A review of the success and failure of tram systems to carry urban freight: the implications for a low emission intermodal solution using electric vehicles on trams

Niklas Arvidsson[1], Michael Browne[2]

[1]*University of Gothenburg, niklas.arvidsson@handels.gu.se*

[2]*University of Westminster, m.browne@westminster.ac.uk*

ABSTRACT
This paper considers the potential use of trams and Electric Distribution Vehicles (EDVs) as cargo carriers in intermodal urban freight distribution. Distribution activities are vital for society but are also the cause of environmental and social problems. Transporting goods in urban areas, where most logistics chains start or end, is an activity that increasingly generates severe problems for all stakeholders, for instance, local authorities, the logistic industry, customers and society in general. New transport solutions are necessary in order to decrease traffic congestion, noise and traffic pollution, e.g., emissions of greenhouse gases and other pollutants in urban areas. A possible solution to these problems is to transform the current freight distribution system within cities, for example by favouring the enhancement of intermodal transport alternatives, i.e. combining road and rail transport. Information has been collected through a literature review and interviews in Amsterdam and from these results a conceptual model is presented, as well as a low emission concept using electric vehicles on trams in Gothenburg. The concept utilizes techniques from the shipping industry, train industry, and the car industry.

Keywords: light rail, tram, electric distribution vehicles, EDV, transport efficiency, sustainability, urban freight distribution, intermodal city freight distribution, urban rail freight transport

1. Introduction

It has been argued that the configuration of freight distribution systems in urban areas is reaching unsustainable levels in terms of economic efficiency and the impact on quality of life - see for example Genta *et al.* (2006). The scientific evidence points to an increase risk of serious, irreversible impacts from climate change associated with business-as-usual paths for emissions (Stern, 2006). BAU is not a sufficient if the major problems are to be addressed. Therefore, the EU White paper for transport aims to achieve dramatic reductions in transport CO2 emissions (Com 144, 2011). The goal of the Commission is to cut the use of 'conventionally-fuelled' cars in urban transport in half by 2030, phase them out in urban areas by 2050, and "achieve essentially CO2-free city logistics in major urban centres by 2030" (p, 9). A Delphi study conducted by DHL (2009) provides some guidance on the implications for production, retail and logistics.. According to over 900 professionals and researchers interviewed many believe a proof of energy efficiency will be necessary to ensure a product's acceptance and marketability. Nevertheless, there are differing opinions regarding the extent to which "global warming" represents a genuine business opportunity, but the interviewees in the study also believe that "An enormous amount of money can be earned with the right answers to 'global warming.'" (DHL, 2009 page 25).

The report focuses on answers not the answer. As there is not yet a single renewable fuel that can replace oil, but many, as well as no one logistic solution that can replace current practice. In this paper, one suggestion is presented for urban freight distribution that would potentially help to decrease emissions significantly[1] for parts of urban freight distribution, but also help the logistic companies to become more profitable.

Logistics companies that want to be green and stay in the 'green' race as well as to become or remain market leaders will need to constantly set new standards. It will not be enough to react; they will also need to adopt a proactive position. Only in this way will it be possible to operate profitably with their 'green' ideas – at least until these ideas become the legal standard. The timeframes during which it is possible to make a profit with sustainable efforts will become shorter, according to the DHL report. The report further states that logistics companies that offer the most intelligent low CO2 solutions will emerge as market leaders. However, it will only be able to maintain its market leadership if it constantly improves these solutions. Thus, logisticians need to continuously set new standards if they want to experience financial gains from the sustainability trend over the long term. It is presently truer than ever that merely reacting is not sufficient. Logistics companies must be actively involved in the formulation of standards and thus assume a leadership role in the economy.

An explicit definition of what is meant by light rail does not exist. In the literature many definitions are found. According to Priemus and Konings, (2001) a common feature seems to be that light rail is a rail associated transport system that can be positioned in the triangle between train, tram and metro.

To use the more general term light rail avoids incompatibilities in American and British English. The British English tram, could mean aerial tramway, trolley car or streetcar in American English, whereas aerial tramway is called cable car in British English (Merriam-Webster online dictionary, 2009-09-23). Cable car in North America usually refers to a trolley pulled along by subterranean

[1] provided that the electricity is produced from renewable sources.

cables. Trolley in American English typically refers to streetcar, while in British English this word means a (shopping) cart (Merriam-Webster online dictionary, 2009-09-23).

Trams and street cars are commonly classified as a subtype of light rail, but this is not always true. There is a significant amount of overlap between these technologies. Light rail is mostly separated from other traffic with dedicated lanes and rights-of-way, passengers get on and off at stations rather than in the street, and the speeds are faster than for trams (Smiler, 2001). In this paper, no distinction is made between trams and light rail for the sake of simplicity, variation and to facilitate keyword search.

According to Merriam-Webster online dictionary there is no significant difference between the use of cargo and freight anymore. Historically the use of cargo, from Spanish cargar used to refer to ships and later airplanes, but now also includes land-based vehicles. Freight, of mixed English, Dutch and German heritage, is somewhat more of a generic term, often attributive as in substituting transportation in transportation costs but also often referring to land based vehicles. The use of CarGoTram in Dresden is a pun, supplying car parts to the Volkswagen factory. In this paper, no distinction is made between cargo and freight for the sake of simplicity, as well as no distinction between transportation and distribution, for the same reasons as above.

The paper consists of five main parts. Firstly, the nomenclature of the terms appearing in the paper is discussed in the introduction. Secondly, a literature review was conducted on the previous projects using light rail in Europe followed by a literature review of the use of electric distribution vehicles in Europe. Thirdly, the four major projects using trams are presented. Information from Dresden, Vienna and Zurich is derived from a literature review and information from Amsterdam originates from empirical data from interviews. Fourthly, a discussion is held based on comparing differences and similarities between the cities. Lastly, barriers and recommendations are identified and an analysis of a possible future concept for the example city of Gothenburg is presented.

2. Cargo trams, Light rail and Underground freight

In this section some of the most recent research focusing on urban freight distribution in relation to rail is presented. The major projects in which this type of research has been evident are Bestufs (http://www.bestufs.net/), Civitas (http://www.civitas-initiative.org/index.php?id=69), Eltis (http://www.eltis.org/) and Sir-C (http://www.sir-c.se/web/page.aspx?sid=7126). Goods have been carried on rail vehicles through the streets since the 19th century and the use of rail in urban freight has been the focus of researchers and practitioners for the last century. Projects aimed at using rail in urban freight in Europe have emerged over the last decades, some with the aim to partly eliminate road freight transport, like in Amsterdam, whilst others are of more limited application. For example, the system in Dresden is a privately owned operation running between two points whereas Zurich and Vienna are non-commercial municipal services focusing on waste recycling and freight transport for the retail industry respectively.

