NEW URBAN GOODS DISTRIBUTION SYSTEMS

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abstract

Urban goods distribution is essential for the prosperity of urban areas but at the same time poses problems related to the environment, traffic safety and accessibility. One way to overcome these problems is to implement a totally new designed logistical system that optimises the efficiency from a business as well as societal perspective. The new system is based on physically separating intra-city transport from goods transport outside the cities. This opens the opportunity of optimising both intra and ‘inter’ urban goods transport systems independently. Within urban areas lightweight, small, highly manoeuvrable, noiseless, safe and low-emission vehicles can be used. And in the further future, maybe underground goods distribution systems. Outside cities larger trucks (up to road-train combinations), rail transport and in some cases even shipping can be used. The system requires a physical transfer, somewhere at the frames of a city (or in a region). Such a physical transfer is normally regarded as an important disadvantage as it is time consuming, costly, and inserts additional risk factors in the process. This disadvantage can be reduced by using standardised load units and by automating transhipment processes. Further more, the transhipment should be integrated neatly in adapted logistical systems. For some products, direct distribution from factories or importers to the ‘grey’ (public) urban distribution facilities will become possible. For other products, intermediate storage will be needed, either near production or trading facilities or again in the urban distribution facilities. Thus far, most initiatives on improving urban distribution have been more or less ‘stand alone’ solutions and often have failed. The proposed new system should incorporate various cities and regions and should be supported by private and public parties. Though implementing the system will certainly not solve all goods transport related problems, it may help to overcome the most important ones and it will also form a good starting-point for further development of underground goods distribution systems.
1 Goods transport in urban areas

1.1 Necessity of goods transport and problems

Urban goods distribution is vital for the prosperity of inner cities, especially the shopping areas that fulfil an important role for the city and its region. Goods transport also causes noise, air pollution, physical hindrance (including congestion) and a decrease in traffic safety are important negative side effects. Reversely, the urban structure and measures that have been taken to limit problems, pose accessibility and logistical efficiency problems to the urban goods transport system (see Ogden, 1992). This results in increased travel times, lower quality (reliability) and in some cases to inefficient logistical systems using more vehicles (vans) than strictly necessary.

1.2 Possible solutions

There is a variety in possible solutions that can be described in a systematic way using the ‘cascade’ model (see paragraph 2.2). Options range from the relocation of shopping facilities, reducing the actual consumption and cleaner engines to traffic measures. To date, most of the measures taken, refer to the physical characteristics of distributing vehicles (weight, size and emissions) and time windows. More recent measures focus on the logistical operations by offering the opportunity (or demanding) the use of urban distribution schemes or by requiring high load-factors for goods vehicles entering the city. As most measures rely on existing infrastructures and are based on local circumstances, they do not fundamentally change goods distribution operations. Some measures even tend to be counter-productive as more vehicles are used or more kilometres are to be made to comply with the requirements. Newly developed concepts like intermodal short-distance goods transport, underground transport and advanced logistical schemes may alter operations profoundly and help to reduce problems significantly.

1.3 Structure of this paper

The paper elaborates on the necessary logistical adaptations and describes the different technologies that can be used to introduce the new systems and describes an implementation strategy. It describes some of the expected effects of the implementation of this system.

The paper emphasises the methodology that is used to determine and describe measures for improving efficiency in goods transport and emphasises the (changes in) logistical organisation that can be used to this end.
2 Methodological approach

2.1 Methodological description of a transport system

To classify and describe different problem-solving options for urban goods distribution, there is a need for a fundamental way of describing the transport process, its actors and its means (equipment and infrastructures).

One model to describe the hierarchy in policy measures is the so-called ‘cascade model’ that was developed to describe options for reducing energy-use and CO$_2$-emission. Next to that, the OSI-layer model can be modified to be used to describe the (physical) transport system. This has resulted in the TRAIL layer scheme that in turn is the basis for an adapted layer model, especially designed to describe the urban goods distribution system.

