Table 1: Implications of ICT applications on transport operations

Application	Role of ICT	Impacts
Road pricing and user charging	Technology for vehicle recognition and revenue collection	Reductions in travel distance, changes in vehicle occupancy and mode shifts
Infrastructure capacity measures	Traffic control technology	May generate additional traffic unless capacity is restricted, either by fiscal, regulatory or physical means
Public transport information	Real-time transport information (e.g. countdown) or Internet based journey planning	Modal shifts in favour of public transport

For the car, there are now many optional systems available to provide the driver with information on recommended routes to minimise delay and advance warning about hazards on the road system. Again, the intention was to provide direct benefits to the driver with privileged information that is paid for so that journey times can be reduced. But there may be increases in travel distances, as second best routes are likely to be longer in both times and distance terms than the preferred route. The two major impacts covered here include "e-everything" and the

ability to use the Internet to make spontaneous decisions about travel and other activities (Table 2).

Table 2: Implications of ICT applications on mobility behaviour

Application	Role of ICT	Impacts
Public transport planning	Integrated public transport planning	Modal shift in favour of public transport
Private transport planning	Real-time route guidance and hazard warning	Savings in congestion and travel time – but may add to journey distance
E-everything: shopping, medicine, education, banking, entertainment etc	Internet, sms, email etc	Reduces the need for individuals to travel for many transactions, but the existence of these services requires more people to work outside "regular" work hours – with implications for transport modes. May also lead to "new" journeys to replace the ones that would have been necessary in the absence of the e-activity
"Last minute" deals: flights, hotels, holidays etc	Internet, sms, email, etc	Assist companies to increase capacity and revenues – create additional travel

E-everything requires the home to have access to the Internet. This is taking place with over half the households in the EU now having a home computer and some 70 per cent of these with Internet access. Even though most traffic on the Internet is business-related, there is a growing increase in "home" use. The most widely reported use is for shopping where online consumer spending is expected to rise from about one per cent of total retailing expenditure to nine per cent by 2004, as a result of consumers becoming more familiar with the system and through overcoming the delivery problem issue. Total spending in 1999 was $20 billion and this is expected to rise to $184 billion by 2004. Shopping has a much wider role than the narrow functional one, as it is one of the main means by which social and family activities take place (Information Boxes 5 and 6). Shopping often provides the pretext for a wide range of activities, hence the growing importance of leisure shopping (shopping whilst the shops are closed - window-shopping).

In addition to shopping, there are many other opportunities for e-activities, particularly in locations that are relatively inaccessible. These include e-medicine, e-education, e- banking, and e-entertainment. In each case, there is a potential substitution effect for existing activities, but the intention is to allow "low-level" activities to be carried out remotely (e.g. self-diagnosis of minor illnesses or primary-school education). Higher-order activities would still have to be carried out through face-to-face contact, involving travel. The intention is also to encourage greater participation in activities and so generate new customers and revenues. This increased participation typically means greater geographical distances between participants. Therefore, even though much of the contacts can be handled at a distance, the remaining need for some face-to-face contact in combination with the greater interaction distances may well lead to increased overall transport demand.

The direct effects on transport may be some replacement of existing travel, but in the longer term new patterns of longer distance travel may take place as the ICT becomes embedded in lifestyles. It should be noted that not all individuals have equal access to technology or the ability (or inclination) to use it. As with the advent of the car (another technology that revolutionised lifestyles), ICTs initially impact on the affluent with the necessary skills to use them. Yet, many of the initial diffusion barriers such as user interfaces and affordability will be overcome within one or two generations at most.

The indirect effects are likely to be far more fundamental as new activity and location patterns emerge. It may allow people to live in remote parts of the EU and to develop locally based travel patterns with occasional longer distance journeys to the city. Other activities may be

carried out remotely, and so the traditional problems of rural inaccessibility may be overcome. However, many questions remain open as regards the importance of social interaction as travel is not only undertaken for functional reasons (e.g. shopping and work), but it also has been instrumental in establishing social networks (Putnam, 2000).

Information Box 5

Verdict Research (2000) has produced some figures for UK expenditure on the Internet for six categories of shopping. The growth over the past three years (1997-1999) in each of these six categories has been substantial, with the total market increasing by three times (€300 million to €872 million). The expected increase to 2004 is a further 13 times. The research is based on forecast methods, limited by the number of households that have had products delivered to their homes in the last year (Verdict claim this figure is about 65%). But other research has put this figure at only 21% for the numbers of consumers who expect to use the Internet for shopping over the next five years (Deloitte Consulting, 2000).

	Category of Shopping	1999	2004 (forecast)
		million €	
1.	computer software	180	1.350
2.	books	158	600
3.	music and video	123	850
4.	grocery	272	3.300
5.	clothing and footwear	12	1.800
6.	other	143	2.800

The figures from the market experts place the values somewhere in between. So the levels of uncertainty are high, even over the five-year horizon, shown below for the percentage of households using the Internet to shop online.

	1998	**1999**	**2000**	**2001**	**2002**
US	20.2	26.1	31.2	35.7	40.5
Germany	13.1	19.5	25.3	30.3	38.3
UK	17.2	18.5	24.1	28.6	35.9
France	11.7	17.0	21.5	26.1	33.6
Denmark	10.9	17.6	22.7	28.8	36.8
Italy	7.7	13.6	18.1	23.5	28.7
Netherlands	14.0	17.5	22.0	27.5	34.5
Finland	13.2	18.4	22.7	28.7	36.8
Sweden	13.6	18.4	22.7	28.7	36.8
Norway	15.1	17.4	22.5	28.4	36.4
Spain	11.8	14.7	17.7	23.7	30.8
European average	*12.5*	*17.1*	*22.0*	*27.1*	*34.2*

Sources: Jupiter (2000), Merrill Lynch (2000) and Financial Times 11 May 2000. All figures are estimates apart from 1998

In the city, the need to own a car may be reduced as the quality of public transport is likely to go up and severe restrictions on emissions are implemented. Car-sharing and innovative forms of leasing may result in less city car ownership. Online booking and debiting systems can be combined with personal digital assistants with embedded intelligence to ensure that high quality options are presented to allow customised mobility (Hoogma et al, 2002). The reduction in city car ownership will have a substantial impact on the efficiency of transport systems as less space would be consumed by parked cars (often on the streets), as accessibility is enhanced, and quality of life in cities may improve.

Information Box 6

According to a study for the German Ministry for Transport, Building and Housing (BMVBV) on the impacts of new ICT on transport and innovative workplaces in the transport sector, business-to-consumer (B2C) commerce is a critical factor. The trends identified for the B2C-sector are the following:

- B2C will result in the increase of small-part dispatches to an increased number of end-customers with individual delivery-places and delivery-times.
- B2C traffic will concentrate on suburban areas.
- B2C induces more courier, express and parcel deliveries.
- B2C will lead to homogenous transport in urban locations, and at the same time to a better consolidation of long-distance traffic.
- Storage concepts, distribution and collecting traffic have to be adapted.
- Return tours of delivery vehicles will produce additional traffic.
- Some shopping trips will be replaced by deliveries.
- Applying logistic concepts can result in package effects (less single traffic).
- In-time deliveries are always price sensible and will almost always lead to street traffic.
- Trends in courier, express and packet deliveries (ongoing but supported by increased online-shopping).
- Cep-services will require more small vehicles.
- The total number of tours will increase.
- Cep-traffic will mainly affect suburban areas (housing areas).
- Delivery drop-offs (pick-up stations) will be demanded in suburban living areas.
- Because of the increasing transport of small-parts, other transports will be substituted
- Specialty transports like grocery deliveries will remain a niche market.

Source: BMVBV 2001, p. 28

Last-minute deals have become increasingly important, as the flexibility of the Internet has been used to sell excess capacity, particularly for flights, hotels and holidays. More generally, the Internet has provided a means for companies to reduce their marketing costs through a direct interface between the customer and the supplier. Apart from cost savings, companies can build up a profile of the market and can adapt their products to meet the perceived requirements of the customer. The databases built up by railway companies and airlines, supermarkets and holiday package firms are now being used to market new products to customers.

The direct effects have been higher occupancy rates on airlines, railways and hotels, as space is sold at prices that are slightly above marginal cost. In the longer term, new markets are being created and services provided that better match expectations. The potential increase in travel is immense, as people take more overseas holidays and cheap trips to see friends, sites or other

destinations. It has facilitated new ownership patterns of second homes in the Sunbelt of Europe and the ability to regularly reach them for long weekends.

Conclusions

- Many of the living opportunities resulting from ICT would initially result in less travel, as there is a potential for substitution effects. But there are two important conditions here. One is that, over time it may encourage greater participation in second-order activities, which still require travel; often over longer distances. Secondly, new customers will become engaged in e-activities and this will again lead to greater involvement and encourage travel.
- There seems to be a strong complementarity between many of these activities, and if some are carried out remotely, there may be more travel for other activities. Home-based entertainment systems, for example, may mean less social activities in the evening, but it may encourage greater participation in other related activities and these require travel (e.g. to visit Disney World or Hollywood).
- It is in the last-minute deals that the greatest potential for additional travel may arise, as individuals seize upon the bargains being offered by airlines and hotels. In the short term, this may just be using up excess capacity and so there is little additional travel, but in the longer term it may result in additional capacity being designed and in a new market being developed. In this case the growth in long-distance travel is likely to be substantial.
- The main indirect effects are the flexibility that technology allows in the location of homes and in the choice of alternative opportunities. ICT permits decentralisation and accessibility increases to take place at the same time. Many other traditional concerns over the isolation of rural lifestyles can be overcome with social networks and shopping choices been maintained through ICT.
- Perhaps surprisingly, there seems to be little quality empirical information about the actual impacts, and much of the evidence on the take-up rate seems to be optimistic. This particularly applies in the context of Internet shopping potential.

2.4 Impacts of ICT on transport and mobility in the sphere "Working"

Teleworking - Much debate has concentrated on the potential for working at home and the end of the division between home and work (Table 3). The latest data from the UK (ONS, 2002) suggests that in 2001, some 2.2 million people (7.4 per cent of the employed population) were "teleworkers". This is an increase of 65 per cent on the 1997 figures. It is really the advent of e-mail that has made the difference as most (82 per cent) need both the telephone and e-mail access to work effectively from home. The figures for the UK quoted here include those who work at home for at least one day a week. The one-day-a-week group probably accounts for about 50 per cent of all "teleworkers" (ONS, 2002).

As with shopping, there is more to work than its functional aspects. The social interaction with colleagues at work is a key factor for job satisfaction, and so new forms of work patterns are developing that mix office work with homework. Teleworking originated mainly for those who were self-employed, but now over 55 per cent are employees (ONS, 2002). There is a realisation that those who work outside the office have a higher level of productivity than those who always come into work. These new patterns of home working increasingly concentrate on skilled workers and more senior staff.

Table 3: Implications of ICT on transport in the socio-economic sphere Working

Application	Role of ICT	Impacts on Transport
e-office	Internet, email, mobile communications, portable computers; Teleservices	Possible reduction in travel frequency but also longer distance travel (when individuals move further for work), and/or substitution of work travel with other travel – with the time saved by not travelling to work. May also lead to the use of more on-the-move working options during long distance travel
e-meeting	Videoconferencing	Potential reduction travel distance but limited in application – many face-to-face meetings may be more useful and productive – telephones have not reduced the need for meetings. There may also be some substitution of meeting travel with other travel – with the time saved by not travelling to a meeting
e-information	Email, ftp, extranet	May reduce the need for meetings to exchange routine information

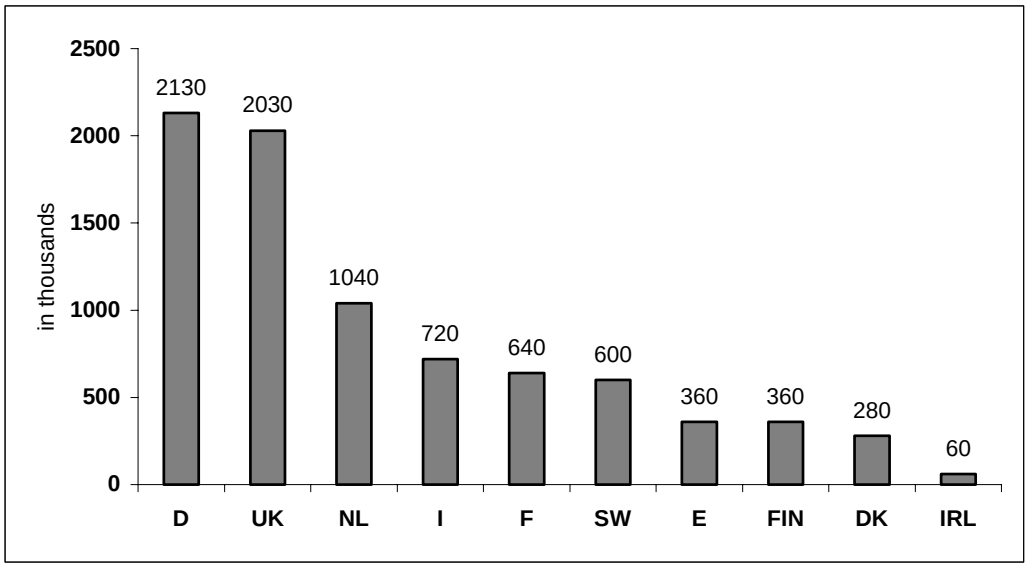
The implications for travel are complex as home working has a substantial potential to reduce the numbers of commuting journeys, which typically are longer than journeys for other purposes. For example, in the UK, the average distance for the journey to work has increased from 11.5 kilometres to 13.4 kilometres (1991 to 2001). Interestingly (Information Box 7), there seems to be a relationship between the average commuting time and the proportion of workers teleworking. The main gain is the increase in flexibility, which in turn results in reorganisation of output processes and businesses. There is a new interdependence between global and local working, as firms disperse their activities and as autonomous market-orientated business units locate in areas closest to customers (Reichwald, 2002).

The same types of linkages can be found in teleservices where routine functions and maintenance can be carried out online or through self-diagnosis, resulting in less travel. More challenging is the opportunity to design products for individual users (e.g. newspapers) where the appropriate mix is made according to their requirements and printed on demand. In a more basic version, such facilities are available for banking, chemists, and shopping.

E-meetings are another dimension of the conflict between face-to-face and remote contact. Video-conferencing allows visual contact as well as spoken contact, but the need to get a "feel" for the meeting suggests that face-to-face is still very important. This means that some substitution may take place, but key meetings needs face-to-face contact and this in turn may result in longer travel distances. However, routine information can be easily transferred without the need for contact, and this should save on movement, both physical travel and traditional mail.

Information Box 7

Although the number of teleworkers has increased, the growth is generally much slower than predicted. According to the latest figures from 2000, 8 million or 6% of all employees in Europe (EU-10) already practise telework in one form or the other (regular teleworkers, supplementary (occasional) teleworkers, home-based/ mobile teleworkers, self-employed in Small Office/Home Office, etc.).



Country	Percentage of workers teleworking	Average commute in minutes (1996)
Finland	17	41
Sweden	15	40
Netherlands	15	44
Denmark	10	45
United Kingdom	7.6	46
EU Average	*6*	*38*
Germany	6	45
Ireland	4.5	40
Italy	3.8	23
France	2.9	36
Spain	2.8	33

Source: ECATT 2000, p.24

Conclusions

- There is substantial potential for substitution of travel to work for stay-at-home working, but that potential has not been fully realised. The increased flexibility has resulted in many self-employed and other workers spending more time working from home, typically one to two days a week.
- The social dimension of real contact with colleagues is important, and this is also reflected in the need for face-to-face meetings.
- Newly dispersed patterns of work may develop as people continue to live further from their workplace and as firms also disperse their activities (internationally and locally). The net result will be fewer journeys to work, but each journey is likely to be longer.
- Again, much of the evidence is limited, and there needs to be more systematic collection of standard information across Europe, both at key points in time and over time. Longitudinal data allows for the identification of the new complexity and flexibility and record actual as well as net changes.

2.5 Impacts of ICT on transport and mobility in the sphere "Producing"

There are three main sets of implications ranging from e-commerce and just-in-time production (manufacturing systems), through logistics and freight distribution to e-marketing and publicity (Table 4).

Table 4: Implications of ICT on transport in the socio-economic sphere Producing

Application	Role of ICT	Impacts on Transport
E-commerce etc.	Internet, sms, email etc	May reduce the need for the movement of goods in certain cases – for example, music is downloaded from the web, and orders are transmitted electronically
Just in time production	Technology for stock control, ordering and tailored production	More frequent deliveries. Smaller loads – often requires fast delivery – air
Logistics and freight distribution	Real-time route guidance, track and trace technology – optimising delivery vehicles and routes	Savings in reliability and travel time, but may add to journey distance. Possibilities for trip chaining and load matching. Also savings in terms of vehicles and route choice
E-marketing and publicity	Internet, email, sms, etc	Potential reduction in the amount of other sorts of marketing/publicity material produced. More likely e-marketing will be an additional source of information

Manufacturing systems have been restructured to bring substantial cost savings to companies by reducing product life cycles and increasing value added. Through the use of computer-aided manufacturing and electronic data interchange, nearly all aspects of the manufacturing process are now interconnected with ICT (Saxena and Sahay, 2000), and even virtual fabrication (Hsieh et al, 2002). Production schedules can be changed weekly according to the variability in demand patterns and suppliers are increasingly acting as retailers. Such developments have led to a reduction in transport requirements as orders are now processed electronically from the supply

of goods to be invoicing of customers. But as requirements become more demanding there may be an increase in the number of deliveries required to meet production deadlines with smaller loads. As customer demands have become more individualised, production lines are being converted to individual requirements (as is happening with computers and cars – Information Boxes 8 and 9). Supply chains may become more extended as sourcing is international, but it may also lead to clusters and strong agglomeration economies as suppliers seek to reduce their risk and locate around the assembly plants (Banister and Berechman, 2000).

Information Box 8

An arrangement between Maxtor (maker of computer disk drives) and Exel, the world's leading firm of pure logistics (formed from a merger of a shipping line and a road hauler), requires the transhipment of drives from factories in Asia to companies such as Dell, Compaq and HP in Asia and America within 48hours. Exel analyses and optimises the supply chain for the company and creates value. Increasingly these specialist companies are taking over from more traditional supply chain management to provide customised services and effectively manage production
Source: The Economist, 7th December 2002, p. 94

Information Box 9

In the automobile industry, where it used to take 10 business days to assemble a car, firms are aiming to respond to specific vehicle orders within five or even three days. With the support of ICT customers will be in a position to customise their new car online to their preferences but without having to wait many weeks for delivery. This requires massive changes in the way not only the manufactures but also suppliers approach the entire process of ordering supplies, producing and delivering parts. The need to sequence the delivery of parts to the vehicle assembly line on time and in the proper order is leading to the formation of supplier villages around each vehicle assembly plant. This means short distances for the transport of supplies and therefore, should lead to a reduction in traffic. Efficient enterprise resource planning systems as well as customer management systems are a prerequisite for achieving the goal of short assembly times.

Logistics and freight distribution has been revolutionised by the increased use of ICT. The structure of the supply chains has changed as the location and size of production, processing and warehousing sites have adapted to the new technology. This has affected the spatial concentration of production and inventory activities, the development of new break/bulk and transhipment systems, and hub satellite networks. The alignment of supply chains has also been altered with the concentration of international trade on hub ports and airports, the rationalisation of the supply base, the vertical disintegration of production, the wider geographical sourcing of supplies, customisation and the increase in direct delivery. Many of these trends have already been noted, but other changes are also taking place. Product flow scheduling has been reorganised through the use of time compression principles, the increase of control by retailers over the supply-chain, and the creative use of time scheduling for deliveries.

Such changes have been reflected in the increased use of road freight vehicles, as these can be more easily adapted to new logistics. Transport costs have been further reduced through improved design, the use of containers and the increase in the freight capacity of ships and aircraft. New automated handling for freight at distribution centres, airports and ports, together with greater modularity and reductions in packaging have all helped to revolutionise freight systems. ICT has played an instrumental role here in information exchange, tracking and tracing, enabling new concepts and production and services to be introduced, in cutting turnaround time, and in determining shipment size (Information Boxes 10 and 11).

Information Box 10

Trucking supply is being optimised through Online Freight Exchanges (OFE) and the development of OFEs is an ICT-dependent trend. In order to prevent trucks making empty return journeys, these exchange portals aim to connect available loads to available trucking space on a dynamic basis. Overall, this could lead to fewer trips and it might affect the role of intermediaries and the reduction of shipment costs along the supply chain. The future of OFEs is nevertheless unclear. Some studies are optimistic, but others remark that most of OFEs do not make profits, and that in the case of successful sites only one dominant player controls the exchange

Source: Visser and Nemoto, 2002; Peters and Wilkinson, 2000.

Information Box 11

Manufacturers want customised delivery systems, using all modes of transport. This is being achieved through Third Party Logistics Market, where the right goods are delivered to the right place on time. Consolidation is taking place in the fragmented freight industry, with international companies acting as "consolidators" or "integrators" – FedEx, UPS and DPWN (Deutsche Post World Net). The services provided ensure the three parallel flows of physical goods, information and financing coexist and complement each other. The total US logistics market is worth about $1 trillion a year and it is expanding by 4% each year. The Third Party Market is worth $50 billion a year, but is expanding by over 15% annually.

The businesses that make most use of this level of logistics are in electronic components, consumer electronics, pharmaceuticals, fashion and cars. With over 10,000 components in each car and sourcing from all parts of the globe, it is important to use ever increasingly sophisticated logistics. For example, TPG (a major transport integrator) organises 800 deliveries from 300 suppliers to the Ford factory in Toronto to produce 1.500 Windstar minivans a day. Loads are timed to arrive at 12 different points along the assembly line within a 10-minute time slot. All the loads are in a particular order in the trucks to ensure a continuous flow of components. The vehicles involved are owner operated, but under contract to TPG, and the 7 year contract with Ford means that TPG have to lower costs by 2% each year

Source: The Economist, 7th December 2002, pp 93-94.

E-marketing and publicity provide a new set of opportunities for businesses to directly market their products to their customers or through a third party as part of their website (e.g. Amazon and Google). In principle, this development could substitute for more traditional forms of marketing through adverts in papers or direct mailing, but it is more likely to provide a complementary form of marketing. As it is a relatively costless means of promotion, the returns do not need to be high, but the aim is to increase the market penetration of products and market share. The transport implications are likely to be small, with some additional deliveries.

Conclusions

- In most cases, changes within production processes are made for commercial reasons and the necessity to improve productivity over time. Investment in ICT is one of the main means by which productivity has been improved and it has also resulted in substantial cost savings for transport.
- There are often conflicting forces at work with the increase in flexibility and production processes as outsourcing and the vertical disintegration of companies takes place. However, appropriate control mechanisms still need to be made in maintaining quality and cost targets. In transport terms, this has led to long supply chains for sourcing, but also arguments for agglomeration to maintain reliability in sourcing.
- Companies tend to only account for the direct (private) cost, not the broader social costs or the costs transferred to users. For example, with the electronic transfer of books, magazines and newspapers, the costs of printing are passed onto the final user. However, the total costs

may be reduced for the electronic version as against the printed version if all costs (including transport costs) are included.

- Transport costs have traditionally only provided a small proportion of total costs, particularly in the new service economy where goods have a high value to weight ratio. The development of hub and satellite networks allows larger units to be transported along the main routes at a higher frequency, but distances are increased.

2.6 Unresolved questions and research needs

One of the main conclusions from the state-of-the-art review (see annex) has been the lack of clear theoretical arguments and empirical evidence of the impact of ICT on transport. Much of the evidence cited relates to the potential for change, often based on optimistic assumptions about the uptake and the use of the technology (Zoche et al, 2002; Dantuma et al, 2002; Hommels et al, 2002). The analysis of the recent literature has shown that several cases of "established wisdom" need to be put into question when it comes to studying the role and impact of ICTs for transport and mobility.

The limits to travel - Taking a historical perspective, it seems that there are no limits to the relentless growth in the demand for travel. Growth rates of 5 to 6% per annum in air travel, means a doubling of demand every 12 years. Even with more modest growth rates, as reported more recently in air travel and in other forms of travel, a doubling of demand still takes place every 20 years. In the past, every technological innovation acted to increase that demand rather than reduce it. The question here is whether ICT acts as a brake or an accelerator in this process. The evidence cited in this report suggests that there is substantial scope for reducing some types of (less valued) travel demands, like the journey to work, but equally it may encourage other (higher valued) longer distance travel, like leisure travel. Despite the increasing concerns over the environmental and health consequences of the increasing consumption of non-renewable resources, it seems that ICTs on their own cannot change the direction of current trends towards a more sustainable transport system.

Not all travel is derived demand – The traditional view that travel is only undertaken because of the benefits derived at the destination being higher than the associated costs is no longer generally applicable (Salomon and Mokhtarian, 2002). Substantial amounts of leisure travel are undertaken for their own sake and the activity of travelling is valued positively. This conclusion has enormous implications for transport analysis as most conventional analysis is based on the premise that travel distances should be short and that travel time should be minimised. As work-related activities become less important in terms of travel, and as the growth takes place in leisure activities, conventional transport "wisdom" needs to be reassessed. And ICTs provide access to information about new opportunities and options for leisure trips. The questions that need to be answered are obvious: How are different types of trips valued? What types of trips are regarded as a nuisance, and are thus in principle open for substitution by ICT applications, and what types are positively valued for their own sake?

The problem of latent demand – The balance between substitutive and complementary effects of ICT use with respect to transport has been one of the main issues of scientific debate over the past decade, and it is based on different assumptions regarding the activation of latent demand. If indeed distance working or any other ICT-based activity leads to the substitution of a trip, it is possible that someone else will make a trip instead. Other road user may take advantage of the "liberated" road space, family members may make additional trips or the teleworker will use the car for leisure purposes instead. Moreover, the balance of modes may be affected because teleworkers use the car for their remaining trips rather than travelling by public transport as they did before. And in the longer-term, location decisions may change, with people willing to live further from their places of work, thus making fewer but longer trips. Getting answers to these questions will be crucial for assessing transport impacts of ICT use.

Necessity to take an inter-modal perspective on transport – There seems to be considerable potential within Europe to exploit the potential of inter-modal transport by means of ICT-use. For instance, there is scope to reduce short distance travel by air through the linking of the air and rail networks, as has been achieved at Charles de Gaulle and Frankfurt airports. Through innovative hubbing solutions facilitated by ICT, it is possible to optimise the use of air space and rail systems. This applies mainly to passenger travel and high value freight movements.

Sustainable supply chains – There is an increasing awareness world wide of the transport costs entailed in providing goods to the final user. One of the main growth sectors in air travel has been the freight sector where high value goods are carried long distances to give year round availability. If transport activities pay for their full environmental costs, transport costs would be a more decisive factor and the need to optimize them would arise. The internalisation of external costs can thus turn into one of the key drivers of ICT-use in transport because of its efficiency-enhancing potential along the supply chain.

Impact of technology and flexibility – ICT provides tremendous opportunity and choice to carry out the full range of desired activities in a variety of ways. It also provides firms with important new challenges with respect to their production processes. The knowledge base is extended and this may result in more travel, but more important is the transfer of power from the producer to the customer. Users are increasingly controlling their own lives and what they want (at a price), and so the production processes have to react to those new requirements. This increase in flexibility requires the extensive use of ICTs along the supply chain, but we are far from understanding the multitude of consequences this is likely to have, nor their joint impact on transport demand.

Any research work aiming to underpin the aforementioned key questions needs to be based on a sound empirical basis. The analysis of available literature and evidence has shown that the empirical base on the interdependencies between new types of ICT applications and the implications they have for transport demand is still in its infancy. Even for the better-researched areas – distance working and e-commerce – most studies concentrate on the direct impacts on trip frequency and distance, whereas second-order effects are hardly taken into account. There is a definitive need for additional empirical research work, broken down for the distinct ICT applications, and their sub-dimensions. In a study for the British Department for Transport, Local Government and the Regions, the following research areas are suggested, which represent a good starting point (Hop Associates 2002, p. 38):

- Distance work (home-based, centre-based, mobile/nomadic, online collaboration, remote monitoring and diagnostics)
- E-business and –commerce (supply chain, logistics, b2b, b2c, dematerialisation of products)
- Electronic service delivery (e-learning, telemedicine, e-government, e-leisure and online media)

In more operational terms, new research methodologies and indicators are needed to capture the impact chains and loops between ICT use, transport demand and changes in the three socio-economic spheres under study. This requires merging transport indicators with indicators on the impact of technological and social change on each of the spheres.

3 CONTEXTUAL DEVELOPMENTS IN ICT AND SOCIETY: TRENDS AND FRAMEWORK SCENARIOS FOR E-SOCIETY 2010/2015

3.1 Socio-economic and technological trends

In this section we identify plausible general future trends that are both relevant in the context of our field of investigation - transport and mobility - and reflect current developments in the ICT sphere.

Socio-economic trends

The general trends towards globalisation mean that more and long-distance travel is required for goods, services and meetings. Changes in the nature of work (from manufacturing to service and information) and the labour force (more women and part-time labour) may act to reduce travel frequency, but again encourage longer distances and some substitution effects. Traditional centralisation of production has been replaced by more flexible location patterns, some where labour is cheap and others where agglomeration and short supply chains are important. Again, the implications for travel are varied with some increases in distance, some remote working, but also the need for face-to-face contact. Such changes had been reinforced by the 24-hour economy where activity is continuous within countries (through shift working), but also on a global scale, where markets are open all the time in the key financial centres of London, Tokyo and New York. Global commerce requires servicing and support at all hours, and this in turn has implications for transport modes and supply chains. New production methods and concepts such as mass customisation, increased flexibility of production through outsourcing and networking will increase.

In the social arena, the aging of population in developed nations results in growing demand for ICT-enabled products and service. There is new demand posed by greater individualisation, changes in life-styles and in consumer preferences with a growing need for instant satisfaction and quality of life. At the same time, more leisure time is likely to increase discretionary travel, tourism and leisure.

Major spatial effects are attributed to two seemingly counterproductive trends: the decoupling of space and time[2] through ICTs, resulting in growing (sub)urbanisation (scarcity of land in general) vs. clustering of economic activities.

Technological trends

Technological trends will meet the demand for comfort, safety and speed through advances in ICT and telematics (traffic and transport management systems, travel information and reservation systems, vehicle guidance systems, mobility cards). Dematerialisation[3] (also advances in new materials) combined with miniaturisation has the potential to decrease freight volumes and weight. Moreover, the search for cleaner, eco-efficient technologies (solar and fuel cells, propulsion technologies) will have implications for vehicle operation.

It is against the background of these general societal and technological trends that effects of ICT on transport and mobility must be placed. It is not a matter of simple cause-and-effect but part of a much richer background of change that creates different responses under different conditions. Much of the development of ICT has been paralleled by substantial increases in travel as levels of affluence have increased, as trade barriers have been dismantled, and as leisure time has increased. The cost of travel has been maintained at low levels and the opportunities to travel have increased substantially.

[2] Pasquini, Velardo, Vicario http://www.eurescom.de/e-living

[3] Pasquini, Velardo, Vicario http://www.eurescom.de/e-living

Table 5: General socio-economic trends in interaction with ICT developments and ICT impacts on transport

Socio-economic Trends	Role of ICT	Impacts on Transport
Global Markets	Improves communication, assists global marketing	More long distance transport for goods and services, and also for business meetings
Changes in nature of work – manufacturing to service and information. Greater female participation	Higher levels of skills and access to ICT at work, home and local centres	Reductions in travel frequency, but longer distances and some substitution
Flexibility of the labour market	Technology for flexible remote working	Reduction in travel frequency, but perhaps longer distance travel (when individuals move further from work) and also substitution of work travel with other travel (with time saved by not travelling to work)
Footloose industry	Technology for industries to be located far from clients	Increases travel distance for business client journeys
24-hour economy	Improves ability to carry out transactions automatically and in real time	Reduces the need to travel for many transactions, but requires more people to work outside "regular" work hours – implications for transport modes

3.2 Framework scenarios for "e-society" 2010/2015

Trends, and even more so changes in trends, pose challenges for future developments. Important questions are: How important are trends, relatively speaking? How certain are the trends? In which directions are they pointing? Do they intensify or counterbalance each other? Will they continue, turn or even reverse (trend breaks)? (Kemp 1997) These salient questions will be taken up in the framework scenarios for 'e-society'.

Framework scenarios represent alternative, qualitatively different futures for 'e-society'. Scenarios typically contain trends and trend breaks in terms of future impacts of ICT on transport and mobility. They thus enable us to find alternative ways to address the focal issue of "What socio-economic impacts could ICT have for transport and mobility in an enlarged Europe in the timeframe of 2010/2015, and what challenges for policy would that bring about?"

In the following, three framework scenarios will be described, each representing a different key perspective on the future of "e-society": "The New New Economy", "Big Business as Usual" and "Smart Social Policy" (cf. Table 6). Thus, each scenario provides a different social, cultural and political context against which ICT may likely impact transport and mobility in the future.

Table 6: Key perspectives of the framework scenarios

Scenario	The New New Economy	Big Business as Usual	Smart Social Policy
Key driver	civil society	business	social policy
Values	quality of life	profit, economic efficiency	cohesion, subsidiarity
Governance	network, dispersed	corporate, top-down	multi-level

Each scenario will be introduced with an abstract and then characterised in more detail along the dimensions "people", "politics and framing conditions", "industry", and "emergent phenomena" (Table 7). A comparative table at the end of this chapter summarises the key characteristics of each scenario (ch. 3.3).