According to Mortimer (2008), rail in urban freight has been on the decline in favour of better suited road transport, with regards to supply patterns, land use planning and regulations. Some of the known limitations of rail are the lack of door to door capability, difficulties in the integration of road and rail and the differences in economic mass. On the other hand, rail has a good weight/volume capacity, low energy and environmental impact, lower fatality risk in comparison to road traffic flows, a good network linkage between cities and in some cities – trams and undergrounds. Today the vast majority of urban freight service is performed by trucks and vans on road and to a lesser extent through intermodal services. Transportation is a vital part of our society but at the same time considered to be a major contributor of emissions and thus also a major impact on the environment. This has triggered planning authorities all over the world to impose a variety of restrictions and constraints on road transport, e.g. access times, weights, dwell times, noise limits and emissions etc. The light rail industry, much like rail and road, is considered to be conservative and the business model primarily focuses on passenger transport with generic constraints also with regards to coverage and access. Alessandrini et al. (2012) investigate the use of a MUDC (multi-modal urban distribution centre) in conjunction with shuttle trains and low polluting vehicles for delivery of fish in Rome the last leg. They also provide a good review of rail based schemes in Europe. Delaître and Barbeyrac (2012) study a rail freight transport system in Paris, the 'Monoprix', which reduces the pollution by almost half but costs more than conventional truck distribution due to extra handling, low volumes, and an uneven freight flow, according to the authors. Another reason to the higher costs is presented in GAO (2011). Marinov et al. (2011) study operational and tactical aspects of short haul rail freight services in the UK and try to demonstrate how it could be successful by calling for a different approach to asset management, planning, technology and resource allocation.

In the Italian TADIRAM project ("Advanced Technologies and Innovative Tools for Freight Distribution in the Sustainable City"), ending in 2006, research activities have been performed with the aim to identify new organizational and technological solutions for the optimization of freight distribution process, see Genta *et al.* (2006). One part of this project studied the cargo tram concept in a feasibility demonstration. The TADIRAM project partners demonstrated a new prototype designed for goods assembled onto load units. A new version of SIRIO Cargo Tram (light rail), the same type of tram ordered by Gothenburg municipality, has been studied. This type of tram is module-based and can also be coupled with passenger trams. Furthermore, the tram has a drop centre design, with a flatcar in the middle with 350 mm from the rail plane to the passenger floor.

The OLS-ASH project has generated knowhow on designing automated underground freight transportation systems that can be used for future underground freight transport projects (Pielage, 2001, Wiegmans *et al.*, 2010). The project stimulated academic research in e.g. innovative transport systems and logistics concepts, received support from local and regional governments and the public. Royal Mail have been operating its own automated underground transport system called Mail Rail, with the aim to move mail across London successfully since 1927 (Bliss, 2000). In Japan, Kikuta *et al.* (2012) propose and demonstrate an integration of the subway with freight operations from the suburbs to the city center. Ooishi and Taniguchi (1999) present a cost-benefit analysis as well as other aspects of underground freight transport.

3. Electric distribution vehicles in urban freight distribution

The electric vehicle is not a new concept; it actually precedes the internal combustion model. The deficient factors identified so far are: the same ability to accelerate and go fast, and to provide the same reach and ubiquity of the gasoline car. (Lesser, 2009; ELCIDIS, 2002). Henry Ford mentioned the electric car in his book "My life and World" in 1922:

> "Practically no one had the remotest notion of the future of the internal combustion engine, while we were just on the edge of the great electrical development. As with every comparatively new idea, electricity was expected to do much more than we even now have any indication that it can do. I did not see the use of experimenting with electricity for my purposes. A road car could not run on a trolley even if trolley wires had been less expensive; no storage battery was in sight of a weight that was practical. An electric car had of necessity to be limited in radius and to contain a large amount of motive machinery in proportion to the power exerted. That is not to say that I held or now hold electricity cheaply; we have not yet begun to use electricity. But it has its place, and the internal combustion engine has its place. Neither can substitute for the other--which is exceedingly fortunate." (Ford, 1922)

The ELCIDIS (Electric vehicle city distribution systems) project succeeded in verifying the principal advantages of using electric distribution vehicles (EDVs), hybrid as well as electric, in urban delivery concepts. ELCIDIS has provided proof that there are no predominant objections to the use of hybrid and electric vehicles in urban distribution, neither from company managers nor from drivers, and certainly not from local authorities (ELCIDIS, 2002). However, they stress the need for further development of the next generation of electric vehicles and hybrids. Furthermore, the project states the necessity of 'home-recharging' equipment close to the city centre for battery-run electric vehicles.

A study was carried out in the Brussels capital region by Van Mierlo *et al.* (2003) and was also presented in Macharis *et al.* (2007) that investigated the environmental benefits of electric heavy duty vehicles in which the Ecoscore or environmental damage rating was calculated. The methodology was based on a well-to-wheel analysis of emissions by calculating the impacts related to global warming, health, buildings and noise. The electric vehicle in the analyzed example was an electric bus and it had more than three times lower environmental impact compared to a diesel truck and twice as low as a liquid petroleum gas (LPG) truck. The study does however not describe how these figures were calculated. It would be interesting to know if the electricity was produced by coal, renewables or a mix. The use of electric cycles and vans in the last leg of distribution in conjunction with an Urban Consolidation Center (UCC) was investigated by Browne *et al.* (2011) with positive results. Ehrler and Hebes (2012) study the implementation of electromobility in city logistics from a multi-actor perspective. A good selection of other studies of electric delivery trucks is available in Davis and Figliozzi (2013).

4. Light rail freight and cargo trams in Europe

Transportation companies in the EU and around the world are trying to combine economic sustainability with finding green solutions for transport. One way of doing this is to apply transport efficiency, a set of measures to utilise resources to move goods with the aim to minimize externalities. One resource efficient way to move goods is by using tram systems with or without electronically driven vehicles. This paper will investigate the issue from a European perspective. One could argue that this type of transport system could have a broad applicability in Europe, as carrying goods on rail (train) in Europe has its roots from the 19th century. The current known tram examples include Dresden which now has a regular Cargo tram service run by the world's longest train sets, 59.4 meters. Cities of Vienna and Zürich are using cargo trams as freight transport and mobile depots for recycling used goods respectively. Amsterdam has developed this concept the furthest in the group, regarding the applicability of trams as freight movers, including a wide variety of consumer goods and the sheer economic size of the project is well exceeding the economic size of the other three projects combined. That is the main reason why Amsterdam was chosen as case in this study, even though it was never fully operational. Furthermore, the authors try an unconventional approach to gain insight into possible future success by analysing a failure. In the following sections a short description of three projects precedes the results from the analysis of the Amsterdam case. Strengths and weaknesses of the experiences from these cities will help in the development of a feasible concept and possibly a more sustainable implementation in the future.

