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Rail Freight Systems: What Future?

Density Delusion?
Urban form and sustainable transport in Australian, Canadian and US cities

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Editorial

The two articles in this issue raise questions that are both important in themselves, and even more important in the wider context of a debate about the global transport system and its ability to deliver a transformation of historic proportions and significance. We have lived through over a century of untrammelled exploitation of fossil-fuelled mobility and its closely associated transformation of lifestyle, consumerism and aspirations so that moving around a lot is regarded as a good thing and anything questioning this good thing is automatically dismissed. The explosion in mobility (passenger and freight) has been based on cheap oil and on a deeply unethical commitment by national and local governments to support systems that propagate death and injury on the roads, kill people through air pollution and deprive the young and the old of safety and security in their own neighbourhoods. We are now at the beginning of the end of this deeply flawed system.

In this issue Marinov points out how rail freight can offer a great deal to the overdue transformation. The transport world we are striving to reinvent will be low carbon, extremely parsimonious in its use of land, highly flexible and efficient in its use of energy and contribute to the creation of safe and secure neighbourhoods by curtailing the degree to which 40 or 50 tonne lorries can populate cities, roads through villages or residential streets in the vicinity of schools. Rail has an important part to play in this transformation. This is a matter of detail but the much needed transformation will emerge from "sweating the detail" as former Mayor Giuliani of New York once said.

Paul Mees addresses a hugely important issue about the relationship between density, compact cities, use of public transport and sustainability. This has been a 20 year plus debate, more in Australia than in the UK, but has been characterised by arguments about data, causality and inference. Mees argues that the relationship between density and use of public transport is weak and based on flawed data. Other authors cited in his paper are more confident. Jeff Kenworthy, one of the proponents of the densification argument, has argued for many years that increases in density can produce significant reductions in car use and carbon emissions. Both Mees and Kenworthy argue from a shared understanding of the importance of reducing car dependency and changing behaviour towards low carbon alternatives but it would be wrong to underestimate the scale of the disagreement.

One way forward in resolving a debate of this kind is something akin to clinical trials. We should embrace a policy commitment in an Australian, US and UK city to systematically work through every geographically distinctive community or suburb or "urban village" and actually do it rather than argue about it. Doing it also means measuring, monitoring and comparing and evaluating the degree to which car use and carbon has been reduced in the intervention suburbs and remained constant or grown in the control suburbs. There are huge swathes of neglected suburbs in Manchester and Liverpool in the UK with tens of thousands of residents in each. There should be no argument at all about what should be done to advance the debate and at the same time improve the quality of life for those who live there. This would include:

- The provision of extensive, well designed, safe and secure walking and cycling routes connecting all homes to all the commonly used destinations;

- The best quality bus services that could be designed and provided at attractive fares should be provided for the same purpose;

- Every identifiable community will be provided with educational, health care, shops and other services that residents access on a regular basis;

- Rail facilities should be provided to link settlements with CBD type functions and higher order functions. All walking, cycling and public transport facilities should be thoroughly integrated with all rail services and with integrated ticketing;

- All public transport/transit services shall be organised and developed within a set of objectives and performance indicators set by public bodies. A privatised system along the lines of the UK bus and rail system is unhelpful and frustrates the wider public policy and low carbon aspirations of society;

- The quality of the public realm should be set at a much higher standard with parks, gardens, play areas, tree planting, water features and much more to create a highly attractive urban environment;

- A solid commitment to achieving zero deaths and injuries on the roads should be discussed and delivered with whatever it takes to achieve;

- Budgets around the world are still dramatically out of line with the rhetoric of sustainable transport, carbon reduction or sustainable development. Budgets should, as a matter of urgency, be realigned so that billions of dollars now disappearing into making things worse (new roads, car scrappage schemes, subsidy) can be re-routed to the re-engineering of communities so that improved access to facilities by safer, non-fossil fuel based transport becomes the norm.

It is clear that density is an important component of this transformation but equally if density is pursued in isolation as a policy objective it risks missing the point. We urgently need a new discourse as well as a new policy and that discourse must address re-engineered cities, resilient cities and zero carbon, zero death transport systems.

Finally, we need once again to emphasise that major re-engineering still has to be applied to what goes on in the heads and minds of professionals. It is clear from a recent policy announcement on transport in the European Union that the heads and minds and spirits of policy makers are still in the dark ages and resisting the inevitability of a renaissance equivalent to anything that happened in the Europe of Leonardo da Vinci.

In June this year the European Commission which is responsible for high level policy development for 27 member countries and over 300 million citizens produced its “Vision for the future of EU transport”. It was so bad that words fail your editorial team and we shall leave it to an impressive Brussels based organisation to comment on the “vision”:

Commission's 'future of transport' strategy needs a reality check says T&E

Wednesday, June 17, 2009
The European Commission has published its vision for the future of transport policy in the European Union. But the paper completely underestimates the challenges and proposes no concrete solutions, according to Transport and Environment.