Table 7: Key dimensions of the framework scenarios

People	Politics and Framing Conditions	Industry	Emergent Phenomena
Attitudes and values to work	Global scene	Business models, industry structure	Techno-economic regime
Attitudes and culture with respect to mobility and mobility-substituting ICT	Social, economic and environmental problem pressure	ICT and ICT industry development	Path-dependencies
User acceptance of transport systems	Scope for policy; development of European structures and institutions	New production patterns and logistics	Substitution, dematerialisation, customisation
Acceptance, competencies and skills to use ICT as consumers, citizens and workers	Social distribution of costs	Development of transport industry	Sophisticated mobile services 24-hour society

3.2.1 Scenario "The New New Economy"

Abstract

The New New Economy scenario corresponds to a situation where e-society is driven by open source technology and networking culture, enabling widespread substitution of physical transport by electronic interactions. This scenario is characterised by a revival of the ICT-based New Economy and a subsequent long boom. Key to this is an increasing importance of the "open source" (OS) culture as a solution to the provision of public goods in contexts characterised by strong network externalities. Starting on the technology side, in particular with the operating system Linux, the OS networking culture starts to spread through society, to affect both production and development and the user side. The "killer application" is secure ICT-supported ride sharing for back-packers and car-free people, incidentally a market segment culturally close to the OS community. This sets in motion a rapid development of ICT applications that partly substitute travelling and increase efficiency of the transport systems. Policy is mainly supportive by providing adequate institutions in response to political pressure from the OS community. As a spill-over from the OS community, political commitment emerges to long-term common goods such as human rights, social cohesion and a good environment, whereas – again inspired by OS – the actual policy practice is adaptive and perceptive of business opportunities.

Description

At the turn of the century the established telecom community, developers and operators, showed little perceptiveness of parts of the emerging user demand. In the face of a sharp decline in investor interest in ICT their interest was minimal in catering to demand that was not easy to satisfy within their existing technological platform. In this situation the "open source" (OS) movement gained momentum among independent academics and telecom workers, inspired, of course, by the process that led to the development of the Linux operating system for the PC a decade earlier.

The initial developments focused on finding ways to support ride-sharing systems based on matching, in a secure way, travel companions via their mobile phones. The intended users were groups of which the OS community was itself part, viz. young people at universities, in high tech regions and in big conurbations. Their needs included both ride-sharing to work – in the context of a "patchy" working life not allowing the regular commuter behaviour of previous

generations, to parties, concerts and other social gatherings, and hitch-hiking or finding a travel companion when back-packing in Asia or Latin America.

The difficult part in developing the Travel Companion OS standard was not the matching of demand and supply. Instead it was the security features. Tracking & tracing and alarm facilities were important aspects. The real keys, however, were the authentication features, including biometrics, and the mechanism for transferral of trust introduced by the famous portal www.small-world.org[4] opened in 2006.

These early OS developments in intelligent transport systems proved path breaking in several ways. Inviting independent customer service providers from the OS community to their network infrastructure turned out a *sine qua non* for mobile telephony operators. Hence the industry split into two very different segments – the big and slow (at least in terms of features offered) infrastructure operators and the small and quick content providers. SMEs that adapted new systems to end-users (packaging) emerged and provided user-friendly network applications. In this way a networking culture spread through society, both on the production and development side and on the user side.

By 2010, several big European cities started to introduce smart public transport systems characterised by ICT for inter-modality and seamless transitions. It was now possible to get all relevant information on available transport opportunities and to order and pay for a trip over the mobile telecom net. Integrated payment systems made combined trips by e.g. taxi, train and rental car more common than trips solely by car, and car ownership stagnated. The volume of personal kilometres by car started declining in cities, a tendency that was facilitated by smart road toll systems around city centres. But the ease with which a trip can be made has stimulated inter-modal travel.

Distance-working became rather common among information workers as self-employment and network companies gradually spread. Again, this reduced daily trips by car to the office. In sum, the urban environment and health improved steadily from 2008.

The strong growth of long distance travel during the end of the 20th century, especially by air, dipped after 9-11 2001 and finally levelled off around 2007. This had to do with the spread of the networking culture based on a new generation that was used to communicating and solving problems over the web. Tele-conferencing also became widely accepted. However, the overall level of CO_2 emissions remained a problem, despite a moderate decrease.

E-logistic companies (independent third party integrators) specialised on supply chain management began to appear in large numbers after 2006. Also, SME transport and logistic companies, specialised in storage, commissioning etc., emerged organised in open networks that cooperated on freight exchanges. There is a well-functioning spot market for transport services running on the Internet since about 2007. This has led to much increased load factors in all freight operations.

Policy mainly supports the march into the network society by setting up institutions requested by strong interest groups. Initially individual US states and EU member-states led this development. Due to the big gains from effective institutions, however, others often followed suit quite swiftly. This is well exemplified by the role of the open source community in IPR, consumers' rights and ICT integrity. Since day-to-day business and transport were running smoothly, policy was directed towards public goods and societal goals over the longer term, such as sustainability. The road tolls are an example of this policy. In most places the resources collected were reinvested in public and inter-modal transport and information systems. Policies could be described generally as adaptive but with an eye on long-term social, economic and

[4] An allusion to the small-world phenomenon discovered by network analysts, viz. that the "number of handshakes" between – or differently put the length of the chain of acquaintances connecting – two randomly selected individuals is typically surprisingly small, and Lonely Planet, the series of travel guides constituting the backpackers' traditional bible.

ecological sustainability. Governments make efficient use of NGOs and private companies for problem-solving. Also NGOs have in some domains taken over traditional roles of governments, or – more commonly – in "new" areas like Internet governance NGOs are performing tasks that during the 20th century would have been considered as impossible for anybody but states.

3.2.2 Scenario "Big Business as Usual"

Abstract
The Big Business as Usual scenario corresponds to the situation where economic efficiency is the main driver for the economy and society. In the context of this scenario, the global scene is dominated by the US waging a long-lasting war on terrorism. Europe is a junior partner of America. This US domination also spills over to other political and cultural arenas. Government support to industrial development is limited to the most generic forms. Big, global companies, mostly US based, exploiting economies of scale and scope are seen as a natural development in the mature information economy – or perhaps as a consequence of the leading political role of the US. In ICT this oligopolistic market structure has led to competing proprietary standards by which suppliers try to lock-in their customer base. Winner-takes-all solutions à la Microsoft exist in some markets but are for the most part pre-empted by competition policies. This means that sophisticated solutions, e.g. in transport telematics, are expensive and limited to business and high-end consumer markets. There is also a thriving but unsophisticated discount travel industry. Freight prices are, generally speaking, low and production systems global and characterised by a high degree of competition. Teleconferencing is big in the globalized production systems but face-to-face contact is seen as necessary for team-building.

Description
Was there, as many argued, a third industrial revolution and the advent of a "new economy" during the last decade of the 20th century? Well, even now, 2015, the jury is out on whether such extravagant vocabulary is really called for. But, clearly, the 1990s saw a number of qualitative shifts in the business environment that have not been paralleled in significance since. Rather, these features – globally oriented enterprises focusing on their core competencies, divesting and outsourcing other activities, and adopting process-oriented organisations – have remained with us and become increasingly ubiquitous.

However, an even more powerful factor in shaping the world as we know it is the *Pax Americana*. Just like Pearl Harbour meant an end to traditional American isolationism, it was the 9-11 attacks that incited the US to embark on the remodelling of the world that has been such a dominant feature of the past decade. The Modernisation of the Middle East and Central Asia have secured oil supply at reasonable price levels – albeit at the substantial cost of the prolonged and still ongoing War Against Terrorism. The political choice of Europe has been to align itself with the world's only superpower.

As junior partner in the transatlantic concert, Europe has adopted more US-like ways in many fields of policy – as well as with regard to cultures and life-styles. For example with regard to competition, information security and IPR, Europe has joined US-lead regimes, not to mention the export controls intended to deny terrorists hi-tech access. Not least the latter regime is thought by many to benefit established US-dominated corporations over independent start-ups or non-US firms. In Europe as elsewhere, most of the economy is controlled by US-dominated global firms.

In the American-led intellectual elite debate – intense as always – some argue that this is a fair price for the rest of the world to pay for US policing. Others argue that the return from the start-up to the big corporation as focal point of economic development is just a natural consequence of the maturing of network economy. In line with this, the big corporation now in 2015 is a lot different from its counterpart 25 or 50 years back. The idea of the vertically integrated production system controlling an entire value-chain seems to be gone forever. Instead

companies are organised around synergistic constellations of core competencies. The exploitation of value-constellations almost always involves multiple firms. In contrast to many happy predictions in the 90s, however, these constellations tended to be rather fixed or, locked-in. The tendency for this type of market structure to end up in global monopolies has been relatively effectively pre-empted by competition policies. Therefore, the typical market situation is global oligopolistic competition where, however, the customer base of each oligopolistic constellation tends to be locked-in by means on proprietary standards. This means that, e.g., the mature market for ICT services is a lot different from what was expected during the *Sturm und Drang* years in the 90s. Instead of ubiquitous standards, the oligopolistic competition led to something like a Babylonian confusion.

About eight years ago, after the crisis of the early millennium that shook many ICT-companies, a specialisation strategy was pursued by some of them quite successfully. Rather than aiming at mass markets, the successful players went for specialised business or high-end consumer markets. By means of lock-in oriented strategies, they tried to establish themselves as leaders in such specialised service markets rather than offering services across the board. To protect their revenues, there was no interest in establishing common standards, but rather in creating individual proprietary standards, combined with very advanced high-quality services.

In person transport ICT systems, the emphasis is squarely on high-end cars and end-to-end integrated inter-modal trips for the wealthiest businessmen. In automotive systems, fixed constellations of car manufacturers and ICT firms form the oligopoly. According to standard market segmentation strategies, the most advanced features are offered only with the most expensive makes. Each of the three global car manufacturers operates its proprietary telematics network. This means that the usefulness of telematics systems – beyond the stand-alone systems within each high-end car – is limited to major cities and roads.

As for low-end personal transport markets, there is ample supply of discount air and bus transport, in addition, of course, to low-end cars, but very little in the way of ICT support.

Teleconferencing is an important complement to business travelling in an increasingly global economy. However, building teams or performing non-standard problem solving requires face-to-face contact. Also, the developments in the personal transport industry facilitate the extensive travelling of high-end business travellers and make affordable international travelling even for junior business people from poorer regions.

Manufacturing systems are quite globalized and this part of the economy is characterised more by cutthroat competition than locked-in customer bases. One of the real core competencies of a manufacturing firm is the ability to put together customised and cost-effective logistics solutions. In doing so one has to make optimal use of the competition between the three to five global firms taking care of each value density market segment.

3.2.3 Scenario “Smart Social Policies”

Abstract
The Smart Social Policies scenario assumes that social issues will have a major role in defining IST and transport priorities. In this scenario, the big consumer markets initially fail to support the big step towards mobile internet and the EU’s social ICT applications couldn’t rely on commercial mass-market developments. Instead, strategic niches and regional clusters are targeted. EU policy promotes multi-modality to accommodate different lifestyles by taking advantage of the diverse assets of the EU25. By 2010 Europe takes the global lead in mobile ICT development as their more cost-sensitive social niche technologies turn out a better source of spin-off than the defence and security applications that dominate in the US. These niches ultimately start cascading and develop into mass markets so that by 2015 Europe is the global champion in mobile internet and ambient intelligence.

Description
By 2008 the "shrinking" on the global scale among the relatively stable as Triade had slowed down the speed of globalisation. Economic growth had been steady and economic activity tended to concentrate on Europe through 'glocalisation' of production. Freight transport and goods distribution became increasingly centralised which led to stronger regional production and clusters. Industry tended to look different since many specialised companies offered specific services.

Regional disparities among the EU25 had shifted from a North-South divide towards a West-East divide. Moreover, multiple "divides" in infrastructure provision, ICT diffusion and use, etc. among and within the Member States of the EU emerge. Thus pro-active policy-making was seen as necessary to secure cohesion within the enlarged EU.

Strong sector-based ICT applications in e-commerce platforms, logistics chains etc. were available with standard-setting processes starting across EU industries. European ICT research and development is carried out at EU level focussing on mobile internet and ambient intelligence. EU companies exploit their almost monopolistic position in selected areas, and prices for ICT-based services were pretty high because European standards and infrastructures prevail. Switching costs for the individual were also quite high. Many application areas were not geared towards creating mass markets.

Many ICT and transport companies pursued a specialisation strategy, some of them quite successfully. By means of protectionist strategies, they tried to establish themselves as leaders in Europe or in specialised service markets rather than offering truly global services. To protect their revenues, there was no interest in establishing global standards but rather creating cluster-specific standards, combined with advanced high-quality services.

In the United States it was defense and security technologies. Just like during the cold war these highly cost-insensitive application areas turned out poor drivers of commercially exploitable solutions. The European Union took a different path. Investment in the development of ICT applications was mainly geared towards meeting the diverse social needs of more disadvantaged groups such as the disabled or the elderly, or cohesion goals particularly in congested urban and peripheral rural areas. EU policies were thus increasingly geared towards coordinating the various sector-based initiatives and pursued as IST-related social policies rather than sector-specific ICT or transport policy. EU policy was also strongly complementary by promoting schemes for education and skills as well as programmes to foster ICT uptake in households, companies, etc. The EU took over horizontal integration of decision-making and integrating operations, also by establishing "good practice" hubs to promote inter- and multi-modality.

In the early stage, variety creation was the central policy strategy. The cultural diversity of the EU25 turns out to be a real asset in developing cost-sensitive social niches in IST-related transport. IST-related transport and mobility policies were adopted widely but in a highly customised way e.g. tailored to specific demands and conditions and targeted areas. Governments are now advancing niche development to stimulate a significant modal shift away from the car to multi-modal mobility concepts such as chain mobility or new ownership concepts such as car-sharing. Multi-modality tries to meet the requirement of increasingly flexible lifestyles. Customisation of services particularly in local and regional markets is thus key to meeting the demand for more flexibility in lifestyles. Successful niches include health applications, public transport and public administration. The "sum" of niche actions eventually allows breaking out of the lock-in of the car-dependent system, by inducing lasting changes in travel and mobility behaviour. Successful transport policy is curbing the growth of the overall number of vehicles despite relatively high total mobility costs due to policy initiatives to make private car use less attractive through parking fees, road pricing, taxation, etc.

Active niche development policies are pursued to ensure the continuous improvement and uptake of ICT services in key areas such as health, mobility, public administration and

communication. Institutional and organisational barriers to widespread ICT use within and between sectors (health, transport, government) are successfully broken up.

Regional and local governments were re-discovered as appropriate levels of policy-making when it came to designing and implementing niches. There were a variety of successful strategies to alleviate congestion in cities, one of the most problem-stricken areas in need for policy intervention. Integrated regional planning involving participatory approaches have paved the way for a high degree of social acceptance for the ban of private cars in inner cities through limited access zoning. Urban mobility centres (UMCs) provide highly flexible and customized means of transport and mobility services for inter- and intra-urban travellers.

Niches helped in promoting an even stronger positive attitude towards ICT and ICT-based services and now allow for more demand-responsive transport and mobility system that in turn also allow for different types of public transport. For instance, user interfaces in individual vehicles have become very comfortable and easy to use, with a high degree of personalisation. Mobility services based on smart card access technologies are taking off and the diversity of vehicle types – highly customised - enhances their attractiveness through “upgrading” them with a range of sophisticated services and gadgets to suit individual life-styles. Less cost-sensitive services increasingly create mass markets.

3.3 Summary of framework scenarios

PEOPLE	Scenario 'Big Business As Usual'	Scenario 'The New New Economy'	Scenario 'Smart Social Policies'
Attitudes and values with respect to work	"American organisation man", lots of work, much stress	Entrepreneurship, exuberance and elitism	Traditional work habits remain, differing by national and regional culture
Attitudes and culture with respect to mobility and mobility-substituting ICTs	Positive attitude towards physical mobility. Teleconferencing used a lot. Discretionary travel characterised by lots of air charter travelling.	Much substitution of business travel due to high quality ICT and emerging acceptance of trust without face-to-face meeting. Discretionary travel demand oriented towards "quality over quantity"	Transport and mobility experienced as time-consuming due to initially limited substitution effects by ICT. Reducing digital and mobile divide are clear policy targets
User acceptance of transport systems	Intelligent transport solutions offered in high-end markets only. As the lack of standardisation has prevented the emergence of integrated, inter-modal mobility chains are realised. Transport relies heavily on individual vehicles.	Good information and physical interfaces for inter-modality taken for granted by all transport users	Preference for public transport systems and demand-responsive transport systems. Range of promising niche policies: - Public transport in urban areas to cope with congestion - Integrated, inter-modal mobility chains for people with special needs (elderly, rural areas, etc. – smart cars).
Acceptance, competencies and skills to use ICT as consumers, citizens and workers	Little change relative to the present	High competencies and skills; high acceptance and concern for user-friendliness and security	Raising skills to use ICT for all EU citizens

POLITICS AND FRAMING CONDITIONS	Scenario 'Big Business As Usual'	Scenario 'The New New Economy'	Scenario 'Smart Social Policy'
Global scene	A world where US leadership in the War on Terrorism carries over to a generally strong US leadership politically, culturally, and economically.	A world where the "open solutions" culture also spreads to the political realm with a combination of commitment to long-term common goods such as human rights, social cohesion and a good environment.	Regional blocks remain; EU25 aims for cohesion after enlargement. Europe is the champion in affordable ICT due to a policy-led and diversity-oriented development strategy. Policy practice that is adaptive and perceptive to social needs.
Problem pressure (social, economic and environmental)	Little concern for social and environmental issues.	High concern, largely channelled through NGOs	Strong concern about social cohesion. Institutional changes: growing interest of unions, interest groups, etc.
Policy, development of European structures and institutions; **Scope for policy**	Strong transatlantic institutions linked to the War On Terrorism, competition etc. Other than that small scope for policy. European institutions subordinated to transatlantic link	Multilevel governance with increasing scope for global and regional levels – and for NGOs. European institutions federal in nature and limited – or enabled – by other governance levels.	Coordination of policies; economies of scale Focus on policy sensitive and adaptive to societal development (equity): active niche strategy Policies broad in scope but ltd. synergies - subsidiarity
Social distribution of costs (private/public)	Less public spending. Traditional interest groups weak.	Less government spending but NGOs are a growth sector for public spending. Traditional interest groups weak.	High taxes to finance active government policies. Comparatively high levels of taxation with redistributive effects to finance social cohesion

INDUSTRY	Scenario 'Big Business As Usual'	Scenario 'The New New Economy'	Scenario 'Smart Social Policy'
Business models, industry structure	Increasing global competition leads to global oligopolies. Core business/outsourcing trend continues, but it is also important for firms to be big in order to have financial muscles and exploit synergies in-house. Mechanisms for developing new business concepts are weak; entrenched firms in adjacent niches can often kill the novelties they don't want to integrate in their own business.	The "open source" (OS) movement introduces a new way of cost-sharing for novelties. Due to early successes OS is embraced by both traditional business and politics. OS culture enables successful developers to quickly build the reputation for acquiring sufficient venture capital to build a start-up.	ICT industry and transport industry have not yet made full use of synergy potential to develop radically new mass-market ICT-enhanced products and services in transport and mobility. Initially slow process, over time uptake – due to increased potential markets
ICT and ICT Industry development	Due to lack of standardisation, sophisticated customised services are expensive. In the oligopolistic markets companies tend to use their proprietary standards, which are incompatible with those of other companies, to lock-in their customer base.	Strong dynamism.	Computing consortia give rise to new industries in Europe around 2010. Standardisation makes sophisticated customised services expensive. Research in ICT at European level, diffusion varies between countries
New production patterns and logistics	International division of labour intensifies. There tends to be only a few production facilities world wide for each product type	International division of labour intensifies. 'Glocal' production system	Local production markets for niches and local needs Local support services for local markets
Development of transport industry	Logistics firms build proprietary systems trying to lock-in their customers world wide. Manufacturing firms integrate their transport suppliers into one system. Transport industry develops sophisticated products at high-end market and simpler solutions /vehicles to the less wealthy. Low end benefits from learning effects at high end	Large and small operators compete and co-operate on an open e-market. Specialised firms make integrated solutions (e.g. payment systems) for freight and person transport.	Transport industry engaged in integrating ICT systems in cars. Tools for drivers, niche market. No big deal until spontaneous take-off

EMERGENT PHENOMENA	Scenario 'Big Business As Usual'	Scenario 'The New New Economy'	Scenario 'Smart Social Policy'
Techno-economic regime	Proprietary standards	Open standards	Cluster-specific standards
Entrenchment, path-dependencies	Strong, but mainly at the level of the individual oligopolies and their standards.	Weak due to effective mechanism for financing development of challengers to established solutions	Alternatives to car-based system Policy efforts to strengthen public transport to overcome path-dependencies in individual sectors and/or infrastructure interdependencies through niche strategies
Substitution, dematerialisation, customisation	Much customisation in high-end markets Limited substitution and dematerialisation.	High	Customisation in high-end markets as a result of policy intervention. Growing substitution and dematerialisation effects.
Availability of sophisticated mobile services	High end markets	Very high	New transport concepts and services
24 hour society	Yes	Yes	No
Transport costs	Not high enough to curb demand	Not extremely high, demand is curbed by value changes and effective 'glocal' production systems.	Relatively high fuel prices High total-cost-of-ownership of cars Standardised road-pricing across Europe

4 TRANSPORT IMPACTS IN SCENARIOS AND ISSUES FOR POLICY

4.1 From frameworks scenarios to policy options

The objective of the second chapter was to review direct and higher-order impact of ICT on transport in the three socio-economic spheres of Living, Working and Producing. This discussion highlighted the lack of consolidated knowledge of *current* impacts, making the assessment of future impacts and the exploration of policy options an extremely difficult task. In fact, we are confronted with two levels of major uncertainty:

The first level refers to major knowledge gaps with respect to the algebraic "sign" and the "order of magnitude" of potential impacts. Being aware of these uncertainties, we nevertheless extracted a number of insights on impacts as well as indications of research needs in the preceding chapters, and this line of inquiry will be carried further into the next section by highlighting a number of key observations based on a deepening and analysis of the individual scenarios from Chapter 3.

The second level of uncertainty has to do with the range of possible future developmental paths and how to prepare ourselves to cope with them. This is the kind of uncertainty for which cross-scenario analysis is a useful tool, and it will be applied in Section 4.3 to explore some key issues and options for policy. Obviously, for this kind of approach it is important to span a broad range of possible futures with the scenarios selected because they are meant primarily as think-tools rather than as realistic descriptions of potential future states or pathways.

We are particularly interested in current policy issues and options in the areas of European transport and information society (IST) policies, but we try to identify them starting from a forward-looking perspective using scenarios. In general, policy is regarded as one among several other factors shaping the future development path of e-society and transport. The three scenarios differ from each other in terms of the general role that is assigned to policy. For instance, the Smart Social Policies scenario is defined as being strongly policy driven, whereas the Big Business as Usual scenario is characterised by a much more passive role of policy. In spite of these differences in principle, there are usually some policy options that would promise to have beneficial impacts in all scenarios. In other words, they would not have gross negative consequences in any of the scenarios, but on the contrary promise to help improve the transport situation across a broad range of futures. These no-regret options are what we call robust policies.

However, there may also be specific risks and opportunities associated with each of the scenarios. Usually, these risks and opportunities cannot be prevented or even predicted in detail. This is what we understand by an adaptive policy approach.[5] It requires the pursuit of policies that avoid rigidities and lock-in situations and having flexible responses on hand ("emergency plans"). For instance, the oil crises of the Seventies took most oil companies by surprise, and it took them many years to adapt to the new situation. Shell was one of the few companies that had in the very least imagined an oil crisis scenario and had taken some preparatory actions in order to be able to cope with such a critical situation if such an occasion arose. Obviously, care needs to be taken that these policy options do not give rise to major risks in some other scenario. In other words, adaptive policy options are a means for cautiously preparing ourselves to be able ro react to changing circumstances. As such, they are an essential part of a policy stategy that recognises the limitations in controlling the future.

In the remainder of this chapter, we will first highlight some important observations from a systematic analysis of transport impacts across the three socio-economic spheres Living, Working and Producing. The analysis has carried out along four main types of impacts that

[5] The notion of adaptivity in strategic policy planning is further elaborated in Eriksson (2003).

represent the linkages between ICT-use and transport: frequency of travel, travel distances, travel mode and the ratio between freight and passenger transport.

We will then focus on a limited set of key issues that emerged as particularly important from the cross-scenario analysis. These issues can be interpreted as decisive levers that will determine if and to what extent ISTs can exert a beneficial impact on transport (or not) in the three socio-economic spheres under study. As such they represent also issues that merit particular policy attention. If the potential of ISTs to improve the situation in transport is not exploited autonomously, policy actions, with respect to these key issues, could be an effective counter-measure. The key issues are formulated as major challenges (in the sense of risks and opportunities), pointing to policy options that would allow the exploitation of the opportunities and reduce the risks. As we look at these issues from the perspective of all three scenarios, it will be possible to highlight elements of robust and adaptive policy options. Whilst the emphasis is put on European IST and transport policy, the subject matter makes it necessary to point to other policy domains and levels as well.

4.2 Policy implications of the ICTRANS scenarios

Whether the effects of ICT are to reduce or travel, displace it or remain largely neutral, policy-makers have a need to know. As outlined above, robust policy options contribute to a generally positive developmental path for e-mobility across all scenarios, whereas adaptive ones display mostly positive, or at least no negative consequences. It is thus of importance to systematically assess the possible transport and mobility impacts for each scenario and for each socio-economic sphere. In order to identify possible types of impacts, four key indicators will be used to characterise the connection ICT developments related to Living, Working and Producing to specify likely changes in future transport demand and mobility. The four indicators are trip frequency, trip distance, modal shift (modality), and impact on the passenger / freight ratio.

The assessment of potential impacts and in how far they might differ across the three scenarios is synthesised in Table 8. The assessments are based on the results of expert workshops. Examples for first and second-order impacts were identified where possible. It is not surprising that indirect effects are the most difficult to assess.

Table 8: Transport impacts in the socio-economic spheres Producing, Living, Working

I ... first-order effect	+ ... increase	**0** ... no effect
II ... second-order effect	**-** ... decrease	**?** ... effect unknown

Socio-economic sphere WORKING			
	Scenario New New Economy	**Scenario Big Business as Usual**	**Scenario Smart Social Policy**
General characteristics	• Flexibility of working and leisure time schedules • Technology empowers people to unfold creativity and start up new companies • Much variation in and sometimes contradiction between lifestyles and attitudes • Groups with dedicated anti-travel attitudes based on environmental considerations and critical attitudes towards the economic production system	• Big international corporations control the labour market • Hire-and-fire mentality dominates the working sphere • More short-term job contracts, exploitation of work force, economic migration • Tele-work as a cost-saving exercise of big companies for low skill / low pay tasks • Few wealthy users develop alternative travel behaviour	• Strategic niches need a highly specialised labour force. Depend on longer-term job contracts in order to develop their qualifications • Flexibility of the work force important, but job-hopping neither desirable nor necessary in specialised clusters • Experts work under relatively stable conditions in specific fields. • Some lifestyle variation, awareness for environment and special needs.
Frequency of travel	**I: 0** Ambivalent nature of flexible job arrangements, self-employed working schemes, increased teleworking. **I: +, -** Some trips substitutable by teleconferencing **I: 0, -** No fundamental change in work-related travel, some anti-travel attitudes **I: +** (leisure travel)	**I: +** As a consequence of growing short-term job contracts - For business travel due to increased use of teleworking. **I: 0** Commuting travel **I: +** Leisure trips	**I: +** More trips for cooperation of specialists in thematic, industrial clusters **I: -** Some possibilities and necessities for telework - increased telework **I: minimal, -** Example e-health: tele-diagnostics **I: 0** (commuting, leisure)
Distance	**I: -** (start-ups have their offices close to where they live) **I: +** (other travel), costumers have to be visited. **I: + (**commuters) **I: + (**leisure travel) People have more free time and holidays.	**I: +** (more commuters) **I: 0** (tele-working, commuting) **I: +** (leisure)	**I: -** (within regional clusters companies and individuals physically close to each other) **I: +** (worldwide specialisation and more commuters. Less trip chaining) **I: 0** (commuters & leisure)
Modality	**New possibilities for inter-model travel** Due to technology for intelligent traffic systems **Development towards public transportation** People increasingly want to work while travelling ICT used to optimise car traffic by car-sharing **Modal choice decisions** supported by intelligent and networked ICT devices. Possibly more efficient use of traffic infrastructures.	**Car-based system** Reinforced by lifestyles and attitudes **Modal choice of individuals not affected** by increased teleworking contracts. **More inter-modal traffic** possible due to intelligent nativagation systems	**More air transport, more telework** due to large world-market and customer base **Car-based travel prevails** **Modal choice not affected** because meaning of telework is not big enough **Alternative transport concepts** used consciously by certain actor groups.
Freight-passenger ratio	**I: 0 , - (freight)** Immaterial products growing in importance. Intelligent systems increase efficiency in freight transport systems.	**I: 0**	**I: + (freight)** Due to the global labor division. Freight better coordinated. Traffic streams optimised due to the regional clusters. **I: 0 , + (passenger)**

Socio-economic sphere LIVING			
	Scenario New New Economy	**Scenario Big Business as Usual**	**Scenario Smart Social Policy**
General characteristics		Increase in air traffic and leisure time	Many new ICT applications
Distance	**I: - II: +** Frequent use of ICT to make international contacts will reduce trip distance over long distances. However, as a second-order effect, trip distance may increase due to the need to see each other face-to-face after digital contacts.	**I: +** Increase for passengers	**I: +, -** Increase due to need for more face-to-face. Decrease since people are more virtually mobile.
Frequency of travel	**I: +** Need for more physical following digital contact	**I: +** See above	**I: +, -** See above
Modal shift	**I: NO** Due to heavy reliance on cars	**I: NO** More air travel, more cars	**I: YES** Depends on type of newly developed ICT applications within individual niches
New modes	**I: YES** Opportunities for environmentally friendly cars. New forms of semipublic transport like ride sharing (booked via the internet) or combination of package and person transport. Highly customized services leading to optimal vehicle use.	**I: (NO)** ICT applications in cars as gadgets	**I: YES, NO** See above
Substitution of physical by virtual mobility	**I: YES** People meet more frequently by digital means	**I: NO** ICT not much used. May change when demand creates supply for ICT services after further deterioration of existing mobility system	**I: YES** In the case of e-health applications like the internet-doctor
Generation of new mobility	**II: YES** See above.	**I: YES** As a result of more leisure time	**I: YES** If e-commerce gains prominence: new mobility for delivery of packages
Flexibility	**HIGH** Due to the use of ICT information systems and the role of intermediaries who try to match supply and demand.	**LOW** Because of the lock-in situation that dominates	**INCREASE** As a result of different e-services if alternative modes of public transport are introduced after 2011. Reliance upon private car (flexible, customised).
External effects	**POSITIVE** Due to optimal use of transportation capacity less congestion and accidents. No peak hours, but more constant traffic flow. Less emissions but higher noise level due to constant road traffic. **NEGATIVE** New digital divide between experts and non-experts	**NEGATIVE** Much environmental damage as a result of increased car and air traffic. More accidents and congestion as a result of the increase in traffic movements. Consumer lock-in.	**NEGATIVE** Potential new digital divides increase the disparities between countries and between city and countryside.

Socio-economic sphere PRODUCING			
	Scenario New New Economy	**Scenario Big Business as Usual**	**Scenario Smart Social Policy**
General characteristics	• Co-production with nobody in control • Productivity growth due to ICT • Global trade; Local physical production in combination with globalized production when economies of scale are considerable • More services and intangibles • JIT tendencies of low transport productivity counteracted by open transport markets	• Increased division of labour leads to more traffic in terms of frequency and distance • Sub-optimal transport services and infrastructure • Distribution and coordination governs transaction costs (how to coordinate?) • Low incentives to adopt transport innovations along the supply chain • Production networks (postponement strategies and more mid-range transport) • No decoupling to be expected until serious grid-lock	• Coordination of scattered production sites • Increase in transport demand • New opportunities for SMEs (more flexibility), limited market opportunities for larger firms • Optimisation of logistics chains within sectors • Lack of integrated ICT infrastructure prevents inter-modal tracking-and-tracing • Better integration of information systems; Teleshopping tends to increase the number of small packages • Use of more ICT to optimise trips and logistics management
Frequency	**-** Frequency of trips to move intermediate goods reduced given the optimal coordination of management experts systems in manufacturing, transport and logistics, and retailing	**+** Retailers maximise the number of goods delivered to e-shoppers. Given an increase in the complexity and small size of parcels the frequency in short distance trips will increase.	**+ , -**
Distance	**-** Local and global productions optimally combined to obtain scale economies that will reduce the movement of intermediate and final goods.	**+** Long distance transport of intermediate and final goods **-** Short distance, due to increased fragmentation of the international division of labour	**+ , -**
Modality	**Socially optimal** Optimisation of mode of transport that takes into account employment in different transport sectors and the lowest (negative) impact on traffic and the environment	**Cost driven** - (freight) + (road transport) Complexity and co-ordination of multi-modality with respect to transport of inputs and finished products will increase cost of multi-modal operation, thus it might decrease.	**+ , -**
Passenger / freight	**Socially optimal** Transferability will be optimised according to the societal goals.	**-** Main rationale is economic growth: inefficiencies are not relevant. Optimisation of transferability less likely.	**+ , -**

Rather than discussing the table in detail, some interesting observations will be highlighted:

Observation 1: Little impact on transport and mobility demand
The 'e-society' scenarios developed in the ICTRANS project did not reveal any clear common trend regarding an increase or decrease of transport demand, but commonalities can be observed for the development of transport demand. If less transport intensity and/or less growth in transport demand are explicit transport policy goals, such goals are unlikely to be met under any of the scenarios, at least as a result of increased used of ICTs. Although there is a potential to change mobility behaviour, particularly in the New New Economy scenario, a reduction in growth in transport demand is less likely to take place.