4.1 Dresden – Volkswagen project

Volkswagen opened an eye catching transparent factory in the city centre of Dresden in 2002. A prerequisite of the Dresden municipality, as the city centre is small and particularly sensitive to heavy trucks, was to seek another solution of the goods flow (P Hendriks, 2010). Volkswagen together with Transportation Services of Dresden came up with an idea to utilize cargo trams. At the new factory access to a local tram line was possible as well as for the distribution centre four km away, this made the cost for additional infrastructure low with only short connection tracks needed. The project with the Cargo Trams started in Dresden on 16 November 2000 and made its first test run in January, 2001.

The trains run every hour on a fixed route that is five km long (frequency can be increased to every 40 min). It takes approximately 15 min for each trip and the cargo is unloaded in 20 min by forklifts at the factory. The public transport provider in Dresden (DVB) system of operations is controlling all public trams and the Cargo trams take advantage of gaps in the regular schedule of the passenger trams. One trip of the ‘CarGoTram’ eliminates three truck rides through the city center. The project ‘CarGoTram’ is unique in Germany (Civitas, 2005). Every day the trams transport the equivalent of 60 trucks to the Volkswagen factory. The 60 m long tram can carry 214 m3 or 60 tons each (DVB, 2013). Over the year this is the same as 200 000 km by road, according to Volkswagen AG’s own calculations. The environmental impact is accordingly reduced drastically.

The CarGoTram have been successful since the start in 2000 but it is a purpose-built project with very specific conditions, the project facilitates one customer on one route only at this point. DVB is looking for further applications for their cargo trams; one is to serve a newly built city center shopping mall with over a hundred stores (PTUA, 2008).

4.2 Vienna – ‘GüterBim’ project.

The project considered as a modern solution to urban logistics for transporting goods within the city using the existing rail network, ‘GüterBim’, examined the basic infrastructure required for operating a cargo tram in Vienna. The aim was to use the existing, well developed public transport network to switch goods traffic from the roads to rail (Fochler, 2005; Ehrlich, 2005). The project investigated potential applications, e.g. hospitals, shops and waste disposal, and a pilot operation on a selected route. In August 2004, the project started and was implemented in the context of a demonstration event in August 2005.

Moreover, in 2005, possible combination of rail and tram freight transport (container transshipment) was tested, in order to introduce a rail bound city logistics solution for densely populated areas. The municipal public transport operator of Vienna carried out freight transport for its own internal purposes. The 'GüterBim' transports spare parts between the main workshop and its satellites. These initial demonstrations across the city of Vienna in 2005 had the intention of exploring options for further traffic applications, and study the needs for designing a feasible telematics system under an open interoperable based platform for logistics, order, and operational control.

In 2004, representing the government, the Austrian Ministry of Transport, Innovation and Technology proposed a joint-venture called 'GüterBim', composed by key players, such as, the Wiener Linien, the railway undertaking Wiener Lokalbahnen (WLB) and the two consulting companies TINA Vienna Transport Strategies and Vienna Consult, to carry out the respective research, and subsequently led the project team to develop follow-up projects (Fochler, 2005). Tests have been performed within the supply chain of different retail companies, to find low-cost solutions for a reliable delivery of their stores and sales points in the City of Vienna, for instance, developing techniques for fast handling.

4.3 Zurich project

The Cargo tram in Zurich is a project that took only a few months to be converted into a pilot after its conception. It was the CEO of "Entsorgung und Recycling Zürich" ERZ (municipal public waste disposal and recycling company Zurich), Mr. Gottfried Neuhold, who initiated the project in April 2003. Along with its future implementation on a daily operating basis, starting with four stops, and by 2004 extending them to eight. The initial approach was to collect bulky waste from households along the city´s outskirts, near the trams' turn around points. Afterwards in 2005, the collection of disposal electronic home and industrial equipment followed. According to Neuhold (2005), the way Cargo tram started to operate was based upon the collection of waste in two standard refuse containers, but the normal containers turned out to have an insufficient capacity for bulky goods. Therefore, a new container was developed, incorporated with a press for bulky goods, which in turn were carried on flat wagons, pulled by a converted tram.

ERZ jointly with the tram company VBZ used the actual infrastructure and the surplus tram units. They started by investing 32.000 Euros, in order to convert old trams and wagons into a functional unit, by adding standard parts. Zurich has a broad tram network serving the majority of the city areas. There are also many sidings not used by regular services which could be suitable. An equivalent road vehicle would have been harder to purchase due to initial funding and environmental constraints (proaktiva.ch, 2005). By strictly following the pre-condition of the system, which is neither disturbing nor slowing down the public transport for passengers, the Cargo tram serves, nowadays, nine different tram stations in the city area of Zurich. Hence, the positioning of Cargo tram is at those stations where additional tracks already exist, mostly turning points at the end of a tram line, where residents can leave bulky items for free. It has been estimated that collecting the same amount of waste by road transport equals 5 020 kilometers covered by lorries (which need about three times longer to move across the heavily congested city during peak hours) which in turn equals 960 running-time hours, (Neuhold, 2005). According to these calculations, the solution of disposing waste by Cargo tram has achieved a reduction of 37 500 liters of diesel annually, thus, avoiding equivalent emissions of harmful substances. In short, Cargo tram not only makes a contribution towards reducing traffic congestion, traffic pollution and noise, it also provides a valuable service to Zurich' residents, offering a low cost service, but faster, moving commodities of low or null intrinsic value that commonly is not time sensitive.

5. Amsterdam case study

5.1 Amsterdam – City Cargo project interviews

The Amsterdam City cargo tram project is by far the biggest of the four investigated projects. The following Amsterdam section is based on a literature review as well as five interviews in Holland and two phone interviews. For the presentation of interviews we used the method suggested in Gonzalez-Feliu and Morana (2010) and Morana and Gonzalez-Feliu (2010), please see Table 1. All the interviewees were approach through LinkedIn, except Willy Nicklasson who was identified by reading the WSP (2008) report. A visit to Amsterdam and Utrecht was made in 2010 to conduct the interviews. The interviews were semi-structured, recorded and later transcribed.