Jos Dings, director of Transport and Environment said: "If this is the strategy for fixing rapidly growing pollution, congestion and accidents caused by transport, then we have a big problem: it doesn't even scratch the surface."

"Climate change, Europe's flagship environmental policy, is mentioned only in passing, despite the fact that transport is the single most important sector holding back progress."

"The International Energy Agency has recognised that conventional oil is running out and ‘unconventional’ alternatives such as tar sands will be even costlier and dirtier. But the Commission doesn't give any clue as to how it proposes to deal with this issue of fundamental strategic importance to the EU."

"The question of managing demand for transport is not mentioned, and even traffic congestion which costs the European economy EUR 120 billion every year gets little serious attention."

"The current economic climate, and the impact that will have on national infrastructure budgets and on demand for transport is not considered. Governments need lean and green transport policies now. Road pricing schemes could help plug the gap and also bring huge economic and environmental benefits. But this has also escaped the Commission's attention."

"The only positive aspect of this paper lies in the recognition that technological leadership in environmental technology will benefit the European economy, not drag it down, as has often been said in the past."

Source: European Federation for Transport and the Environment

http://www.transportenvironment.org/News/2009/6/Commissions-future-of-transport-strategy-needs-a-reality-check-says-TE/

The original European Commission document can be seen on:
http://ec.europa.eu/transport/strategies/doc/2009_future_of_transport/2009_comm_future_of_transport_policy_en.pdf
Given the lack of understanding on the part of the European Commission on what a vision could and should involve

we have produced our own vision and sent it to them today. This is it:

The World Transport Policy and Practice Vision for transport in the UK to be in place by 2050

Transport in the future will be zero carbon. The zero carbon future will provide better access for more people to more things than is currently the case. Traffic congestion and time wasted stuck in jams will be a thing of the past and time currently wasted on commuter trips will be spent on rewarding and enriching activities. All urban and rural areas will by 2050 have significantly enhanced public transport and cycling facilities bringing high quality and low cost transport choices within the reach of everyone. Those who opt not to use a car will save thousands of pounds a year by avoiding the fixed and variable costs of car ownership and use and will also avoid the uncertainties and potential disruption of oil price shocks as the world adjusts to shortages of supply and increased demand from developing countries. Individuals and families will have much improved air quality, reduced noise and stress from traffic and much improved community life stimulated by reduced levels of motorised traffic and reduced traffic on streets and through villages.

The shift to bike, foot and public transport will increase the spend of local people in local areas and will result in a renaissance of local shops and newly created jobs in local communities serving the increased level of spending locally that previously leaked out to global oil and car making sectors of the economy. Those that have given up individual car ownership will have an average of £3,000 - £4,000 each to spend on local goods and services giving a further boost to local economies.

The car will still exist and be used by those who feels it has an advantage over other choices but fuel prices will rise to cover the full costs of supporting motorisation (the polluter pays principle) and parking will be recognised as a valuable asset that must be charged for at market rates. Speeds will be limited to a maximum of 20mph/30kph in all residential areas and through villages to support the rapid take up of walking and cycling and to create high quality living environments. Speeds on motorways and dual carriageways will be limited to 60mph to reduce CO_2 emissions and to encourage the take-up of eco driving techniques. Cars will be alternatively fuelled either as plug in electric vehicles (PEVs) or hydrogen powered or hybrids of various kinds and all electric vehicles will be using electricity from a decarbonised electricity supply system based on renewable energy and micro-generation in all businesses, homes, schools and health care facilities.

Businesses of all kinds will find ways to introduce flexible working, videoconferencing, more family and child friendly working practices and will actively promote the end of the long commute. Links between businesses, businesses and customers and workers at home or in local “area offices” will be facilitated by a large number of electronic methods. Deliveries of raw materials and goods to manufacturing sites will exploit the advantages of canals, inland waterways, estuaries and the UK’s excellent network of 300 ports as well as make better use of the rail network e.g. the German “Rollende Landstrasse” where whole lorries go on trains for sections of their journeys. Lorries will operate in ways that avoid cities, avoid long trunk-haul routes on motorways and are fuelled by alternatives to diesel that significantly reduce CO_2 emissions.

More UK residents than is currently the case will take holidays within the UK and broaden the concept of tourism to include a wide range of activities that involve gaining new skills and becoming expert in a wide range of sports and leisure activities. Traditional package tourism based on flights will be much reduced in number as a result of changes in the price of oil and the clearly developed policies of the Treasury to internalise the externalities associated with flying and driving. Travel opportunities to European destinations will be available in abundance and rail dominated (including Greece and Turkey). Shipping, cruises and ferries will be an integral part of the holiday experience.