Observation 2: General direction of indicators in each scenario
In the New New Economy scenario, all indicators will tend to be socially optimal according to the overriding principles of the economic activities. Welfare Given the wide access to open source expert systems to coordinate transport of goods and people all indicators will remain at the socially desirable level.

In the Big Business as Usual scenario, all indicators tend to increase as the scenario description indicates that there would not be any restrictions for the intensive use of transport for the sake of profit and economic growth.

In the Smart Social Policy scenario, all indicators are expected to be relevant but the direction of the impact will decrease or increase depending upon the desired social optimum and the context of the ICT application. In some cases the goals of a niche creation policy will promote the decrease or increase of the indicators according to needs of correcting market failures.

The differences among scenarios may be exemplified by the implications for modal shift in the Working environment: whereas in the New New Economy scenario, car-sharing is likely, Big Business as Usual will remain car-based, and the Smart Social Policy tends to increasingly promote car alternatives.

Observation 3: Some homogenous developments for Working and Living, unclear for Producing
The socio-economic spheres Working and Living exhibit some quite homogeneous developments. Frequency and distance of travel, for instance, tend to increase in both spheres in all scenarios. As already indicated in the state-of-the-art review papers, Producing is the socio-economic sphere where there is currently the least amount of data and knowledge on ICT impacts on transport available. It is thus, not surprising that also in terms of future scenarios this is the area where potential effects are more difficult to gauge.

4.3 Robust and adaptive options for policy: a cross-scenarios perspective

When looking at the three socio-economic spheres across all three scenarios, a comparatively small number of key issues can be identified as particularly pertinent for the extent and direction of ICT impacts on transport and mobility. Their importance may differ in each of the scenarios, but overall they seem to play a crucial role for exploiting the potential of ICTs with respect to a reduction in the growth of transport demand. In the following we will elaborate on six of these key issues:

- The co-ordination of manufacturing, logistics and distribution
- Making distance working reduce transport demand
- Matching customized mobility services with diversified lifestyles and attitudes
- Avoiding digital divides that limit the potential positive impact of ICT on transport

- Turning relative cost increases in transport into a benefit
- Lock-in and how to overcome it

Each of the six issues is described in terms of the main challenge it represents, and in terms of their main determinants. We will then look at the differences across the scenarios, i.e. how these issues are likely to evolve under the conditions of the three scenarios described above. This allows then highlighting some possible directions for policy, taking into account the notions of robustness and adaptivity that are key from a cross-scenarios perspective.

4.3.1 Issue 1: The coordination of manufacturing, logistics and distribution

Challenge: With the transformation of production activities into highly integrated and coordinated supply chains, ranging from component manufacturing to distribution, the importance of efficient logistics has greatly increased. Just-in-time and on-demand concepts have been introduced in response to more demanding user requirements in terms of customisation and service-orientation, pointing to a shift of influence towards market pull forces. This development has been partly driven by the widespread use of ICTs, but also depends on the ability to introduce organisational changes along the supply chain. As regards to transport, we are confronted with two counteracting effects. On the one hand, efficiency gains in freight logistics due to the widespread use of ICTs have had a positive effect on transport. For instance, tracking and tracing technology enables real-time logistical planning and an increase of load factors. Other promising developments result from better coordination of transport activities across sectors, because large-scale distribution and logistics companies can optimise a wider range of transport flows. Finally, the inclusion of final service and product delivery to the end user as part of B2B and B2C e-commerce concepts may lead to an optimisation of distribution traffic and a reduction of shopping trips, even if these reductions in passenger traffic may entail a shift towards more freight distribution traffic. On the other hand, the coordination of geographically dispersed sourcing, production, and distribution activities by means of sophisticated logistics schemes tends to generate additional direct transport demand, both in terms of distance and frequency (although the magnitude of impacts may differ by sectors).

Determinants: The balance between those mechanisms that exert a reinforcing impact on transport demand along the supply chain on the one hand and those that curb the growth in transport demand on the other depends on a number of key determinants that can play out differently in our scenarios:

- *Technologies for coordinating production and logistics along the production chain and across sectors:* Major efforts are required in terms of standardization, both with respect to IST-solutions and for “hardware” such as container systems, in order to improve the possibilities for a well-coordinated production and distribution process.
- *The organization of supply chain systems:* Beyond technologies, the organization of the supply and distribution chain determines transport distances as well as the efficiency of transport operations. Of even more fundamental importance is the architecture of such systems, although we still know very little about their impact on transport.
- *Framework conditions:* e.g. in terms of standards and pricing, that support the comprehensive use of advanced logistics technologies for optimizing transport flows (tracking and tracing, freight delivery exchange etc.), both within sectors and across sectors and countries.
- *Infrastructures for inter-modal services:* The development of the physical infrastructure for inter-modal transport lags significantly behind the development of ICTs that can facilitate inter-modal operations. The main weaknesses of inter-modal infrastructure concern inter-

modal terminals for long-distance transport and local distribution centers as well as systems for inter-modal co-ordination and traveler information.

Differences / similarities across scenarios: When looking ahead in terms of the three scenarios, the co-ordination along the production chain seems to be most difficult to settle under the conditions of the Big Business as Usual scenario. The growing division of labour between large-scale companies goes hand in hand with a growth in transport distances and frequencies, especially as long as transport costs remain comparatively low. Neither would an active policy be pursued to internalise external costs of transport. Road transport would tend to remain the preferred mode due to the high degree of flexibility it offers. This would only change once major problems of gridlock occur that put into question the reliability of the supply chain. The dominance of road transport would also be a result of underinvestment in advanced infrastructures and services enabling inter-modal transport. Businesses would also tend to postpone longer-term investment in IST and transport innovations along the supply chain due to the economic imperative determining transport choices. It is unlikely that policy or private players would take anticipative actions before "gridlock" is actually reached.

In the New New Economy scenario a higher degree of diversity and service orientation in terms of supply chain organisation would be realised, due to the decentralised and open source type of ISTs used. Global trade in IST-based production recipes combined with local physical production would in principle allow reducing long-distance transport of physical goods. In particular, advanced decentralised production-consumption systems (virtual manufacturing) would appear to be a feasible option under the conditions of this scenario.[6] The potential negative side-impacts of just-in-time and customised production are limited by optimised logistics systems operating in open transport markets. Also in terms of value orientations, this scenario is characterised by great attention to environmental concerns. The pervasive use of ISTs throughout the economic and social system would favour the implementation of intelligent inter-modal transport systems. However, physical infrastructure for inter-modal operations would still represent a major bottleneck.

Finally, in the Smart Social Policies scenario, a lower degree of cross-sectoral coordination of logistics flows than in the New, New Economy scenario can be assumed. The co-ordination of scattered production sites is not very likely in a world where SMEs tend to play a key role as niche producers, unless government plays an active role in facilitating co-ordination. Advanced logistics systems would be applied only in certain geographically or application-specific niches. Neither does the lack of a comprehensive integration of transport infrastructures into inter-modal systems offer much scope for highly optimised logistics chains across sectors, for instance cross-sectoral tracking and tracing. Standardisation is less advanced and widespread than in the New, New Economy scenario.

Policy options: The most important policy options with respect to the co-ordination of production chains also fall outside the range of conventional transport and IST policy and overlap rather with industrial labour and trade policies.

- *Technical coordination and standardization:* Whereas in the New, New Economy scenario, standards and coordination in the IST field seem to emerge almost autonomously (though not necessarily in the transport field), additional policy efforts may be required in the two other scenarios. In particular, the Big Business as Usual scenario is characterized by proprietary standards in both ISTs and transport industries, leading to a duplication of efforts and the co-existence of several large, but closed worlds. In the course of the Smart Social Policies scenario, where initially ISTs are applied in a highly scattered way, active attempts by government to improve on standards would be beneficial, for instance to improve coordination of cross-industrial integration of logistics chains.

[6] Compare similar suggestions as part of the scenario developed in the context of the DG RTD "Future of Manufacturing" project. The economies of scale which are nowadays taken almost as given in manufacturing would give way to equally economic decentralized solutions where the software "recipes" are the key asset rather than the production machinery.

- *Inter-modal infrastructures:* A better co-ordination of transport flows along the production chains requires not only IST infrastructures to be in place but also major changes to the infrastructures for physical transport.
- *Pricing policies:* The relative prices for transport and IST services could operate as a powerful steering mechanism. However, as discussed in more detail under Issue 5, only significant changes in relative prices are expected to make a difference. However, active unilateral pricing policies in Europe are rather unlikely in the scenario Big Business as Usual where fierce global competition will be the main driving factor in industry.
- *Piloting new supply chains:* Transport costs and distances tend to be a negligible factor for today's supply chains. The supply chain model that is becoming dominant (i.e. hub and spokes system) exploits economies of scale but disfavors regions and locations outside of the main hubs. Both in the New New Economy and the Smart Social Policies scenarios, government support for pilot schemes with less transport-intensive, possibly more regionalized supply chain architectures, would be potential policy inroads.
- *New business models:* In particular the Smart Social Policies scenario, but to some extent also the Big Business as Usual scenario, suffers from the lack of viable business models for new ICT services. Here, new models of Public-Private Partnership, for instance in specific application areas with a "social" mission, would be a promising way to foster innovation. Obviously, monopoly and competition issues need to be closely monitored in such cases.
- *Public procurement:* government can take the role of a lead user who pays particular attention to the transport impacts of the services it uses. As part of an environmental impact assessment (which is increasingly required for most public services anyway), criteria relating to the transport intensity of the underlying supply chains could be applied. This role is implicit in the Smart Social Policies scenario, anyway, but it could also be one of the few levers for government compatible with the Big Business as Usual scenario to exert an technological change along the supply chain. Even in the New New Economy scenario it could support the emergence of less mobility-intensive solutions.

4.3.2 Issue 2: Making distance working reduce transport demand

Challenge: Distance working offers the potential to decrease the demand for transport, but both the extent to which it is actually adopted and the magnitude of the potential impacts on transport depend on the existence of conducive framework conditions of various kinds. In principle, the flexibilization of working patterns, reflected in the growth of telework and work on the move, is supposed to continue to grow in importance in all scenarios but the specific types and concepts for realising distance work may differ. As a consequence, also the net impact on transport will be different. It depends largely on the occurrence of second order effects for each type of distance work. For instance, a lower frequency of commuter trips as a result of conventional teleworking schemes tends to be associated with longer trip distances and more frequent leisure or shopping trips, or with additional trips by family members.

Overall, it is important to note that due to the occurrence of counter-balancing second and higher order effects, the expected positive net impact of distance working on transport is likely to be very small, if not negligible, unless a scenario is realised in which such second-order effects are effectively prevented.

Determinants: While few technological and organisational barriers to distance working seem to remain, its uptake still depends on a wide range of boundary conditions such as labour market regulations, attitudes of employers (e.g. their willingness to introduce significant changes in work organisation) as well as values and attitudes of employees, the type of activity conducted,

etc. Many of them are dependent on local, regional and national policies rather than on EU policy:

- *Spatial structure:* The spatial distribution of workplaces and living places, but also of shopping and leisure facilities has a major influence on travel distances. In the longer term, the spatial structure may change if the possibilities for distance working improve. Spatial planning has a key role to play in this respect.
- *Labor and labor market regulations:* Labor-related framework conditions often constrain the possibilities for self-employment and distance working.
- *Availability of high-quality public transport:* If the tendency of distance workers using their private cars is to be stopped, the quality and flexibility of efficient, door-to-door public transport options need to be improved.

Two key topics thus need to be addressed: First of all, how can framework conditions be adjusted to improve the conditions for distance working? This would in the first instance require making distance working (and associated to this also self-employment) more attractive to both employees and employers. Secondly, how can the emergence of negative second-order effects be avoided? This will require significant changes in terms of spatial planning, demand-side management and lifestyles would be needed, complemented by the provision of real alternatives to the use of the private car for realising daily activities.

Differences / similarities across the scenarios: Distance working is likely to be most widely used the New New Economy scenario. The assumed shift in attitudes and habits is geared towards exploiting as much as possible the potential benefits of "e-everything" by a large part of the population. Labour regulations are likely to be conducive to distance working as well, and public transport systems are expected to be upgraded to offer seamless inter-modal mobility options that facilitate the switch to public transport. Overall, good conditions for distance working prevail, promising a smoothening of peak hour traffic, but also a 24 hour traffic load, driven mainly by the allowance of flexibility of working conditions. The scenario is also in line with decentralised "tele-villages" types of concepts and the widespread acceptance of IST-based solutions to substitute for face-to-face interaction (e.g. teleconferencing). Together, these allow reducing the number of work-related trips. However, the future evolution of spatial structures is uncertain in this scenario, putting a question mark behind the overall potential for reducing transport demand due to distance working.

In the Smart Social Policies Scenario, a more limited use of distance work will be made. Overall, a more conservative scenario, the flexibilization of labour market regulations will remain more limited, and, companies would be more restrictive in promoting distance work concepts. However, in this policy-driven scenario it seems more likely that active demand-side-management measures and planning policies are pursued that explicitly aim at reducing travel distances. Thus, while the distance worker community may be smaller than in the New New Economy Scenario, the impact on transport may be of a similar order of magnitude.

In Scenario Big Business as Usual, distance working is mainly regarded as a cost-saving exercise for big companies. It will mainly be used to increase efficiency and to save labour and office costs. In contrast to the New New Economy Scenario, here low skill, routine tasks will be at the core of teleworking, but affecting a significant share of the workforce. The impacts on transport will depend on the distances between workplace and living place, but it is unlikely in this scenario that planning decisions will be geared towards optimising transport.

A reduction in the number and frequency of trips is thus likely in all scenarios, but as trip distances depend on spatial structures and planning, only the Smart Social Policies Scenario is likely to show a reduction in distances. On the other hand, a modal shift is to be expected in scenario New New Economy only, based on the assumption that intelligent inter-modal mobility systems are more likely to emerge.

Policy options: From a policy perspective, the key issue consists of defining framework conditions that contribute to reducing the second-order transport effects of distance working. Many of the policies that have a role to play in this respect should be defined and implemented at national, regional and local levels rather than at the EU-level. Moreover, they tend to be outside the realm of IST and transport policy, but involve – for instance, regional development policy:

- *Demand-side management and spatial planning:* Both demand-side management and spatial planning are mainly local and regional policy issues, for which the EU can play a supportive role by facilitating the exchange of experiences and good practices. For certain aspects, structural funds can be a potential source of finance. In all three scenarios, spatial distances between living, working, shopping and leisure locations ought to be reduced in order to prevent the benefits of distance working to be compensated for by longer trip distances. Especially in the New New Economy scenario with its widespread use of tele-activities, this would be an important policy inroad.

- *Labor market policies:* Labor markets are predominantly a national policy domain. However, both the Smart Social Policies and - in particular - the Big Business as Usual scenario are characterized by rather traditional working patterns, where active impulses by policy could reinforce the uptake of self-employment and/or distance working. In the New New Economy scenario the distance working would be driven by both employers' and employees' interests.

- *Local competitiveness policy:* The New New Economy scenario is characterized by a positive attitude towards distance working. Offering good possibilities for distance workers is even regarded as an asset to attract qualified people, reflecting the emergence of a new type of "white collar" distance workers. Conscious policies to favor and facilitate distance working (e.g. public telecenters and access points, broadband infrastructures, etc.) could thus become part of local competitiveness, regional development and quality of life policies. The EU could play a modest role as well, for instance regarding the exchange of advanced practices, subsidies for innovative "lead cities", but also as part of the common regional and structural policy.

- *Corporate labor policies:* Conservative corporate labor policies tend to discourage distance working. Public policies to support the exchange of experiences and monitor effects of distance working on working culture could contribute to improving the knowledge and awareness or firms. This would be a useful contribution of (European) policy in the Smart Social Policies and the Big Business as Usual scenarios, while it seems unnecessary in the New New Economy scenario.

- *Transport policy:* We know from empirical studies that teleworkers tend to switch to using their private car when commuting to the office. Offering intelligent and attractive alternatives in public transport would thus be an essential complement to prevent these types of second-order effects from occurring. While this is an issue in all scenarios, it is particularly important in the New New Economy scenario where distance working is expected to play a significant role. Pricing policy could further improve the attractiveness of distance working (see also Issue 5).

- *Transport technology policy:* Measures to support the development of technologies to facilitate distance working represent another inroad for policy that could be relevant at European level, at least for the Smart Social Policies and the Big Business as Usual scenarios. In the New New Economy scenario there does not seem to be a major need for public action. Actions may even go beyond the funding and monitoring of pilot applications, but may include initiatives to promote the use of Galileo for advanced distance working applications.

- *Awareness raising, training and education policies:* Policy initiatives in the field of training and education would be helpful in all three scenarios to increase the adoption of ISTs that would help meet the transport policy objectives. Awareness raising measures would be particularly called for in the Big Business as Usual scenario where negative side-effects of ICTs and transport are not at the forefront of attention.

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Overall, the scope for policy intervention at EU level appears to be rather limited in the case of distance working. Most areas of policy action are at national, regional and local levels. However, European policy could play a role in the exchange of best practices and in supporting the implementation of advanced schemes and test-beds of transport-related IST-applications. Moreover, the potential of European technology platforms such as Galileo still remains to be exploited, including applications in support of distance working.

4.3.3 Issue 3: Matching customised mobility services with diversified lifestyles and attitudes

Challenge: Changes in lifestyles and attitudes exert a major influence on the way ISTs are used and thus on mobility patterns. There are indications that mobility patterns will change and become more diffused and diverse. However, it is uncertain whether the widespread use of ISTs will allow breaking the past trends towards ever increasing individual mobility needs. In fact, many individual trips are are performed for a certain purpose other than that of pleasure; they are assigned a positive value in themselves. The scenarios differ in the extent to which a further individualisation and diversification of lifestyles as well as shift in values is expected to happen, for instance due to the importance of environmental consciousness or the symbolic value attached to the private car. As long as the car continues to offer significant advantages in terms of quality, speed and flexibility, it is very unlikely that people will switch to using public transport systems more widely.

Determinants: Electronic services have a major potential for substituting certain types of physical trips (e.g. online shopping, e-health), if they are amenable to a simple usage by non-expert users. Due to the uncertainties of several new forms of e-services, it is currently very difficult to anticipate impacts on transport. However, it is pretty clear what *should* happen in order to achieve a better match between mobility services on the one hand and diversified lifestyles and behaviour on the other:

- *A closer link between values, intentions and behavior:* In order to achieve a more efficient use of mobility options, good intentions (which are often expressed) must translate into behavior (which is often not the case).
- *Provision of services that meet the diversified lifestyles of citizens:* The availability of customized and personalized mobility options are key to meeting the new trends in lifestyles and values. So far, new solutions for customized public transport or e-services do not meet the requirements of people with highly mobile lifestyles. Such services require a high degree of coordination between different kinds of services (e.g. for seamless, inter-modal, door-to-door mobility), a requirement that is difficult fulfill.
- *A high degree and quality of coordination:* Improving the performance and quality of public transport systems, especially the possibility for seamless inter-modal mobility services, requires much better coordination between electronic and physical mobility services and service providers. An additional dimension of quality thus needs to be added beyond speed, reliability and comfort, namely inter-modal system performance.

Differences/similarities across the scenarios: The scenarios differ in terms of the extent to which lifestyles are assumed to change. The New New Economy scenario is characterised by a wide variety of lifestyles and attitudes, including those of the people who reject excessive mobility as

well as those living in a world of hyper-mobility. Both are made possible by the range of e-services offered.
In the Big Business as Usual Scenario, only a limited range of high-end users will show significant changes in life- and working styles. They will have access to very advanced IST-solutions, but overall the impact on transport will be rather limited. The limitations arise for two main reasons. First of all, the majority of the population will not benefit from the most advanced business services that could substitute for travel (for example advanced teleconferencing). Secondly, public investment in infrastructures is limited, and inter-modality not a real issue, implying that the quality of public transport systems will not sufficiently increase so as to attract a large number of new users.

In the Smart Social Policies Scenario, the changes in values, attitudes and practices with respect to ICT and mobility will also be restricted to some social groups, but in contrast to the Big Business as Usual scenario they will not be defined on the basis of economic well-being. Communities of advanced users will emerge in specific niches that may be driven by social needs, but due to the limitations of public infrastructure investment, the emergence, expansion and branching of niches will take a long time. As this scenario is also characterised by a high awareness and concern for the environment (and societal concerns in general), the changes in lifestyle have a certain potential of being translated into less transport-intensive behaviour.

Overall, the New New Economy Scenario offers the highest probability of a change in attitude with respect to individual mobility, for instance in terms of giving up individual car ownership, combined with the availability of an attractive and inter-modal transport system.

Policy options: Two main inroads for policy can be distinguished in this case: on the one hand, improving mobility services to meet more diversified lifestyles, and on the other affecting attitudes of individuals with respect to mobility. This points to a range of possible policy inroads that differ in importance across the scenarios:

- *Smart and user-oriented mobility systems:* Smarter, demand- responsive and user-oriented public transport and ICT systems are an essential pre-condition in achieving a better match with lifestyles and attitudes. This requires better user interfaces, better cooperation between regional transport systems to achieve service integration, standards for system interfaces, etc. Large-scale demonstration projects may be needed to move in this direction of providing seamless mobility systems. While this is of concern in all scenarios, it is probably least problematic in the New New Economy scenario.
- *Policies for coordinated mobility:* Liberalization policy in infrastructure systems like transport and telecommunications has had many positive impacts on economic efficiency, but made co-ordination and inter-modality / inter-operability more difficult. This points to a set of further policy initiatives:
    - Regulatory framework conditions in transport and IST need to be put in place that enable and facilitate the emergence of organisational innovations for the provision of inter-modal, door-to-door mobility service. In the New, New Economy scenario, this is a critical issue in order to ensure that the wide variety of service providers operate on a common basis. A similar observation can be made with respect to the niche application areas in the Smart Social Policies scenarios.
    - Technical and organisational standards are a pre-condition for efficient inter-modal operations and interoperability between different service providers. Policy initiatives may be needed to support the establishment of such standards in the field of mobility service provision. This is an issue in all scenarios, but requires particular attention in the New New Economy scenario where a wide variety of mobility solutions are expected to emerge for which compatibility within the Open Source framework needs to be ensured.

- *Transport and technology policy:* As for other key issues, niche development policies appear to be an important measure to adjust mobility services to user requirements in the scenario Smart Social Policies. This approach would be equally important in the Big Business as Usual scenario in order to increase the variety of service options.
- *Awareness raising*: Policy initiatives aimed at raising awareness about the potentials of ICT services as well as new mobility services could be useful in the Smart Social Policies scenario in particular to increase their acceptance and adoption.
- *Equal access policies:* In scenario Big Business as Usual, access to advanced ICT and mobility services is restricted to a comparatively small group of citizens. Access and accessibility should be reinforced, for instance by means of financial incentives to users as well as to service and infrastructure providers.

4.3.4 Issue 4: Avoiding digital divides that limit the potential positive impacts of ICT on transport

Challenge: Digital divides are an important issue in themselves and have been frequently discussed in the context of the information society debate. Their relevance for mobility may be less obvious, but the exclusion (for various reasons) of people and firms from the use of ISTs in general implies that they are not able to benefit from taking advantage of the benefits of mobility-related IST-services and options, either. ISTs tend to exert their full impact on mobility only, if it is pervasively used in society. There are important positive returns to adoption at play that make the digital divide also an issue for mobility and transport.

Digital divides are not only a matter of social disparities, but also of regional differences. There has been a long-standing debate about the "death of distance" as a consequence of the widespread use of ISTs, i.e. a situation where physical distance from the urban centres does not represent a major disadvantage for economic development any more because ISTs and virtual presence allow overcoming distance. However, in reality we can observe that spatial proximity still matters a great deal. There are agglomeration effects at play that favour central locations, for instance in terms of the quality of the IST-infrastructure or due to the clustering of training and education institutions. Gaps may thus continue to open up between urban centres and more remote areas, as well as between different regions in Europe.

Determinants: The main issues that determine the extent of the digital divide and thus the extent to which IST can exert a beneficial impact on mobility are as follows:

- *Knowledge, skills and competencies:* Both citizens and firms depend on the necessary skills to make use of ICTs in their daily activities, even if user-friendly interfaces have facilitated the use of IST-based services. If only very few users can fully exploit the benefits of IST for mobility, the net effect on transport will be marginal.
- *Ease of access and use of mobility services:* In relation to transport, IST-based services can ease, but not overcome the more substantial disadvantages of public transport as compared to individual car-based transport. Public transport systems are not geared towards the type and quality of services requested by users interested in door-to-door and customized mobility services. These drawbacks on the transport system side are obviously among the main challenges for an efficient inter-modal integration of transport systems based on IST services.
- *Disinterest in ISTs:* An additional problem consists of the fact that some people are not interested in using IST-based solutions, for various reasons. While this may have to do with a lack of knowledge about the potential benefits, it may also be more deeply rooted in values in attitudes, not least with respect to the reliability and security of IST services.

- *Costs:* The financial possibilities of users, and especially the lack of a sufficiently large community of users with high acquisition power may limit the scope for making a business case out of advanced IST solutions. A limited number of advanced users obviously reduce the potential impact on mobility as well.
- *Infrastructures:* Especially with respect to regional differences, the lack of appropriate (broadband & wireless) infrastructures may limit the potential impact of ICTs on transport in all scenarios.

Differences and similarities across the scenarios: While the New New Economy scenario gives generally a positive picture with respect to the reduction of transport demand growth by means of IST, it entails the risk of a divide between ICT-experts and non-experts, between those who belong to the Open Source communities and those who have difficulties in following the fast changes in technology and practices. The potential impact on transport can only be realised if a significant share of the population makes use of the new opportunities available. Mobile access and corresponding infrastructures are offered pervasively, and, in general, skills and competencies are supposed to be well advanced. However, just as some people may have an anti-travel attitude, there will be others with an anti-information society perspective.

The digital divide between cities and the countryside is a major problem in the Strategic Social Policies scenario because niches of advanced IST-applications are expected to emerge predominantly in cities. Being a policy-driven scenario, but under conditions of slow economic growth, only the hotspots of IST usage (and of traffic density) attract the attention of policy-makers and investors. In contrast, the social divides are less pronounced in this scenario due to the attention paid by policy to issues such as equity, access for the disadvantaged, etc.

The Scenario Big Business as Usual is characterised by notable social differences between high-end (professional) ICT-users and the rest of the population. In terms of skills and competencies, the situation will be comparable to today, i.e. there are many people with limited IST skills, but sufficient to use the basic services. A lack of standardisation hinders potential efficiency gains that would make IST-services more accessible to everybody. The limited size of the market represents a constraint for investment in infrastructures off the main hotspots. As a consequence, digital divides will be quite significant in this scenario, and the extent to which advanced IST solutions can exert an influence on transport limited.

Policy options:

- *Awareness raising, training and education policies:* Policy efforts in terms of training and education would be helpful in all three scenarios to overcoming digital divides. Awareness raising measures would be particularly called for in the Big Business as Usual scenario where digital divides are supposed to be particularly strong.
- *Regional and cohesion policy:* Regional divides driven by differences in IST-diffusion are an issue for regional and cohesion policy. It is an obvious problem in the Smart Social Policies scenario, and it is at least unclear in how far regional gaps may open up in the world of the New New Economy scenario. Public investment in IST and transport infrastructure (which could be difficult to finance, though) would be conventional policy responses to this issue, as is the full range of regional development policies. In the Smart Social Policies scenario, investment would be expected to come to a significant extent from public sources.
- *Purchasing power:* The Big Business as Usual scenario is characterized by a discrepancy between purchasing power and high costs of advanced ICT services that limits the diffusion of these services. Therefore, social policies or subsidies for lower income households could foster a wider uptake.

4.3.5 Issue 5: Turning relative cost increases in transport into a benefit

Over the past decades, we have seen a continuous decline in transport costs, which – until now – has driven the transport-intensity of our societies. IST have also shown a very steep decline in costs per performance unit. For the coming years, it is not unlikely that there will be a reversal of the trend in transport costs, leading to an opening up of the price differential between IST and transport. This change will be driven by several forces: legislation (e.g. internalisation of external costs of transport, regulation), growing logistics costs (e.g. in response to congestion problems), external supply factors (e.g. increase of oil prices). Such a shift in relative prices could work as a powerful lever for reinforcing the diffusion of IST-based mobility solutions, to the detriment of physical transport. However, this requires alternative IST solutions to be available in times which are sufficiently advanced to substitute for physical mobility (from distance working to e-health) once the price signals become fully effective.

Determinants: There are a number of factors that could contribute to widening the price gap between IST and transport and thus foster the adoption of IST-based solutions:

- *Competition in the IST-markets:* Competitive pressure on the IST-markets is a necessary pre-condition for translating changes in cost differences into (lower) prices. Obviously, this requires particular attention to be paid to monopolistic developments and the control of key segments of the IST markets.
- *Reliable long-term conditions for investment in IST:* Long-term investment in alternative IST-based mobility concepts is more likely if the framework conditions, and in particular the political ones, represent a reliable basis for investment planning.
- *Availability of advanced IST-solutions:* As a special case of the preceding determinant, incentives are needed to ensure R&D investment in the advancement of transport-substituting technologies. (Short term) competitive pressure thus needs to be balanced with favorable (longer term) conditions for advances in specific technology trajectories.[7]
- *Organizational and structural settings:* Technology alone is not enough; many other factors intervene in order to be able to adapt fast to new conditions. For instance, conducive regulatory and planning framework on the demand side can facilitate the uptake of distance working as well as of other innovative ICT applications (e.g. in e-health, e-shopping, e-government, etc.).

The key point here is to be prepared for such changes in relative prices to happen. If we accept that this assumption is realistic and just a matter of time when it will happen, it will be important to have advanced technological options on the shelf that may not seem promising under the current economic framework conditions, but would be very promising once the expected cost reversal materialises.

Differences across scenarios: The likelihood of such a cost reversal differs in the three scenarios, and it can also be increased by additional factors in each of them. In the Big Business as Usual scenario, the tendency towards a gridlock could worsen the reliability of transport operations, which corresponds to a growth in transport costs. This, in turn, would make transport substitution solutions, for instance based on enhanced electronic interactions, more attractive. However, this scenario does not offer particularly promising conditions for such a substitution to take place. Although gridlock is a serious problem in this scenario, the oligopolistic tendencies are not helpful in driving IST-service prices down.

[7] The recent example of investment in UMTS-licenses shows the risks entailed by a change in the medium- to long-term perspectives for a technology trajectory, even if other factors, such as the over-optimistic expectations regarding consumer needs, have also played an important role.

The Smart Social Policies scenario offers better conditions for the diffusion of IST-based solutions. The niche development policies that characterise this scenario lead to the establishment of certain core areas, where very advanced solutions have been tested already. They represent the starting point for a more widespread uptake. The heterogeneity and lack of standardisation across these niches may nevertheless hamper diffusion of transport substituting IST services.

Once the costs for physical transport go up, the conditions for a fast uptake of IST-based mobility solutions are very good in the New New Economy scenario. Of the three scenarios, it offers the best opportunities for IST-use, both organisationally and in terms of competitive conditions and technological opportunities.

Policy options: The issue of a reversal of relative costs of IST and physical transport and how this may affect their relative attractiveness points to a policy approach that a) supports this long-term shift and b) improves the adaptiveness of our IST and mobility systems once the shift occurs. Elements for achieving this may be as follows:

- *Niche development policy:* From the perspective of being prepared for a reversal of relative costs, a niche development approach seems to be promising in order to keep technological options open and learn about their applicability under real-world conditions. This is mainly an issue for the Smart Social Policies and the Big Business as Usual scenarios, but also a promising approach to technology policy in general
- *Pricing policies:* In order to accelerate the shift from physical transport to ICT-based mobility services, a longer-term taxation or pricing policy could contribute to getting prepared for a future situation where we will have to cope with significantly higher prices for physical transport. Such an approach would aim to smoothen the transition process and induce innovation by means of price signals. Especially for the Big Business as Usual scenario, such a strategy could help prevent a gridlock situation in transport, although it may be hard to reconcile with the general political approach characteristic of this scenario.

4.3.6 Issue 6: Lock-in and how to overcome it

Challenge: One of the rather specific negative side-effects identified in the scenarios is the risk of a lock-in situation, where there are no alternatives left to escape from an overstretched transport system and move towards a sustainable mobility system. Such a lock-in can have many facets. In terms of infrastructure it is obvious that without appropriate transport and IT-infrastructures, new inter-modal and efficient mobility services will not be offered. This implies a lock-in into the dominant, i.e. currently car-based system, where there are no real mobility choices offered to the final user. Moreover, in a monopolistic economic setting where very few actors dominate the scene, the incentives for introducing innovative, user-oriented solutions are limited. Finally, government can play a crucial role in breaking up monopolistic structures and stimulate investment in infrastructures, but this requires that an active government role be accepted to break out of such a vicious circle.