Name	**Post**	**Entity**	**Type of interview**
Willy Nicklasson (2009-06-12)	Technical Manager	Gothenburg Tram Company	Phone interview
Peter Hendriks (2010-01-15)	CEO	Cargo tram	Recorded semi-structured face to face over lunch
Michael Hendriks (2010-01-19)	Financial Manager	Cargo Tram	Recorded semi-structured face to face over breakfast
Jan Dijstelbloem (2010-01-18)	Municipality Project Manager	Amsterdam Municipality	Recorded semi-structures face to face
Jupijn Haffmans (2010-01-18)	Public affairs	Cargo Tram	Recorded semi-structured face to face over lunch
Stefan Saalmink (2010-01-18)	Former project leader MindsinMotion.net	Utrecht	Recorded semi-structured face to face over dinner
Annick Driessen (2010-05-05)	Writer, MindsinMotion.net	Gothenburg	Phone interview

Table 1: Presentation of conducted interviews

5.2 Description of the city center

As for many European cities the construction of the city centre with its narrow streets during the seventeenth century did not provide a favourable situation for the modern day vehicles. At the start of the twentieth century the city was adapted to the needs of motor vehicles by filling in many canals of the city. However during the process major canals still remained intact. All administrative officials in all cities in the Netherlands follow the same agenda in formulating development plans for a city; pollution and noise caused by the traffic ought to be reduced, traffic safety ought to increase and quality of space available for general public ought to be enhanced. This emphasizes the need to develop measures in order to reduce traffic congestions and reduce the effect of cargo transport on the environment.

5.3 Process

Cargo trams in Amsterdam were expected to start their operations in 2008. The rationale of these trams was to shift the traffic load from trucks on the road to the trams for distribution of goods among the various stores and restaurants in the city. Also the restrictions on truck access would present an opportunity for an implementation of the cargo tram operations. The trams would provide service from the distribution centers to the central parts of Amsterdam to reduce traffic load on the roads and would help improve the environmental aspects of the city transport. The door to door service could be maintained by the carrying of goods the last mile through the use of EDVs. According to Valkering (2009), the project was met by opposition from some residents who lived on a square (Cornelis Troostplein) that was planned to become a reloading point; however, this information is from an unconfirmed source. In the month of March 2007 the test phase of this project included running of the cargo trams without loads from Osdrop to central Amsterdam. The trams used for this test phase belonged to GVB trams and after this test phase the trams were planned to be running with goods (Technisch Weekblad, 2007; P Hendriks interview, 2010).

Amsterdam's project regarding the Cargo trams became a reality with the accomplishment of the test phase as it was carried out in March 2007. During this test phase the trams ran without goods but from 19th March, they were supposed to run with cargoes from De Aker to the city. Cargoes included Heineken beer for pubs in the city and clothing for the Mexx store. During the last week of the phase waste paper was also carried in the opposite direction. (Cargotrams Yahoo group, 2007)

According to M Hendriks, the city council of Amsterdam allowed City Cargo to carry out trial operations whereas the full scale operations were expected to start in 2012. The trams were responsible for delivering goods to the city business companies. These cargo tram operations were restricted to the lines which have enough capacity to avoid problems with passenger trams. The operations were also limited within the time frame of 07:00-23:00 to avoid noise disturbances during the night. This project could result in the reduction of 2 500 lorry movements within the city per year and the particle pollution in the air by 15 percent according to calculations made by the company. The trams used for these initial trials belong to GVB trams whereas in the later stages of the project City Cargo would use its own designs (M Hendriks, 2010), also in interview by local newsfeed in 2006 (Nieuwsuitamsterdam.nl, 2006). The economics of the operations were calculated to save almost 15 percent compared to a conventional set up with trucks (Haffmans interview, 2010).

5.4 Operations

According to a press release of Amsterdam tourist information dated 17 July, 2007, a joint venture of City Cargo BV with Amsterdam municipality, signing a 10 year contract to launch a cargo transport project employing freight trams running on the existing tram tracks used for public transport. According to P Hendriks (2010), ten cargo tram units were planned to start working by mid 2008. To ensure that the freight trams did not disrupt or alter the existing passenger tram schedule, a pilot was tested in March.

Jupijn Haffmans, City Cargo spokesman told the press after the test that this was the municipality's main concern and they demonstrated that by using 'follow mode' with the passenger trams, hindering the existing passenger tram schedule could be avoided. The 'follow mode' could easily be performed since the cargo trams did not have to stop to pick up passengers. The contract requires close collaboration between Amsterdam tram company GVB and City Cargo which uses GVB's schedule to establish when and where they can operate. As central Amsterdam is still reminiscent of its medieval times having only narrow streets and canals, the municipality allows heavy vehicles only between the hours of 7:00-11:00 hence stores and businesses are in need of a quicker and efficient supply system (M Hendricks interview, 2010). Haffmans (interview, 2010) also highlighted the future plans of expansion, City Cargo did aim to increase its number of trams from ten to fifty in the next four years. This was expected to half the daily truck load in the inner city.

The project would have employed a system of a number of strategically located distribution centers or cross docks situated in western suburbs near Schiphol airport. Therefore the inbound goods arriving at Schiphol airport could also be transported onboard the freight trams. At cross dock locations goods would be transferred from trucks to trams, after being sorted in the delivery area, and transported to inner city transhipment hubs.

Sophisticated networks of electric distribution vehicles were to deliver the goods to their final destination. Although the cargo trams took fifteen minutes extra compared to direct transport trucks, the City Cargo claimed that it cuts the cost by fifteen percent (P Hendriks interview, 2010) and accordingly being significantly more useful for small businesses like restaurants and boutiques.

Peter van der Sterre, policy consultant of EVO, a Dutch organization of companies dealing with cargo transport, as part of their core business acknowledged and appreciated City Cargo's initiative and its usefulness to small companies but at the same time pointed out the limitation of its use for larger companies like supermarkets. EVO, have lent only conditional support to City Cargo so as to make sure those companies are not forced into using the tram system and still have the freedom to choose between the two.