The aviation industry will still be important but no larger than in 2009 and airlines and companies owning airports will be far more profitable and successful as they diversify into all kinds of communication and mobility activities and services. There will be significant job gains across all sectors of the aviation, rail and bus industries.

The health of all citizens will improve in the zero carbon world. There will be more lively local economies making jobs available in the community. There will be more social interaction giving everyone the health generating social context of living in a supportive community. There will be less noise and air pollution with attendant health benefits and much more physical activity contributing to a reduction in rates of obesity.

The demands on public finance and spending will be reduced. There will be no need for new roads, bypasses and motorway widening at current prices approaching £25 million per mile. A healthier and more supportive population and community will reduce NHS costs e.g. the predicted £50 billion pa costs of obesity by 2050.

Local communities will be far more resilient in the sense that a larger proportion of jobs, food and other items of consumption will be sourced locally and this will reduce the risks of disruption associated with long distance sourcing, oil price disruption and vulnerability to interruption in supply as transport infrastructure succumbs to damage from extreme weather events or shortfalls in fuel availability.

Cities will change so that there is far more green space and woodland and a higher number of homes and employment opportunities than is currently the case in low density developments. Land for eco-efficient car free housing can be found on car parks that will now be surplus to requirements and the projected need for new homes can be met without taking away valuable land in rural areas that will be needed for increased food production.

Cities will be far more friendly and supportive of children and the elderly with calmer environments, reduced traffic and increased feelings of confidence and security. The shift away from the car will increase the amount of walking and cycling and the degree of mutual, friendly “surveillance” of all those using the public realm by each other. Everyone will feel safer. Children will rediscover the delights of independent mobility, the joys of getting to and from school, friends and local swimming pools under their own steam and the elderly will find it much easier to cross roads, hold conversations on the street and engage with neighbours in ways that ends social isolation and its related health damaging consequences.

Urban and rural residents alike will be happier. A much improved local environmental quality linked to higher levels of integration with local food production, an income from microgeneration, heightened involvement with neighbours and community activities and a greater feeling of security and comfort from a more resilient society will all contribute to increase happiness and to higher levels of social cohesion.

The transformation of urban and rural society into one that has shifted a rather one dimensional emphasis on economic growth to one based on community growth, growth in happiness, reduced pollution, improved health and the creation of far more jobs, jobs that are far more evenly located across every locality and far more resilient to the unpredictable shocks and challenges of a globalised economy will also bring enormous benefits to population groups and sub-groups. No groups or sub-groups are worse off in the decarbonised transport future when compared with 2009.

John Whitelegg
Editor

Abstracts & Keywords

Rail Freight Systems: What Future?

Marin Marinov & Thomas White

Today, a variety of *environmental problems* threaten our world. We are witnesses to climate changes at global level caused by environmental damages and ecological disproportions. Society has to struggle with this imminent threat quickly and efficiently otherwise the situation will soon become irreversible. On one hand, unfortunately, statistical data for CO_2 emissions in European Community over the past years show undesirable stable states characterised with a slight increase, where, among all the sectors transportation contributes to CO_2 total emissions by up to 25%. On the other hand however, freight transport continues to grow, with the largest increases being for the least energy efficient transport modes, i.e. road and air freight. Rail freight and inland waterways by contrast show a worrying decline in market share overall which is undoubtedly not a good thing. We believe that one possible way to change the trends in the transportation sector is to modernise the existing railway freight systems and then strongly encourage freight forwarders to transport by rail. This will have a direct positive effect on the greenhouse gas emissions, and hence on the environment as a whole. In this paper, a comprehensive discussion on railway freight systems and prognoses of how these systems shall evolve in the coming future is provided.

Keywords: CO_2 emissions, Freight Transportation, Railway Freight Systems

The Density Delusion?
Urban form and sustainable transport in Australian, Canadian and US cities

Dr Paul Mees

This paper re-examines the relationship between population density and transport mode choice, taking another look at the ideas that have come to be known as the 'compact city'. It begins by reviewing the origins of the view that density determines mode choice, and that viable public transport cannot be provided below a density threshold variously estimated at 30 to 100 persons per hectare. The claim has been widely made, but an examination of the alleged basis reveals multiple layers of citation ultimately deriving from a single source, the Chicago Area Transportation Study 1956. The CATS analysis erroneously attributed poor suburban public transport to low densities, when the real causes were failures of planning and policy. The paper then reviews the more recent data provided by Newman and Kenworthy, who found a similar relationship to that reported in CATS. Use of the most recent census data from Australia, Canada and the United States suggests that the existence of errors and inconsistencies in the estimation of urban densities. When these are corrected, the results reveal only a very weak correlation between density and public transport use, and no correlation at all with walking and cycling. The paper concludes that the 'compact city' notion is not substantiated by evidence.

Keywords: Transport planning; urban density; mode choice; journey-to-work

Rail Freight Systems: *What Future?*

Marin Marinov & Thomas White

I. Environmental Issues and Transport

Because of the industrial revolution in the past, society faces environmental problems today. We are witnesses to climate changes at global level caused by environmental damage and ecological disproportions.