The key challenge is thus to avoid a situation where the different facets of lock-in reinforce each other. Opportunities need to be sought to break such lock-ins, and ISTs offer such opportunities, for instance by enabling to break the infrastructure lock-in between different modes of transport, or by making certain types of usage of physical transport infrastructures obsolete.

Determinants: In other words, there are several domains that can drive a lock-in into the established transport and mobility system:

- *Infrastructure lock-in:* This is the most obvious example of lock-in situation where (physical) transport infrastructures prevent the switch to alternative modes and services due to the large sunken costs. Infrastructure lock-in represents a major barrier to innovation.

- *Organizational lock-in:* Incentives for innovation can be low for organizational reasons. For example, vertically segmented transport service supply chains make it very difficult to set up seamless inter-modal services. Also a monopolistic or oligopolistic structure in service provision as well as in technology supply can prevent the switch to other than established development paths compatible with the interests of the dominant players.
- *Political lock-in:* If government is captured by key players in transport or ICT, or pursues a passive approach with respect to monopolies in service supply, there is almost no possibility left for a restart to overcome a lock-in situation. Moreover, inflexible legislation and regulation can sustain a lock-in situation.

These three domains of lock-in tend to reinforce one another, but similarly, measures to overcome them individually can interact to dismantle them effectively. An infrastructure lock-in can be broken by a re-organisation of the transport and the economic systems in which it is embedded (e.g. by favouring inter-modal operations across infrastructure systems), and the political system can be at the origin of the decisive regulating impulse able to overcome a lock-in between infrastructure, transport system and economic organisation.

Differences/similarities across the scenarios: The danger of a lock-in is particularly pertinent in the Big Business as Usual scenario.[8] In fact, it reflects a vicious circle because the passive role of government assumed in this scenario implies that government cannot break the oligopolistic lock-in in IST and transport industries. The consequences are higher prices and a lack of incentives for innovation, for instance, in integrated mobility services. Rather than government, some strong, but deviant players in industry may be in a position to break the vicious circle, e.g. by introducing new rules for their own operations.[9]

In the Smart Social Policies scenario, the emergence of islands of IST applications implies that the risk of an emergence of monopolies or oligopolies is rather limited. However, lock-ins into sectorally segregated IST-solutions due to a lack of standardisation are quite likely, preventing an optimal use of ISTs for mobility purposes.

Scenario New New Economy is the one where the lack of coordination rather than lock-in would be the main problem. There is a risk that open source-type of approaches are not reliable and stable enough to guarantee seamless and integrated IST and inter-modal transport solutions. However, the positive interpretation that has been given to this scenario assumes a successful functioning of Open Source, offering good possibilities for adaptation and flexibility if required.

Policy options: Maintaining a variety of technological options and players is key to avoiding lock-in situations. This approach is of relevance not only to transport and IST policy, but also to a wide range of adjacent policy areas, of which we will mention only some:

- *Competition policy:* In infrastructure systems competition policy is a contentious issue due to the need for coordination on the one hand and the necessity to open up markets and prevent barriers to access on the other. It is the decisive means to ensure that a variety of players with different strategies effectively compete in the market, and that new players with deviant strategies can emerge and grow to prevent lock-ins. The Big Business as Usual scenario shows the dangers of a high lock-in potential because the necessary variety of players is not maintained. In more limited domains, the same holds true for the Smart Social Policies scenario.

[8] The issue of the Big Business as Usual scenario representing a typical lock-in situation points to the possibilities of whether it would be possible to move from this scenario to a situation that comes closer to the Smart Social Policies or the New New Economy scenario. This idea of "sequencing" of scenarios could not be elaborated in more detail, though.

[9] One of the – not entirely fictive - examples discussed in this context are the pricing systems of airline companies, which could be threatened by a newcomer using more flexible schemes without Saturday night rules and an excessive price premium for business travelers.

- *Industrial policy:* Political efforts to develop and promote specific industries, for instance to induce structural change, have had a mixed success record in the past. Several of the European success cases in the IT sector (e.g. Nokia) can at least partly be attributed to industrial policy efforts, for instance by improving framework conditions for industry (not least by standard-setting initiatives) or by the creation of regional lead markets. However, there have also been several attempts to nurture "national champions", many of which have failed. In spite of this mixed record, these experiences with efforts to overcome lock-in situations of different kinds should be used to instruct future initiatives in relation to IST and transport.
- *RTD policies:* Maintaining technological diversity is one of the key roles of research and technology policy, but the active policy role may have be expanded further towards innovation and diffusion policies in order to make sure that new technologies become sufficiently advanced to represent a threat to incumbent technologies and players.
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Finally, for government to maintain its ability to induce a "policy restart" in a lock-in situation it is indispensable to be able and willing to play an active role in the aforementioned policy areas. This is the key problem of the Big Business as Usual scenario where public policy plays a comparatively limited role and can thus hardly intervene to prevent a gridlock to happen. However, also in the two other scenarios, policy needs to be prepared to intervene to prevent lock-in situations.

5 CONCLUSIONS

5.1 General conclusions

One of the main objectives of ICTRANS was to improve and systematise our understanding of the inter-relationships between the widespread use of ICTs in the spheres of Living, Working and Producing on the one hand and the demand for transport and mobility on the other. In particular, the underlying question was whether the growth in mobility demand could be decoupled from economic growth with the help of a more extensive use of ICTs in the spheres of living, working and producing. In this respect, it could be shown that very optimistic expectations regarding the impact of ICTs on growth in transport demand can so far not be confirmed by the available empirical data. Particularly second-order effects and the existence of parallel, often contradictory impact chains, determine the net impact. While we know that these effects play an important role, very little empirical research has been conducted so far as regards their magnitude. However, what the report shows is that more use of ICTs will not automatically result in less use of the transport infrastructure. This conclusion is obtained once the analyst takes a broad perspective (i.e., not only counting the average number of trips of teleworkers to and from work). Perhaps a comprehensive strategy to "tele-everything" (working, shopping, learning, entertaining, administration, etc.) could reduce growth in transport demand more significantly but also in this case the counter-balancing role of second-order effects remains to be understood.

This points to three major inroads for future research. First of all, in depth case-studies of regions or cities are needed where the parallel and interrelated impacts on transport of different ICT applications can be studied. For instance, ICT use at home and at work complement each other and jointly exert an impact on mobility patterns. Secondly, individual ICT applications should be investigated in order to obtain a better understanding of how they change behaviour and what specific higher order effects they trigger. Thirdly, further work is needed on the development of rigid conceptual models that would allow integrating and combining the effects of different impact chains in a holistic way. In more operational terms, this also implies harmonising indicators used in the context of transport modelling with those originating from work on living and working.

One should also be aware of the rather limited order of magnitude of impacts of ICT use on transport demand. Even if, for instance, the potential of e-commerce or tele-working were fully exploited, the net impact on overall transport demand would still be marginal. The best one could expect is a modest reduction of the growth in transport demand due to the use of ICTs. However, tele-activities and e-services could make a difference with respect to the spatial and temporal patterns of mobility and thus of traffic and transport.

The future evolution of the information society is characterised by a high degree of uncertainty which lends itself to a scenario-based approach to explore potential transport impacts of future ICT applications, even we can anticipate many developments only vaguely. The potential future impacts of ICTs on transport have thus been explored in the context of three scenarios: Big Business as Usual, The New New Economy, and Smart Social Policies. The development of these framework scenarios has actually been a second main objective of this project. They cover a broad range of possible futures in social, economic, political and technological terms and provide rich material as food for thought on how the relationships between ICT use and transport may develop in the future. On that basis, relevant combinations of direct and second-order impact chains were identified and systematised. In some cases it was even possible to point out the rough directions of net impacts under the conditions of the three scenarios, based on an assessment of the impacts on trip distance, trip frequency, modal shift and passenger / freight ratio (Table 8). However, such a systemic approach to analysing transport impacts of ICTs is still in its infancy, mainly due to the aforementioned shortcomings of available empirical knowledge and the complexity of the interrelationships between ICT use and transport.

The aim of scenario analysis was to identify critical issues and to devise options for a broad range of possible futures developments. Therefore the policy analysis concentrated firstly on select key issues across the scenarios that would make a difference for the magnitude of transport impacts of ICT. Six such key issues were discussed in order to explore policy options, predominantly at a European level, that could have a beneficial influence on their future evolution. It was shown that the potential impact of ICT on transport depends to a significant extent on non-transport and non-ICT policies as well as on policies at national and regional level.

For instance, the perspectives for distance working present a policy challenge: If tele-working were to increase, what would be the impacts on transport? How can we increase tele-working but not increase transport? The solution will depend largely on labour market regulations with respect to self-employment as well as on company policies. The impact distance working may have on transport demand growth further depends on local spatial planning and the availability of an intelligent, user-friendly and inter-modal public transport systems. Also the framework conditions with respect to location decisions of firms will determine travel distances in the longer term.

This implies that there is not a single best policy to be pursued, but individual policies may fare reasonably well under the conditions of the different scenarios. Rather, a comprehensive transition strategy is needed to curb overall transport demand and EU policies will consist of a robust and adaptive portfolio to be prepared for the risks and opportunities with which we may be confronted in the different scenarios. These considerations show that there is no simple remedy; reducing negative effects of transport is necessarily a holistic exercise as part of which ICTs have a role to play. Therefore, the expected contribution of ICTs to the decoupling of transport growth and economic growth should not be overestimated and needs to be seen in the wider context of social, economic, political and technological developments.

5.2 Policy options and the current policy agendas

The analysis of these key issues from the perspective of the three scenarios delivered a number of specific options that could be pursued by policy-makers. While the emphasis was on European IST and transport policy, national and regional policies have also been considered. The rationale behind highlighting these options was that they should allow tipping the balance between positive and negative impacts of ICT on transport, or helping avoid major risks. Some of them are already considered in current EU policy strategies, others may add a new perspective on the possibilities and limitations for EU policy.

There are two main directions where IST policy could be reinforced to ensure a wider uptake of ICTs that would also contribute reducing growth in transport demand. Firstly, the attention paid to users and user needs should be strengthened. Secondly, targeted initiatives to develop ICTs for niche applications with a major relevance for mobility seems to be a major issue. These two general directions can be translated into more specific areas where European policy action may be useful:

- Standardization has already been identified in the eEurope 2002 Action Plan as a key element of IST policy, but it needs to be balanced with measures to ensure technological diversity as part of a “robust” policy portfolio.
- Improved access, both for mobile and fixed line, is a precondition for enabling ICT applications that will have an impact on transport and mobility. Broadband and better service quality in general are the main technical elements of this, and they figure prominently in the Action Plan, but from a user perspective it needs to be complemented by R&D efforts to improve user-friendliness of devices and services.

- Ensuring equal access for all is another key element of the Action Plan. This is certainly a matter of training and education, including life-long learning. However, although ICT services are becoming cheaper, it is still a major challenge to ensure that the prices for advanced services are in line with the purchasing power of large parts of the population.
- Fostering competition in industry is another cornerstone of European IST policy aiming to ensure that prices are driven down, but it has potential drawbacks with respect to ensuring long-term investments in new technology and applications and in terms of ensuring the use of common standards. Especially at the interface with transport, co-operation, interoperability and common standards are essential to ensure the necessary co-ordination between development in ICTs and in transport.
- Increasing the attractiveness of ICT-services as compared to conventional services that require physical transport is also a matter of the usefulness of the content that is offered. Much more effort ought to be put into making services realistically useful to final users, and avoid being driven by technological opportunities. Taking greater care of user requirements is thus crucial for developing a promising market perspective for offering new services and applications. This implies also paying more attention to the serious concerns about data security and privacy that give rise to a general reluctance to use ICTs widely, an issue well known from the ambient intelligence debate.
- Promoting test-beds and pilot projects represent a way of learning about new configurations of ICTs jointly with users, an aspect that seems to have attracted too limited attention in the last few years. IST visions have been mainly driven by technology, but recent experiences in, for instance, mobile communication (WAP, UMTS) have shown that the user requirements have not been fully taken into account. Promoting comprehensive niche development processes, in the sense of technology and user platforms for mobility applications, could thus be a policy option for the future.
- In order to make participation in the e-society more attractive, electronic public services could be enhanced and expanded. The easier interactions with public administration can be made, the more interesting it becomes to get connected.
- Similarly, there is a potential to reinforce new public and private service areas where ICT use could have a major impact on transport demand. E-health applications are an example of a domain that still remains to be developed.
- Developing and testing viable business models for integrated ICT services are another element of a niche development strategy.
- The use of ICTs in the context of production, distribution and logistics coordination in these same areas is a typical issue that cuts across policy domains. Closer interaction of IST research with research on production systems is thus needed to achieve a better integration.
- Public procurement can be a powerful device for influencing and shaping future IT markets, also in ensuring a major and continuous user; including also broadband access, public marketplaces for public procurement already mentioned.

Many of these options already make part of the eEurope 2002 Action Plan and represent important pre-conditions for enhancing the use of ICTs at a general level. However, little specific attention has so far been given to the mobility dimension.
As far as transport policy is concerned, three main directions for action can be distinguished: co-ordination along the transport chain, but also with ICT-systems, pricing policies, and the development of customised mobility service concepts that are geared to user needs. Specific issues along these three main directions can be suggested as follows:

- Co-ordination in freight logistics has been an issue on the political agendas for several years, but they tended to be addressed in isolation from the production concepts in which they are embedded. Similar co-ordination issues can be raised with respect to passenger transport where integrated and customised mobility services are still rare. There is a need to develop and test business models for such services and test them under real-world conditions. Some experiments of this kind are under way, but they could be given stronger focus on their complementarity with advanced ICT applications.
- Standardisation of ICT applications along the transport chain has major benefits for improving the co-ordination of transport operations as part of production and distribution concepts. In other words, the point is to go beyond telematics applications in logistics, but to explore their role in the context of new and advanced, possibly decentralised production concepts.
- Policies aimed at better co-ordination may stand in conflict with the objective of introducing competition on the transport markets. Here, a new balance needs to be struck if transport and ICT systems are to be better adjusted to one another.
- Inter-modal transport infrastructure, both passenger and freight, still represent a major technological bottleneck for realising better co-ordinated production and distance working concepts that make comprehensive use of ICTs. While in principle, the necessary ICT solutions are available, but they cannot be put to work due to a lack of complementary transport infrastructures. Examples are inter-modal freight distribution systems as well as public transport systems geared to the needs of teleworkers.
- A whole spectrum of new applications for mobility could be developed on the basis of the Galileo platform. It actually represents one of the new infrastructures that could help optimise transport use and give room to the development of new ICT applications with positive benefits on transport.
- Road pricing is not only an important application of ICTs in transport, but also an important steering mechanism to stimulate the uptake of ICT-applications that have a potential to substitute for physical transport. This way the increased costs of road transport can be compensated for by the use of comparatively cheap ICT applications.
- Raising awareness about the potential benefits of new integrated and customised mobility services will be necessary to overcome the prevailing reluctance and induce a shift in value judgements about these innovative concepts.

IST policy is important to reinforce the uptake of ICTs in general, as is transport policy for improving and optimising transport systems in a way that allows making most efficient use of the potential of ICTs to limit demand for transport. However, as ICTRANS has shown, the most important issues arise at the borders between these two policy areas, and at the intersection with other policy domains such as labour market policy, regional development policy, industrial policy, competition policy, etc. This situation has been explicitly recognised in the Transport White Paper "European transport policy for 2010: time to decide" (CEC 2001), pointing to the importance of backing up transport policy actions with actions in other policy domains dealing with industrial production systems, land-use and town planning, work organisation, etc. for making transport policy fully effective. Similarly, in a recent communication from the Commission on "Electronic Communications: the road to the knowledge economy" (CEC 2003) the issue of structural funds is identified as a potential source to finance broadband in remote areas.

In other words, the issues raised in this report have only recently entered explicitly the agendas of transport and IST policy, possibly because they are exactly at the interface between these two (and possibly other) policy domains. If the widespread use of ICTs is to contribute to the decoupling of transport growth from economic growth is regarded as an important policy objective, the co-ordination between these policy domains needs to be improved. In particular,

the linkages with the following - often national and regional - policy domains should be strengthened.

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Impacts of ICTs on Transport and Mobility (ICTRANS)

Background Paper: The impact of ICT on mobility and transport in the socio-economic sphere WORKING

Peter Zoche, Bernd Beckert, Martina Joisten
FhG-ISI

TABLE OF CONTENTS

1 TELEWORKING

1.1 Problems and Issues

Triggered by technological development and the increasing use of information and communication technologies the working world is in a process of profound change. One characteristic of this development is the rise of new forms of work that offer a larger degree of freedom for flexible individual working conditions providing independence of time and place. The new forms of work are generally less dependent on geographical restrictions and thus also influence traffic conditions. Because of its characteristic to bridge geographical distances this type of work is called telework.

1.2 Possibilities

The early narrow focusing of telework on mainly repetitive office and administrative activities as well as programming jobs has widened. Since the 1990s the term increasingly also includes sales and fieldwork, management tasks as well as jobs in research and development and in teaching, training, and education (Kordey / Korte 1996; Korte / Wynne 1996). Thus telework is no longer defined by a narrowly formed activity spectrum. Telework is imbedded in processes of virtualization of job and recreation behaviour that is generally becoming more important (Cuhls et al. 1998; Zoche 1998).

With the gradual integration of telecommunications-supported applications into the normal workday an increasing number of employees take advantage of the possibility to take home work from the office now and then in order to continue working on it at the PC at home (Kordey / Korte 1996). This leads to smooth transitions to alternating telework, which often is considered to be the popular work organisation of the future. Mobile technologies support this process.

Telework activities are considered in several expert surveys and Delphi studies to be the central promoters for the demand of broadband technologies in Europe and the USA that will contribute to the achievement of efficiency gains and cost savings (LBS 2000; Beck / Glotz / Vogelsang 2000; Cuhls et al. 1998; Harnischfeger / Kolo / Zoche 1998). The potential of telework jobs has thus increased tremendously. With the quantitative growth of telework potential traffic effects are also gaining on quantitative importance.

The development and implementation of concepts for the internal and external organisational integration of telework in companies is considered decisive for the (sustainable) success of telework (e.g. working time models, output oriented control and incentive models, remote decision competence). In this context questions as to the management strategies practiced in a firm as well as personal attitudes of management are increasingly becoming central factors for the (success prone) realization of telework models (Hoffmann 2002; Godehardt 1994). However, in general such strong information oriented and complex working conditions call for special aptitudes and skills of employees. These include the ability of integral sensory perception, the trait of an emphatic relation to work tools, a dialog interactive action and associative imaginative thinking (Pfeiffer 2001).

Today, one can largely observe a certain withdrawal from mainly stationary telework in telework centres and homes of the employees (home telework). Wider spread is alternating telework that is characterized by a more or less frequent switch between places of work. Ultimately the success of this concept rests on the experience of service technicians and field workers i.e. active mobile employee groups (Kordey / Korte 1996).

With the increasing availability of inexpensive mobile equipment the tendency towards mobile telework could grow even stronger. After all, many travelling employees (e. g. consultants and

project leaders as well as additional employees with management functions) are experimenting with the possibilities of telework, i.e. remote work, while underway. However, their saturation limit is estimated at a much lower level than for home telework, mainly because their work environment has to be considered as rather restrictive (e. g. due to disturbances from others, insufficient data protection or security measures, Gareis 2000).

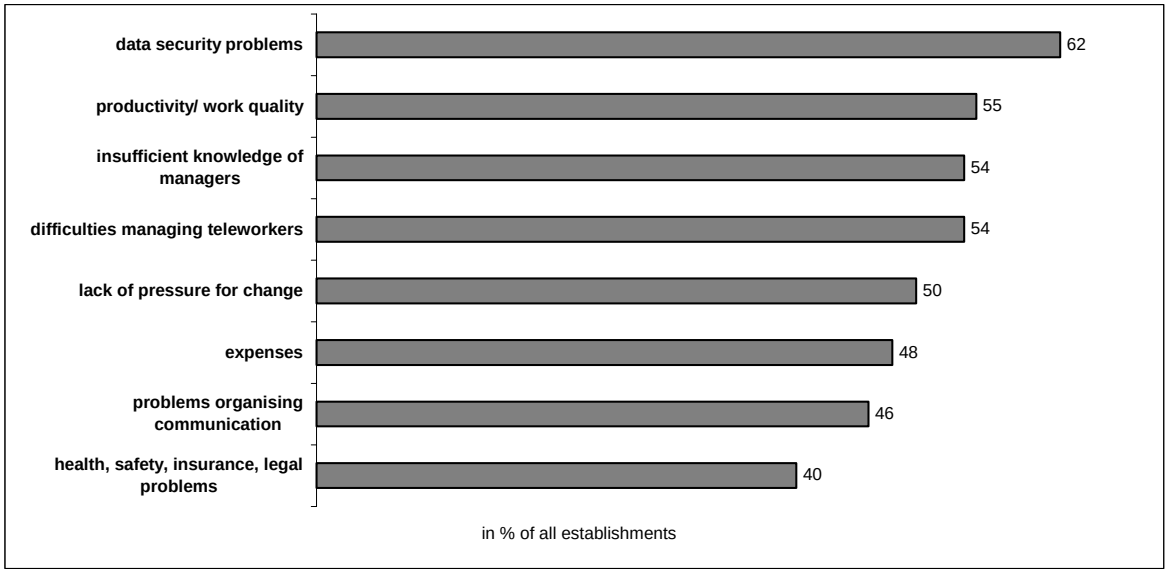
Short time mobile telework should increase in popularity due to a gain on flexibility. This development is being driven by the perspective that mobile added value processes offer new possibilities of output networks. Thus, as a consequence of the use of new information and communication systems, a reorganisation of output processes and organisational structures of modern enterprises is taking place, which leads to global and location independent working. According to business economists firms may thus give up their central locations and will distribute themselves – also geographically – as autonomous market oriented business units in areas closest to their customers (Reichwald 2002).

1.2.1 The Quantitative Significance of Telework

The complex organisational and personal preconditions to implement telework make it extremely difficult to estimate the future overall diffusion of telework. When asking employees if they were interested in teleworking in one form or the other, the concept proved to be very popular. According to the ECATT survey of 1999, two third of the European labour force is interested in either occasional (supplementary), alternating or permanent telework from home. By far highest the level of interest was found in Sweden with over 70 % of employees saying they maintain an interest. Across the other European countries there are only small differences with respect to levels of interest in telework on an average of about 60 % (ECATT 2000, p. 38). In an earlier survey of empirica (1994) European decision makers in enterprises were asked if they were interested in realising organisational forms of telework. The result was that on average, around 40 % and for some types of telework top values of about 50 % were reached in some countries.

However, mere interest on this type of work either by employees themselves or by the enterprises can on its own not be used as a prediction model. By considering additional aspects of techno-organisational feasibility and the current barriers to introducing resp. extending telework (see Figure 1) the realistic potential of telework in Europe will be limited to about 20 % of the total workforce to this study by Empirica (1994).

Figure 2. Barriers to the introduction and/or extension of telework in Europe (Source: ECATT 2000, p.56)



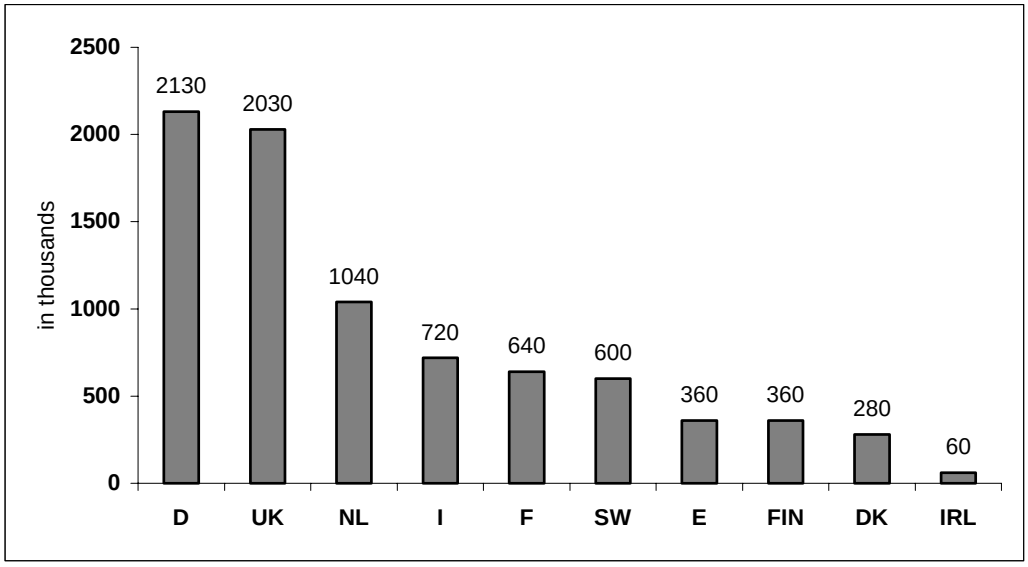
It has to be noted, however, that this estimation is one of many telework-estimations that can be found in literature. From the 1980s onwards, academic researchers felt a need to get a better grip on the phenomenon of teleworking, which resulted in more quantitative estimations, more empirical research and more conceptual discussions, for instance on the concepts of "information worker" and "teleworking". Geels and Smit (2000) compiled the different estimations in a table (see Table 1) noting that these studies use different definitions, which makes it difficult to compare.

Table 1: Some estimations of numbers or percentages of teleworkers (source: Geels / Smit 2000, p. 876)

References	*Estimations*
Stanford Research Institute in 1977	50% of white collar jobs (in the high range scenario)
Toffler in 1980	35-50% of working population in information societies
Magazine „The Futurist" (June 1983)	10-15 million tele-workers in 1990 in the USA
Nilles in 1984	20 million teleworkers in 2000 in the USA
Electronic Services Unlimited in 1984	20% of working population in 1990 in the USA
Dutch Organization for Applied Scientific Research (TNO) in 1984	50% of office functions in 2010 in The Netherlands, for part of the week
Nilles in 1985	10 million tele-workers in 1990 in USA
Miles et al. in 1985	10-15% of British working population in 1990; 15-20% in 2000
Dutch Telecom in 1986	600,000-1,800,000 people tele-working part of the week in 1995 in The Netherlands (11-34% of working population)
Weijers and Weijers in 1986	40,000-80,000 tele-workers in The Netherlands in the near future (0.8-1.6% of working population)
Meijer et al. in 1992	A potential of 25-37% of working population (1.3-1.92 million people) in The Netherlands for at least one day per week

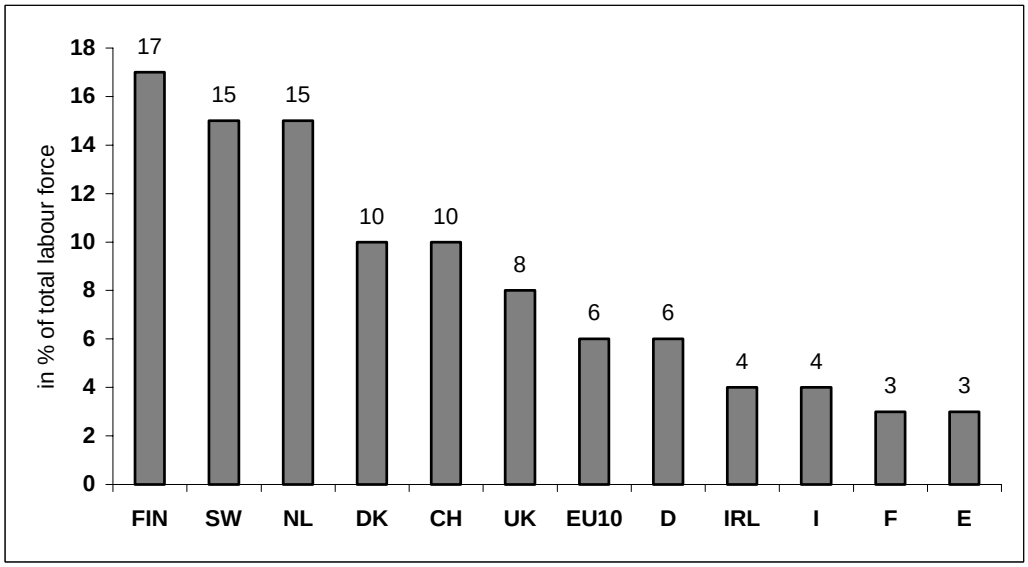
Although the number of teleworkers has increased, the growth is generally much slower than predicted. According to the latest figures from 2000, 8 million or 6 % of all employees in Europe (EU-10) already practise telework in one form or another (regular teleworkers, supplementary (occasional) teleworkers, home-based/ mobile teleworkers, self-employed in SoHo, etc.) (ECATT 2000, p. 23ff, see Figure 1).

Figure 1: Number of all teleworkers in Europe (EU-10) in absolute figures in 2000 (Source: ECATT 2000, p.24)



When set into relation to the total labour force in the respective countries, it shows that there is a remarkable difference in the speed of diffusion between the northern and the southern European countries. Apparently the better prerequisites for telework exist in the Scandinavian countries and the Netherlands (see Figure 2).

Figure 2: Teleworkers in Europe (EU-10) as percentage of total labour force in 2000 (Source: ECATT 2000, p.26)



For Germany, Empirica estimate about 2 mio. teleworkers resp. 6 percent of the total German workforce (1999 / 2000). This number of teleworkers is based on the following definition:

> *Employees or self-employed persons who, during regular office hours, work at home one to five times a week. They have at their disposal equipment to support electronic transmission of work related data (facsimile, e-mail, etc.). Telework exists when work is carried out at home on a minimum of at least one day a week.*

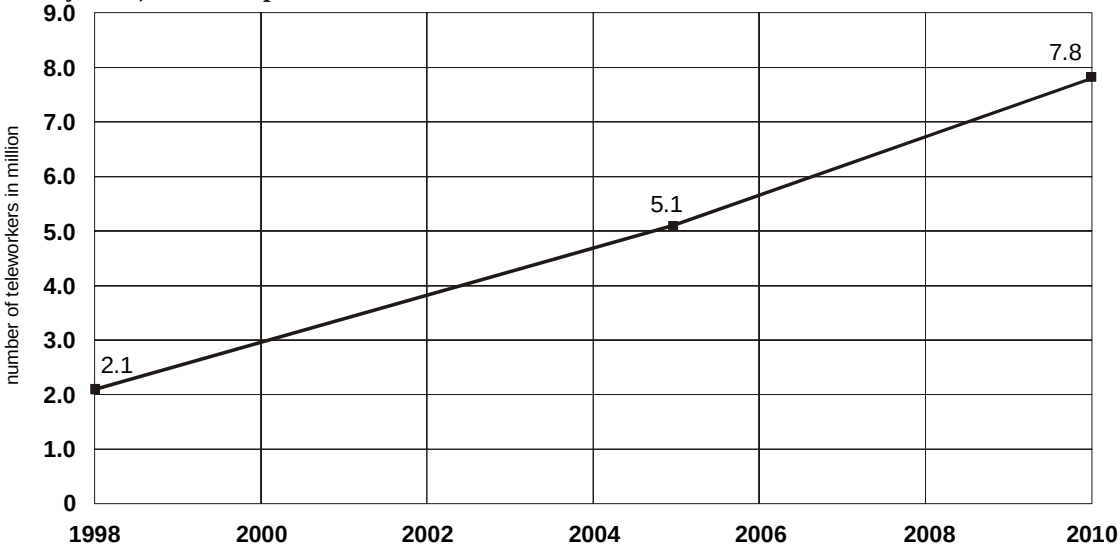
It has to be noted that other studies have come up with different figures. A more recent estimate comes from the German Federal Ministry for Transport, which takes the Empirica percentage of 6 % of the total labour force as being the potential and assumes instead a number of 540,000 teleworkers in Germany today (BMVBW 2001).

According to the projections of Empirica the number of telework jobs will further increase in the future. For Germany they assume a share of 12.6 % by 2005. The continued growth will show saturation only after 2010. They assume that by 2010 about 19 % of all employed persons in Germany, this means just about 7,8 million Germans, will be teleworkers (see Figure 3). As Germany ranges in the middle of a scale of telework in Europe, the potential for telework should be realized at an earlier date in countries like the UK and France and only after 2010 in countries such as Spain or Italy. The shape of the curve should not change fundamentally and could be adapted to other countries accordingly.

In a more recent study titled "eWork 2002. Status Report on New Ways to Work in the Knowledge Economy," (eWork 2002) the same numbers were used to describe the status of telework in Germany. The report explicitly states that in the meantime "no further empirical data have become available" (eWork 2002, p. 102).[10]

The forecast is based on the assumption that hightech and service-oriented companies will grow in numbers and weight in the economy, especially as compared to the production and manufacturing sector. The service-sector will continue to show high growth-rates and will generally cover larger sections of the job market. Because working which directly relates to the actual production of goods will decrease and at the same time sales and marketing activities will become more important, more and more mobile telejobs will become possible.