Meanwhile, Haffmans unfazed by Peter Van Der Sterre's cautious approach told the media that City Cargo has received encouraging feedback from around the world. Tokyo and San Francisco showed an interest in addition to many European states like the Netherlands and Germany, to mention a few. He also stressed the need of expanding the tram network to all the metropolitan areas of Amsterdam in order to be truly successful. While for smaller cities like Utrecht or Rotterdam a single company may be enough. He went on to quote the examples of some other European cities employing the cargo trams, like Dresden (Driessen, 2007; Haffmans interview, 2010).

After the successful trial, the company faced a problem with financial stability. The company board admitted they were not yet stable. As Peter Hendricks pointed out "almost no company is profitable from the start", similarly City Cargo would have needed at least three years to be profitable according to Hendricks. According to Driessen (2007) and Dijstelbloem (2010), the municipality gave the City Cargo a three weeks' notice to come up with a bank guarantee in November 2008. Having failed to meet the 1st December deadline, City Cargo was declared bankrupt.

6. Analysis of case study – reasons for failure

Quite a lot of research point to success stories of innovative transport solutions (van der Straten *et al.*, 2007; Wiegmans *et al.*, 2007) but few researchers focus on providing insight into possible future success by analyzing failures (Wiegmans *et al.*, 2010). With this in mind, the people at Cargo Tram identified two reasons for failure; inability to acquire adequate finance for investments and politics. Cargo Tram, through Peter and Michael Hendriks, focused on receiving finance from major banks. The timing with the financial crisis was, to put it mildly, not working in favour of the project. Furthermore, the banks would much rather invest in bigger projects according to Mr P Hendriks, thus one of the reasons for the project not starting out small scale and then scaling up. The business plan estimated the project costs to 70 million Euros, ten percent of this amount was Peter's private money (M Hendriks interview, 2010). The investment included trams, EDVs, new infrastructure, tracks and distribution center.

Others additionally identified a lack of understanding between Alderman Marijke Vos[2] and Peter Hendricks, two people at the opposite ends of the political spectrum. It was ‘unfortunate’ that Mr Hendriks went to the meetings with Mrs Vos in a big car with a personal driver, while Mrs Vos herself chose the bicycle.

The municipality, through Jan Dijstelbloem, identified finance as the main reason for failure, the lack of finance led up to the bankruptcy of this start up at the end of 2008. Up to the end of 2008 the municipality, through Aldermen, had helped Cargo tram by allocating a project group working with the company as well as fast tracking many of the necessary adjustments and changes in regulations, all in all, much more than normally provided for a new private company. City Cargo was amongst the projects the City embraced. One of the things the City did was extending the concession from the usual six years to ten years to give the company more time to become profitable. In addition, the municipality seriously considered the question of City Cargo to financially partake in the project. In the end the City made a proposal for City Cargo in what way the City would participate (financially) in the project. This proposition was never realised as City Cargo went bankrupt during these discussions (Dijstelbloem interview, 2010).

This was one of the reasons for the city refusing to contribute to the construction of extra tracks that were going to be needed. The city administration was interested in the project without including any additional subsidy. On the other hand, according to Mr Hendriks, City Cargo had already collected 69 million Euros from various companies like Nuon and Rabobank and had asked the city administration for a contribution of 6 million Euros for the construction of extra tracks (Dutchnews.nl and Railway Gazette, 2008).

The cargo trams use the passenger tram lines for transport and the no longer used tramways, called ‘dead tracks’, were used as parking lanes and loading and unloading bays. Being electrically run they have the added advantage of low carbon emissions and replacing the trucks on the roads and reducing the city congestion, especially at the motorways to and from the city. The City council also admits to this benefit, pursuing a policy of adopting measures to reduce air pollution (Dijstelbloem interview, 2010). Dijstelbloem stressed that the municipality took this project onboard and really supported the company with an extended concession mentioned above and the support of a project group to help City Cargo in all their affairs with the municipality.

The company director Peter Hendriks revealed that the municipal transport company GVB has objected to the use of dead tracks by City Cargo. The GVB claimed these tracks to be ‘calamity tracks’ and therefore could not be provided to City Cargo (P Hendriks interview, 2010). He continued by stating that this meant that City Cargo had to build its own parking track which is an expensive ordeal with a cost around one million Euros per kilometre, *ibid* (2010). The extra tracks were difficult to finance for City Cargo since, by law, all tracks being built were owned by the municipality and a privatization of the trams or its tracks was not on the agenda at this point.

[2] http://en.wikipedia.org/wiki/Marijke_Vos

7. Concluding discussion

We choose to summarize by presenting a table (see Table 2) with differences and similarities between the cities presented in the paper. From the table one could argue that an evident conclusion on a business model that works in all cases is quite hard to identify. Comparing the only two on-going projects at the moment one comes to the conclusion that starting small seems to be the only common denominator between the two projects. But the sample could be argued to be too small and the context, e.g. size of city and logistics character, is different from case to case making it difficult to compare the different cities. What can be derived from the cases however is a set of barriers for implementation and this will be the focus of the reminder of this conclusion.

City **Key factors**	**Amsterdam**	**Dresden**	**Wien**	**Zurich**
Project owner	Private (City cargo)	Private (VW)	Municipality/Private	Municipality
Funding	Banks/private	VW	Municipality	Municipality
Size of project	Large	Medium	Small demonstration	Small
Type of goods	Commercial, parcels etc	Automotive parts	Commercial, mainly retail	Electronic waste
Type of customers	Commercial	Private (VW)	Commercial/public	Public
Logistics character	Logistic service provider	Internal logistics	Commercial/recycling logistics	Recycling logistics
Infrastructure investments	Large	Small	Small	Small
Current status	On hold, bankrupt late 2008	Ongoing	On hold	Ongoing

Table 2 – Cargo tram projects in Europe

Barriers identified other than scale, are not to interfere with personal traffic (all), high initial investments (Amsterdam, Dresden), limitations in battery technology (Amsterdam), resistance to try something not tried before (initially all), number of actors cooperating (Amsterdam). It is important to repeat that the two identified reasons for failure of the Amsterdam project were: inability to acquire adequate finance for investments (supported from interviews by both Cargo Tram and the municipality) and, to a lesser extent, politics (supported only by Cargo Tram). The barriers is summarised in five categories in the following paragraphs.

Perhaps the most important feature of a concept that utilizes public transport for freight, as learnt from Amsterdam; is not to interfere too much with the daily city picture of urban space and life – **Barrier 1: not interfere with personal traffic**. According to Zunder (2004) trucks produce over 40 percent of pollution (congestion) and noise in cities although only accounting for 10 percent of operations in urban areas. It could be of interest to investigate what the reasons behind this congestion are and how much of the truck's contribution to congestion can be deduced from size? Furthermore, how would a decrease in size and increase in numbers of distribution vehicles effect congestion, if smaller vehicles were used the last mile?