Realising the danger, the United Nations signed the so-called "Kyoto Agreement" which is a legally binding agreement between signed-up countries to meet emissions reduction targets of all greenhouse gases by 2012 relative to 1990 levels (UN 1998).

If we look at the data, however, it appears that insignificant reductions have been achieved so far. Chart 1 maps CO_2 emissions in the European Community by Sector for a period of 8 years, from 1998 to 2005. Unfortunately, this shows undesirable trends with a slight increase.
Among all the sectors, transportation contributes to CO_2 total emissions by up to 25% in EU. The European Environment Agency has announced concern that the transport trends in Europe are still pointing in the wrong direction. The following results have been published (EEA 2008):

- In the EU 27 - driven by the growth in transport volume, emissions have increased by 27% between 1990 and 2006 (excluding international aviation and marine). If international aviation and marine are included this increase would be approximately 36%.

- Road traffic is by far the main source of exposure to transport noise. Almost 67 million people (about 55% of the population living in agglomerations with more than 250 000 inhabitants) are exposed to daily road noise levels exceeding 55 decibels.

- The transport sector has disproportionate impacts on the environment and there is little evidence of improved performance, or a shift to sustainable transport across Europe so far.

- Travel by road and air has continued to increase throughout EEA member countries. Between 1995 and 2006 car ownership levels in EU-27 increased by 22% (or 52 million cars), and passenger car use increased by 18%. Although the number of kilometres travelled by passengers in EEA member countries only grew by 1%, from 2005 to 2006, this still represents 65 million extra kilometres travelled.

- Freight transport continues to grow, with the largest increases being for the least energy efficient transport modes, i.e. road and air freight. The total volume measured in tonne-kilometres for EU member states increased by 35% between 1996 and 2006. Rail freight and inland waterways by contrast show a decline in market share overall.