2.2 Descriptive models

cascade model

Schoemaker and Hamel (1993) developed a cascade-like scheme that describes the subsequent (fundamental) options for energy-use reduction by:

- ‘transport demand and supply’ – the amount of goods to be transported;
- ‘traffic’ – the amount of vehicle kilometres necessary to comply with transport demand;
- ‘energy use and produced emissions’ – the amount of energy and produced emissions to produce the required ‘traffic’;
- ‘consumption of fossil fuel and hindrance’ – the exposure level.

On each level, measures can be taken to reduce the final consumption of fossil fuel and hindrance. Demand (and thus consumption) can be limited and logistics can be optimised so for the same transport demand there is less need for traffic. ‘Clean’ technologies can reduce the amount of energy or produced emissions necessary for the required traffic performance. As a last resource, technological options and ‘end-of-pipe’ measures can be taken to limit the use of fossil fuels and the hindrance given a certain need for energy.

OSI and TRAIL layer model

In the adapted version of the OSI-layer model, the TRAIL reference model [TRAIL, 1996], five layers are distinguished:

- ‘transport market’ - describing potential demand;
- ‘cargo’ - referring to the individual subjects of the transport operations;
- ‘transport units’ - referring to the actual subjects of transport;
- ‘means of transport’ - comprising the physical means of transport for all modalities;
- ‘infrastructure’ - comprising all fixed material and immaterial provisions to facilitate the traffic movements by the means of transport.

‘Society’, ‘resources’, ‘technology’ and ‘management’ define the environment of the transport system. Between the layers, multiple levels of interactions can be defined, the interaction is not limited to the adjoining layers, but interacts with all underlying layers.
Figure 1: TRAIL layer model

2.3 Adapted layer model

The adapted layer model, as displayed below, combines the OSI-style layer model with the cascade model. Actors, means and phenomena (supply and demand, transport, traffic, output/impacts and needs/demands) are included. Each phenomenon can be interpreted as an interaction that touches actors and means. Needs and impacts cause environmental, financial or spatial capacity problems. The population experiences the problems, but also benefits from the earnings.

Transport means use infrastructure, resulting in traffic flows. And the transport needs ‘use’ the available transport capacity.

Note that producers (and workers at production facilities) and consumers are part of the population and that goods can be seen as resources – resulting in the ‘loops’ in the scheme.

Figure 2: relationship between actors, phenomena, and means

The model is used to describe and evaluate new developments that may be used to overcome problems that relate to urban goods distribution.
3 Goods flows: logistics

3.1 Traditional logistics

Traditional logistical operations focus on optimising transport flows between subsidiaries of one company or between trade partners. This results in direct distribution (no intermediaries or intermediate transhipments) or more complex schemes involving one or more distribution centres and intermediates. With help of advanced planning methods, information and communication technology and sometimes adapted vehicles, efficient systems can be operated. Notwithstanding the efficient operations of some large companies, most single company or single relation oriented logistical schemes are not very efficient from societal point of view. These operations often result in low average load factors, large detours and transport distances.

3.2 New developments in logistical organisation

Within developments in the logistical organisation, distinction can be made between ‘operational’ and ‘fundamental’ changes. Operational changes affect flows and routes, but do not affect the integrity of individual shipments and operational relations. The only means of consolidation is putting together small shipments of different consignors, in place and/or in time. Fundamental changes also affect shipments. Either the consignor or the logistical service provider can split shipments to transport ‘components’ separately. This, of course, profoundly changes the way logistics are organised, as the very nature of the shipments will change. Changes in logistical organisation are made possible by development in information and communication technology that enables exact tracking and tracing of shipments (or its components) and streamlines communication (data exchange) between the different partners in a logistical chain.

3.3 Alternative options for operational changes in logistics

For operational logistics, all options come down to combining logistical activities of different firms. Different variants are (examples refer to retailers; see: Van Binsbergen et al, 1995):

- retail chain distribution, combining logistical activities of retailers belonging to the same chain (in fact an extension of traditional logistics);
- retail group distribution, combining logistical activities of similar retailers;
- area distribution, combining logistical activities of all retailers within a certain area.

And combined forms, of which the ‘urban distribution’ concept is one example (see also Ter Brugge, 1991).
3.4 Alternative options for fundamental changes in logistics

**composite warehousing**
In composite warehousing, shipments from different origins are combined in a distribution centre and from there-on transported to the final destinations. The system is used by some retailers (in The Netherlands Ahold was the first to use it) and reduces the number of stops, and thus the amount of traffic, in an urban area.

