1. Introduction

Along with the growing use of information and communication technology (ICT) there is a need to examine what should be the roles of the public and the private sector, respectively, in providing ICT infrastructure and ICT based services in the transport sector. ICT based systems in transport are often referred to as Intelligent Transportation Systems (ITS). In 2003, commissioned by the Norwegian Ministry of Transport and Communications a study was carried out by the Institute of Transport Economics. One of the purposes was to point to how the public sector could contribute to efficient utilisation of ICT infrastructure in the transport sector. As ICT has a wide range of applications in transport, it was necessary to limit our project to two case studies, as a first step into this problem. Information for travellers and information flows in intermodal freight transport were the selected fields. These covered both passenger and freight transport and offered a variety of relevant topics. A qualitative approach was used in the project. This paper gives an outline of the study and the theory on which it was based, and presents the main findings.

The term electronic infrastructure includes the installations that are necessary for electronic data exchange (e.g. satellites and telecommunication network) as well as the transmitters and receivers necessary to utilise these (e.g. telephones and
computers). Here we will let the term include also the communication systems that can be established by means of this infrastructure. That is, we consider for instance a fleet management system in freight transport, or the components of a traveller information system, parts of the electronic infrastructure.

2. Public sector objectives for ITS

The Ministry of Transport and Communications (2002) states three objectives for the use of ICT in transport:

- Increase safety in the transport sector
- Increase the utilisation of the capacity of the transport infrastructure
- Increase benefits to the users of the transport system

The Ministry formulated a strategy which purpose is to make distinct the significance of ICT when shaping the transport policy. The strategy includes showing the potential for added value from ICT applications in transport, coordination of efforts in the field, and clarifying the division of roles and responsibilities between the public and private sectors in pursuing efficient use of ICT in transport. Table 1 indicates the roles of different parties as presented by the Ministry (2002).

Table 1: Division of roles. Ministry of Transport and Communications, 2002.*

| Ministry of Transport and Communications | • Stimulate and govern development through overall objectives and a demand for solutions  
|                                         | • Lay down external conditions through national and international requirements and agreements  
|                                         | • Identify barriers to efficient solutions in the legislation  
|                                         | • Contribute to cooperation and coordination between own subordinate agencies as well as other public authorities of relevance for transport  
|                                         | • Contribute to financing of research |
| Subordinate agencies                    | • Develop solutions  
|                                         | • Communicate user needs  
|                                         | • Ask for solutions  
|                                         | • Develop own competence |
| Service providers – transport           | • Develop solutions  
|                                         | • Serve user needs  
|                                         | • Ask for solutions |
| Service providers – information and communications technology | • Develop solutions  
|                                         | • Ask for competence |
| Transport users                         | • Use the provided services  
|                                         | • Demand services and solutions |

*: My translation.
3. Some theoretical aspects

What is the rationale for public sector intervention in a market? Following standard economics textbooks (e.g. Stiglitz, 1988) we can identify some conditions under which the market left to itself will not produce an efficient solution. According to the Pareto criterion, an allocation of resources is not efficient if a reallocation can make someone better off without making anyone else worse off. Examples of market failures include the presence of externalities, economies of scale (section 3.1 below), and public goods (section 3.2). Further, the government might aim at some control of development, such as securing a minimum service level in all regions, although there is not a business case for the service everywhere. The government might also wish to counter possible disadvantages of fragmentation. Private service provision might lead to a rather fragmented market with many small firms who do not have incentives to cooperate, although it could be in the interest of society for two reasons: Innovation might be too costly and risky for small firms, and consumers could benefit from coordinated services.

In general, public ownership and operation is a solution when the business case is weak and there are large benefits to society. A decision for the public sector to invest should be based on cost benefit analysis or guided by other political goals.

3.1 Economies of scale. Vertical integration or separation

Production of infrastructure-based services typically requires large investments, while the marginal costs of the service production are small. In economic theory these characteristics are associated with natural monopoly. Once the necessary infrastructure or network is in place the cost of serving one additional customer is relatively small. Hence it would be irrational to have many firms establishing their own network, each of them serving a minor fraction of the customers.