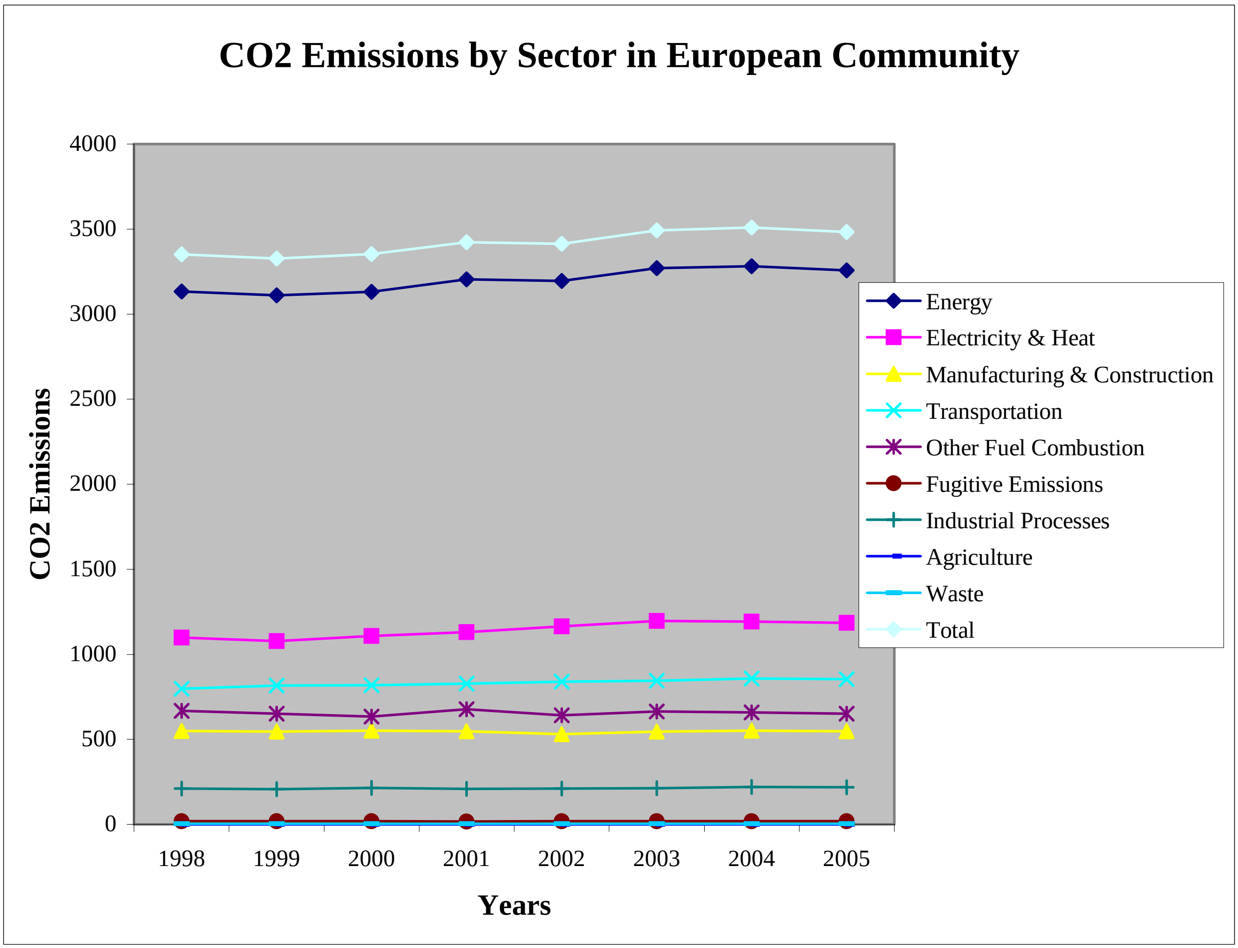

Chart 1: CO_2 Emissions in the European Community by Sector.
Source: World Resources Institute, CAIT UNFCCC, http://cait.wri.org, consulted on 30th July, 2009

Unfortunately, the current situation does not seem to be promising, quite the contrary. Radical changes are needed in all sectors. In terms of transportation, many have argued that rail transport has to be promoted. Arguments have also been put forward stating that switching freight from road to rail is imperative today: "*Freight rail is fuel-efficient and generates less air pollution per ton-mile than trucking. Rail also is a preferred mode for hazardous materials shipments because of its positive safety record…* (AASHTO 2000, pp 2.).

We believe that one possible way to change the trends in the transportation sector is to encourage freight forwarders to transport by rail. This will have a direct positive effect on greenhouse gas emissions, and hence on the environment as a whole. The rest of this paper is dedicated to railway freight systems and our prognoses of how these systems will evolve in the coming future.

II. Current Situation with Railways

Railways are a major component of the international, national, regional and urban transport systems. They have several desirable characteristics including relatively low fuel consumption for the transportation they provide, low emissions as a result of low fuel consumption, and safety. The promotion of transport by rail is beneficial to society

in general as well as to the railway industry.
For several decades however, European Railways have experienced a worrying decline. They have steadily lost market share, falling from 10% to 6% in passenger kilometres and 20% to 8% in freight tonne kilometres. In its White Paper, 'European Transport Policy for 2010: Time to Decide' published in 2001, the European Commission addressed the following factors underlying this situation:

- A lack of infrastructure suitable for modern services;
- A lack of interoperability between networks and systems;
- Shaky reliability of the service provided, which is failing to meet customers' expectations

A set of "*remedy actions*" has been launched by the European Commission in order to revitalise the European railway sector by creating an integrated, efficient, competitive and safe railway area as well as setting up a network dedicated to freight services.

It is thought that the new European Union rail policy, based on encouraging competition in the rail market by implementing vertical disintegration in the sector, is the remedy. More precisely, vertical disintegration in terms of European Union railways signifies the separation of railway infrastructure from operation, where further opening of the railway market for entry of new railway operators (also called "undertakings") has been expected. Moreover, every Railway Operator must possess an operating certificate and must pay fees for infrastructure use ("access fees"). This new policy has been underpinned by a number of regulations, which have stipulated and framed the pace of the railway structural and legislative reform in Europe. We shall not provide a detailed discussion on this matter since the discussion is not new and has been debated already. All the information can be sourced from the official site of the European Commission: http://ec.europa.eu/transport/rail/index_en.html, consulted on Nov., 5, 2008).

Focusing on rail freight, roughly speaking, the main tendencies have been towards the opening of national markets, stimulating competition and promoting integration with the intention of encouraging rail freight operators to have a more commercial attitude and hence better performance.

However, except for a few successful stories reported in some case studies (see CER, 2005, e.g.) and on the web page of the EC dedicated to rail transport and interoperability, the situation in the European rail freight sector remains unchanged.
"*On some major European rail corridors such as the one between Rotterdam and Genoa, traffic performance has increased in recent years from around 5% to 10%. This growth has been realised mainly due to block train/shuttle train activities where the new entry of railway undertakings has so far been the strongest*".
Source: http://ec.europa.eu/transport/rail/market/freight_en.htm, consulted on Nov., 5, 2008)
The key(words) for this success appear to be rail corridors and block train/shuttle train activities which specify, to a certain

extent, new freight transportation services by rail to be exercised in the future.

III. Freight Transportation Services by Rail

Freight transportation services by rail should be categorised according to the type of customer being served and according to the type of operating form being exercised.

Customers are classified as Bulk Customers and as Non-Bulk Customers. Bulk customers are further categorised into customers that require the transport of primary products such as: aggregates, iron, ore, coal, agricultural, forestry products, sand and petrochemicals, and customers that require the transport of manufactured products such as cement, processed metals, construction materials, nuclear waste, waste products, steel and automobiles. Non-Bulk Customers are those that require the transportation of consumer goods, manufacturers and retailers, as well as containers.