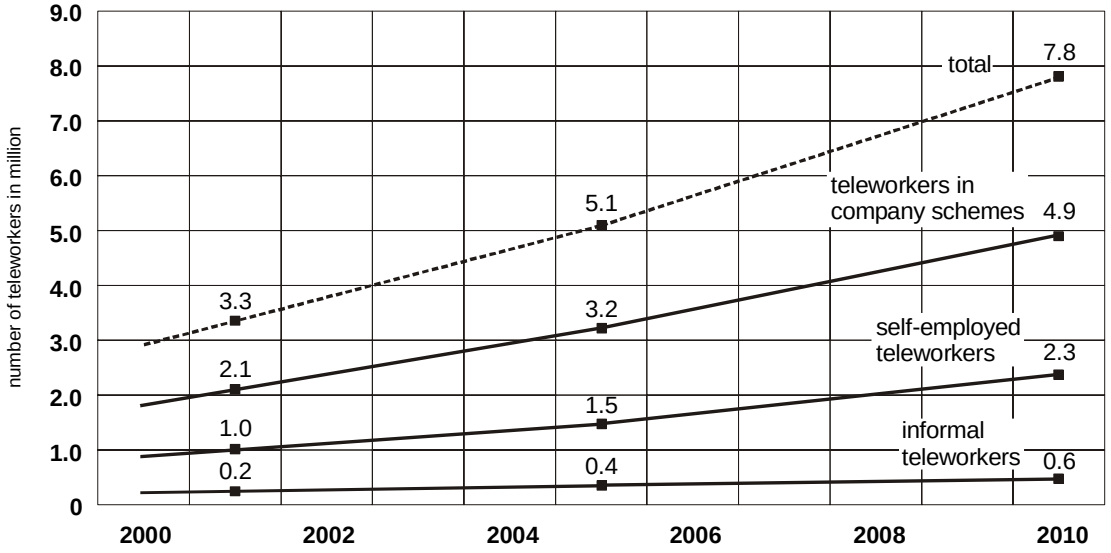
Figure 3: Projection of number of teleworkers in Germany. Source: EITO, Empiricas (Gareis / Kordey 2000), own computations.



In addition, it is assumed that the current management trend to focus on core-competencies of the company will continue in the future, thus enabling the individual company to react to market changes more quickly. Another trend underlying the above forecast is the increasing usage of ICT in the corporate world: ICT, the Internet, e-procurement and e-commerce will increasingly be adopted by companies, saving costs and making coordination processes more effective. This development will increasingly build the ground for more flexible working patterns in several occupational fields.

[10] Nevertheless the authors of the study see telework on the rise and assume further growth in the years 2000 and 2001. Their assumption is based on „anecdotal evidence which tells that in Germany eWork mainly spreads in ´quiet´ implementations, i.e. organisations just do it without making a big fuss about it" (eWork 2002, p. 102). The announced new results concerning telework which are expected to come out of the SIBIS-project (www.sibis-eu.org) were not yet available as of June 2003.

Figure 4: Kinds of telework and projected numbers for Germany. Source: EITO, Empirica (Gareis / Kordey 2000), own computations.



Another assumption in this relatively optimistic forecast is that highly qualified employees will be scarce from 2005 onwards. Software developers, engineers, technical and management consultants will become rare which will then create a growing market for teleworkers.

A more differentiated look at the forecast for Germany reveals that the greatest number of the future teleworkers will be "teleworkers in company schemes", meaning that they will have an explicit teleworking-contract with their employer. A smaller number will be "self-employed teleworkers" (see following section "Self-employment") and finally there will be "informal teleworkers" (see Figure 4).

As shown above, there are some country-specific quantitative forecasts on the future of teleworking. However, there is an apparent lack of quantitative data based on systematic surveys for larger regions and Europe as a whole. This deficit is in part due to the differences in the definition of teleworking, the country-specific uptake of ICT in the working sphere as well as the different economic structures resp. the unequal progress in the economic change of European countries.

1.3 About the Mobility Effect

In the early days, the concept of telework was looked upon as being futuristic. After all, the necessary infrastructures were insufficiently available. The PC was scarcely used. The connection to a computer network and an interactive processing of documents was either not possible or required a bit of patience. Telecommunication costs were considerably above today's level and hampered an economic implementation of telework.

This early phase marks a normative fixing of telework to the basic idea of sustainable resource use (Huber). As the starting point for this one can consider the 'oil shock' of the year 1973 that shook up the (auto) mobile industrial society to a considerable extent. Thus during the dispute on substitution possibilities mainly for the production and use of energy, settlement areas, and transportation means alternatives were seen in the use of telecommunication. Specifically, the positive possibilities of telework in avoiding physical traffic were generally believed to have considerable chances. With the question "Telecommunicate or Travel?" (Pye / Tyler / Cartwright 1974) this target entered the public dialog. Jack Nilles (1976) coined the expression "telecommuting" which, up to now, has found broad international resonance.

Critique on the promises regarding the advantages of teleworking comes from traffic experts: According to these experts (Salomon 1986; Nijkamp / Salomon 1986 cited in Geels / Smit 2000,

p. 884) the first order of effect on substitution of commuter traffic may not be the only effect of teleworking. They point out that traffic should be seen as an integrated whole of several subsystems, for instance regarding recreation, social, commuting and shopping. Changes in one subsystem may go together with opposite changes in another subsystem. Thus, the reduction in commuter traffic may have as a second order of effect an increase in recreational or social traffic. Teleworking, therefore, may well have traffic generation effects besides substitution effects. For instance, it is possible that the teleworker will make more non-commuting trips in the extra "free" time (e.g. seeing friends, going shopping). Furthermore, other members of the household may use the car when it is not being used for commuting. Another traffic generating aspect that is often mentioned is that teleworking may contribute to moving house to more distant, "green" locations ("urban sprawl"). The substitution of trips on tele-working days is thus partly offset by longer trips on commuting days (Geels / Smit 2000, p.878). Also, more flexible arrangements of work can be used to get more coherent leisure time on weekends that will be increasingly used for short trips to European cities. There is still a lack of empirical research regarding these aspects.

Frequently, the substitution effects of telecommuting were systematically overestimated. This happened because often only the substitution effects arising from foregone trips to the place of work were determined and not the rebound effects. Mokhtarian (1990) critically pointed to the circumstance that telecommuters generate additional traffic by going on shopping trips or similar activities during the days of working at home. She determined a corresponding compensation effect of approximately 10 % for a small group of teleworkers.

While there will be substitution effects, there will be at the same time be more intense mobility in different parts of the mobility system, like social and recreational trips.
Because it is difficult to grasp the whole of all systems of teleworking on the one hand and mobility on the other together with its effects and counter-effects, at the same time a common quantitative understanding has not yet been achieved.

Until today, empirical data on achieved mobilisation effects of teleworking are therefore obtained on the basis of individual small model projects (Harmsen / König 1994; Rotach / Keller 1993; Qvortrup 1992; Hamer / Kroes / Oostroom 1991; Vogt / Denzinger 2001). However, these projects often do not represent the full range of effects or time-spans. In fact, dedicated studies on aspects of using telecommunication to substitute and reduce physical traffic have been insufficiently considered in publicly funded projects and programmes so far (Harmsen/ König 1994). So, until today there is, at best, dispersedly obtained data on the mobility effects of telework, e.g. data that is not supported by systematic and empirically based procedures.

In some model projects on telework carried out in the USA, substitution effects of business commuters were estimated significantly higher than in European countries. This is most probably a result of the considerably longer travel distances of the American commuters. A recent US study provided results indicating that telecommuting has a statistically significant effect (p=.06) on reducing personal vehicle travel. The magnitude of that effect appears to be small, probably less than 1% of total Vehicle Miles Travel (VMT) (Mokhtarian 2002). The study is based on a statistical analysis of aggregate data and time series for VMT and telework in the US.

In Germany the study of Glaser et al. (2002) found similar effects. In addition to reducing traffic he found that teleworkers and their households reduced car traffic by approximately 8 km per day, because they centred their life within a smaller radius of their homes. However, this study was based on the behaviour of 80 participants of telework pilot projects and can hardly be regarded as representative. To the contrary, the examined households were rather atypical households consisting of high-level managers and research personnel.

While appreciating these findings, one also has to consider that the studies on telework impact on traffic were usually based on the analysis of small pilot group(s) that more often were only

analysed for a short time and not over a long time period. It is questionable as to how far such innovators or early adopter groups can be considered as representative. In any case, the analysis of mobility effects of online-banking showed a traffic behaviour that was atypical for all population groups (Zoche et al. 2002). As a methodological limitation one should also consider that the results generally depend on the estimates of pilot participants (with a positive attitude towards telework) and not on systematic observations or time budgets of traffic behaviour. In most cases, a before and after analysis of the pilot participants was not done.

Summing up the state-of-the-art research on telework and traffic substitution it can be said that, apart from some local case studies with limited potential to quantify the effects, there is no quantitative data on the effects of teleworking on traffic substitution or creation available which would allow for country comparisons or forecasts. To the contrary: the questions developed in the ICTRANS-project concerning direct effects (trip distance, frequency, modality) and indirect effects (spatial distribution of housing and production) of teleworking cannot be answered in a reasonable fashion with the data available. Further research is needed. This concerns the complex interaction between the execution of telework, the inclusion of additional virtual activities (e. g. e-shopping, e-banking), and the utilisation of a larger organisational scope in the use of geographic and time options. It can be assumed that the use of flexibility options will have considerable effects on the change of the mobility behaviour. In addition to finding suitable definitions of telework which reflect the current developments as well as designing a systematic survey in the European Countries, points like the following should be verified in a new research project: direct and indirect effects of teleworking (see above), long term patterns of teleworking, effects on residential location, and net effects of mobile workers.

1.4 Policy

In some cases incentive systems for telecommuting were created in the United States via political regulations such as the Clean Air Act in California (1994). A procedure that recently was also practiced in Japan (Mitomo / Oniki 1999). With this legal background and the fact that US-workers usually travel a longer distance to their working places, an overall higher substitution effect was determined in the United States than in European countries (Bovy 1992). In comparison with Europe, this background has contributed to a more intensive uptake of telework that in turn leads to stronger effects.

2 SELF-EMPLOYMENT

2.1 Issues and problems

The ideology of futurologists and economists of self-employment (e. g. Jeremy Rifkin ”The End of Work“ und Daniel Pink ”Free Agent Nation“) leads to the thesis that a future work elite will determine their work themselves without superiors, hierarchies, and subordination. They will be part of a worldwide network within which they will be able to choose their own work, their residence, and the level of pay earned.

A strong demand for qualified knowledge workers, whose central instrument will be the networked PC, is a necessary prerequisite for the development of such a network of "free agents" as this group is called in the USA: "In the USA almost one third of the working population belongs to the free agents. But to every elite always belongs a proletariat. The digital proletariat divides into home office workers, office workers who have moved their place of work into their home, and temporary workers, temps for short, who are being brokered to firms for short time jobs by agencies." (Rifkin 1995)

The web site www.Free-Agent.com (since discontinued) understood itself as the organ and job broker of this "movement" (Süddeutsche Zeitung, 6. July 2000). However, even during the high season of the free agents, most of these freelancers did not work loosely spread across the globe but were predominantly organised with others as teleworkers in an office. They are represented by one person as their customers usually requested only one competent contact person (Caine 2002; Bowe / Streeter 2000). Integrated into such organisational structures, they are subject to an enormous market pressure and are occupied with techno-organisational problems: the effortless working around the globe proved to be an illusion (Caine 2002).

2.2 Possibilities

Mobile technologies are, besides PCs connected via Internet, central technical prerequisites for the development of self-employment. With a correspondingly developed infrastructure these technologies will enable self-employed persons to access and distribute information regardless of what location at or surroundings they work within. Characteristics of the technical requirements are: interoperability between networks, context specific and equipment independent presentation of content (e. g. independent of display size, computing power), the personal assistance of software agents, the technical realisation of man-machine-cooperation (gestures, mimic as communication medium), realisation / diffusion of equipment capable of communicating (Raffler 2001). With the help of mobile technology it is also possible to provide at any instant in time and any geographic location customized offers for the respective customers.

Mobile technologies permit (different from the Internet) if needed a unique identification of a user. This prerequisite for secure tele-interaction is considered an essential point for the increasing digitalisation of products and processes (Negroponte 1996). Mobile applications are thus an important promoter of time and location independent communication and thus important prerequisites for substitution as well as generating effects of traffic (Reichwald 2002).

Applications will be of interest especially in cases where "geographical distances no longer have to be covered by persons or material goods" and where "fast and spontaneous agreements and the reduction of unproductive transport times are possible" (Hofmann 2002). "Previous time factors of transport, of arrival and departure can be minimized, reaction times massively reduced.” Conversely however, concertation and co-operation can be intensified (Hofmann 2002).

2.3 Trends in self-employment

- In spite of global economic relationships and growing mobility there is evidence that in Germany the number of more flexible jobs and self-employed have only slightly increased.
- Tendencies of dramatically increasing precarious employment situations, higher fluctuations in staff or even self-employment are not being supported in the current job market statistics (Dreher 2001). Thus one should ask whether self-employment is a phenomenon of the dot.com euphoria or if it will prove to become a (future) mass phenomenon.
- With virtual organisations and the employment of freelancers, many SMEs will have the chance to reach the minimal size needed for flexible and competitive operation on the market (Scholz 2000).
- Empirical studies in start-up multimedia firms show that the portion of employed freelancers is reduced with increasing economic stability of firms (Zoche et al 2001 and 2002).
- Mobile work in extended understanding will become an essential building stone of the majority of activities. Within the new "infrastructure of work" jobs will undergo structural changes. Normal jobs will noticeably decrease and instead new forms of self-employment, virtualisation, and "non-office work" will generally gain in importance (Schröter 2002).
- With the growth of partial virtual work conditions employees will more often manage individual activities, not only real-to-virtual but increasingly, in parallel, also virtual-to-virtual. The mobility between the virtual assignment and activity environment will increase (Schröter 2002).
- The living situation of the freelancer is highly insecure and extremely influenced by market fluctuations. The transition between productive and reproductive work will become more fluent, the securing of a family stability on the basis of "secure" employment more uncertain. This could have considerable influence on the dependability of social structures. An imaginable success of self-employment could especially for this reason prove to be questionable / unstable.

2.4 Policies

Self-employment is facilitated by e-society concepts and triggers similar changes in mobility patterns as telecommuting. Flexible options to organize and link trips with different purposes might lead to less traffic, while the overall travel behaviour of the self-employed obviously depends on type and place of their work. If the freelancer’s business can be done from home, the determinants and conditions of his travel behaviour are comparable the ones of teleworkers (see section above “Teleworking”).

3 TELESHOPPING

3.1 Problems and Issues

With the spreading of Internet-based applications in private households and enterprises, the process of offering, selling and delivering products changes in a fundamental way. Private shoppers can gather product information online, place orders and pay over the Internet, and wait for the delivery at home instead of having to drive to a store themselves (Business-to-Customer e-commerce, B2C). Also, enterprises can buy supplies online and even coordinate their complete purchasing process over the Internet (Business-to-Business e-commerce, B2B). These changes have specific effects with respect to transport and traffic issues. However, when focussing on the area of "working" not all aspects of teleshopping are relevant. In this section, only aspects of teleshopping will be examined which directly relate to the working sphere, e.g. to the way people and companies work in the evolving e-society. Consequently, the assumption that teleshopping leads to a reduction of individual traffic will not be dealt with in detail here but in the section covering the "Living"-sphere.

Concerning changes in the work sphere, B2C e-commerce is especially relevant as it enables more flexible working hours for employees who do not have to rely on store opening hours anymore. Also, the growing number of e-commerce platforms and service providers enable new forms of highly specialized, time-flexible and not location-based work. In this respect, the emergence of teleshopping enables and requires more flexibility of employees at the same time. Because these aspects directly relate to new forms of work, the expected effects of this development on the substitution of traffic are described in more detail in the sections "Telework" and "Self-employment".

With more and more advanced ICT-systems and B2B e-commerce applications implemented in enterprises, the need to actually travel to suppliers and customers seems to become obsolete. In some areas face-to-face meetings can be substituted by advanced ICT-applications like video-conferencing, net meeting, e-mail, and other computer-aided cooperative work systems, thereby avoiding some business trips. On the other hand, the global reach of the Internet also expands the group of potential customers and suppliers beyond regional or national boundaries. This could also lead to more traffic since initial contacts and sensitive coordination meetings still require face-to-face contact.

3.2 Possibilities

3.2.1 Business to Customers (B2C)

Lyons (2002) examined the effects of the Internet on transport activities in his paper "Internet: investigating new technology's evolving role, nature and effects on transport." After describing the possibilities of teleshopping and their potential to substitute private shopping trips to grocery stores, he identifies trends behind the increasing demand for B2C-services. Two trends directly relate to the working sphere:

- An increase in length of the average working week leaving less time for shopping, and
- An increasing number of people in work - particularly women.

In the "Working" domain, teleshopping mainly concerns the ability of employees to be able to work more flexible hours because they do not have to take opening hours into consideration. They can organize their working time more freely and more flexibly. However, this applies almost exclusively to management and information working jobs. Real transportation might be reduced because food, grocery goods and the like can be ordered from the workplace or from home and delivered directly to the door or to a delivery-outlet. In this context, changing working time patterns are a key driver of change.

Harvey et al. (1997) contributed to the list of trends in the working area that can be seen as drivers for teleshopping. In their study "24-Hour Society and Passenger Travel" they examined the conditions of a flexible society without closing times and its consequences on personal traffic. The starting point of their study is the observation that European countries have varying restrictions on stores hours, resulting in a diversity of shopping times. Increasingly demands are being made to further liberalise shopping time. Changes in social trends such as more single parents, dual career families, and single person households provide a major incentive for extending store hours in many countries. The rising cost of time in today's society is also a major issue associated with store hours. To answer questions concerning the effect of such changes on travel behaviour Harvey et al. (1997) reviewed current research on these topics. They found indications that growth in female employment may have caused an increase in peak-hour non-work travel due to such things as delivery and collection of children at day-care centres. This leads one to believe that there has been an increase in linked trips, as trips to the day care and shopping are likely to be made on the way to and from work.

The deregulation of store hours is seen as the alternative to providing individuals with more flexibility in the allocation of disposable time and as a measure to reduce peak hour congestion. The research reviewed by Harvey et al. 1997 was not clear or unanimous on the potential impact of deregulation on travel. However, there was a suggestion that regulation of store hours has promoted proliferation and the sprawl of shopping areas. If deregulation were to reverse this, rather than a reduction of travel, an increase of trip distances would be the result (Harvey et al. 1997).

Other research on teleshopping and transport focuses on the substitution of store shopping by virtual shopping, which means the use of e-commerce or TV-teleshopping-platforms. Transportation and geographical studies of shopping behaviour like Salomon / Koppelman 1988, focus on destination choice assuming a trip has to be made. New telecommunications technologies enable home-based teleshopping to substitute for store shopping. Frameworks for studying the choice between modes of shopping were developed. It was noted that shopping also seems to fulfil some psychological and recreational functions in addition to obtaining information. An integration of perspectives from different disciplines in order to create a conceptual structure for empirical studies of the impact of telecommunications technologies of human travel and activity patterns was attempted by the authors (Salomon / Koppelman 1988).
Also, the question was raised under which conditions people will decide to actually "go shopping" and when they will order online. The most prominent paper on this issue is from Nagurney / Dong / Mokhtarian (2001) in which a multicriteria network equilibrium framework is developed concerning the question as to when people go shopping versus teleshopping.

Matthews and Hendrickson (2001) calculate the economic and environmental costs for book retailing in the US – both online and traditional – using a bestseller as a sample. Due to their findings and an assumed remainder rate of 35% for best-selling books, e-commerce logistics are less costly and create lower environmental impacts, especially if private auto travel for shopping is included. Even without book remainders and returns, costs and environmental effects are comparable for the two delivery methods.

In a study of the German Ministry for Transport (BMVB 2001) the effects of teleshopping on the creation of traffic are listed. The study reviews existing, mainly German, studies from different institutes and private organisations and summarized their main findings. The insight and data from the used studies is very heterogeneous and often the methodology is not made explicit. However, the study is considered state-of-the-art research, especially by German policy decision makers. The trends that the study identifies in the B2C-sector are the following:

- B2C will result in the increase of small-part sending to an increased number of end-customers with individual delivery-places and delivery-times.
- B2C-traffic will concentrate on suburban areas.

- B2C induces more courier, express and packet deliveries
- B2C will lead to inhomogeneous transports in urban surroundings and at the same time to a better consolidation of long-distance traffic.
- Storage concepts, distribution and collecting traffic have to be adapted.
- Return tours of delivery vehicles will produce additional traffic.
- Some shopping trips will be replaced by deliveries.
- Applying logistic concepts can result in package effects (less single traffic).
- In-time deliveries are always price sensitive and will almost always lead to street traffic.
- Trends in courier, express and packet (cep) deliveries (ongoing trends but supported by increased Online-shopping).
- Cep-services will require more small vehicles.
- The total number of tours will increase.
- Cep-traffic will mainly affect suburban areas (housing areas).
- Delivery drop-offs (pick-up stations) will be asked for in suburban living areas.
- Because of the increasing transport of small-parts, other transports will be substituted
- Speciality transports like grocery deliveries will remain a niche market.

(Source: BMVB 2001, p. 28)

It has to be noted that this list presents assumptions and educated guesses as opposed to empirically assured facts. Also it is obvious that some predictions are contradicted by others. The net effects of increasing B2C, e.g. the question whether individual traffic will decrease enough as to compensate for increased delivery traffic is not at all solved.

Summarizing the B2C area it has to be noted that there are a lot of studies and speculations concerning the substitution or creation of traffic and very little empirical research or data that would allow for a direct analysis of the effects of teleshopping on travel behaviour. This may be due to the fact that the area of Teleshopping for private customers is a relatively new field that has become relevant only since the mid 1990s with the boom of the Internet. Most research is still occupied with reporting and analysing uptake patterns, penetration and shopping behaviour in the digital era.

In a paper presented at the STELLA Focus Group 2 “ICT, Innovation and the Transport System” in 2002, Carsten Gertz from the European Centre for Transportation and Logistics summarized the research situation in the following way: “There is no data available that could give a clear answer to the question on how teleshopping might influence the individual mobility. All that can be done at this stage is to put some pieces together and show possible directions of the most likely effects.” (Gertz 2002) Similar to the list of the German Ministry for Transportation shown above, Gertz supplied a list of assumptions on the effects of teleshopping:

Kilometres travelled:

- In Germany the share of all kilometres travelled by car for shopping is relatively small (11% of total car travel) and remained relatively unchanged over the past years. Christidis (2001) reports that numbers for the UK are similar (13%). Even if one would assume a high substitution because of teleshopping, the net effect would therefore be relatively small.

Number of trips:

- It looks slightly different for the number of trips while 20% of all car trips made in Germany are for shopping purposes. Again, according to Christidis, findings for the UK do not differ much (21%). Private cars are used for 80% of the distance travelled, but trips with a car only account for less than 60% of all shopping journeys (UK).

Trip chaining:

- Shopping has a high share of unchained trips: here would be the potential for substitution. But a lot of shopping trips combine shopping at different stores because different products were bought. If we take into account that the acceptance of product groups in the Internet is very different, certain purchases over the Internet do not reduce the need for other shopping trips.
- If different activities are combined, a substitution of trips in total is less likely especially for the tripchain work-shopping.

More VMT through delivery vehicles?

- Teleshopping requires a large number of small shipments to geographically dispersed customers. Still, it must be taken into account that part of these shipments will be accommodated by existing parcel delivery operations and will therefore only add to ton-km, but not to vehicle-km. (Browne 2001)
- Reverse logistics are an important success factor. The dot.com failure showed that the new enterprises underestimated the importance of a reliable logistics network.
- The winner of a growing e-commerce section is the traditional mail order companies and the cep-providers (Gertz 2002, p. 30ff).

Summarizing the B2C-teleshopping section it has to be noted that there is (still) a general lack of quantitative data that would allow answering questions on traffic effects (substitution vs. creation of new travel). One of the reasons for this deficit is that the recruitment of samples is very difficult. Often, sample sizes in surveys are too small to allow for representative conclusions. In addition, identifying and reporting changes in the travel behaviour is often very difficult because non-work trips are more disperse and often linked with very different activities. Thus, teleshopping activities might not be as regular as expected or wished for by researchers.

What's more, the dynamics in the e-commerce development are very high. Available data therefore often does not keep track of the current developments and is outdated very quickly. We are practically without any timely and reliable data about the number and turnover of online shops. The available data about spatial differences in the usage of the Internet is also very poor. And finally, there is no comparable quantitative data in the logistic sector in Europe. A new study would have to start at these questions to approach the question of net substitution of shopping trips by teleshopping activities.

3.2.2 Business to Business (B2B)

The concept of electronic data transfer between enterprises (electronic data interchange, EDI) is more than 20 years old. Mainly larger enterprises use EDI whereas SMEs were often not able to make the necessary investments in the IT-infrastructure. However, the spreading of the Internet and the process of globalisation and virtualisation enable more and more enterprises to use the Internet as a platform for comprehensive and flexible interactions which are not limited to electronic procurement but also enable market transparency, electronic ordering systems and the fulfilment of logistic processes, e.g. the supply chain management (SCM). With the Internet, this instrument is available for all enterprises, including SMEs. In addition, larger companies develop their own online purchase portals. Examples are COVISINT (automotive industry), Myaircraft.com (aircraft industry) or Aeroexchange (air travel and services). Other enterprises, especially SMEs use commercial online marketplaces for their transactions.

The other dimension of B2B e-commerce relates to enterprises that offer teleshopping services. They are probably not covered in the realm of "producing" because in a narrow sense, they are not producing but selling goods. Here the research focuses on e-commerce platform providers. Concerning traffic creation, platform providers might contribute to the reduction of traffic because the actual enterprise can be lead as a virtual organisation: Employees do not have to be physically at the place where the service is created. Programming, customer database management, customer service, orders, and other functions can be either provided by employees from their home or from a central office. The physical presence at a certain place is no longer essential. Teleshopping in this sense supports the concept of teleworking (reference to key application area "teleworking").

Similarly, manufacturing firms with their own e-commerce systems may contribute to reduced traffic. E-Commerce platforms are, for example, operated by the automotive industry where the manufacturers are coordinating their purchases from suppliers over the Internet. Product information, pricing and quality can be negotiated online. Physical travel might be reduced because they may reduce the visits to their suppliers.

Consolidation within industries might also have a decreasing effect on traffic by using existing transport networks in different and more efficient ways. (Browne 2001)

Here it might be necessary to distinguish between physical products and products that can be distributed digitally. Physical products, e.g. vegetables, foods, tires, brakes, etc. need to be stored somewhere, even when ordered and payed for online. They have to be delivered via traditional transport methods. Digital products such as research papers, entertainment products like movies, news, etc, music, books which can be delivered over the Internet or any other network can reduce traffic supposed by a person or company who would otherwise have to travel just for this one item.

The trends and key drivers in the B2B-area can be summarized in a list of the BMVB study of 2001:

- globalization, an increasingly trans-national purchase and selling process
- apply ICT in enterprise to lower transaction costs
- availability of a more sophisticated IT-infrastructure, almost all enterprise processes are accompanied or mapped by computer systems
- more demand for personalized/ individually manufactured or combined products

Also in the BMVBM paper (2001), results from a Volkswagen study on e-commerce and transport creation are cited. The report claims effects on traffic creation in the areas "Electronic Supplier Link (ESL)", "Online Negotiations", "Electronic Capacity Management" (eCAP) and "Catalogue Buying". The following table displays their findings:

Table 2: Changes induced by the use of ICT in the purchasing process: Examples from VW

User	*Without E-Commerce*	*With E-Commerce*
Electronic Supplier Link	• Demand documents were ordered, copied, and sent internally. Afterwards they were checked and edited manually. • Demand documents were sent to all suppliers by mail • Suppliers submitted written offers	• Download demand documents from system • Demand documents are provided to suppliers on server • Supplier is informed about the process per email • Suppliers submit their offers online
Effect: Tons of documents sent by mail are saved		
Online Negotiation	• Buying department develops negotiation strategy after demand • Buying department negotiates personally with every supplier	• Negotiation is carried out online in the system • All suppliers log in simultaneously on the day of the negotiation and submit offers from any place
Effect: time-consuming business trips and negotiation time are reduced		
Electronic Capacity Management	• Demands were submitted to suppliers by data transmission or fax • In case of capacity problems the supplier notified • In case of capacity problems it was partly reacted very late	• Demands are submitted to the supplier online • Supplier adapts his capacities simultaneously • In case of deviation between demand and capacity a co-operation takes place in time
Effect: extra activities, extra tours, and flights are reduced		
Catalogue Buying	• Office supplies were carried out by an internal store • Material was sent within the factory • Tools and machines were kept available in the factory • Material was picked up in the factory	• Orders for office material are submitted directly to dealers • Delivery takes place within 24 hours • Orders for tools and machines are submitted directly to dealers • Delivery takes place on demand
Effect: possibly flow of goods makes higher traffic intensity necessary		

Source: BMVBM 2001, p. 12

Whereas this study expects some reductions in transport activities, others have argued on a more general level that new technologies have always lead to the creation of more traffic because people want to meet each other face to face. For example Smith 2001 states: ”E-commerce expands the reach of business beyond current boundaries. B2B contacts will lead to increased trips to visit new clients and collaborators overseas (all by air), interstate (most by air) and in regional areas (air and car). Earlier significant changes in communications had exactly that effect. Introduction of the telephone increased rather than decreased trip making.“ (Smith 2001). Also, Button et al. (1994) argue that despite technology’s improved offers for teleconferencing, it has proven to be a poor substitute for face-to-face communication in many applications. Teleconferencing may substitute for some meetings, for example seminar presentations, but it is likely to prove less successful for delicate negotiations.

Summarising the trends in the B2B-sector, again the collection of statements from the study by the German Federal Ministry for Traffic can be used:

- the tendency towards global purchasing structures will lead to greater transport lengths and to an increase in aircraft and ship transport,
- transport ways may be changed due to a change in delivery companies,
- the Just-in-Time problematic situations will increase,
- more frequent and smaller part-transports will be expected,
- physical storage capacities will partly be replaced by virtual storage,
- turnover spots (Umschlagpunkte) like pick-up-stations and their design will become more important (BMVB 2001, p. 28).

Summarising the state-of-the-art research in the B2B-area it can be said that research concerning the effects of teleshopping on traffic in the working sphere is quite heterogeneous as has to deal with very different aspects of the subject. Quantitative studies examining the effects of ICT in the working sphere with respect to the number of trips, the length of trips, the modal switching or the passenger-freight-substitution do not exist. In addition, speculations about the future development of traffic streams have to take into account side effects or contradicting influences.

3.3 Policy

Under these circumstances, policy recommendations are difficult to make. For example the deregulation of store hours can be seen as a way to provide individuals with more flexibility in the allocation of disposable time and as a measure to reduce peak hour congestion. However, the research reviewed by Harvey et al. 1997, was not clear or unanimous on the potential impact of deregulation on travel. It was stated that the regulation of store hours has promoted the sprawl of shopping malls in the past. If deregulation were to reverse this, rather than a reduction of travel, an increase of trip distances would possibly be the result (see Harvey et al. 1997).

Whereas it may be difficult to give policy recommendations with respect to the substitution of traffic by teleshopping in the working area, more general recommendations concerning the uptake and use of ICT in the economy and society can be made. Here, the political framework should cover the following issues:

- compatibility,
- inter-operability,
- intellectual property,
- data ownership and
- confidentiality (Smith 2001).
- security issues when delivering products to consumers, how can companies avoid fraud?

4 MANUFACTURING SYSTEMS

4.1 Problems and Issues

Production and manufacturing processes are undergoing far-reaching changes. Many of the changes are triggered by new developments in ICT and the wide spread use of these technologies. They lead on the one hand, to improved processes and co-operations. On the other hand, new services and ways of producing and distributing goods are created. Not all changes will lead to an automatic and noticeable reduction in transport volume. Information and data on substitutions and reductions are scarce. The part that ICT plays will have to be studied further. Application areas with a high potential for substituting physical transport or at least reducing volume and or distance are described below.

4.2 Possibilities

In the *automobile industry* for example, where it used to take 10 business days to assemble a car, firms are aiming to respond to specific vehicle orders within five or even three days. With the support of ICT, customers will be in a position to customise their new cars online to their preferences but without having to wait many weeks for delivery. This requires massive changes in the way not only the manufactures but also suppliers approach the entire process of ordering supplies, producing and delivering parts. The need to sequence the delivery of parts to the vehicle assembly line on time and in the proper order is leading to the formation of supplier villages around each vehicle assembly plant. This means short distances for the transport of supplies and which should, therefore, lead to a reduction in traffic. Efficient enterprise resource planning systems as well as customer management systems are a prerequisite for achieving the goal of short assembly times.

The *machine and plant manufacturing industry* has a long tradition of providing excellent service to their customers. The globalisation of markets, increase in machine complexity, and high labour costs has made it considerably more difficult to live up to this expectation. Many hours have to be spent by service technicians on the road or in a plane. With the more advanced digital control systems now available for machines and plants it is today possible to provide troubleshooting and service support from a remote location (e. g. the manufacture's site) using ICT. Utilizing established data networks and telecommunication services; a technician can obtain diagnostic information of a remote machine or plant directly on his computer. In some cases he can directly take the necessary action to remove the problem source or he might have to tell the local personnel what actions to take. The need for travelling can thus be greatly reduced, resulting in more time for work and less traffic. The acceptance of this kind of teleservice has been rising in Germany over the last years. Firms in the manufacturing industry that use teleservice have increased from less than 10 % in 1992, to almost 50 % in 2001 (Kinkel 2002). With teleservice, savings on after sales costs can be considerable (Hudetz / Harnischfeger 1998).