The production of infrastructure-based services can be described as in Figure 1. At the upper level there is the infrastructure provider and at the lower level the service producer. The two levels might be integrated in one firm or there might be vertical separation. In the latter case one or both levels could be monopolies.

![Figure 1: Structure of the production of infrastructure-based services](image-url)
If the upper level is a profit-maximising monopoly, the price of the good it sells to the lower level will be higher than marginal cost. If the lower level also is a monopoly, its price to the consumer will also be higher than marginal cost. It is well known from economic theory that profit-maximising monopolies lead to higher prices and lower output than a solution based on marginal cost pricing. A chain of monopolies in Figure 1 results in an even lower welfare to society than an integrated monopoly would do, due to the double marginalisation. While such a situation should be avoided, there are other arguments in favour of vertical separation. E.g., competition at the lower level might be desirable (a motivation for vertical separation in the railway sector during the 1990s). Further, if the infrastructure provider is publicly owned it might be governed by other objectives than profit-maximisation and hence be able to counteract the disadvantages of a monopoly, e.g. by offering a lower price.

3.2 Public good

Some traveller information services bear the characteristics of a public good. Traffic messages delivered by radio or by variable message signs along the road will not be more costly to produce if one additional individual should receive the messages. When one individual has “consumed” this kind of good it is still possible for another individual to consume it at the same level of quality. Further, it would be difficult to exclude individuals from consuming the good once it is provided. On the other hand there are traveller information services that would be characterized as private goods. These can be delivered to some individuals and not others, such as messages delivered by SMS. Then it is also possible to obtain direct user payment from those who demand the service.

Since direct user payment cannot be collected (or would be very costly to collect) in the provision of public goods, the private sector will not find the production of these goods attractive unless revenue can be obtained in other ways, as our study provides examples of.

4. Case study 1: Traveller information

4.1 Description

Traffic formation for drivers as well as traveller information for public transport users are major branches of ITS. They are both termed traveller information here. Three providers of traveller information were interviewed, representing quite different positions in the traveller information market. The first is one of the five regional traffic management centres of the National Public Roads Administration, Vegtrafikksentralen (VTS) located in Oslo. The second is the commercial radio station P4. Other studies (e.g. Killi and Samstad, 2002) have found that P4 is one of the two most frequently used sources for traffic information among car commuters in the Oslo region. The third information provider interviewed was Trafikanten, which is owned by public transport companies and provides
multimodal information about public transport services in the Oslo region. Hence the interviews covered private as well as public modes of transport, and state-owned as well as private, commercially run information services.

The topics of the interviews were:

- Sources and infrastructure used for the flow of data or information into the service provider’s system
- Data processing by the service provider
- Infrastructure and medias used for the flow of information from the provider to intermediate and end users
- Financing of activities, and payment following the information flows
- Possible barriers to improvement of any part of these processes or to implementation of new solutions

Table 2 gives an overview of processes involved in providing traveller information at VTS, P4 and Trafikanten.

**Table 2: Processes in the production of traveller information**

<table>
<thead>
<tr>
<th>Processes</th>
<th>VTS</th>
<th>P4</th>
<th>Trafikanten</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data input</strong></td>
<td>Data on traffic flows, weather conditions, traffic accidents and other incidents affecting traffic</td>
<td>Information from VTS, radio listeners, P4 helicopter, the police, public transport companies, P4 traffic team³</td>
<td>Data on public transport (PT) services from PT operators</td>
</tr>
<tr>
<td><strong>Infrastructure used for input</strong></td>
<td>Surveillance cameras, telephones, sensors in the road</td>
<td>Telephone, internet</td>
<td>Data are delivered electronically from PT operators in a format developed by Trafikanten to fit automatically with the database on which all their services are based.</td>
</tr>
<tr>
<td><strong>Data processing and product adaptation</strong></td>
<td>Updating of database. Preparation of messages for different media. Quality assurance of information received from e.g. travellers and radio stations.</td>
<td>Quality assurance, editorial work, preparation for SMS</td>
<td>From the database a range of products can be offered, such as travel planner and timetable information through several channels.</td>
</tr>
<tr>
<td><strong>Infrastructure used for output / Distribution channels</strong></td>
<td>Radio, RDS¹, internet, text TV, telephone, VMS²</td>
<td>Radio, Internet, SMS</td>
<td>Internet, telephone, SMS, WAP, counters at two service centres</td>
</tr>
<tr>
<td><strong>Intermediate and end users</strong></td>
<td>Travellers, radio stations, occasionally other media</td>
<td>Radio listeners</td>
<td>Travellers</td>
</tr>
</tbody>
</table>