Operating forms are subordinated to the 'structure of service' exercised. These 'structures of service' can be described as follows:

- Hub and Spoke Structure – employed by rail freight systems[1] in which freight trains run according to classification (marshalling) yards of bigger dimensions. Demand origins and destinations are assigned to the classification yards over the railway network. Normally, there is one classification yard per region and all demand origins and destinations within this region are assigned to this yard. There are daily freight trains between the classification yard and its demand origins and destinations as well as daily freight trains between the classification yards in the railway network;

- Point to Point Structure – typically exercised by truck systems, the point-to-point structure enables a greater number of routes over the network but some routes may have a low frequency of service, which is quite likely. Hub-and-Spoke structure is a mutation of the point-to-point structure and concentrates the movement on a lesser number of routes but the frequency of service is higher, thus minimising time between most demand origins and destinations;

- Collection and Distribution Structure – broadly spread among the freight transport modes focusing on the trans-shipment from one mode to another providing local solutions for "How to collect and How to distribute" the freight.

[1] Also successfully practised in the maritime and airline businesses for a long time service, namely by the dominant players who are thus able to serve many O/D pairs with greater productive efficiency.

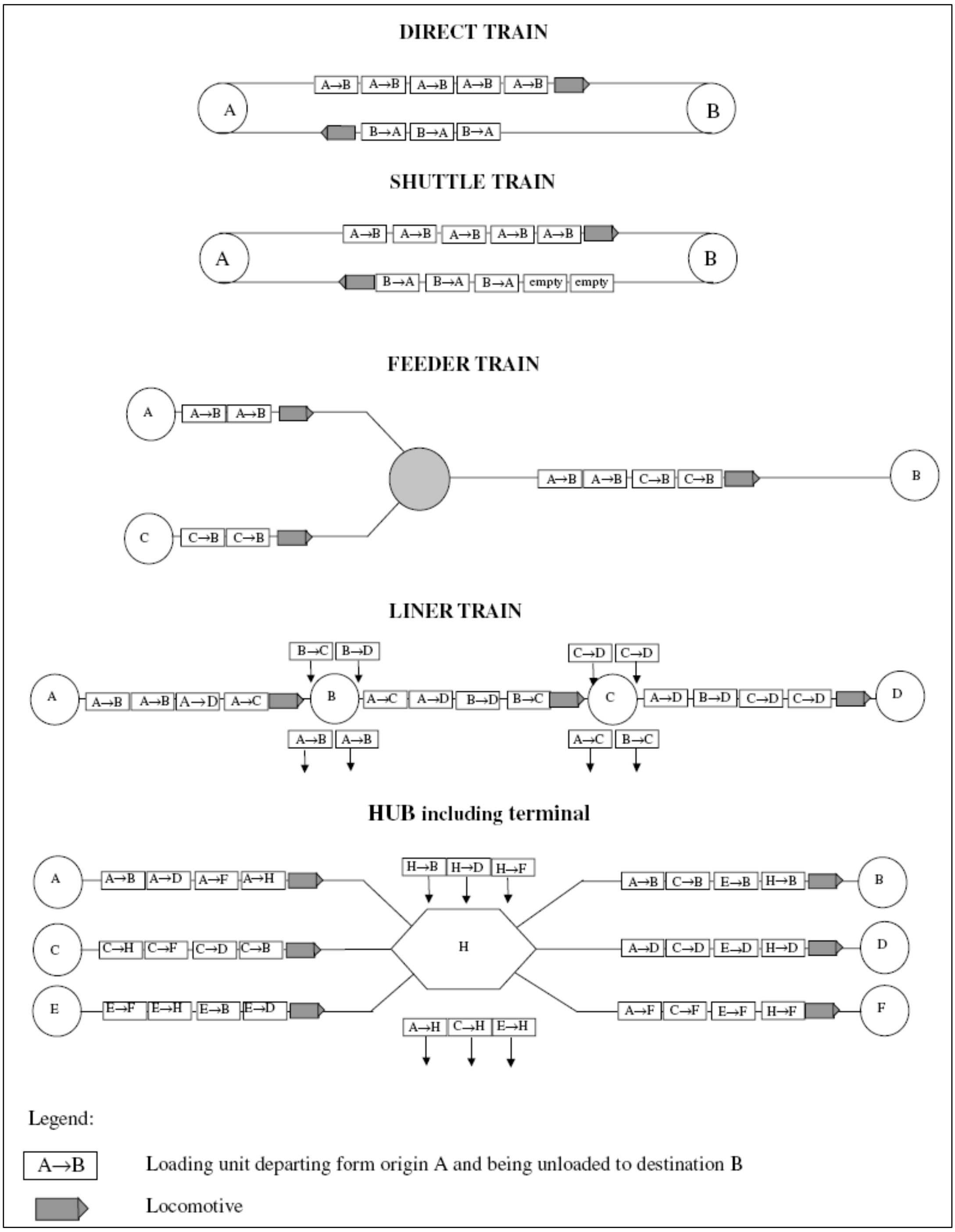

Figure.1: Alternative Rail Operating Forms
Source: Ballis and Golias (2004, pp. 422)