Building add-ons, or sidings, to tracks for loading and unloading in the city center are very costly as learnt from Amsterdam, according to Peter Hendriks, one million Euros per kilometer. Partly, also one reason to why City Cargo started filing for bankruptcy in the end of 2008, see section on Amsterdam. The funding of the project was estimated at an impressive 70 million Euros, not a small scale endeavor – **Barrier 2: scale**. Cost calculations for any type of set up need to be conducted before any new projects are considered. The business model for the Amsterdam operations were calculated to save almost 15 percent on an operational basis compared to a conventional set up with trucks according to Haffmans interview, (2010). Unfortunately the authors of this paper did not get the opportunity to have a look at these numbers. The "15 percent" is thus secondary information. For future cost calculations it is important not to compare apples with oranges. Tram costs are normally higher than truck cost when one considers distance. Tram and truck costs are usually calculated in cost/km but for a city distribution scenario one of the advantages of an all day delivery tram is to partly avoid the busy hours in the morning and in the afternoon, which a delivery truck does not since it usually makes one round trip per day3. However, trials with night deliveries with trucks are becoming increasingly popular. It is therefore suggested that both cost for trucks and trams are calculated in hours rather than kilometers. Also, the cost for trams is divided on a set of 2-3 wagons and that some of the variable costs, if one tram is used for delivery, ought to be adjusted accordingly. Furthermore, if old trams are used this means that the total tram park can be utilized for a longer period of time and thus affecting the depreciation, which has to be accounted for.

"An electric car had of necessity to be limited in radius..." (Ford, 1922). Solutions to this 'range anxiety' that some users of electric vehicles feel is put forward by Kley et al. (2011) – **Barrier 3: radius of action.** An electric vehicle has more than three times lower environmental impact compared to a diesel truck and twice as low impact compared to an LPG truck according to Van Mierlo *et al.* (2003). But it is important to point out the importance of where the line is drawn in the analysis, whether a well-to-wheel or a tank-to-wheel analysis is used. For instance, the production process of an electric car and its battery is far more carbon intensive than the manufacturing of a combustion engine car, according to Zehner (2012).

From the interviews some agreement was received, but not from all, on a potential opposition from the other logistics competitors of the new, now bankrupt, company: City Cargo. The transportation industry is argued, for example, by Behrends *et al.* (2008), to be particularly resistant to change. In a report on Intermodal City Distribution from WSP (2008) a great concern was the lack of interest and motivation among the stakeholders. The Dutch UFT project also experienced the same reluctance from the freight transport industry (Wiegmans *et al.*, 2010). – **Barrier 4: conflicting objectives amongst stakeholders**.

The number of actors involved in the decision process is greater in light rail freight than traditional freight by truck set-up, thus making the implementation and cost-benefit division amongst the actors more complex. Unfortunately, excerpts from conducted interviews with the logistics industry in general do portray a similar picture. Phrases like "we were forced to cooperate" have been recorded – **Barrier 5: stakeholder involvement**.

To conclude the paper we present an outlook for a project that would refine and develop some of the interesting work already done concerning the use of light rail for urban freight movement (see Box 1 below). In the outlook we consider whether there may be an opportunity to test a novel concept to combine the use of small electric vehicles delivered to the city centre by means of a tram system. To

[3] Interviews with Schenker and DHL

provide a clear spatial focus we consider the possibility to apply this trial in Gothenburg and draw on the results from Amsterdam due to its close realization of implementation, business orientation and because of these two cities many historical, geographical and political similarities is presented. The barriers and obstacles are manifold and the success of a cargo tram project is uncertain. However, the authors of this paper are optimistic about the scope to try a small scale test, for the simple reason that it has never been tried out commercially before. Potentially, the world leading truck manufacturers like Volvo and Scania would see the concept as a challenge and try similar approaches substituting the tram with a truck or trolleybus?

Box 1 Outlook –A truly intermodal solution that might break down some barriers?

Some do claim that one part of research is to investigate and compare projects and concepts and see if it is possible to learn from potential mistakes or change some of the parameters in order to acquire a different result? In the following outlook we will therefore try to do this in the case of Cargo Tram moved to a new setting. One might ask why Gothenburg is chosen as a possible arena for future implementation, apart from being the hometown of one of the authors. The city of Gothenburg is almost the same size as Amsterdam, according to Wikipedia, 530 thousand inhabitants versus 820 thousand. Gothenburg city is with its 450 km2 bigger than Amsterdam, 219 km2. A coincidental fact is that the city was heavily influenced by the Dutch. Dutch city planners had the necessary skills to build in the marshy areas around the city and were contracted to build the city to have canals, using Amsterdam as a blue print, according to Henriksson and Älveby (1994). The tram system in Gothenburg is extensive covering an area of 3 700 km2 (Amsterdam 1 800 km2) and dates back to 1879. One could argue that the tram is synonymous with Gothenburg but also with its culture. Many of the tram tracks in Gothenburg are integrated with the street at the same level as the tracks, unlike for instance train tracks. This would facilitate the RoRo technique presented in the next section.

Willy Nicklasson (2009), a technical manager at the Gothenburg tram company, revealed that a great number of old tram models but fully functional trams, known as M28 and M29, are available to a fraction of the price for a new tram. M28 and M29, are high floor trams, which makes it harder for older people to board than the newer drop center design. But on the other hand the floor is flat on the inside allowing for up to three electric distribution vehicles no wider than 2 600 mm to fit. And as identified from Amsterdam, the cost of the trams together with the cost of new infrastructure, tracks and a distribution center, are by far the most expensive investments in a cargo tram project. The low cost of trams would support a low cost and small-scale approach.