**commodities and specialities**
In commodities/specialities distribution, commodities (high turnover – low profit goods) are distributed along other paths than specialities. The system requires a very reliable logistical system and local or regional storage facilities for commodities. These regional depots serve all destinations in a specific area. Retailers themselves directly distribute specialities (see Visser et al, 1998).

**split&combine distribution (pipelining)**
Split&combine distribution optimally allocates individual packages to the logistical system (vehicles, handling systems, depots), this to make optimal use of available capacities. This means that shipments may be split and the contents can be transported along different routes and at different times, At the end of the chain, shipments are re-combined and delivered to the final addressee (Koekenberg, 1999).
4 Traffic flows: transport means

4.1 Traditional goods transport for urban areas

Goods transport for urban areas almost fully relies on motorised road transport. Trucks, vans and passenger cars are used to distribute and collect goods in cities. Neither inside urban areas nor outside, real alternatives exist.

4.2 Key developments in transportation

Important areas in transport developments are:
- information and communication technology (ICT);
- engine technology;
- mechanisation and automation.

ICT developments open advanced opportunities for tracking and tracing of vehicles (and thus cargo) that help streamline logistical optimisation. Further more ITC can help to enhance traffic safety and to increase infrastructure capacity (see also chapter 5).

Improved ‘traditional’ internal combustion engines (ICE), powered by gasoline, diesel fuel, LPG or LNG, will use less fuel and/or produce less emissions and noise. Catalytic converters may further reduce harmful emissions. Though diesel-ICE can not be equipped with these converters yet, this will probably change in future. Electric powered vehicles (EV’s) may gain ground if they can be equipped with powerful and reliable advanced battery systems or, in future, with fuel cell technology. These fuel cell EV’s offer comparable driving characteristics as traditional IC vehicles, though load capacity may be somewhat limited.

4.3 Alternative options for inter-city transport

Outside cities there is no real physical obstacle for using larger scale goods transport means. In road transport, long ‘traditional’ vehicles could be used (like in Sweden) and in the future maybe automated guided vehicles. Specialised types of trains (like the German Cargo-Sprinter) and maybe even inland shipping or coastal navigation can be used for short-distance combined transport for urban distribution. To operate such systems, load units and appropriate handling equipment must be developed and used.

4.4 Alternative options for intra-city transport

The spatial characteristics (narrow streets, bridges, sharp turns) and the high density of human presence (inhabitants, workers, visitors) of urban areas ask for specific vehicles for urban goods transport. Lightweight, small, safe, highly manoeuvrable, low-emission vehicles are needed. Thus, EV’s and low-emission ICE vans and small trucks may do the trick and some manufacturers already proposed concept ‘urban distribution vehicles’ (Mercedes Benz, VOLVO).
5 Traffic flows: infrastructures

5.1 Traditional goods transport for urban areas

Traditionally goods transport by road and rail mixes with other traffic flows. Only at certain periods, some infrastructure (notably within inner cities) is reserved for goods-transport only. Rail infrastructure is seldom used for urban distribution purposes.

5.2 Key developments in infrastructure technology

Two main fields of development can be distinguished in infrastructure, namely the (further) development of dedicated infrastructures and all information and communication technology (ICT) related developments.

The development of dedicated infrastructures for specific user groups changes the open access and non-discriminating nature of public infrastructures profoundly. Nowadays, special infrastructure is proposed or build for public transport, car sharers (HOV-lanes) or freight vehicles. Further segregation is proposed in studies for autonomous infrastructures, for example for freight transport vehicles. Autonomous infrastructure opens possibilities for automation.

ICT technologies are on the brink of wide application for optimising the use of existing infrastructure capacity on link and network level (tolling, route guidance, car following, speed control).

5.3 Alternative options for inter-city transport

Dedicated lanes for freight traffic may enhance accessibility of urban areas and autonomous infrastructures (eventually used by automated vehicles) will do this to an even larger extend (see Van Binsbergen and Schoemaker, 1996; CTT, 1996).