Relying on definitions provided by Ballis and Golias (2004, pp. 422 - 423), rail operating forms are introduced next, as follows (refer also to Figure 1):

- Direct trains - run between two terminals without handling on the way and are the most economic and rapid operating rail mode known today;

- Block trains are direct trains by nature and the number of freight cars that they carry in their compositions vary according to the daily demand for transport;

- Shuttle trains are direct trains too, however they are characterised with fixed composition seen in number of freight cars. The shuttle trains do not bear coupling/uncoupling services at terminals or yards;

- Group trains or feeder trains aim to link terminals of a region through short-feeder links and fulfil the long distance transport in a complete train. Feeder trains are run in serving less-than-trainload (LTL) flows;

- Liner trains or multi-stopping trains are seen today as compositions which are loaded and unloaded. Freight cars are coupled and uncoupled during stops in stations along their route. The number of freight cars in the multi-stopping train can be fixed, but this is not compulsory.

Traditional rail freight systems have been serving *Bulk Customers* mainly by running *Multi-stopping* and *Feeder trains* on *Hub and Spoke* principles. A failure of the "conventional" Hub and Spoke system is root of delays. Delays occur when connections between freight trains fail and the clients do not receive their freight at the appointed time. The whole service is considered to be of poor quality and the rail freight providers experience a huge amount of long term average costs, i.e. diseconomies of scale.

In North America, this practice was addressed by car scheduling. Generally, car scheduling is what is called scheduled operation in North America. Every car is scheduled a complete list of connections. Freight trains operate when they have all their freight cars (except in the case of extreme delay, when freight cars are "rescheduled"). On the other hand Union Pacific has used a similar concept. Packages of freight cars are always on time because if they are delayed, they are rescheduled to be on time. This is an improvement over old loose freight car methods, but has a great shortcoming in operation. The variability involved in ensuring connections between freight trains adds to the chaos of improvised operation[2] in the railway network.

Looking at the official statistics of the EC for the last decades (e.g. Eurostat news release 'Transport in the EU27', 49/2008 - 10 April 2008), it appears that freight transport markets of today suggest these traditional rail freight systems are obsolete to some extent, and therefore new, alternative rail operating forms ought to be exercised and implemented in the future, starting from today as *Rotterdam* and *Genoa* rail corridor suggests. It would be foreseen that Direct, Block and Shuttle trains running on rail corridors dedicated to freight and serving more and more Non-Bulk Customers will become traditional operating forms of European Rail Freight Systems in the future (by 2030 e.g.).

IV. Interoperability

An important factor in the railway freight success experienced in North America is that of interoperability. Standards for vehicles, signalling, operating rules, and accounting have been in place for over 100 years. In general, the standards have been developed and implemented by the industry. Often, government

[2] On "Scheduled vs. Improvised" Rail Freight Operations, the interested reader is encouraged to consult White (2005) and Marinov (2007).

regulation of the industry is based upon standards developed by the industry.

Generally, a freight car loaded anywhere in North America may travel to any destination in North America. There are over 100 railway companies in North America, but they form a generally seamless railway network. The shipper must only make arrangements with the originating carrier, regardless of the number of carriers involved in the complete shipment. Payment arrangements for pick up, delivery, interchange between carriers, and delivery are made among the carriers and included in the fee paid by the shipper. There is an established payment structure for the use of wagons. A carrier will pay the owner of the wagon a specified fee for each hour (or in the case of wagons owned by private parties that are not carriers, each mile) that the wagon is on its line. There is a specified procedure for the return of wagons after a shipment is delivered. Fundamentally, an empty wagon may be loaded with any shipment that will take it closer to the lines of its owner. This reduces the amount of distance that wagons travel empty.

Wagon standards include specific dimensions and weight restrictions for wagons that can travel unrestricted throughout the continent. Procedures are in place for the movement of wagons and shipments that exceed the standard for unrestricted movement. As with billing, the entire movement is arranged among the carriers, generally with no requirement of participation by the shipper. Regardless of wagon weight or dimension, all wagons have standardised braking and safety appliances.

Although there are some differences in application among the railways, all of the railway operating rules in North America are based on a single set of principles. It is not difficult to know the application of the principles to the specific operating rules of a carrier. Thus, it is not unusual to find the operating crews of a railway handling a train on the lines of one or more other carriers during the course of a tour of duty. Signal systems are likewise based on some common principles regardless of the differences that may be found in the specific standards of each railway.