Using the lessons learnt from the failure of Amsterdam we arrive at a potential future transport system for Gothenburg that would be suitable for smaller shipments, like parcels. This transport system borrows techniques from three industries; the shipping industry, the train industry, and the car industry. RoRo, intermodality, and the assembly line technique, respectively:

Barriers 1: not interfere with personal traffic. In order to minimize the building of sidings and maximize the use of existing infrastructure the EDVs could catch a ride, 'piggy-back', on a rebuilt tram from the tram end point into the cities, rather than waiting in the city centre and thus avoiding the costly operation of re-loading from tram to EDVs. Allowing for these EDVs to drive onto the trams via a ramp in the back would also mean that they are not obstructing traffic on the motorways to and from the city and by using 'follow mode' (see the Amsterdam section) avoids the risk of obstructing the personal tram traffic. By using a rebuilt distribution wagon, type M28 or M29, in 'follow mode' the time for rolling off and rolling on (RoRo) the trams in the city centre and at the tram end stations would be the time between the existing trams in the system, varying between twelve to twenty minutes depending on route and time of day (Nicklasson. 2009). This would also mean no necessary investments in infrastructure. So, why did Amsterdam not consider this method? The trams in Amsterdam are quite narrow because of the narrow streets of the city. They are about thirty centimeters more narrow than in Gothenburg, and the design of the trams is not suited for a roll on and roll off setup. The old versions have a drop center design meaning that the middle wagon is lower than the other two and the new ones are built for accommodating disabled people with low entrance possibilities throughout the entire tram, requiring the wheels to be built in and sticking up in the compartment. Thus making it impractical to drive EDVs on and off without a complete rebuild of the tram. The floor of a M28/M29 on the other hand is flat from the back to the front and fifteen meters long but would need to be reinforced in between the wheel houses.

Barrier 2: scale is potentially the most important lesson from the failure of the Amsterdam case; to try this concept in a more small scale fashion, allowing for test and necessary changes before a possible scale up. Lessons learnt from Dresden and Zurich, the only ongoing projects at the moment, it seems sound to start small scale and gradually scale up. Furthermore, a test could be carried out for a limited time period with normal express diesel or renewable fuel vehicles commonly used today, like MB Sprinter, instead of EDVs. This could be an inexpensive way of trying out the concept in a real life situation before investing large amounts of money on EDVs.

The system could benefit from the use of the assembly line technique, separating the driver from the goods. The drivers of the EDVs could circulate in the city center delivering goods and adding value and let the tram transport the EDVs back and forth from the distribution center to the city center. The same idea of separating the driver from the goods has been used in intermodal transportation, where it is not always necessary for the truck driver to partake on e.g. the ship journey. The driver simply parks the truck on the ship, picks up a new one going the other way, and another driver assumes the transport at the ship destination. By keeping driverless EDVs on the tram into the city center facilitates the charging of batteries inside the tram on the way to the city center, thus resolving **Barrier 3: radius of action**. This could potentially lower the costs since an extra handling of the goods at the city center could be avoided. This is a cost issue, but also a social issue since there were indications that inhabitants around one of the squares in Amsterdam were against their square turning into a logistics center. It would also make the distribution a team effort rather than an individual endeavor.

Rather than creating a new competitor and in order to increase the chances of the recommendations to be implemented in Gothenburg by decreasing initial investments and to tackle **Barrier 4: conflicting objectives amongst stakeholders**, the recommendations ought to be presented to the already existing distribution companies, as well as the municipality and tram operator after a thorough cost-benefit analysis has been made. By doing this, additional competition in an already competitive industry as well as a, "not invented here" mentality is avoided. An "open source" mentality could be preferable until falsified.

Unfortunately, there might be no other way of resolving **Barrier 5: stakeholder involvement** other than to call for an increase in cooperation between the logistical actors, municipality and the Gothenburg tram company.

8. Acknowledgements

We would like to thank the students Fawad Awais, Patric Lindquist and Rafael Serrado for their valuable input in the creation of this paper, Mentors4research for their financial support, and finally the editors of this special issue and the two anonymous reviewers for the valuable comments and recommendations.

9. References

Alessandrini, A., Delle Site, P., Filippi, F., Salucci, M.V. (2012) "Using rail to make urban freight distribution more sustainable", *European Transport - Trasporti Europei*, 50, pp. 1-17

Behrends, S., Lindholm, M., Woxenius, J. (2008) "The impact of urban freight transport: a definition of sustainability from an actor's perspective", *Transportation Planning and Technology*, 31 (6), pp. 693-713.

Bliss, D. (2000) "Mail Rail: 70 Years of Automated Underground Freight Transport", Compass Logistics Ltd, 2nd International Symposium on Underground Freight Transportation by Capsule Pipelines and Other Tube/Tunnel Systems: September 28-29, Delft, The Netherlands.

Browne, M., Allen, J. and Leonardi, J. (2011) "Evaluating the use of an urban consolidation centre and electric vehicles in central London", *IATSS Research*, 35 (1), pp. 1-6.

Civitas (2005) "Cleaner and better transport in cities", EU funded initiative, Available at: http://www.civitas-initiative.org/docs1/CIVITAS_Award_2005_nondemonstration_city_Dresden.pdf

Com 144 Final (2011) "White paper - Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system", EUROPEAN COMMISSION, Brussels.

Davis, B. A., Figliozzi, M. A. (2013) "A methodology to evaluate the competitiveness of electric delivery trucks", *Transportation Research Part E: Logistics and Transportation Review*, 49, pp. 8-23.

Delaître, L., De Barbeyrac, C. (2012) Improving an Urban Distribution Centre, the French Case of Samada Monoprix, Procedia - Social and Behavioral Sciences, 39, pp. 753-769.

DHL (2009) "DELIVERING TOMORROW Customer Needs in 2020 and Beyond", A Global Delphi Study

DfT (2004) "Road freight transport survey 2004"; central statistics office (CSO); www.rws.avv.nl/goederenvervoer2003/index)

Driessen, A., (2007) "Amsterdam cargo tram in desperation" Amsterdam News, July 9, DPA

Dutchnews.nl (2008) "Amsterdam cargo tram in doubt", Newslog, Available at: http://www.dutchnews.nl/news/archives/2008/09/amsterdam_cargo_tram_in_doubt.php

DVB (2013) "CarGo Tram", Facts and figures, Homepage, Available at: http://www.dvb.de/en/The-DVB-AG/Facts-and-Figures/CarGoTram/

Ehrler, V. & Hebes, P. (2012) "Electromobility for City Logistics–The Solution to Urban Transport Collapse? An Analysis Beyond Theory". *Procedia - Social and Behavioral Sciences*, 48, pp. 786-795.