¹) Radio Data System. ²) Variable Message Sign. ³) Members are professional drivers (local knowledge required in order to distinguish between ordinary and extraordinary congestion)
4.2 Cases for public sector involvement

Note that all of these information services (except SMS) are free of charge for the end user. The realisation of a solution with price equal to zero is made possible in three ways. In the case of the traffic management centre it is the public funding. In the case of the radio station it is the available information produced by the public sector combined with commercial radio broadcasting. In the case of public transport information it is horizontal as well as vertical integration. Different public transportation companies together own the information provider, hence horizontal integration on the level of the companies, and vertical integration between this level and the level of the information provider. The information can be delivered to the end user free of charge because it is indirectly financed by fare revenue.

Road traffic information

To develop, build, operate and maintain a system for road traffic information is costly and the possibilities of cost recovery small. The business case is weak. No explicit cost benefit analysis has been carried out, but benefits to travellers from traffic information services have been identified in several studies (e.g. Khattak et al. 2003, Killi et al. 2002). Further, the responsibility for providing traffic information has, not only in our case, but in general, been a natural extension of the responsibilities of the road owner. Many of the necessary installations and routines were already in place. These points together with the economies of scale argument support the existing situation, with public ownership and operation. However, the effects of using other models could be examined, such as public ownership and private operation through tenders. In the latter case, public subsidies would offset the lack of a business case, and public authorities would be able to influence developments by specifying requirements.

Passenger information in public transport

Here we focus on integrated information services like Trafikanten. Developing the necessary database is costly and has been supported by the government. The operation of the database is mainly financed by public transport companies, some of which are publicly owned but operated on a commercial basis. Three major companies in the Oslo region are owners of Trafikanten, while there are contracts with other companies concerning the communication of their timetable information to travellers. This has been a successful arrangement so far, judging by the popularity of the services\(^1\). However, the success depends on the willingness of the public transport companies to participate. The owners of Trafikanten fear that external conditions might change and companies find it more attractive to brand their own information. Involvement from public authorities is called for. (In what ways: See below.)

\(^1\) 4.5 million inquiries handled in 2002, mostly on the internet, but also by phone (three digit number), WAP, SMS and customers visiting the centres at the airport and near the central railway station.
Looking into the future the issue of an integrated multimodal traveller information service comes up. This means a service offering travel planning, covering public transport modes as well as car and possibly walking and cycling, with updated information on travel times and costs. There are no plans for developing such a service in Norway so far. Integrated multimodal real-time information might seem somewhat farfetched to some transport planners and to the public. However, there are several trends that support the development of more advanced traveller information systems. Firstly, the developments in the field of ICT make integration of different systems more feasible. Secondly, increased road congestion leads to increased travel time variability and calls for information about expected travel times and alternative transport options (i.e., promoting a shift towards public transport). Thirdly, people become more and more accustomed to using the possibilities of various technologies to gather information in their daily life (Schuman, 2003).

Trafikanten is an example of an integrated multimodal service covering public transport modes. The web-based traveller planner suggests the least time-consuming alternative regardless of mode and transport company. If the same kind of service also included the mode private car, with continuously updated travel times, the potential for affecting mode choice would increase. People’s mode choices tend to be habitual, and when they seek information it is often about a pre-selected mode. Now they might be confronted with attractive alternatives other than the ones initially considered (Kenyon and Lyons, 2003). There might still be other obstacles such as attitudes preventing the traveller from actually choosing a different transport mode, but at least the obstacles of awareness and information would have been removed.