ICT has already in the past caused significant structural changes in the *printing industry*. More recently, with the rise of new media and with better and faster telecommunication, services changes are also taking place in the product line and distribution (Hudetz et al. 2000). Technologies and concepts such as digital printing, cross-media-publishing, distributed publishing, and print-on-demand will lead to a reduced demand for transportation of printed goods. Already today a number of newspapers are printed at several locations distributed across a region, country or even across continents using broadband telecommunication for transport of the large size electronic print-ready documents. This will assure on time delivery of current news. Aside from saving time and money, this form of distributed publishing will also reduce the volume of and the distance covered by newspapers shipments. The distribution of books will be changed with the diffusion of book-on-demand. It will no longer be necessary to produce and ship books in large numbers to distributors. Instead, the local distributor will be able to print just

the number of books being ordered. The over-stocking of books will be eliminated along with a reduction in transport. It is not certain whether electronic publishing will actually reduce the amount of printed matter consumed. However, there is considerable potential if electronic books, newspapers, etc. should become widely accepted by the public. This would lead to a considerable reduction in physical transportation needs.

Networking, like other strategic partnerships has become central to competitive success in the rapidly changing business environment. Networks, strategic alliances and partnerships are no longer an option, but are now a necessity (Doz /Hamel 1998). Network arrangements result from strategic cooperation between more than two independent companies, and have the aim of pursuing economic advantages. Especially for small and medium sized enterprises (SME), partnerships and networking offer a chance for success in future markets. Utilizing each partner's strengths and resources, SMEs have a better chance to compete against large and multinational firms. Co-operations can take place vertically with each partner contributing at a different stage of the production chain to produce an overall product. Horizontal co-operation implies that partners share the production capacities for better utilisation. It was found (Eggers / Kinkel 2002) that co-operation of some kind is practiced in almost 50 % of the firms in the German manufacturing industry, however, only a small percentage (8 %) are part of a production network (more than 2 partners). Networking implies comfortable and efficient communication and coordination of activities between partners. ICT tools and services largely form the basis for network transactions and support networks spanning across wide geographical areas. With the implementation of modern technologies and telecommunication services (e-mail, data transfer, videophone, CSCW, etc.) travel between partners can be reduced considerably.

Main factors that are or will be promoting ICT in manufacturing systems are:

- internationalisation of markets
- customer demands
- complexity of machines and plants
- rationalisation
- use of new media, e-commerce
- changes in production chains.

A number of trends are influencing manufacturing systems and its industry.

- Customers and competitors can increasingly be found worldwide. Being active in a global market requires better and more efficient communication means.
- The use of modern telecommunication services such as e-mail, video conferencing, CSCW, mobile telephone, etc. has become part of business communication and will continue to grow.
- SMEs are beginning to form networks for surviving in more competitive markets. This trend will continue with rising international competition and the demand of customers for system solutions from one supplier / contractor.
- The use and the familiarity with new media and information services will increase. The demand for traditional print media will slowly decrease. New distribution methods will gain in importance and in volume with a corresponding decrease in physical transport demand.

5 LOGISTIC SERVICES

5.1 Problems and Issues

In recent years logistics has expanded from traditional material flow towards the chain connecting the network of production sales, maintenance and recycling. (Cser 2000) Logistics now has a broader scope than transportation, because it ”focuses in all physical activities including warehousing, transhipment, information flows and the need to manage the entire transportation system. Chain monitoring (tracking and tracing) and auction markets for capacity trading are now part of new logistic systems.“ (Smith and Ferreira 2001) Cser describes changes in the production of goods as a result of globalisation: Worldwide production networks that operate from different places form virtual factories ”whose main components are logistics and the information technology background”. Virtual factories need a global logistic concept in order to make sure that material flow is still ”as simple and effective as possible, with little need for inventories and buffers”. (Cser 2000)

5.2 Possibilities

These trends in logistics and, in addition, the companies’ general outsourcing tendencies lead to an increased demand of so-called Third Party Logistics (3PL). Suppliers of 3PL are capable of organising almost the entire logistic process, including the selection of carriers, intermediate storage and transhipment. Moreover, they broker information, e.g. in pricing, load matching, real-time routing. (Song and Regan 2001)

Rail, air, ship and truck transport companies involved in logistic systems make extensive use of information technology, e.g. for booking and routing. So-called e-Logistics provide ICT-support along the entire supply chain, e.g. using barcode, EDI or lately the non-proprietary XML as well as mobile devices. (BMWi 2001)

The following key drivers of change can be identified:

- Increasing globalisation of supply and demand markets changes the flow of commodities and promotes the air cargo and shipping industry. (BMWi 2001)
- Business trends like focusing on the core business and on agility promote outsourcing, information technology and e-logistics being the enablers. (Andersson 2002)
- Extended division of labour and production (virtual factories) results in an increasing demand for superior logistic services. (Cser 2001)
- Consumer demands regarding frequency, service and punctuality of deliveries are rising, particularly in connection with e-commerce. This results in smaller, more frequent shipments, tight time slots for delivery and an overall individualisation of logistic services. Parcel services with small vans will probably benefit from this development. (Hvolby 2002)
- E-Commerce platforms, electronic marketplaces and online auctions create more transparency in the market.
- Transactional cost reduction and the expected further increase in JIT-production put more pressure on the logistic chain. (Stopford, 2002 and Hvolby, 2002)

The increasing deployment of IT will cause disintermediation, better organised hubs, reductions in extra tours and better bundling of goods because of a higher overall transparency in the market. (Hesse 2002) Cser (2000) expects a growing number of industrial parks that are directly linked to assembly plants and allow a better bundling of goods.

ICT in logistic networks and supply chains enables better truck utilisation. Reasons are the improved fleet management, transparency in regards of resource availability and better bundling of goods. (Breiter et al. 1997) The application of ICT is expected to cut out unnecessary transactions, eliminate under-utilised infrastructure and avoid redundant traffic flow. (Meyer) In rare cases physical transport can even be eliminated, for example, if music files and documents are downloaded from web pages or sent by email. (Hesse 2002)

Transport due to B2B might increase traffic in industrial areas because of smaller loads, whereas transport due to B2C is expected to have a positive impact on traffic in urban areas because goods can be bundled by the delivery company. Increase in air cargo and shipping creates additional traffic at harbours and airports (BMWi 2001 and Smith and Ferreira 2001).

On the one hand the demand for basic transactional, repetitive and fast logistic services that can easily be traded on an electronic marketplace might grow, on the other hand advanced logistic services that require deep strategic alliances between company and logistic service provider might gain importance.

Store-based order picking and e-fulfilment centres can be identified as the main logistic models in e-commerce concerning food. In both cases commercial vehicles must travel extra distances, but the actual impact on traffic depends still on the customer travel behaviour. (FORESIGHT 2000)

E-business and JIT may not necessarily lead to smaller consignments, but will rather move business to larger freight forwarders who are able to consolidate loads. (Smith and Ferreira 2001)

UPS and FedEx have both established their own front and back ends for electronic commerce with associated airfreight operations and newly constructed parcel consolidation and distribution facilities. This points to an expected increase in small bundles of freight being delivered by parcel companies with small vans and planes. (Hesse 2002)

Hesse (2002) states that rail freight cannot cope with the demand for flexibility as well as with the decreasing size of the truckloads. He expresses his concerns regarding the future choice of carrier type: “A significant and alarming outcome of the increased market penetration of IT and EC is the likely acceleration in the shift in domestic freight mode share away from rail and waterways, towards all-highway movements. [...] By all indicators, the widening gap between truck and non-highway modes in domestic freight service will continue to increase with the growth in EC.” On the other hand efficient intermodal freight transport - often being mentioned as one prerequisite for sustainability – requires the establishment of a seamless information chain in order to be competitive. Adopting and integrating new telematic technologies like EDI / XML, automatic location systems or computer-based booking and dispatch systems can help to improve the information chain and therefore reduce costs and remove barriers in terms of intermodal transport. (European Commission 2001)

A seminar held by the OECD and ECMT on ”The Impacts of E-commerce on Transport“ in 2001 concludes, ”E-commerce does not cause new problems but magnifies and intensifies existing problems of transport, (e.g. need to increase efficiency in rail and sea transport).“ ICT has the potential to solve some of these existing problems and to generate opportunities for intermodal transport.

Stopford (2002) describes the impact of ICT in the shipping industry: In his opinion, especially the Internet-technologies are enablers of growing trade with more volume. ICT will allow medium sized liner companies to offer effective door-to-door services without the complex overhead structure. Small ports and niche operators might attract customers with competitive rates enabled by cheaper and better ICT.

5.3 Policies

To meet the requirements of modern transport and to cope with the growing use of ICT in logistics, logistic workers must receive further qualification and training, since low-qualification jobs are likely to be replaced in the future. Creating more transparency in the logistic market might lead to better utilisation of trucks. Traffic policy, e.g. concerning tolls for highways, might also lead to a modal shift from truck to railway and ship usage.

Research comes to different conclusions regarding the impact of teleshopping on traffic. If the delivery by small vans should be promoted (assuming this will reduce overall travel because of bundling), changes of traffic regulations in suburban areas, e.g. for parking permissions, might be necessary. Moreover, delivery times in the evenings would have a positive effect on congestion in peak-times, the downside being more late traffic and noise in residential areas.

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Impacts of ICTs on Transport and Mobility (ICTRANS)

Background Paper: The impact of ICT on mobility and transport in the socio-economic sphere PRODUCING

Dantuma, L., Hawkins, R. and Montalvo, C.
TNO-STB

TABLE OF CONTENTS

1 PROBLEMS AND ISSUES

ICT has been acknowledged to be one of main enablers of the globalisation of production. Business strategies at both regional and international levels now typically imply the subcontracting of various stages in the production processes. This often involves changes in the geographical location of these stages with important implications for transport. Arguably, none of these changes would be possible to implement or sustain without substantial investment in ICT. On the other hand, in the form of more sophisticated command-and-control and distribution management systems, ICT can play potentially a key role in solving problems created by greater geographical distribution of production processes.

The problems are nevertheless compounded in that various concepts that originated in the production sector have migrated to the distribution sector. For example, the 'just in time' concept which originated on the production side in order to reduce the cost of inventories has now been adopted by leading retailers, relabelled as 'lean retailing'. This development has shifted some of the traditional inventory burden of retailers back to the suppliers and it places an extra stress on logistics and transport. It also creates paradoxes for retailers and suppliers who are now constantly faced with trade-offs between distant and cheap suppliers who may increase delivery problems, or local but expensive suppliers who can ensure timely delivery.

In this paper we will look at questions relating to the ever-increasing use of ICT in the production domain specifically in terms of what this might mean for transport. Clearly, the range of possible applications of ICT in the production domain is enormous and not every application can be examined with respect specifically to its transport implications. In order to manage this problem, we are concentrating on those aspects of the production function that have the most direct transport implications. These apply mainly to the management of inputs and outputs within the production process. Furthermore, as the transport problem pertains in the first instance to the movement of physical objects, we will concentrate on production as embodied in manufacturing systems.

Thus, we focus specifically on the role of ICT in manufacturing systems, logistics services and distribution services. For clarity, these aspects are treated separately although in reality they are all connected within the business and operational strategies of complex production systems.

2 DEVELOPMENTS AND TRENDS

2.1 Manufacturing systems

In the last 30 years there has been massive restructuring in how firms organise their competitive, location, production and marketing strategies. Wide scale introduction of information systems into production processes began in the 1980s. They now pervade not only the shop floor organisation of manufacturing production but also the logistics and distribution of finished goods.

Access to new markets for products, services, raw materials, and skills has always been a powerful incentive for organisations to expand internationally. Recently, the establishment of global alliances to leverage core competencies has led firms to seek new ways of conducting business. These have demanded the rethinking of organisational structures, processes, and co-ordination between business units, suppliers and customers. One of the fundamental tasks has been the establishment of appropriate ICT platforms to co-ordinate business processes and provide coalition mechanisms for global business (King and Sethi, 2001). Once the appropriate ICT is in place, they make possible the co-ordination and control of geographically dispersed production and distribution activities (King and Sethi, 2001).

The introduction of ICT has contributed in larger and smaller firms to cutting down on operational costs, reducing product life cycle, increasing value, co-ordinating distant operational and business units and generally enhancing competitive and financial positions. It appears that there is little differentiation between large and small firms with respect to the degree to which information systems support such tasks as strategic planning, shop floor automation, control of manufacturing process, process improvements, quality control and concurrent engineering (Gurhaxani and Whang 1991; Gupta and Capen, 1996; Au and Choi, 1999).

The use of ICT in manufacturing systems has progressed from the discrete use of computer aided design (CAD) and computer aided manufacturing (CAM) at the level of the single factory, to computer integrated manufacturing (CIM) and electronic data interchange (EDI) systems that link production facilities. In the last stages of production automation, virtually all aspects of manufacturing systems are in some way interconnected through ICT (Saxena and Sahay, 2000; Hsieh *et al*., 2002). However, interconnection between business units alone does not ensure the levels of co-ordination and reaction readiness necessary to respond to changes in market conditions. In other words, the challenge is use ICT in order to link business strategy with the more operational spheres of manufacturing (Lai, 2001). The most advanced manufacturing systems are now oriented to achieving the concept of virtual fabrication (Hsieh *et al*., 2002; Korczynsky, 1997). These new 'virtual' manufacturing systems are expected to expedite co-ordination between business units, thus improving marketing efficiency by increasing the responsiveness of manufacturing systems to changing market conditions.

Such advances in manufacturing systems are now being adopted also by the retail side. Advances in the application of ICT to retailing are enabling retailers to estimate consumer demands more accurately and, accordingly, to require manufacturers to replenish smaller orders much more quickly and frequently than in the past. Suppliers who used to plan their production scheduling every six months, now find this process truncated to perhaps one week. Thus, pressures on inventories spread throughout the supply chain. This has fundamentally changed the relationship between suppliers and retailers. There is now great pressure for suppliers and retailers to adopt the same operational standards and technological platforms (Abernathy et al., 2000).

In order to meet these challenges, one could envisage the production environment of the future as embodied in a fully automated facility in which all material-handling, assembly, and inspection will be done by ICT-controlled machinery and equipment. Likewise, other activities such as incoming orders, production planning and scheduling, operational decisions, shipping,

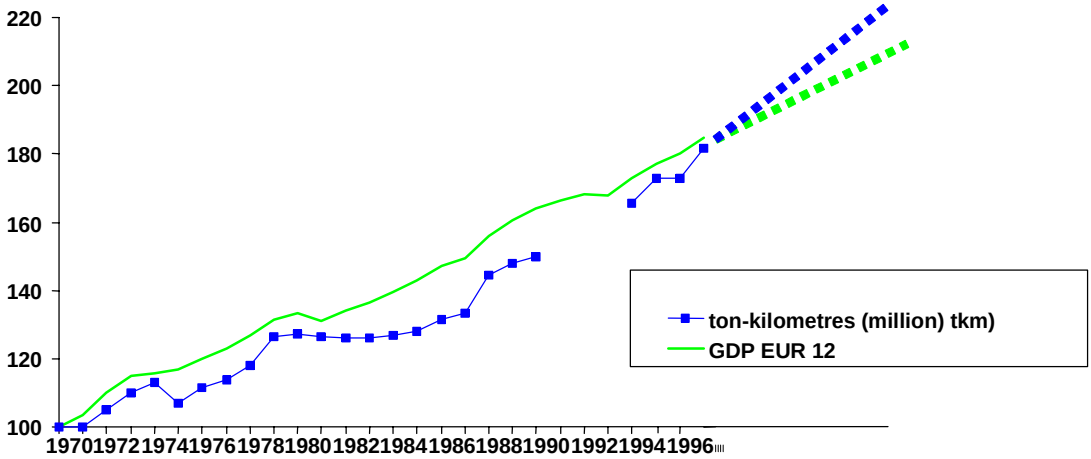
receiving, and consignment tracing will be controlled by ICT (Ostwald and Muños, 1997; Kalpakjian and Petronis, 2001; Wright, 1988).

In order to achieve this virtual enterprise, a new a generation of information and knowledge systems supported by ICT has been rolled out, including knowledge based engineering (KBE), product data management (PDM), and the enterprise resource planning (ERP). A KBE system will contain all knowledge and accumulated experience needed for the design and manufacture of a new product. PDM will manage data and knowledge during the product life cycle and will integrate with Enterprise Resource Planning (ERP) (Au and Choi, 1999; Hsieh *et al*., 2002).

Most of the literature relating to ICT application to manufacturing systems is concerned with the co-ordination between functional units, productivity gains and technology integration problems (e.g., Kaplinsky, 1995; Gupta and Capen, 1996; Lai, 2001; Donobue, 1996). Studies of international location strategies suggest that given the increased distribution of manufacturing operations and systems across the globe (e.g., Gereffi, 2001; Gourevitch *et al*., 2000) and the new relationship between 'just in time' and 'lean retailing' (Abernathy *et al*., 2000), significant impacts on transport will accrue as components, materials, subsystems, equipment; and human resources must be moved more often and more efficiently between regions and countries.

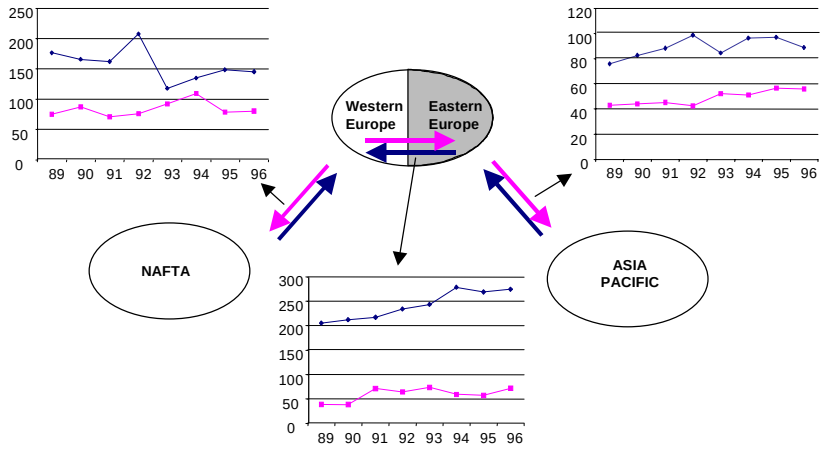
However, in reviewing the literature on the application of ICTs to manufacturing systems, no clear indication could be found as to the degree of impact on transport in quantitative terms. That these impacts exist is indicated by the extreme example of international manufacturing and subcontracting schemes. Traditional export platforms located in newly industrialised countries (South Korea, Singapore, Mexico, etc.) that export finished products to industrialised countries, host manufacturing systems that integrate products where the local input into the products accounts for less than 3% of total input (Montalvo, 2002; Gonzalez-Arechiga and Ramirez, 1990; Sklair, 2000). This is confirmed by TNO-Inro (1999) who report that the constant growth in inter- and intra-trade flows (in ton-kilometres) implies an intense activity in multi-modal transport in order to source inputs from and deliver goods to several regions and countries (see figures 1 and 2 below).

Figure 1: Growth in freight transport and GDP.



Source: TNO-INRO (1999)

Figure 2: Time-series of trade (in mil tonnes) between Europe and NAFTA/Asian Pacific and between the EU and Eastern Europe.



Source: TNO-INRO (1999)

2.2 Transport and logistics

In the last 30 years we have witnessed the development of complex trading networks, that evolved in the first instance, to gain access to raw materials, reduce labour costs and widen markets. The creation of trading blocks and trade liberalisation has removed many barriers to the trans-national movement of goods and direct capital investments. In many ways, ICT has enabled these changes and facilitated new types of relationships between suppliers and retailers that have had an effect on transport and logistics. REDIFINE (1998) classifies the trends in transport and logistics as follows:

- structure of the supply chain
- alignment of the supply chain
- scheduling of product flows
- the management of logistics resources
- changes in product configuration.

These categories are useful as a means of organizing the discussion concerning the new dynamics of trading structures that have implications for transport.

2.2.1 Structure of the supply chain

Considering the structure of the supply chain in relation to the location and size of production and processing plants and storage sites, the main changes to the structure of the supply chain include the spatial concentration of production and inventories, development of break-bulk and transhipment systems, and the creation of hub satellite networks.

Spatial concentration of production and inventory

The traditional system of nationally-based production, where a factory would manufacture a broad range of products for the local market, has in many sectors been replaced by 'focused manufacturing' where the entire production of a particular product for a continent or, in some cases, the world market is based at a single location. Inventory centralisation is now occurring on a larger geographical scale (e.g. within the Single European Market) as companies take

advantage of the removal of frontier controls, the deregulation of international road haulage and improvements to road and rail infrastructure.

Development of break-bulk / transhipment systems

Traditionally, the stockholding and break-bulk functions were combined at local / regional distribution centres. Many firms have now separated them geographically, centralising inventory while retaining a network of non-stockholding, break-bulk facilities to maintain the efficiency of their transport operation. This enables companies to enjoy inventory cost savings while minimising the delivery cost penalty associated with centralisation.

Creation of hub-satellite networks

Centralisation has also occurred in parcel and mail delivery systems. Unlike break bulk / transhipment systems designed for single users, companies are dealing in this case with consignments that have already been created and are working for multiple users.

2.2.2 Alignment of the supply chain

The alignment of the supply chain refers to the breakdown of the chain into different and smaller processing segments, the number and location of suppliers and the final destination of finished goods. Some trends identified concerning these aspects include the concentrations of trade in hub ports; the rationalisation of the supply base, the international contracting of production, the wider distribution of input sourcing and finished goods, local customisation, and increased direct delivery.

Concentration of international trade at hub ports

Economies of scale in terminal and vehicle operation have led to the concentration of international trade through a smaller number of hub ports. The latest generations of deep-sea vessels, for example, can only be accommodated at a few major gateway ports, such as Rotterdam, Antwerp and Le Havre.

Rationalisation of the supply base

Companies have reduced steadily the number of suppliers used to provide a particular manufacturing input. By so doing, they reduce transaction costs and strengthen their negotiating position with respect to the chosen supplier. At the same time, they expose themselves to greater vulnerability should their chosen supplier fail to deliver. This rationalisation of the supply base applies to the purchase of logistical services as well as material goods. Several surveys have confirmed a general decline in the average number of logistics service providers used by a given firm. [11]

Vertical disintegration of production

The transformation of raw materials to the final product may involve a number of phases and associated transport links in the chain. In many sectors, firms have been concentrating on core competencies and sub-contracting non-core, ancillary activities to outside contractors.

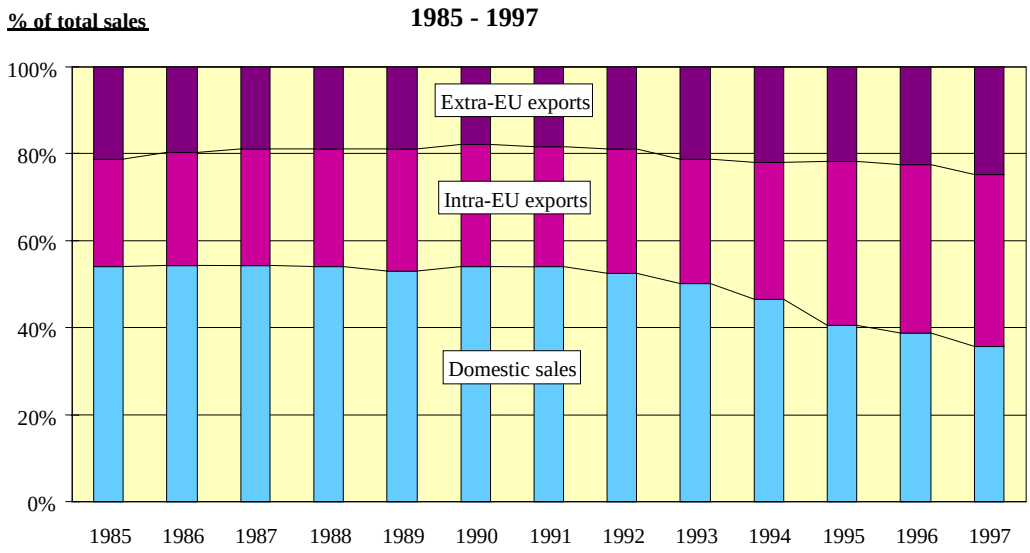
Wider geographical sourcing of supplies

Companies' have steadily expanded the geographical scale of their sourcing and distribution operations. The length of upstream supply lines and downstream distribution channels has been termed 'logistics reach'. The extension of this reach at a continental and global scale has been one of the dominant trends in international logistics over the past 30 years. Cooper (1993) observes that there is a close relationship between logistical reach and the value density of the

[11] E.g. Holland International Distribution Council, *Worldwide logistics: the future of supply chain services*, 1998 and P.E. Consulting, *The changing role of third-party logistics*, Institute of logistics, 1996

product. An example of such a geographical expansion of long distance trade in the Netherlands between 1992 and 1997 for the chemicals sector is shown in Figure 3 below.

Figure 3: Distribution of chemical products.



Source: TNO-INRO (1999)

Postponement / local customisation

To overcome the tension between centralised production and product customisation, companies are centralising the core production of standard products, often in low labour cost countries, thus delaying customisation until the product reaches a regional market. This represents an application of the postponement principle. Companies hold inventory in generic form as long as possible and defer their final configuration until they have a good idea of the likely demand for particular models or types. The number of stock keeping units is minimised until the point of customisation, thus reducing the amount of inventory in the global supply chain and the risk of over- or under-supplying a particular market with a specialist product.

Increased direct delivery

Direct, transit and multi-country logistics systems appear to be expanding at the expense of more traditional systems. In the latter, exports are distributed via warehouses in each of the foreign markets. These warehouses have a stockholding as well as break-bulk function; supplying foreign customers from locally held inventories rather than through direct or transit systems. The increasing popularity of direct delivery, in-transit and multi-country systems is partially associated with the centralisation of inventory as mentioned above.

- *Direct system:* Orders are despatched from a factory or warehouse in the home country directly to the foreign customer.
- *Transit system:* Exports are channelled through a transit (or satellite) depot in another country that acts as a break-bulk point. This makes it possible to transport goods more economically over long distances in bulk loads, disaggregating them into smaller consignments for final delivery to the customer within the foreign market.
- *Multi-country system:* This closely resembles the classical system, though instead of having a separate warehouse(s) in each foreign country, one warehouse can serve several adjoining countries. This has the advantage of economising on warehousing and inventory costs.

2.2.3 Product flow scheduling

The scheduling of the product flow concerns the frequency of delivery, the mode of ordering and delivery. Major trends in the scheduling of inputs and finished goods include the application of time-compressing methods to both retailing and manufacturing, increased control of retailers over the supply chain and a rapid increase of 'nominated day' delivery and timed delivery systems.

Time-compression principles applied in retail and manufacturing

A series of new management principles and approaches, such as just-in-time, quick response, lead-time management, time compression, lean logistics, agile logistics and efficient consumer response, have been developed over the past twenty years to help firms accelerate their logistical operations. Process and pipeline mapping techniques have been developed to analyse the expenditure of time in the supply chain and assess the opportunity for eliminating slack time and non-value adding activities.

Increase in retailers' control over supply chain

In several countries in Europe large retailers are undertaking the whole responsibility for the supply chain – from supply to final purchase. This is particularly true in the UK where the major grocery retailers, such as Tesco and Sainsbury, have pioneered developments in supply chain management for competitive advantage.

Growth of 'nominated day' deliveries and time delivery systems

Firms operating a nominated day delivery system achieve much higher levels of transport efficiency by forcing customers to adhere to an ordering and delivery timetable. Customers are informed that a vehicle will be visiting their area on a nominated day and that to receive a delivery on that day, they must submit their order by a certain period in advance. The advertised order lead-time is thus conditional to the customer complying with the order schedule.

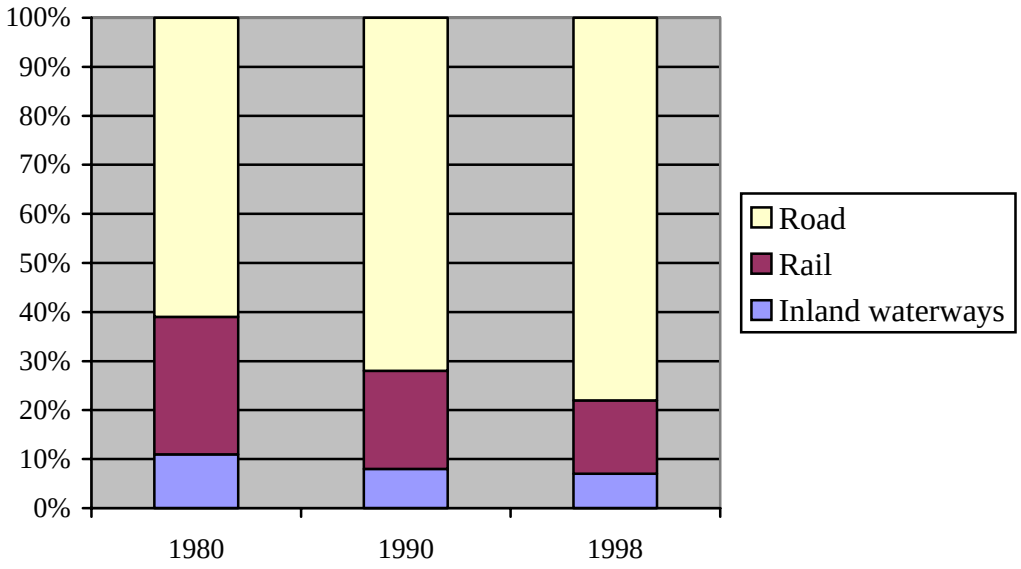
2.2.4 The management of logistics resources

The management of logistics resources refer to the size of vehicles used, the types of handling and storage systems employed and the effectiveness of their use. Some trends in this respect include changes in the freight modal split, reduction in international transport costs, impact of legislation and regulation, developments in vehicle and handling technology and increased use of ICT.

Changes in freight modal split

The relative performance changes of different modes of transport over time is due to a variety of factors, which can include changes in the cost of factors of production and improvements in technology. All modes of transport have enjoyed reductions in unit costs due to improvements in vehicle design, vehicle production processes, lower maintenance requirements, better fuel consumption etc. On balance, those improvements have favoured road transport as reflected in the increasing share of the freight market. These changes at the European level between 1980 and 1998 are illustrated in Figure 4 below.

Figure 4: Evolution of the modal split for inland goods transport in EU-15 (tkm in %).



Source: Eurostat - EU Intermodal Freight Transport 2002

Reduction in international transport costs

The real cost of international freight movement has been declining as the carrying capacity of ships and aircraft has expanded and transport operators enjoyed greater economies of scale. Competitive conditions in the shipping industry have further depressed rates.

Impact of legislation and regulation

Concerns for the environment and for safety are the major drivers behind regulation and legislation affecting freight transport. Policy makers are desperate to find measures to alleviate growing congestion in major European cities and transport networks. A key area of policy is trying to force transport operators to pay themselves for the external effects of their operations.

Increased use of information and communications technology

The Logistics Futures (1993) Delphi study predicts that electronic communication along the supply chain is set for massive growth. Transport documentation (e.g. proof of delivery) is expected to grow fastest, almost doubling in volume by the year 2005. Continuing on from transport documentation, growth is expected in electronic invoices, order instructions and payments (which are expected to grow in volume by 59%). Intra-European electronic communication is expected to grow slightly faster than such communication between Europe and the rest of the world, at 67% and 42% respectively. Growth of some 70% is predicted for automatic vehicle positioning and navigational systems, whereas real time dynamic routing and scheduling systems will grow by almost 60%, and real time links to order processing systems (e.g. in-cab mobile data communications) and mobile telephones will both grow by half. It may turn out, however, that these are gross underestimates of future expansion: it seems likely that the actual penetration of such systems by 2001, will be rather greater than predicted by Logistics Futures.

Developments in vehicle and handling technology

New developments in vehicle and handling technology offer the potential to change the operating costs of different modes of freight transport and bring about a change in the pattern of traffic flows. For example, the introduction of fast ferries on short sea routes within Europe,

with faster turnarounds at ports, is opening up competition to established long-distance truck services following these routes.

2.2.5 Product configuration

TNO-Inro (1999) describes product configuration in terms of changes in the design of a product arising from technical change or customer preferences and what this could imply for the value of the product and its packing and weight. Two trends are identified with regard to new configurations in products: de-materialisation complexity, packing and modularity.

Complexity, packaging, modularity

An increase in complexity and sophistication of products will lead to more value added per unit of weight; this will especially be the case with final products.

De-materialisation

It is often argued that some products currently transported in physical form could be converted to digital form, thus circumventing the need for physical transport. The most well known example of substitution is audiovisual products like CDs and videos. Recent reports show that each year, more music and videos are downloaded from the web and interchanged and that the sale of their physical counterpart products is declining. For example, users of networked music-sharing technologies are 45% more likely to have increased their overall music purchasing than nonusers are (Jupiter Communications, Inc., 2000). [12]

Concerning the dematerialisation of products, there are several issues to consider. First of all, most studies confirm that digital products generate complementary rather than real substitution effects. Another issue is that typically the downloaded product will be saved on a blank CD or other form of storage device that still needs to be sourced physically, thus generating the need for transport. Therefore the degree of substitution will depend to a large extent upon the storage and retrieval capacity of new devices. It is predicted that entertainment products will increasingly be downloaded from the Internet rather than physically transported.