Terminals for road-rail and road-inland shipping transport and by increased physical infrastructure capacity, will make these alternative modes more attractive for urban distribution activities (especially on longer distances).

5.4 Alternative options for intra-city transport

Within urban areas there are only limited opportunities to enhance physical capacity of road infrastructure at surface level. Nevertheless, ICT technologies can be used to smoothen traffic flows, to guide goods vehicles through the urban areas or to introduce timeslots. During these periods, access to specific infrastructures is reserved for goods vehicles (and for example public passenger transport).

In some cases, specific goods transport corridors (maybe shared with public transport vehicles) can be introduced.

For the future, underground options certainly must be taken into account. For Japanese, American but also Dutch cities such options are now considered.
6 Integrated approach

6.1 Intermodal transport

Intermodal transport is mostly concerned with intercontinental goods flows and related ‘hinterland’ connections. Intermodal transport also plays a role in long-distance continental transport (combined road-rail or road-inland shipping). At short distances, up to about 150 kilometres, combined transport is mostly not regarded as a cost-efficient alternative. This is mainly due to organisational (different operators), logistical (lack of consolidation opportunities) and economical (expensive transhipments) problems. Newly developed logistical systems make use of shared distribution facilities (depots, transfer centres) and vehicles (trains, trucks) while maintaining the option of differentiating between different service levels.

The introduction of these new logistical systems opens the opportunity to use different modes within the (urban) distribution chain. The systems also allow ‘independent’ optimisation of goods and traffic flows in and outside cities, resulting in more efficient (cheaper) logistical operations. Furthermore, the introduction of standardised (small) load units and automated handling equipment reduces transhipment costs. This way, intermodal short distance transport will become a reasonable alternative for single-mode road transport.

<table>
<thead>
<tr>
<th>phenomena</th>
<th>changes</th>
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<tbody>
<tr>
<td>demand and supply</td>
<td>unchanged</td>
</tr>
<tr>
<td>transport (logistics)</td>
<td>need for transfers between modes</td>
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<tr>
<td></td>
<td>re-organisation of logistical services to reduce costs</td>
</tr>
<tr>
<td>traffic – transport means</td>
<td>optimised use of multiple specialised modes</td>
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<tr>
<td></td>
<td>need for transhipment equipment</td>
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<tr>
<td>traffic – infrastructures</td>
<td>optimised infrastructure design for specific vehicles</td>
</tr>
<tr>
<td></td>
<td>need for interchange points</td>
</tr>
<tr>
<td>output/impacts, needs/demands</td>
<td>less (local) pollution, noise and physical hindrance</td>
</tr>
</tbody>
</table>

Table 1: changes in phenomena when introducing combined transport

Combined transport schemes are essential to implement new dedicated transport systems (both surface and underground transport systems) as is described below.

6.2 New surface transport systems

Innovations in road and rail vehicles and infrastructures take place, so that in the future autonomous freight transport systems may be developed. In the Netherlands, concepts for automated road freight vehicles are researched. These systems could run between container terminals, but also between industrial estates and/or cities. The fully automated systems should preferably use autonomous infrastructures (free carriageways), but there are some intermediate alternatives that also may use free lanes. Attention will also be paid to inland shipping options where specialised ships may play an important role in distinctive market areas (positioning of empty load units, transportation of ‘bulk’ consumer goods like
beverages and the transportation of waste). Especially in Germany, attention is focused on ‘downscaling’ and automating rail freight transport vehicles. Here autonomous rail infrastructure is planned between the main urban areas (Ludewig, 1999). In some Scandinavian countries and in Japan short-sea shipping (coastal navigation) can also play a role in ‘urban distribution’. Within urban areas there literally is not much space for innovations, but traffic management/routing systems may improve logistical operations.

6.3 Underground goods transport for urban areas

Within urban areas underground goods transport creates an opportunity for streamlining goods flows and at the same time eliminating hindrance. The fully automated underground transport systems bring goods either to the final destination or to a inner city ‘service point’ from where goods are transported at surface level to their final destination. Underground transport implicates the use of intermodal transport schemes and thus implicates a completely new designed logistical system (see Visser et al, 1998; Brouwer et al, 1997).

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