Developing such a service would require coordinated efforts from road traffic authorities, public transport companies, technology providers etc. According to British research related to the Transport Direct Programme (Lyons et al., 2001; Lyons and Harman, 2002) this will not come about without the involvement of public authorities. Hence, looking ahead, the case for public sector involvement in the provision of traveller information services seems not at all to become weaker. Possible ways of public interference are legislation that promotes the participation of public transport companies, and financial support for the development of integrated information services.

5. Case study 2: Exchange of information in freight transport

5.1 Description

This part of the study identified information flows related to the planning and accomplishment of freight transports, who are involved, as well as what infrastructure is used for data collection, data processing and output. This was studied by drawing on experience from other projects (Eidhammer, 2003) and

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2 This section is based on Olav Eidhammer’s contribution to the study.
interviewing four parties: a retailer with own storehouses and freight terminals nationwide (Coop Norge), a freight forwarder with own terminal network nationwide (Nor Cargo), an intermodal railway freight carrier (CargoNet), and finally a sea freight terminal (Oslo harbour). Imagine the following transport chain: Producer – Carrier (road) – Retailer (terminal) – Carrier (road) – Freight forwarder (terminal) – Carrier (road) – Freight terminal (railway) – Carrier (railway) – Freight terminal (railway). The interviewees covered all of the implied links. This chain is intermodal with railway transport on the main link and road transport to and from railway terminals. Alternatively the intermodal example could have had sea transport on the main link. Road transport on the main link would have been an example of a unimodal chain.

Through the transport chain a set of data are exchanged several times. These data include shipper’s and receiver’s names and addresses, product type, weight and volume of shipment and of items, order reference number etc. The data are used for booking (or confirmation/cancellation) of transport capacity, control of received and delivered goods, tracing of goods, notification of deviations from transport plan, as well as for invoicing and statistical purposes. It is evident that information and communications technology plays an important role in an efficient exchange of information in freight transport, the alternative being manual registration of almost the same data by several of the involved parties.

Technologies used are telephone, fax, manual registration for later punching, electronic data interchange (EDI) and Internet. Tables 3 and 4 summarise the findings in our study. Telephone and fax are typically used for booking and confirmation of transport capacity, while manual registration is used in unloading at terminal. More advanced companies use hand-held terminals when loading. EDI is often used by the freight forwarder. The customer might use Internet for tracing of goods.

In the unimodal chain sketched here most of the exchanged messages relate to activities organised by the freight forwarder and is exchanged in an internal, closed system. Similarly, in an intermodal chain each actor has a closed system. The different systems are often not compatible with each other, and this is an obstacle to efficient data exchange. The tendency is that freight forwarders and large firms develop their own systems that others have to adjust to. This implies that a customer might face different requirements with respect to data format.

There is a huge variety in the degree of ICT use by transport firms. Smaller transport firms tend to be less ICT-based than larger firms due to the obstacles of competence and investments. Investments in ICT systems have proved to increase the efficiency of logistics significantly, however, the development and implementation is perceived as too costly by many smaller firms. Further, the need for frequent exchange of information varies with types of firms. Eidhammer (2003) found that the firms who exchange messages more frequently than others are also the firms that stress the importance of high quality and punctuality in their deliveries.
Table 3: Messages, actors and type of communication in a unimodal transport chain from producer via retailer and freight forwarder to customer.