2.2.6 Possible impacts of ICT in logistics and transport

According to TNO-Inro (1999) the possible impacts of ICT on logistics and the supply chain can be divided into essentially two categories:

- *operational impacts:* ICT has the potential to help improve the way in which information is exchanged, possibly leading to more transparent supply chains
- *conceptual impacts:* ICT acts potentially as an enabler of whole new concepts in production and services that in turn lead to new supply chain forms.
- *Operational impacts*

There is some evidence to indicate that ICT is leading to more information visibility within businesses (TNO-STB 2001). This transparency is noted at many levels of the organisation and takes the form of better internal and external communication, better integration of business processes, more transparency in business processes, and more transparency in the logistics process for the client, and generally more flexibility in the logistics process. According to Viswanadham (2001) the increase in information visibility occurs because it is needed for the management and synchronisation of the supply chain.
But information exchange can also be used for making business operations more efficient that in turn have spin-off effects for transport systems. A good example is tracking and tracing: one of

[12] http://www.jupiterresearch.com/xp/jmm/press/2000/pr_072000.xml

the most promising applications of ICT for both suppliers and customers. Customers can use this to track their bought products and businesses can see where their products as well as their trucks are at any given time (KPMG 2000). That makes it possible to change their logistical planning when needed (Nagarajan 2000). According to KPMG in the Netherlands, 83% of the Dedicated Logistics Service and Logistics Solutions Providers use tracking and tracing systems. The more valuable the freight, the more this system is used.

Table 1: Use of software by Dutch road transport companies in %

	Creating freight documents	Order administration	Trip administration	Trip planning	Positioning	Navigation	Freight exchange	Mobile communication	Internet + e-mail	Homepage
101 or >	96	96	96	76	32	24	61	92	100	96
51-100	78	94	92	35	10	17	56	100	100	69
21-50	57	73	66	34	12	16	49	100	92	54
11-20	38	51	50	28	9	12	38	98	88	39
5-10	32	33	30	15	2	12	24	98	82	30
1-4	15	19	25	15	1	16	11	95	73	18

Source: TLN/Heliview 2001

Conceptual impacts

The capabilities of ICT can stimulate new concepts in products and services as related to changes in the structure and operation of the supply chain, including the interface with the final customer or consumer. These in turn challenge the transport capability to respond in new ways.

- ICT-based command and control systems can be used to gain competitive advantage by raising the level of service expectations. For example, retailers can compete on the duration of delivery slots, the range of times when deliveries are available and the accuracy of the delivery system (Foresight 2000). Likewise, logistics providers use ICT competitively to enhance service levels (TNO-STB 2001).
- As ICT enables more responsiveness in the supply chain, the chain likewise becomes increasingly customer driven, resulting in increased demands for flexibility in the transport infrastructure (Viswanadham 2001, (Rallet 2000).
- Some functions in the supply chain become detached from the supplier or the retailer. For example, order fulfilment services can be assumed by any number of third parties (Skjoett-Larsen 2000). This leads to a new breed of logistics service providers: third parties who do not provide physical distribution but merely broker logistics information (Golob 2000).
- Logistics providers move up in the value chain: There is a general trend for individual logistics firms to embrace more of the logistics value chain, thus tending to become more closely integrated into the operations of client firms. (TNO-STB 2001).

3 CHALLENGES FOR MEASURING THE IMPACT OF ICT ON TRANSPORT IN THE PRODUCTION DOMAIN

The previous section has outlined such trends as are currently observable in the evolving relationship between ICT application in the production domain and the impacts on transport. The state-of-the-art with respect to the second part of the task – obtaining measurements of these impacts – is currently at a much less advanced stage. Furthermore, it is beset by many of the same conceptual and methodological problems that apply to overall measurement of ICT impacts on production processes.

In this section, we review some of the impact measurement problems. We then review several indicative attempts at impact measurement relative to a range of indicators. Some of these indicators relate to modes of transport – i.e. air, sea, road. Others relate to transport processes and methods. Still others relate to overall transport demand.

It must be said at the outset that generally we have rather little confidence in the accuracy of current impact measurements relative to the production domain, especially where effects on aggregate demand are being claimed. This is partly due to definitional problems – clarifying what exactly is being measured and what relationship it has to real transport issues – and partly due to a general lack of verifiable information on the data gathering and assessment methods employed in most of the available studies. Most of the evidence cited in studies is anecdotal and such quantitative findings as are available are based upon projections and extrapolations rather than measurements. The kinds of findings as contained in these studies are summarised below more so to indicate the magnitude and importance of the impact assessment problem than to suggest that adequate knowledge exists in any particular area.

3.1 The impact assessment problem in the production domain

The living and working domains are directly associated with demand factors for transport and the potential role of ICT in this relationship is often fairly clear. Effective teleworking, for example, is not possible without advanced ICTs. Consequently, if teleworking increases significantly and the degree of commuting traffic decreases significantly in the same period, it is reasonable to assume that correlation between the two phenomena could be demonstrated statistically.

Relationships between ICT and changes in transport patterns and requirements are considerably more opaque. Production is geared to supply factors, which in turn are susceptible to demand signals, such as could be generated by changes in the living and working domains. In other words, it is much more difficult conceptually to isolate an effect on transport that could be attributed mainly or solely to the production context. The further attribution of these effects to ICT is even more difficult. It was shown above, for example, that gains in inventory reduction first made on the production side soon were neutralised to some extent by equivalent practices as adopted in the retail sector.

Although there is now a growing amount of literature about e-commerce and logistics, most of this concentrates on issues of supply chain management rather than on issues relevant to transport as such – like locational advantages, inter-modality etc. Concerning the impacts of ICTs in the transport sector, it is widely acknowledged that there is much uncertainty and that very little factual knowledge underpins current policies (Galit *et al.*, 2002; Janelle, 1997). Moreover, doubts have been expressed that traditional transport indicators are adequate to describe this dynamic.

Golob and Regan (2001), for example, argue that the effects of ICT in the transport sector in relation to production activities can no longer be assessed in terms of travel time, distance or

travel cost. The actual role of ICT in influencing these indicators is not direct. Rather, it occurs as a result of structural changes in the transport sector that are induced by ICT applications. These relate to items like transaction costs (Glushko et al., 1999; Maes et al., 1999); third party logistics (i.e., freight forwarders, brokers, facilitators, inter-modal facilities management, etc.) (Parker, 1999; Lieb and Randall, 1999); carrier selection and shipper-carrier relationships (Larson, 1998); and so forth. As such, measuring the influence of ICT on transport in terms of standard indicators may give entirely misleading results.

Also, there are many methodological pitfalls in assessing ICT impacts due to rebound effects, self-correcting developments and uncertainties about future possibilities. There are as yet no universal statistical definitions covering ICT application domains (like e-commerce) or their relationship to transport (like e-logistics). This makes it difficult to compare data; especially as the transport chain can vary considerably from one kind of enterprise to another. Many transport chains are extraordinarily complex, with various intertwining functions performed by different players. This makes it difficult to separate each activity, let alone to measure the specific impact of ICT.

Accordingly, we turned up rather little by way of data on the transport impacts of ICT (see also Hop Associates, 2002). Two main sources of quantitative forecasts were located – by the UK economic consultancy NERA and by the Dutch association for freight companies (TLN). As for the rest, the data given are mainly speculative and derivative.

3.2 The state of current knowledge

The summary that follows organises available impact data according to three basic types of indicators – impacts on general transport demand, transport modality and transport processes and methods.

3.2.1 Impacts on general transport demand

Shift to market pull in the production dynamic

In the traditional supply chain model, a major systems integrator or prime contractor determines most of the production dynamics. This model now seldom applies. More common is a market pull model where other players in the chain (including wholesalers, retailers and even logistics firms) can determine the pace, characteristics and quantities of production. Now a new pull model has become dominant. Most of these systems are designed to be responsive to changing customer needs. One of the results is that there are fewer requirements for inventories. For e-commerce it is now the total time from order to delivery that counts and longer international shipping times might be offset by more rapid order fulfilment (NTS, Global e-business, 2001).

Shift to global procurement

In principle, ICT facilitates longer supply lines that cross national and regional boundaries. ICT has also made it possible for suppliers of logistics systems to control the whole procurement process. According to NTS the expanded geographic scope of procurement has already led to increased demand for long-distance and cross-border transport movement in Europe and America. Interestingly, shippers choosing carriers prefer those with multi-modal and worldwide service coverage (NTS, Global e-business, 2001).

General transport demand changes

A NERA study (2001) gives projections for 2005 (based on the situation in 2000) that due to e-commerce there will be a reduction of car-based shopping travel of 5%, raising to 10% by 2010. Delivery trips (primarily by light goods vans) are predicted to increase by 0.25% in 2005, and 0.5% in 2010. NERA also estimates that the more widespread use of ICT in the transport sector will lead to a reduction of ton-kilometres: 17% by 2005 and 18.5% by 2010.

The Dutch Association for Logistics and Transport (TLN) calculated the impact of e-commerce on freight traffic for the Netherlands (TLN 2000). They predict that in 2005, some 3.5 million tons of freight will be sold through electronic stores and that the consumer segment will account for 10% to 15% of Internet commerce. TLN estimates that by 2005, this will create an 8% growth in business to consumer freight trips. In supply chain, TLN estimates that patterns will become more unpredictable and orders will become smaller. This will cause a 9% growth in business to business freight trips. Together, e-commerce will account for 17% more trips.

We regard both of these studies with considerable scepticism. All are projections, but the basis upon which they were made is not available for scientific scrutiny. They are oriented mainly toward e-shopping and are typical of the hyperbolic projection 'culture' which has dominated the discussion of e-commerce in recent years. Problematically, the TLN study does not take into account the possibility that the transport sector could gain efficiency with even with extra trips (AVV 2002). It is widely acknowledged that the increased demand by small JIT shipments may be counterbalanced by overall lowering of demand by exploiting all transport opportunities more efficiently (Nezu 2001).

3.2.2 Impacts on transport modality

Inter-modal transport

By 1999, the transported volume in the EU was nearly 3000 billion tonne-kilometres, of which 44% was transported by road, 41% by sea (intra EU), 8% by rail and some 4% by inland waterways (Janic, 2002). Part of this total freight transport is inter-modal – requiring more than one type of conveyance. This doubled during the period 1990-1997, from about 113 to about 214 million tonne-kilometres. The share of inter-modal freight with respect to total freight volume increased from 5% in 1990, to 8% in 1997. About 91% of shipments included some form of international inter-modal transport, where short-sea shipping was predominant (78%). In domestic inter-modal transport, railways carried out 97% of the volumes.[13]

According to the European Commission, the average distance over which a tonne of goods was transported was 100 km. Similarly, the average for short-sea shipping was 1430 km (European Environment Agency 2001). Heuer (2001) argues that e-commerce could magnify and intensify existing problems related to efficiency in rail and sea transport, in that inter-modal transport via the increasing use of ICT-aided outsourcing and collaboration of logistics services, in conjunction with the logic of international subcontracting of production operations, could lead to greater consolidation of long distance consignments. In this regard, a recent study stated that in 2007, almost three quarters of all logistical tasks of European companies would be outsourced. At present, the most outsourced task is outbound transport (86%). Warehousing and inbound transport come next with 70%. In comparison, it indicates that in the US much less is being outsourced: outbound transport (68%), warehousing (65%) and inbound transport (52%). (NT Transport, 2002).[14]

Containerisation

According to Airries (2001), the production strategies of transnational corporations have revolutionised the structure of global port and container shipping industries. Containerisation is now an integral component of production strategy. For example, the percentage of the world's non-bulk trade that was containerized increased from a share of 6% in 1970, to 60% in 1995. Between 1987 and 1997, the share of global TEU[15] throughput among the three busiest container ports in the world increased from approximately 13,6% to 21%.

[13] Eurostat, EU Intermodal Freight Transport Key Statistical Data 1992-1999, 2002 edition

[14] NT Transport, *Europa bouwt voorsprong logistiek uitbesteden uit*, 22 October 2002, 16e jg, nr. 5

[15] Twenty foot Equivalent Unit (the size of a standard 20 foot container)

ICT controlled container handling networks optimise the synchronisation of distribution networks operating under JIT logistics. Containerisation is an ICT-dependent service and its growth has paralleled that of ICT. However, although the container-ICT synergy enabled a supply chain with longer transport distances, the direction of causality is not clear. The expansion and operation of containerisation could be largely explained also by national and regional industrial and trade policies (Airries, 2001).

Sea freight

Short sea shipping increased from 35% of the total freight volume in 1995, to 42% in 2001 (NT Transport 2002). NTS (Global e-business 2001) states that e-business is bringing significant change to the various actors in the sector by increasing productivity and decreasing costs. According to the European Community Ship Owners' Association (ECSA), European governments have stimulated this change. Although much is said concerning the positive impact on sea freight, there is hardly any research on the impact of ICT on sea freight. How much of the reported increase in sea freight activities could be attributed to the effects of ICT applications remains unclear (Global e-business 2001).

3.2.3 Impacts on transport processes and methods

Order turnaround time

The order turnaround time is defined as the time between when the order is received and the moment of physical delivery of the product (NDL, Improving chains, 1999). Various authors agree that electronic exchange of information reduces the order turnaround time (e.g. TNO-STB and NDL). Reasons given are fairly straightforward. The necessary information is available at the right place and at the right time. Tracking and tracing makes it possible, even during transport, to change planning schedules in order to efficiently use the vehicle and thus reducing overall order turnaround time. Examples of these efficiency gains are present in Air Express International as they experienced a reduction of 50% in order turnaround time for their client Hewlett Packard-TMO and 10-15% for HP-CPO. The order turnaround time of Vos Logistics reduced from an average of 24 hours to 4-8 hours. DHL and NetlLoyd also experienced similar reductions (NDL, 1999).

Shipment size, complexity and frequency

Hop Associates **(**2002**)** study found some case study evidence to the effect that e-commerce did not lead to smaller vehicles. Instead, the companies involved met a large increase in demand by using larger vehicles and reducing the size of the overall fleet. Hop Associates cites Hassall[16] who speaks of one case study where a company increased business growth 65% over a 5 year period but managed to use larger trailers and not increase its overall fleet size. A second company met a 21% increase in demand by introducing larger vehicles and reducing their overall fleet by 7%. This outcome was contrary to predictions of e-commerce effects on shipment size. The actual effect of e-commerce was a change from bulk to mixed shipments.

Pre-packing is now done by the manufacturer instead of at the distribution centre. This means that the individual packages are smaller, but that the shipment size does not necessarily change (NDL, Improving chains, 1999, and TNO-STB**,** 2001). Siebel (2001) gives an interesting insight into how package characteristics are changing. Traditional retailing was characterised by complete pallets (60 packaging units), by unit handling and by few recipients. E-commerce changed this. Now you have euro-pallets (600 consumer units) for 600 customers rather than one pallet for one recipient. The delivery day is now 24-hours, geared to individual addresses and delivery times.

[16] Hassall K: Emerging Trends and Hindrances for E-logistics. An Australian Perspective in 2001 as cited by Hop Associates (2002)

Freight Marketplaces

Trucking supply is being optimised through Online Freight Exchanges (OFE) and the development of OFEs is an ICT-dependent trend. In order to prevent trucks from making empty return journeys, these exchange portals aim to connect available loads to available trucking space on a dynamic basis. Overall, this could lead to fewer trips and it might affect the role of intermediaries and the reduction of shipment costs along the supply chain (Transport impacts 2001). The future of OFEs is nevertheless unclear. Some studies are optimistic, but others remark that most of OFEs do not generate profits and that in the case of successful sites, only one dominant player controls the exchange (Visser 2002; Peters 2000).

4 CONCLUSIONS

At this point, there is very little rigorous conceptual work and even less empirical work either on the transport-related impacts of ICT applications within the production process, or on the impacts of ICT-enhanced transport capabilities on production processes. The application of ICT in the production domain is now so generally pervasive that to single out the specific impacts in transport-related terms can be very difficult.

Most of the studies and hence most of the available data relate generally to the role of ICT in managing industrial inputs and outputs. Some of these roles have direct relevance to transport and logistics issues and the data yield often significant inferences as to the likely effects in terms of the quantity and quality of transport demand. But most do not relate directly or primarily to transport. As the trends analysis at the beginning of this paper shows clearly, where any such linkage does occur, the potential for impact is great. But as the impact assessment review illustrates, we are at the very early stages of being able to quantify any of these impacts.

The important overall observation is that ICT has been an essential ingredient in the overarching reconstruction of production-related transport capabilities that has occurred over the past 25 years. The system as a whole has evolved from one in which the transport user learned to optimise an otherwise fairly rigid system, into one where the transport system strives to respond to high degrees of variation in customer demand. This links the transport and logistics segments ever more closely into the production system and creates synergies of technological and organisational development. A consensus is beginning to emerge that in order to monitor and measure this relationship effectively, traditional transport indicators may need to be merged with indicators of the impacts of technical change in the production process.

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Impacts of ICTs on Transport and Mobility (ICTRANS)

Background Paper: The impact of ICT on mobility and transport in the socio-economic sphere LIVING

Anique Hommels, René Kemp, Peter Peters & Theo Dunnewijk
MERIT / International Institute of Infonomics, Maastricht, The Netherlands

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Transport and mobility as a social dilemma

Within the socio-economic sphere of "Living", two ways can be distinguished in which people can experience problems that are related to transport and mobility. The first is as *users* of transportation systems. In this role, people choose between different modes on the basis of expectations, costs, time budgets etc., have different motives to travel and different preferences in relation to their modal choice. In sum, they expect fast, reliable, comfortable and efficient transport systems. The second is as *residents* who live in cities and towns and who are concerned about the quality of life in their neighbourhoods, road safety and the consequences of urban planning issues that are related to transportation policies. More or less connected to this typology are two other roles. People are on the one hand, *consumers* of a range of products and services that are related to mobility and 'living'. In this role they will mainly act from self-interest and make rational choices, e.g. about the allocation of travel time. On the other hand, they are *citizens* who have (political) opinions about the way transport problems should be solved or about topics on a national or even global scale, like sustainability and the state of the economy.

In these different roles – user/resident and consumer/citizen – people often have contradictory interests and demands. The contradictory nature of individual preferences reflects the key social dilemma that defines the structure of many problems (and policy strategies) related to transportation and mobility, the fact that individual benefits in the short term lead to collective and individual burdens in the short and longer term. Since the 1980's, this key dilemma is usually phrased as a tension between economic development and sustainable development. The definitions of problems and policy strategies to solve these problems usually have a dualistic character. The White Paper *European Transport Policy for 2010: Time to Decide*, presented by the European Commission in 2001, provides an example where it seeks to develop 'a strategy designed to gradually break the link between constant transport growth and economic growth in order to reduce the pressure on the environment and prevent congestion while maintaining the EU's economic competitiveness'. Apart from these collective goals, in the White Paper on transportation policy, the European Commission is for the first time placing users' needs at the heart of its strategy and proposing 60 or so measures to meet this challenge.

1.2 Problems and solutions

As the European Commission acknowledges, there is a strong relation between economic development and increasing mobility. On the basis of the assumption of a law of constant travel time, Victor & Schafer (1998, 2000) have projected a fourfold increase of global mobility on the basis of two assumptions: higher incomes that lead to a shift towards faster modes (car, high speed train and airline). This means a "move away from sustainable development" (Nijkamp [et.al.], 1995), because sustainability is usually associated with slow modes like walking and bicycling, the use of public transport or even, more recently, with 'customised mobility'. Increased mobility leads to a number of problems that can be summarised as: congestion in urban areas, unsafe roads17, problems that are related to the quality of life (noise, pollution, health risks, urban sprawl etc.) and problems resulting from unequal access to car centred transportation systems, leading to social exclusion for specific social groups (e.g. Whitelegg 1993 &1997, writes in this respect about 'time pollution', the fact that people who don't have easy access to fast transport systems spend more time in transit.).

In the last decades, European transport policy as well as transport policies within the member states reflected the key dilemma. On the one hand, transportation policies aimed at reducing

[17] In 2000, more than 40.000 people were killed as a result of traffic accidents in the EU and another 1.7 million were (seriously) injured. One out of every three inhabitants of the EU will be injured as a result of a road accident during their lifetime. (Source: EU White paper *European Transport Policy for 2010: Time to Decide*.)

mobility growth, e.g. by developing and (partly) implementing pricing policies or by creating institutional and legislative frameworks to enhance sustainability of the transport systems. On the other hand, policies aimed at improving accessibility and decreasing congestion, thereby speeding up the road system, or at liberalisation of the transport sector, which in countries like Great Britain and The Netherlands has led to increased productivity of transport service production but also to a decreased efficiency and reliability of public transportation system as a whole. This suggests that problem definitions and the resulting policy strategies are not undertaken as part of a co-ordinated programme that is strategic, holistic and pro-active (Banister [et.al.], 2000).

As users and residents, people can have problems that are not directly, but indirectly related to transportation and mobility. Developments like globalisation, individualisation, and flexibilisation of labour and related time schedules (e.g. combining child care and work), etc. (Castells, 1996) can all change people's travel behaviour (Parkes & Thrift, 1980; Stopher, 1997; Steg & Kalfs, 2000). For example, more complex daily trip patterns increase the need for reliable and flexible transportation. In general, ICT seems to enable people to lead more footloose lives, but this mobile way of life of the digital nomad (Makimoto & Manners, 1997) also leads to new complexities and transportation systems do not automatically keep pace with this development

1.3 Divergence and convergence

There are major differences in problem definitions, public debates on mobility and 'problem ownership' (Gusfield, 1981) of transport and mobility problems both in time and between different member states within the EU.

A thematic comparison of transport policy approaches (pricing policy, environment and sustainability, congestion and accessibility and liberalisation of the transport sector) in a number of European countries (AVV, 2000: 115) concluded that national transport situations vary substantially in a number of cases, and policy responses vary even more. The European transport sector remains a sector dominated by national (sometimes regional) interests, which themselves are largely dictated by geographical, historical and sociological factors. E.g. the topic of (urban) congestion has a much higher profile in The Netherlands than in neighbouring countries (the UK excepted). In the UK "consumer choice" (was) a powerful concept; in France the "public service" doctrine remains essential. According to the report, convergent trends are: the taking into account of environmental impacts, a greater reliance on market principles and private sector involvement and a shift from narrow, modal infrastructure policy to a comprehensive, multi-modal transport and mobility policy, to name a few.

Problem definitions and policies not only vary between EU-member states, in a historical perspective we can also see major shifts in the ranking of problems on the agenda of public debate on transport problems and policies. Peters (1998) describes how environmental issues dominated the Dutch debate around 1990, but during the 1990's the problem of (urban) congestion rose on the agenda. The public perception of problems changed radically within ten years. However, this did not have an immediate impact on the policy instruments (like road pricing) that were developed. Only recently, the Dutch government has postponed the introduction of a kilometre levy, giving priority to the improvement and building of new roads. Also recently more attention is being given to new technologies, especially ICT's, to create what is called 'new mobility' (mobility internalising all costs) and 'seamless mobility' (multi-modal approaches).

1.4 Conclusion

Continuing growth of mobility will lead to dilemmas that can be summarised as economic versus sustainable development. As far as the problem area 'Living' is concerned, no clear starting point for the development of scenarios on the influence of ICT on mobility and transportation can be discerned. In the remainder of this state of the art review, four aspects of future developments (both in terms of problem definition and transport policy approaches) will be crucial in determining the bandwidth of possible scenarios:

- Users/Residents;
- Consumers/Citizens;
- Information & Communication Technologies;
- Transport policies

These four factors are interrelated and their interaction may lead to different possible outcomes that will be outlined in the next paragraphs.

2 POSSIBLE DEVELOPMENTS AND IMPACTS

Before sketching out possible developments, it is important to pay attention to a number of contextual developments of which are expected to will profoundly shape the (im) possibilities in the area of ICT, mobility and living. Mobility is a basic constituent of modern societies: mobility is supported, constituted and sustained by strong cultural values and ideologies. As Haddon et al. (2001) points out: it is for instance in tune with the ideology of individualism and freedom to move. Indeed, the process of individualization is a crucial development that has consequences for the mobility system and the role of ICT in this system.

The process of individualization has resulted in an increase of car mobility, but on the other hand, people living alone travel less by car than people who are sharing a household or married couples (Adviesdienst Verkeer en Vervoer, 1997). The preference of most people for the individual car-based system has its roots in an increasingly individualised society in which personal freedom and "instantaneous satisfaction" are important shared values. The car as a status symbol, further adds to the cultural entrenchment of the car system. Moreover, societal institutions and services (like the road infrastructure and gas stations) are primarily geared towards supporting the individual car based system (Schot, Hoogma, & Elzen, 1994).

New ICT developments in mobility and transport on the one hand seem to further consolidate this trend by introducing ICT applications in private cars that make car driving more safe and comfortable. On the other hand, ICTs are also being used to facilitate forms of public transport and chain mobility that form a counter trend to the individual car based system. On a more theoretical level, much thought is given to the idea of virtual mobility: How can the concept of mobility be redefined to include not only physical, corporeal mobility, but also forms of virtual, ICT-based mobility? (Kakihara & Sørensen, 2002).

A related trend that is expected to have important consequences for mobility is the changing demographic constellation of the population in Western countries. The ageing of the population has consequences for the availability of leisure time, for day patterns and lifestyles which can all have impact upon the choice for certain means of transportation and for the mobility of these people in general. Although the general expectation is that car mobility will continue to grow until 2010, it is expected that after 2010 the number of car kilometres in the Netherlands will decrease as a result of the ageing of the population. Another factor that may lead to a diminishing of car use is the stabilisation of car ownership in the next decades (Adviesdienst Verkeer en Vervoer, 1997; Nijkamp, Rienstra, & Vleugel, 1995).

Yet, still a further development that deserves attention in this context is the process of globalisation. Globalisation may increase the demand for long distance transport (Nijkamp et al., 1995). In the past decade economists have identified the emergence of a "New Economy", of which a shift from industry to services, mass customisation, lean productions, outsourcing, networking and streamlining of organization are crucial characteristics (Kemp, 1997). The emergence of new industrialising countries (NICs) and the transition of Eastern European economies to free market economies is a crucial transformation process that should also be mentioned in this context. Until a few years ago, western countries perceived the strong emergence of NICs like Taiwan and Korea as a threat. Western countries neglected the fact that no economy can have a continuous high level of economic growth and that the distribution of income in these countries can open new market opportunities for western countries as well. Here we see a change in thought about emerging economies which is confirmed, for instance, by the admission of Eastern European countries to the EU (Kemp, 2000). In a part of the literature a direct link is made between the economic welfare of a country and the mobility of its population. The general argument in such studies is that the richer a country is, the more mobile its citizens (Victor & Schafer 1998, 2000).

The trend to develop faster transportation systems is another development that has crucial impacts on the way people deal with ICT and mobility. Speed is a dominant value in western culture and most attempts to adapt the mobility system are aimed at increasing the speed of

transport. As Peters' points out: "the increasing speed of travel seems irreversible" (Peters, 2002). ICT is often used to 'speed up' the mobility process and to make it more efficient: congestion can be relieved by electronic forms of controlling road access, mobile phones and electronic travel information can help the driver to take the optimal route and to arrive in the quickest possible way at his or her destination. At the same time, slower cars are more sustainable technologies: they have less toxic emissions, they can make traffic safer and they are less space consuming. In this sense, the (increasing) speed of cars is a problem (Peters, 2002). The huge growth of air travel of the past decade underlines this trend of speeding up the transportation process. This development is facilitated and enhanced by ICT developments: online booking of flights has decreased the costs for airlines and as a result air tickets can be made cheaper. This in turn generates more air travel, which has several environmentally harmful effects.

In this paper, we distinguish three levels of analysis in the (rough) description of possible developments in the area of ICT, mobility and living. First of all, we deal with the impacts of ICT and mobility on (urban) households: How do developments in ICT change the living patterns of people? And how do living patterns cause impact upon people's mobility patterns? Secondly, we focus on ICT developments in the urban context. Mobility problems are most clearly visible in densely populated urban areas where pollution problems, accessibility and liveability issues most frequently become acute. Thirdly, we analyse the relation between ICT, mobility and living on the level of the mobility system as a whole. How do engineers and policymakers try to improve the safety, reliability, and efficiency of the mobility system? What role does ICT play in this process and what kinds of policies can we expect in the future?

As indicated above, the problem area 'living' relates to a great number of (possible) developments in trends. These could well be quantified and researched by using time budget and time allocation studies. Time budget data on mobility, transport and ICT-use are generally available for EU-countries but are, in our view, not very well suited to extrapolate the trends that are mentioned in this paper. The impact of ICT (directly and indirectly) on mobility patterns and lifestyles has up till now been theorised (e.g. 'digital lifestyles'), but has to be operationalised depending on the type of technology in order to quantify effects. The research conducted in a number of European research projects in mobility and ICT (especially STELLA), do not reveal any quantitative studies that are relevant to the problem area 'living'. Hence, the operationalisation of the many possible direct and indirect effects of ICT on mobility patterns and lifestyles in general falls outside the range of this paper. In our view this lack of hard data underlines the need for more quantitative research in this area.

The following analysis of possible developments is partly based on Dutch literature in this field. We think, however, that most of the developments described here can also be applied to other EU countries, especially to densely populated urban areas. In fact they are applied in many instances. Because of the high level of urbanisation in the Netherlands, the problems of transportation and land-use are in general more pressing than elsewhere and therefore it is understandable that in the Netherlands much research has already been done to alleviate these problems. In many of these policies, ICTs play a crucial role. Where it is fruitful to make a distinction between different countries, it will be indicated.

2.1 ICT in households – possible impacts on transport

2.1.1 Potential substitution effects

In a study of trends in information and communication technology that are specifically related to the way people live, Bouwman et al. (2000) point at the over-estimation of the impact of certain technological developments. They argue that technological developments such as the penetration of the satellite, videotext, HDTV and ISDN have been heavily over-estimated. On the other hand it is also remarkable that technologies that were not foreseen 10 years ago, are now being considered as a 'natural' part of the household: internet, email, downloading music

files on PC's, mobile telephones etc. Bouwman et al. expect that in the next 10-to15 years Personal Digital Assistants, embedded intelligence, and digital communication possibilities will greatly increase in the household. These developments might have an impact on mobility because a substitution effect may occur.

In the literature on tele-shopping and tele-working, a decrease of mobility is often expected: on-line shopping would substitute physical shopping activities, at least to a certain extent. In 2000, on-line consumer spending was only 1% but it is expected that this will increase with a factor 9 in the coming years as a result of improved distribution and consumers getting becoming accustomed to online shopping (from 20 billion dollars in 1999 to 184 billion dollars in 2004). 80% of e-commerce is business to business (B2B) and takes place in the chemical, computer and electronics industry. Other sectors follow. E-commerce provides opportunities for micro marketing and contributes to consumerism (conspicuous consumption). Competition pressure will increase as a result of e-commerce (this is visible in the travel branch, for example). Large retail companies are actively creating online distribution channels. E-commerce changes the rules of the game and creates winners and losers (Kemp, 2000). Haddon et al. (2001) argue that technological trends such as tele-shopping and tele-working are dependent on people's preferences. In the 1990s the amount of TV shopping channels increased as well as the number of tele-shopping services offered by mainstream retailers. Online banking also increased. They are not overly optimistic about the chance that tele-shopping will reduce mobility. People like to combine online and physical shopping. They find much pleasure in physical shopping and they like to get out of the house at some point in time. In the end, the impact of ICT on mobility on everyday life is limited according to Haddon et al.

Martens (1999) argues that "tele-commuting is the future", but he ads that substitution effects are limited due to "second order" effects. Martens argues that there is less need of a second car as a result of telecommuting. The largest effects can be expected in urban areas, due to higher congestion levels, higher education levels and the presence of the service sector. Martens argues that the impact of ICT on mobility will also depend on the population density of a country. Tele-justice, tele-education and tele-medicine can substitute a large number of trip kilometres when used in a low-density country like Norway or Australia. In the Netherlands, the mobility effects of such services will be limited. Tele-recreation and tele-trade have a large potential according to Martens, although the direct effects on mobility will probably be limited. But because tele-trade stimulates globalisation and the unification of the European market, the effects could be large. Telecommuting, tele-shopping and tele-conferencing are considered to have the greatest potential in terms of the effects on the transport system. Because of ICT, citizens and companies operate much more worldwide. Economic growth results –until now- in a strong demand for products. Also physical transactions and the average distance increase.

2.1.2 Neither generation nor substitution

Other reports argue that mobility will not increase of decrease a result of ICT, but that mobility patterns will change: Because of ICT, a more diffuse pattern of traffic and transport becomes visible during all times of the day (KPMG, 2000). This relates closely to socio-economic trends such as the increasing diversity of patterns of living together, and day patterns becoming less and less synchronous. Among the most important factors driving travel mode options and travel needs are social factors such as: composition of the household; place of residence; occupation; lifestyle; income/activity patterns (Nijkamp et al., 1995). De Haan & Huysmans (2002) in their report on e-culture, point at the change in day schedules as a result of ICT developments. They argue that there exist certain "collective rhythms" and the question they try to answer is whether such rhythms will change as a result of ICT. They point out that ICT has only to a very limited extent resulted in a flexibilisation of working hours. Patterns of behaviour seem to be very stable despite rapid technological changes. ICTs become incorporated to a large extent in existing routines and practices. Thus, ICT seems to confirm rather than change social habits and routines. De Haan & Huysmans conclude that with respect to impacts for mobility and

transport, congestion at peak hours will remain the same: there will be no great impacts on mobility patterns.