Ehrlich (2005) "'Güterbim': Vienna's cargo tram attempt (AT)", fact sheet, Wiener Linien, file://localhost/Available at/ http/::www.umwelt.nrw.de:umwelt:pdf:pronet:factsheets:41.pdf

ELCIDIS (2002) "Electric Vehicle City Distribution", FINAL REPORT, European Commission

Fochler (2005) "Project GuterBim", TINA Vienna, Report, Avaialble at: http://www.eurailtelematics.com/fileadmin/eurailtelematics.com/abstracts/2_10.pdf

Ford, H. (1922) *My Life and Work*, The Project Gutenberg EBook

GAO (2011) SURFACE FREIGHT TRANSPORTATION - A Comparison of the Costs of Road, Rail, and Waterways Freight Shipments That Are Not Passed on to Consumers Report to the Subcommittee on Select Revenue Measures, Committee on Ways and Means, House of Representatives, United States Government Accountability Office, Report, pp. 1-61.

Genta, S; Marangon, F; Messina, M G; Valentini, M P. (2006) "TADIRAM project: Organizational and technical proposals for Freight Distribution in the Sustainable City", co-funded by the Italian Ministry of Research. Available at: http://stuff.mit.edu/afs/athena/course/11/11.951/OldFiles/oldstuff/albacete/Other_Documents/Europe Transport Conference/freight_and_logistics/tadiram_project_or1584.html

Gonzalez-Feliu, J., Morana, J. (2010) "Are City Logistics Solutions Sustainable?" The Cityporto case. *TeMA. Journal of Land Use, Mobility and Environment*, 3 (2), pp. 55-64.

Henriksson, D., Älveby, R. (1994) *Vårt Levebröd - Göteborgregionens näringsliv Igår, I dag och I morgon*. Publisher: Akademiförlaget. Page 5.

Kikuta, J., Ito, T., Tomiyama, I., Yamamoto, S. & Yamada, T. (2012), "New Subway-Integrated City Logistics System", *Procedia - Social and Behavioral Sciences,* 39, 476-489.

Kley, F., Lerch, L., Dallinger, D. (2011) New business models for electric cars—A holistic approach, Energy Policy, 39, pp. 3392-3403.

Lesser, K. (2009) "No Stopping the Gravy Train of Car Support?", *World Transport Policy & Practice*, 15 (1), pp 6-8

Macharis, C., Van Mierlo, J., Van Den Bossche, P. (2007) "Combining Intermodal Transport With Electric Vehicles: Towards More Sustainable Solutions", *Transportation Planning and Technology*, 30 (2), pp. 311-323.

Marinov, M., Mortimer, P., Zunder, T., Islam, D.M.Z. (2011) Short haul rail freight services, Journal of Transport Literature 5 (4), pp. 136-153.

Morana, J., Gonzalez-Feliu, J. (2010) "Sustainable supply chain management in city logistics solutions: an experience's comeback from Cityporto Padua (Italy)". In Proceedings of the 3rd International Conference on Information Systems, Logistics and Supply Chain, April 14-16, 2010, Casablanca (Moroco), BPC, Rabat, Moroco.

Mortimer, P. (2008) "Bestufs UK paper – Urban freight and the use of rail", BESTUFS, UK Seminar 2008, New rail. Available at: http://www.bestufs.net/download/BESTUFS_II/national_seminar/2008-04-21_uk/BESTUFS_UK_Seminar_2008_Phil_Mortimer.pdf

Neuhold, G. (2005), Cargo Tram Zurich. The environmental savings of using other modes. First Bestufs II Conference, Amsterdam, June 23-24. Available at: http://www.bestufs.net/download/conferences/Amsterdam_Jun05/BESTUFS_Amsterdam_June05_Neuhold_ERZ.pdf

Nieuwsuitamsterdam (2006) "Snel proef met goederentram", Local based newsfeed, Available at: http://www.nieuwsuitamsterdam.nl/2006/061124_goederentram.htm

Ooishi R, Taniguchi E. (1999) "Effects and profitability of constructing the new underground freight transport system". In: Taniguchi E, Thompson RG, editors. City logistics I, Institute of Systems Science Research; 1999, Kyoto, 303-316.

Pielage, B-J. (2001) "Underground Freight Transportation. A new development for automated freight transportation systems in the Netherlands", Proceedings from the Intelligent Transportation Systems IEEE 25-29 Aug, Oakland, CA.

Priemus, H; Konings, R. (2001) "Light rail in urban regions: what Dutch policymakers could learn from experience in France", Germany and Japan, *Journal of Transport Geography*, 9 (3), pp. 187-198.

Proaktiva (2005), Unofficial webpage of Zurich Trams, Webpage, available at: http://www.proaktiva.ch/tram/zurich/cargotram.html

PTUA (2008) "On the East West Link Needs Assessment", Submission to the Victorian Government, Public Transport Users Association, Available at: http://www.ptua.org.au/files/2008/PTUA_EWLNA_submission_20080715.pdf

Smiler, S (2001) "Trams, Streetcars and Light Rail Vehicles", Webpage, Available at: http://citytransport.info/Trams02.htm

Stern, N. (2006) “Short Executive Summary. Stern Review Report on the Economics of Climate Change, pre-publication edition.” HM Treasury. Available at: http://www.hm-treasury.gov.uk/d/CLOSED_SHORT_executive_summary.pdf.

Straten, P., van der Schelling, A. and Wiegmans, B.W. (2007) “Enablers and barriers for adoption of alternatively powered buses”, *Transport Reviews*, 27 (6), pp. 679-698.

Valkering, R., (2009) “Comment on the World Changing forum”, internet forum, post available at: http://www.worldchanging.com/archives/009513.html

Van Mierlo, J., Maggetto, G., Vereecken, L., Favrel, V., Meyer, S. & Hecq, W. (2003) “Comparison of the environmental damage caused by vehicles with different alternative fuels and drive trains in a Brussels context”, In: Proceedings of the Institution of Mechanical Engineers Part D _ Journal of Automobile Engineering, I MECH E, SAE and IEE, issn 0954-4070, 2003, 217 (7), pp. 583-593.

Wiegmans, B.W., Hekkert, M. and Langstraat, M. (2007) “Can innovations in rail freight transhipment be successful?”, *Transport Reviews*, 27 (1), pp. 103-122.

Wiegmans, B. W., Visser, J., Konings, R. & Pielage, B. J. A. (2010) ”Review of underground logistic systems in the Netherlands: An ex-post evaluation of barriers, enablers and spin-offs”, *European Transport - Trasporti Europei*, 45, pp. 34-49.

WSP (2008) “Intermodal stadsdistribution”, Report 2008-11-19.

Zehner, O. 2012. Green Illusions: The Dirty Secrets of Clean Energy and the Future of Environmentalism, University of Nebraska Press.

Zunder, T; Ibanez, N. (2004) “Urban freight logistics in the European Union”, *European Transport - Trasporti Europei*, 28, pp. 77-84.