<table>
<thead>
<tr>
<th>Messages and actors</th>
<th>Messages per shipment</th>
<th>Type of communication</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Retailer – Carrier</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1. Retailer’s booking of capacity from carrier | 1 | Telephone: 50 %  
Fax: 50 % |
| 2. Final order of transport capacity | 2 | EDI: 100 %  
Fax (copy): 100 % |
| 3. Driver picks up and signs for the goods at producer | 1 | Manually |
| 4. Message to retailer if deviations from transport plan | Seldom | Mobile phone |
| 5. Unloading at retailer’s | 1 | Manual registration for later punching |
| **Retailer – Freight forwarder** |                       |                                |
| 6. Retailer’s booking of capacity from freight forwarder | 1 | Telephone |
| 7. Final order of capacity | 1 | EDI via stationary phone |
| **Freight forwarder – Carrier** |                       |                                |
| 8. Message to driver about job | 1 | Telephone or fax |
| 9. Info. from driver to freight forwarder about goods collected from retailer | 2 | EDI via mobile phone |
| 10. Unloading at freight forwarder’s terminal | 1 | EDI via mobile phone |
| 11. Internal messages between freight forwarder’s computers | 4 | EDI via stationary phone |
| 12. Loading at terminal | 1 | EDI via mobile phone |
| 13. Internal messages between freight forwarder’s computers | 4 | EDI via stationary phone |
| 14. Tracing of goods. Customer inquiries about expected arrival | n.a. | Internet and phone |
| 15. Unloading at destination or terminal | 1 | EDI via mobile phone |
| **Sum** | 10 – 13 |                                |

Table 4: Messages, actors and type of communication between freight forwarder and CargoNet regarding an intermodal transport.

<table>
<thead>
<tr>
<th>Messages and actors</th>
<th>Messages per shipment</th>
<th>Type of communication</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Freight forwarder – CargoNet</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Freight forwarder’s booking of capacity from CargoNet</td>
<td>75 % ordered in advance</td>
<td>Already in database</td>
</tr>
</tbody>
</table>
| 2. Final order of capacity | 1 – 2 | Fax: 90 %  
Email: 5 %  
Phone: 5 % |
| 3. Message to driver about job (road) | 1 | Phone or fax |
| 4. Loading at forwarder’s terminal | 1 | EDI via mobile phone |
| 5. Internal messages between freight forwarder’s computers | 4 | EDI via stationary phone |
| 6. Unloading of truck – Loading of train | 1 | Internet |
| 7. Tracing of goods. Customer inquiries about expected arrival | 1 | Fax: 60 %  
Email: 20 %  
Mobile phone 20 % |
| 8. Message to customer about deviations from transport plan | Seldom | Fax: 80 %  
Email: 20 % |
| 9. Message to customer about train ready for unloading | 1 | Fax: 80 %  
Email: 20 % |
| **Sum** | 10 – 13 |                                |
5.2 Cases for public sector involvement

The most important barrier to efficient exchange of information in freight transport was found to be different standards and lack of compatibility. If this is a persistent problem it might be categorised as a form of market failure. Here the public authorities could play a role as facilitator for coordination. To encourage ICT use by smaller firms and standardised solutions from freight forwarders, public authorities could initiate a forum for these agents.

Agreeing on a certain standard and expect everybody to convert to it is an unrealistic strategy, since large firms often are part of international enterprises with their own systems implemented in several countries. It is expected that private solutions will emerge, offering services that take care of the data flow between incompatible systems. Public authorities are sceptical to the extra costs this will impose in logistics. If so, they could initiate a cooperation forum that could investigate the possibilities of interfaces between different systems. Like the private solution, this would not have zero cost. The motivation for public involvement must in that case be that a more efficient solution was expected to emerge.

6. Conclusions

This study identified characteristics in the traveller information market and in the information flows in freight transport chains, and related the findings to phenomena described in economic theory. On this basis, roles for the public sector were suggested. The main findings are summarised here.

There are elements of economies of scale in the provision of infrastructure for road traffic information (i.e., by the definition of infrastructure in section 1). This calls for public involvement, possibly by a continuation of the existing situation, with public ownership and operation of the infrastructure. Other models of public roles, including opening for tender, could be explored further.

Although the communication of traveller information to end users in some cases bears the characteristics of a public good, it is shown to be of interest to private service providers if it is possible to finance it in other ways than by user charges. Private and public services complement each other.

The most important role for the public sector in order to improve the efficiency of information flows in freight transport seems to be as facilitator for coordination. The purpose is to overcome the problem of incompatibility between different standards and at the same time reduce the risk faced by small firms with respect to investment in ICT-based systems.
References