Another 'trend' in traffic and transportation that points in the direction of a limited impact of ICTs on mobility is the so-called Brever law (Law of Constant Travel Time and Trip Rates). It claims that (on average and at an aggregated level), people travel 75 minutes per day and undertake 4,5 trips per person per day. If this law is used as a starting point, ICT will not result in a change in travel time: time spent on virtual mobility will just add to physical mobility (Peters, Wilde, Clement, & Peeters, 2001a, 2001b). Although the BREVER Law is claimed to be applicable to all countries, cultures and historical eras, other studies have pointed at the existence of big differences in trip rates between EU countries. Data[18] shows that the number of yearly passenger trips by public transport varies considerably among the EU countries. Austria, Finland and Switzerland are countries with the largest amounts of passenger trips: between 300 and 400 on a yearly basis. In Belgium, Denmark, France, Greece, Italy, Norway, Spain and UK these numbers are much lower: between 100 and 200 yearly passenger trips. The Netherlands, Portugal and Sweden are in between with 200 to 300 passenger trips a year. So there is variety in use of public transport, or its complement, that needs a sound explanation in relation to the Brever law.

2.1.3 Generation of mobility

An important part of the literature focuses on increasing mobility as a result of ICT use in households. It is argued, for instance, that tele-working will lead to longer distances between home and work and that this will generate more mobility. A report by KPMG points out that, in person transport, the need for displacement has strongly increased (KPMG 2000). Others point at the "constant psychological need of people for mobility": they need face-to-face contact and physical group interaction (Bullinga, 1999). Therefore, the increasing amount of virtual contact by means of ICT will lead to more mobility: the need of people to see each other more frequently in real life will increase. Dijst (2001) points out that the human "drive for mobility" is based on adventure seeking, variety seeking and independence. This is completely in line with the current trend of "pleasure seeking" and the "experience economy". The recent rise of theme parks and the increasing "Disneyfication" of recreation lead to an increase in mobility.

In a report by Origin (1998) it is expected that ICT will increase mobility because travel time can be used in a more convenient way as a result of ICT developments. ICT may lead to less peak pressure, because people have more freedom in deciding when they want to travel. This may result in the situation in which there is 24 hours a day 'almost congestion'. The authors of this report envision a future in which ICT working people don't leave the home at fixed times, children may learn at home and there is video contact between parents and children. In this way, ICT can be of help to families struggling with the combination of work and care for children. In this report it is claimed that ICT will increase the demand for second homes, and that it softens the disadvantages of rural and urban environments.

In a similar way, a conference paper by Dijst (2001) points at the changes ICT causes in living, time and mobility patterns. He makes clear that ICTs offer the possibility to perform (work) activities in several temporary places: in the (second) home, on the road, in tele-centres etc. ICT can be used as a strategy to relieve time pressure on the household, but increasing commuting distances can diminish this potential advantage of ICT. Furthermore, Dijst argues that ICT makes it easier to shift work activities. But this fragmentation and flexibilisation of time has its limits: there are certain groups within a population who have more opportunities to do this than others (e.g. families with children are less flexible). The flexibility offered by new ICTs is also limited by the spatial separation of activity places that is often based on car use. Finally, Dijst mentions that the value of travel time can change as a result of developments in ICT because more activities can be performed while travelling. Haddon et al. (2001) confirm this claim. On

[18] Taken from http://www.publicpurpose.com/ut-eurnation97.htm reporting on November 1999 data.

the basis of a qualitative research they found out that some people like to use their mobile phones while travelling to make phone calls that would be more difficult to make on other occasions. Moreover, some people welcomed the use of ICT (SMS's etc.) to make better use of travel time that they otherwise consider 'boring'.

It is expected that in the area of tourism much will change as a result of ICT developments. Lower air travel costs will lead to a boost in tourism. For the first time, small individual suppliers or regional tourism associations are able to contact potential tourists directly. Commercial intermediaries provide products from the web equivalent to holiday guidebooks to complete search services. Extra international access beyond the resources of conventional advertising channels will certainly increase opportunities to attract travellers. Web based services also allow companies to better cater to niche markets and special interests, such as adventure tourism or eco-tourism. Resultant increased markets will mean more demand for international air travel from tourists and possibly more car tourism within the country, as tourists learn more about opportunities in various regions. In the short term, the extra demand will come from traditional sources of tourists. However, e-business and associated changes may result in growth of a prosperous middle class in South East Asia and India providing an entirely new and very large market (Foran et al., 1999, based on Smith 2001). On the other hand, especially in the case of air travel we see the opposed interest at work: the consumers who wants to fly away to foreign destinations, while the citizen takes the burden of ever increasing nuisance in urban areas due to air traffic.

2.1.4 Conclusions

It is clear that the literature on the relationships between ICT and mobility in the area of "living" (including patterns of behaviour, lifestyles and individual preferences) shows widely diverging viewpoints on the developments we can expect in this field. Some authors argue that the introduction of ICT applications in households (including ICT-based activities like tele-working and tele-shopping) will radically change living patterns and will either increase or decrease mobility. Others emphasize the robustness of certain human routines and habits, which will not even change under the influence of ICT. The cultural entrenchment of the car system and the embedded and people's obduracy over the physical infrastructures (mostly based on the car system) are other reasons why some authors do not expect much change in mobility as a result of ICT. Table 1summarises the effects of ICT in households on transport and mobility.

Table 1: Effects on transport of ICT in households

Direct effects:	
Substitution	- Bouwman (2000): increase of PDA's etc. in households may substitute mobility - Martens (1999): less need of a second car as a result of tele-working. This may lead to a reduction of mobility. - Martens (1999): In low-density countries tele-justice, tele-education and tele-shopping may lead to lower trip frequencies.
Generation of mobility	- Tele-working will lead to longer distances between home and work and this will generate more mobility. - KPMG (2000): in person transport, the need for displacement has strongly increased. - Bullinga et al. (1999): There is a "constant psychological need of people for mobility". The increasing amount of virtual contact by means of ICT will lead to more physical mobility: the need of people to see each other more frequently in real life will increase. - Dijst (2001): the human "drive for mobility" is based on adventure seeking, variety seeking and independence. - Origin (1998): ICT will increase mobility because travel time can be used in a more convenient way as a result of ICT developments.

Direct effects:	
Neither generation nor substitution	- Haddon et al. (2001): tele-shopping will not lead to substitution because people like to combine virtual and physical shopping - De Haan & Huysmans (2002): ICT seems to confirm rather than change social habits and routines. Congestion at peak hours will remain the same: there will be no big impacts on mobility patterns. - Peters, Wilde, Clement, & Peeters (2001a, 2001b): If the BREVER law is used as a starting point, ICT will not result in a change in travel time: time spent on virtual mobility will just add to physical mobility.
On modality	- Foran et al. (1999): More air travel as a result of advanced electronic booking possibilities. - Foran et al. (1999): More car travel as tourists learn more about travel possibilities in regions (through the Internet)
Indirect effects:	
On spatial distribution	- Dijst (1999): increasing commuting distances can diminish the potential advantages of ICT
Other indirect effects	- Martens (1999): second order effects of tele-trade may be large because it stimulates globalisation and unification. - Dijst (1999): ICT can be used as a strategy to relieve time pressure on the household

2.2 ICT in urban areas – possible impacts on transport

2.2.1 ICT to enhance efficiency and capacity in urban areas

In Western countries populations are concentrated in cities and when discussing the impacts of ICT on daily lives it is important to pay attention to the ways ICT becomes embedded in urban areas. Problems of congestion and liveability are most acute in cities and therefore, most developments in the area of ICT and the city is aimed at increasing the efficiency of the urban transport system. Information, navigation, safety, monitoring and control technologies can help to increase the capacity of urban transport, and as a result the accessibility (Hodge & Koski, 1997) and liveability (Bartley, 1995) of certain places can change very much. In the EU context, many projects have been set-up under the fifth framework programme to investigate new forms of mobility in the urban context. The PLUME project (Planning and Mobility in Urban Europe) comprises a synthesis of all research findings and 'best practices' of urban mobility projects under the 5th framework.[19] Developments in rural areas are also covered by projects like ARTS (Action on the integration of Rural Transport Services). This project, which is based on 10 demonstration cases throughout Europe, aims to test and demonstrate the most effective ways of providing rural transport services and to make recommendations for the future planning and implementation of rural transport systems.[20]

In a report on ICT and the city (Tijdelijke adviescommissie ICT en de Stad, 2000), the authors give a range of examples of ICTs that are presently gaining importance in cities: cameras, toll systems, e-commerce, email, mobile phones, community voice mail, home ICTs, intelligent light. The authors of this report claim that ICT makes a more intensive use of urban space possible, for example because of semi-automatic parking systems. ICT is used to make traffic more efficient and it can improve public transport (e.g. public transport à la carte, light rail). ICT can also be used to regulate drivers' behaviour, control of traffic flows, flexible tariffs on certain road sections, and traffic deviation with the use of information boards. With the help of chipcards, different categories of road users can be distinguished (Tijdelijke adviescommissie ICT en de Stad, 2000). Kemp (1997) mentions the emergence of electronic reservation systems and vehicle detection systems as a means to organising traffic in cities more efficiently.

[19] See the PLUME website: http://www.stadt-koeln.de/europa/projekte/artikel/00044/index.html.

[20] See the ARTS website: http://www.rural-transport.net/demonstrations.shtml.

In the area of logistics much hope is focused on ICT making the process more efficient and controllable. In a forecast study by Bullinga et al. (1999) the authors point at the increasing importance of underground logistics systems (made possible by ICT). According to these authors, these developments culminate in the replacement of highways by underground logistics systems. Less traffic movements can have an environmentally benign effect. It increases opportunities of making joint deliveries, and it may decrease the problems of costs, of inventory and problems of delivery in cities. In the Netherlands, the cargo card has been introduced to make custom processes at the border more efficient. Furthermore, a more efficient logistic process, made possible by ICT, can reduce the number of "empty trip kilometres". However, as a result of diminished stocks, the number of smaller packages will increase, which will result in more displacements (Roggen, 1989). In general we can say that the introduction of ICTs like GPS or EDI in the logistics process has made it by far easier to carefully plan the transportation of goods. Moreover, tracking and tracing technologies make it easier for consumers to follow the product they ordered in real-time via the Internet.

2.2.2 ICT and spatial developments

According to Origin (1998), ICT may be easily embedded in the urban context because it takes very little space (this is in contradistinction to other authors). The authors conclude that ICT will have tremendous impacts in the area of spatial planning. Another part of the literature is more reluctant in claiming that ICT will automatically improve the urban traffic and mobility system. A KPMG report argues for instance that spatial arrangements change slowly (also as a result of ICT developments) because of long lifecycles of physical infrastructure (KPMG, 2000). Moreover, spatial developments are embedded in legal structures, like land use plans. The obduracy (resistance to change) of existing structures (whether they are social or technological) makes it difficult to embed new technologies, even ICTs. Economists have claimed that ICT is a "general purpose technology" (Helpman, ed.1999). That means that ICT is much more flexible in use than other break-through technologies. In theory, this might imply that there are many more opportunities to adapt these technologies, and that there are less irreversible, path dependent influences on space (Soete, 2001). But what happens when new ICT infrastructures are confronted with the obduracy of existing urban infrastructures, the city's road network, its buildings and rail infrastructure? Soete claims that radical change might indeed become problematic.

2.2.3 Conclusions

In urban areas developments are primarily geared at improving the efficiency of the urban transport and logistics process. In this context, more efficient transport means less space consuming systems, improving accessibility of the city and enhancing urban liveability. It is expected that ICT play an important role in achieving this. Table 2 summarizes the effects of ICT in urban areas on transport and mobility. Here, within the urban boundaries, the interest of the user / resident and consumer / citizen are more or less aligned, but vested business interest are not always.

Table 2: Effects on transport of ICT in urban areas

Direct effects:	
Substitution	- Bartley (1995): High quality urban living implies high quality urban transport and public transport: bus lanes, high occupancy vehicle lanes, and facilities for pedestrians and cyclists. It may induce people to stay more in the urban area and walk or cycle around instead of having car trips into the countryside.
Generation of mobility	- Roggen (1989): as a result of diminished stocks, the number of smaller packages will increase, which will result in more displacements. - More efficient regulation of urban transport system and logistics will lead to a more optimal use of urban infrastructure. As urban areas become more accessible, mobility will increase.
Neither generation nor substitution	- Pooley et al. (2000): effective change will only be achieved if longstanding attitudes to commuting are also taken into account.
On modality	- Bullinga et al. (1999): There will be more ICT-based underground logistic systems. Highways can eventually disappear. - Light rail in high quality urban regions reinforces the increasing use of the train (Priemus et al. 2001)
Other direct effects	- Tijdelijke adviescommissie ICT en de Stad (2000): ICT is used to make traffic more efficient and it can improve public transport (e.g. public transport à la carte, light rail). - Tijdelijke adviescommissie ICT en de Stad (2000): ICT can also be used to regulate driver's behaviour and to make traffic safer. - Hodge & Koski (1997): Information, navigation, safety, monitoring and control technologies can help to increase the capacity of urban transport, and as a result the accessibility of certain places can change very much.
Indirect effects:	
On spatial distribution	- Tijdelijke adviescommissie ICT en de Stad (2000): ICT makes a more intensive use of urban space possible, for example because of semi-automatic parking systems. - Origin (1989): ICT will have tremendous impacts in the area of spatial planning.
Other indirect effects	- Attractive urban areas partly substitute private interregional traffic with interurban public traffic.

2.3 ICT in the mobility system – possible impacts on transport

2.3.1 ICT and customised mobility

At the level of the mobility system, two recent developments might be distinguished that potentially have huge impact on the mobility system and how citizens use it. The first development is the role if ICT in enhancing customised mobility. The second trend concerns the introduction of ICT based pricing instruments in transportation systems.

ICT's facilitate customisation of services, which is why people speak of "customised mobility" meaning the supply of mobility services customised to the users' needs. In this view, car use is combined with other types of transport provided by mobility providers. It concerns new types of public transport, such as individualised public transport, where you are picked up from your home and brought to your destination. Customised mobility involves changes in ownership, infrastructure, car accessibility, policy and behaviour. The trend towards the ownership of more than one car is reversed. People increasingly use cars owned by car sharing organisations and public transport companies, which can be accessed through smart cards and reserved. In this view ICTs can greatly enhance the system of customised mobility. Personal travel assistants (PTAs), mobile phone-like devices, help people find and order mobility services. Within such a system, there are mobility agencies and mobility centres where people can shift to other types of transport: light rail, public cars, bicycles etc. Intra and interurban traffic is linked at city

mobility stations. In such a system, car accessibility is reduced through zoning policies, making cities more liveable, and there would be a greater variety of cars, for instance (silent) urban cars and (energy efficient) long distance cars. Congestion, transport emissions and nuisance are considerably reduced, by a factor 5 (compared to factor 2-4 improvements that are possible with car-based forms of transport). Electronic travel information systems supply travellers with real-time information of the trajectory they are travelling: delays, connections between different modes of transportation (bus, train, metro etc.). It also provides information about services and cultural events they pass by on their trip (e.g. museums, cinemas, theatres).

ICT also offers some advantages for car sharing, an emerging form of customised mobility. According to Meijkamp (1996) car sharing can be an alternative to individual car ownership because the costs are lower; it leads to a more conscious car use which results in fewer cars and less spatial pressure in crowded cities. In some EU countries in the past decade, car sharing has become a very popular system: "The car-sharing idea, said to have begun in Switzerland in 1987, now has over 30,000 members in that country. Switzerland's achievement inspired other efforts in Sweden, Germany, and throughout the Continent, with car-sharing serving 70,000 members in more than 350 European cities" [21] In 1996, car sharing organizations (CSOs) in major European cities had only about 20,000 members (Steiniger et al., 1996). Car sharing is one of the key themes in the MOSES project (Mobility services for urban sustainability). This EU project aims at developing innovative mobility services based on car sharing experience. The project is co- financed by the key action "City of Tomorrow and Cultural Heritage", and it is carried out in eight European cities / regions. The overall objective of this project is to improve the efficiency and attractiveness of cities.[22]

2.3.2 Electronic pricing and ticketing

A second potential development in the area of ICT, mobility and living is the introduction of electronic pricing instruments. During the past decade, policy makers and engineers introduced pricing instruments for mobility as a method to reduce car traffic and to stimulate public transportation. As Hodge and Koski (1997) claim: "congestion pricing has great potential to provide a more rational pricing of a limited public good" (p.2). A KPMG report mentions dynamic travel information, pricing policies and chip card technology as the most relevant technological developments in this area (KPMG Bureau voor Economische Argumentatie, 1997). Electronic road pricing plans have been introduced in several European countries. The MobiMiles project is an example of a dynamic system in which different types of roads are distinguished and different prices for peak-hours are automatically calculated. Car drivers will be charged afterwards. Some believe that (road) pricing is an effective instrument but its implementation needs accommodating and complementary ICT investments as well.
Another instrument that is meant to make public transport more attractive for customers is the use of chip cards for electronic payment in public transport systems. Currently two systems are being used: the so-called proximity card (electronic ticketing) and the long-range card: a chip card that people carry with them in their bag or pocket. When passengers leave the transport vehicle the trip price will be charged automatically. The long-range card system has been introduced in Switzerland. Many countries now experiment with electronic ticketing in public transport. In Hong Kong and Singapore, these systems are widely used already. In some countries there are plans to combine travel information and electronic payment. Recently, European initiatives have been set-up to ensure the interoperability of e-ticketing schemes. The European FASTEST project (Facilitating Smart Card Technology for Electronic Ticketing and Seamless Travel) aims at defining common user requirements and needs for European mobility. Furthermore, the project tries to define the functional requirements for interoperable e-ticketing systems throughout Europe.[23]

[21] http://www.wired.com/news/culture/0%2c1284%2c36588%2c00.html

[22] See the website of the MOSES project http://www.moses-europe.org/

[23] See FASTEST website: http://www.nen.nl/wsfastest

2.3.3 Conclusions

In this section, we sketched two ICT developments that might profoundly change the mobility system and the way people use certain modes of transport: customised mobility and electronic pricing instruments. Customised mobility is closely related to current trends such as car sharing and chain mobility (or "seamless mobility"). Adaptation of the mobility system in the direction of these, more collective forms of mobility will not be easy, but ICT can play a facilitating role in this. Road pricing is a returning policy theme in the past decade in several EU countries, but the implementation of this instrument requires much societal and political commitment. Table 3summarizes the effects of ICT in the mobility system on transport and mobility.

Table 3: Effects on transport of ICT in the mobility system

Direct effects:	
Substitution	- Meijkamp(1996): a more conscious use of cars may reduce the number of car trips.
Generation of mobility	- Organising 'flow' by using ICT's triggers latent demand and leads to mobility growth. - The possibility of multitasking (e.g. work and travel at the same time) enables and encourages footloose travel behaviour.
On modality	- Kemp (2002): It is expected that within an ICT-supported system of customised mobility, a modal shift will take place to other types of transport than private cars: light rail, public cars, bicycles etc.
Other direct effects	- Meijkamp (1996): a more conscious use of cars
Indirect effects:	
On spatial distribution	- Better public transport facilities, may lead to different choices of people regarding the location of their living and working activities.
Other indirect effects	- An increase of customised mobility and a decrease of individual car use, may lead to less environmental pollution and less noise, depending on the technological solutions chosen.

In the next section we will pay closer attention to current policies in the field of ICT, mobility and "living". What kinds of policies are proposed to solve the dilemmas that were posed at the beginning of this paper? What kind of policies can we expect in the future?

3 POLICIES – CHALLENGES AND IMPLICATIONS

3.1 Key themes in EU policies and their implications

Policies are problem-oriented and reactive. In the past two decades, problems of congestion, pollution, safety and reduced accessibility have been addressed with limited success. Pollution and traffic deaths have been reduced through technical fixes: catalytic converter, safety belt, airbags, roundabouts, and sleeping policemen. Congestion has grown worse, as has nuisance from motorised transport (cars and planes). CO_2 from road transport is increasing and projected to be 50% higher in 2010 compared to 1990.

As we outlined in the introduction, mobility problems usually have a dilemma character as can be shown in the example of congestion. Building extra roads might (momentarily) solve the problem of time losses due to congestion, but it could also lead to increasing auto mobility, CO_2 emissions and it will worsen pollution problems. Solving mobility problems involves difficult tradeoffs. CO_2 reduction requires different types of vehicles and a range of support measures few countries are willing to undertake. Problems of congestion and liveability are most acute in cities. At this moment congestion and liveability is the main drive behind transport policy, especially local transport policy. It is expected that auto mobility will continue to grow, but other types of mobility are increasing as well. Passenger transport by rail, bus or inland waterways won market share in Austria and the Netherlands during the nineties, and so did freight transport in Austria, Finland and Portugal, while very significant reductions in CO_2 emissions were achieved by Germany, Sweden and UK. (TERM, 2001).

At the moment, within the European context, two policy goals are taken to be of paramount importance: facilitation of (auto) mobility demand and preserving accessibility. As to the economic aspects, three important policy principles are widely[24] supported:

1. Use tax / regulations to ensure the consistency of policy measures. An important possibility is emphasising variable transport costs and de-emphasising fixed costs and the users should pay (for infrastructure use);
2. Assessments of infrastructure investments should include external costs and these should be internalised;
3. Markets should be liberalized

In line with these three principles, a wide variety of policies can be observed that are relevant for the ICT-transportation nexus. Apart from transport policy and transport technology policies (RTD) other policies such as land-use planning, internal market policies and energy policies are relevant. Table 4 summarises current and future policies for thirteen European countries. Four policy themes appear to be central in this playing field: (1) pricing policies (e.g. by pricing and regulation mechanisms), (2) environmental and sustainability policies, (3) investments policies (mainly by infrastructural investments), and (4) market organisation policies which today means liberalisation / privatisation of the transport sector. One of the possible conclusions that we can derive from this table, is that the role of ICT's are more prominent in environmental sustainability policies and in investment policies than in e.g. pricing policies.

[24] European wide: The European Conference of Ministers of Transport in 1990 agreed upon a resolution with the following statements: use tax/regulations to ensure their consistency; use traffic management to further other environmental objectives both in relation to demand management and changing the model split; reduce use of private cars in urban areas; assessment of infrastructural investments should include environmental evaluations or alternatives.

Table 4: Transport policies, recent developments and their impacts, 2002 - 2015

Theme	Features	Recent developments and impact	Relation with ICT
Tax/regulation	Trend from centrally set taxes to decentralised and charges, no congestion pricing, freight easier to target than passengers, tolling in F and I	Urban road pricing on agenda in UK and B. Not to be expected fully implemented before 2010. Impact depends on intensity of policy, but always small/moderate	Very weak, except for urban road pricing
Environment and sustainability	Listed as main objective, multi modal approaches, some non infrastructural measures, differentiated taxes	Experiments based on greening principles and theoretical possibilities / motives, is gaining gradually momentum in B, D, F, CH, UK	Strong, especially intra modal and innovative solutions
Infrastructural investments	More coherent programmes take environmental effects into account but do not solve problems; Congestion and nuisance are to stay, are maybe facts of life.	Optimistic view: Problem to be solved with technology ITS (D and DK) or otherwise (DTM). Pessimistic view there will "always" be congestion, each supply generates its own demand	Moderate, especially inter urban roads
Liberalisation/privatisation	Pressure from EU, planning and financing decentralised, more need for rules (not less)	Divergent practices esp. British "consumer choice" and French "public services" models	Low to moderate, more important with regard to travel information and intermodality

Inspired by: Ministerie van Verkeer en Waterstaat, AVV (2000). A thematic comparison of transport policy approaches in Europe, Final Report.

The EU combined the last three principles into the fair and efficient pricing concept in the Communication to the Commission "Fair and Efficient Pricing", which also includes transparency of transport costs and non-discrimination across transport modes and nations as additional principles. These principles have not been fully implemented in any country, but countries are (slowly) moving into this direction. Moreover, transport policy is rather ad hoc and oriented to specific problems (safety, pollution, congestion). They are not undertaken as part of a coordinated programme that is strategic, holistic and pro-active (Banister et al., 2000).
To gain more customized services that will increase the attractiveness of public transport, liberalization and privatisation are prerequisites for the badly needed versatility of transport services. It may also cause companies to only provide profitable services and reduce accessibility in general. But transport and communication networks always induce some kind of universal services provision, so intervention is then needed. But in general the link with new transport technologies is still weak.

Existing policies in the field of new transport technologies (e.g. hybrid or electric cars) is very fragmented, being scattered over various National and European stimulation programmes. There is a good reason for this fragmentation: let may flowers bloom and the winning concept will announce itself or be picked by the market. However, experiments are not linked to a vision of sustainability and to transition and marketing programmes. There have been a lot of experiments for instance using electric vehicles because of the attention to air pollution. Very often, the outcome of the experiments is that the particular technology is not ready for the (existing) market, which means the (temporal) end of the experiment. Learning *across*

experiments (where learning experiences from one project are used as input in a new project) hardly takes place (Kemp and Moors, 2001).

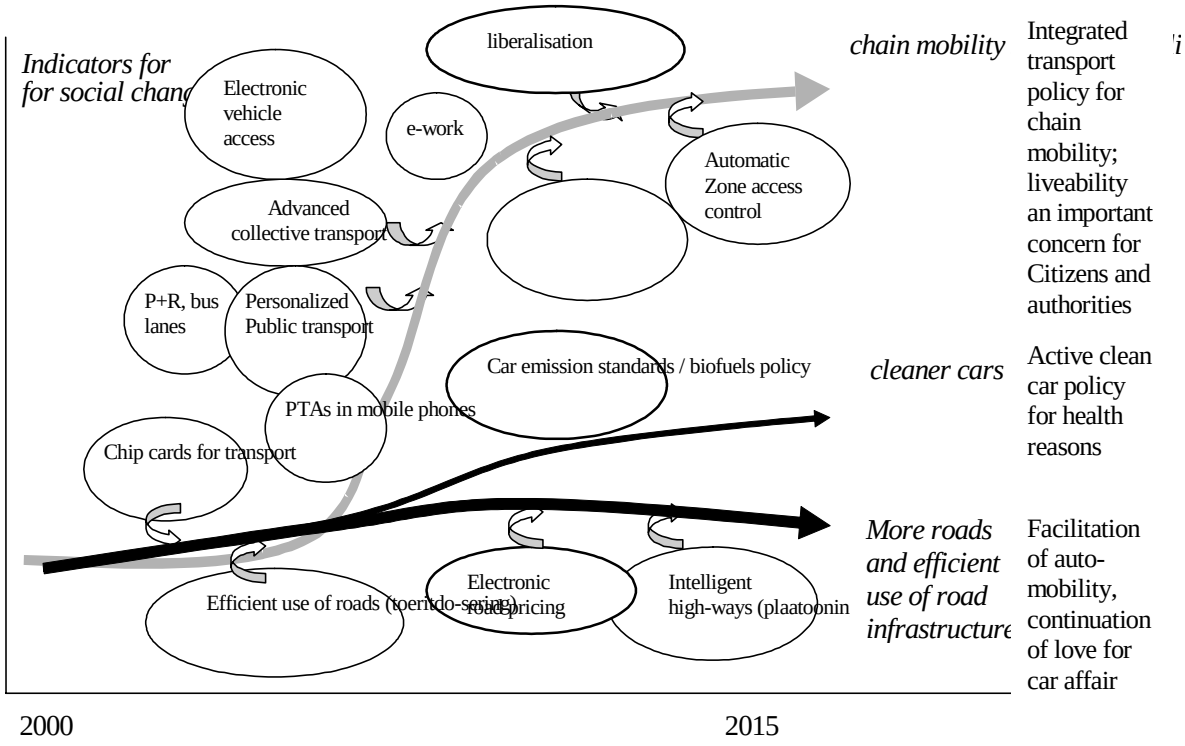
Experimentation with sustainable mobility at the local level (in cities, see Mackett & Edwards, 1997; Kenworthy & Laube, 1997 and 1999; the various RTD projects on the Cordis web site and the SURBAN database) in the form of better transit systems, more infrastructure for cycling, traffic-calming systems, and car-zoning policies is common practice in the EU. But this has not led to significant results. Car use, car ownership and auto mobility continue to grow. However, such projects show at least the willingness on the part of cities to deal with transport problems in a co-ordinated way. Liveability and quality of life is the driver behind such initiatives. There is thus a bottom-up development for alternative mobility. The anonymous and calculating user and the citizen may have different preferences, but in the end have to deal with each other to arrive at a (second best) solution for residents of the urban area, maybe at some economic cost but compensated by social and other welfare gains. So if commitment is strong enough, there will be a future policy that serves the interest of many parties, the key question then is what trend breaks will occur to cope with existing problems and what role ICT will play? This is the subject of the next section.

3.2 Policy trends and possible trend breaks

Trend breaks with regard to behaviour and values are very hard to predict. Trend breaks in policy are better discernable as policies are tied to problems and popular opinion. Policy is not predictable though: in some countries road pricing and tolls are introduced, in others it is not, due to opposition. Problem priorities are dynamic in how they have changed and probably will change in the future.

The dominant drivers for transport policy these days are: congestion, urban liveability, and CO_2 policy; of these congestion has the highest priority. They reflect different concerns of people as mobility users, residents and citizens. Societal change interacts with developments in technology and policy. This may give rise to three different patterns for passenger land-based travel. The elements supporting the patterns are shown in the graph. With regard to technology, the focus is on ICT, which may be used for public transport, to offer more customised services, and in car travel. Thus far, ICT was oriented to auto mobility (car phones, driver assistance/information systems) on the larger scale. The great potential for customised mobility has been under-exploited and probably will be better utilised in the future, depending on the attention given to seamless mobility by private and public actors.
Figure 1 summarises the impacts of ICT's and their concomitant policies.

Figure 1: Impact of ICT and policy on passenger road transport



Hypothetical impact of ICT developments and policy passenger transport policies are described in the graph, for the 2000-2015 period. It shows that developments are tied to problems, innovations and interventions based on different concerns. The lower arrow in the graph represents the trajectory of increased auto mobility involving very little social change. The drivers are anti-congestion policy and the love for cars. The second trajectory is that of cleaner and energy-efficient cars, driven by control policies for automobile emissions. There will be some social change, but seemingly little. The upper trajectory is that of chain mobility. Chain mobility is a consequence of a multitude of interacting elements and suits a nomadic, individualistic and responsible lifestyle. Public transport is the backbone in terms of infrastructure. New elements are mobility-pass, car & bike hire, reservations made via mobile phone, electronic personal travel assistants (PTAs) and other mobile devices yet to come (e.g. mobile internet). A key organisational innovation is the creation of intermediaries or mobility agencies buying and selling mobility services and processing financial aspects. Chain mobility amounts to system innovation and requires integration of several transport services, organisationally and in terms of infrastructure in the form of mobility centres where people can change modes of transport and fulfil other tasks (such as shopping). Cars will be less owned by private people but rented from car sharing organisations and public transport companies. The main drivers for this trajectory are ICT's, liberalisation, and liveability policies resulting in increased investment in advanced public transport, bicycle infrastructure, mobility centres, customised services and preferential treatment of public transport in urban areas through bus lanes, restrictions for cars, etc.)

For expositional reasons the elements are positioned as fixed points in time. But each element will diffuse and change. Behind the patterns one should picture a series of diffusion curves that are interrelated. This means that there are cross-impacts, reinforcing developments and counter developments. Policy is endogenous, not exogenous. The dilemmas involved in transport and likely shift of attention makes policy rather erratic. Past transport policy has shown this.

An important development, only touched upon in this paper, is the great rise in passenger air travel. From 1990 until 2000 passenger kilometres rose 70%, while total passenger kilometres

rose only 17%.[25] Low cost carriers and ICT largely facilitated this. ICT is an important factor: booking a flight is simply clicking the buy button on an Internet site, including making a hotel reservation. Increased air travel will increase nuisance and CO2 emissions. The smart use of ICT may help to control auto mobility and facilitate chain mobility and thus help to reduce some of the problems related to mobility. But as the example of air travel shows, ICT is in no way the solution for transport and mobility problems. The policy view of ICT as a panacea for transport problems is incorrect. ICT facilitates the long-term trend towards faster modes of transport. Whereas in the past 80 years this trend favoured cars and more recently planes, this may now begin to favour collective transport, beginning in urban areas. What we will see is individualist people using collective transport, besides using cars. ICT will facilitate both. It probably will not result in less travel. Even under an active government, adopting an integrated policy for chain mobility, mobility will probably increase. ICT does have an important role to play however, in better using existing transport infrastructures and in facilitating the change to seamless mobility, producing societal benefits in the form of less CO2 emissions, more safety and less nuisance and countering the devaluation of travel time.

3.3 Conclusions

Transport policy principles are widely supported in the EU: tax traffic and regulate mobility, assess infrastructural investments coherently and liberalise transport markets. These principles are sound enough and supported for more than a decade. Practical policy is something different and the policy choices are not always in line with these principles and differ widely among European countries. ICT's play an important role in the transport and travel networks, especially in urban areas. Transport policies are aimed at solving traffic related problems while maintaining liveability, accessibility and environmental standards. European cities perform better than Australian but worse than the prosperous Asian cities. Kenworthy and Laube (1997) contribute this to the costs of infrastructure, direct and indirect cost of the automobile and the disappearance of quality pedestrian friendly urban environments. Not all of these policy options need ICT applications, but urban solutions like intermodality, customised mobility and road pricing etc certainly do. They cannot be carried out without a fierce backing of ICT solutions. It is very likely that optimal or second best solutions are an impossibility in practice because of the entrenchment of the car based system and obdurate users and consumers, political hurdles, or other obstacles, while technological solutions are feasible. But the likelihood of a triggering event that paves the way to solutions that before seemed impossible now becomes all the greater more the voice of the citizen and the preference of the user communicate.

[25] http://europa.eu.int/comm/energy_transport/etif/transport_passenger_a/performance_by_mode_pkm.html

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