The use of common information technology is of foremost commercial importance. The important characteristics (e.g., length, width, tare weight, load limit) of all wagons in North America are found in one common database. As well, movement information of every wagon is found in a single database. The common database is updated by the information system of each carrier. A customer may determine the current location of a shipment anywhere in North America. Each terminal receives detailed information about the wagons in each train long before its arrival. Each carrier is provided a detailed list of wagons to be delivered in interchange long before arrival. The same advance information is also provided in advance of the shipment crossing the Canada/USA or USA/Mexico border. Unless there is a specific security threat associated with a shipment, a border crossing may occur in an hour.

We believe that interoperability in the North American model, to a certain extent provides opportunities for success for the European Rail Freight Systems. Therefore, this model could be explored in greater detail with the purpose of identifying best practices and successful stories, and further developing strategies of how such practices and stories could be adopted and implemented in Europe in order to increase the probability of success in European rail freight transportation, regardless of the structure and form of the service.

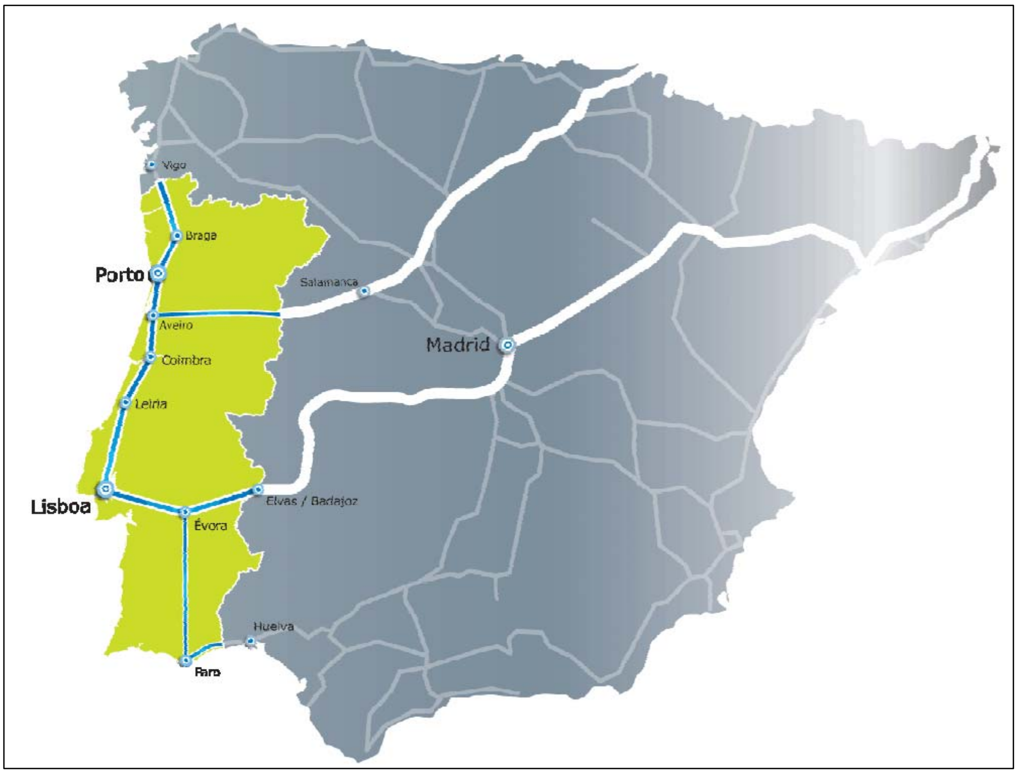

Figure: 2 Portuguese High Speed Rail Network
Source: RAVE (2008, p. 6)

V. High-Speed Rail for Freight

Nowadays, high-speed trains are the booming systems, providing faster transportation services. European high-speed trains have revived passenger services which will connect more major cities in Europe over the next decade with further openings of new rail lines.

Given the European rail corridors dedicated to freight, one should also consider High-Speed systems for freight. Needless to say, High-Speed systems for freight will speed up the time for transport and delivery giving rise to a significant increase in the level of production. This in turn directly competes with air freight as a mode of transport. But high-speed track and rolling stock is very costly. High speed trains also have a much higher operating cost because of the energy consumption. High speed trains are suitable for only a very small portion of the entire freight market, and for freight traffic, it is something of a distraction. However, how true is this? According to RAVE[3], "... *a strong pillar of the Portuguese High-speed rail network is the strategic bet on the freight. Lisbon to Madrid, Porto to Vigo and (in the next future) Aveiro to Salamanca axis will be prepared for freight, connecting the biggest national ports and airports to the rising national logistics platforms network, creating new high-capacity*

[3] RAVE - Rede Ferroviária de Alta Velocidade S.A., Portugal

corridors to Spain and to the rest of Europe."
RAVE (2008, p. 5) Press Release

Figure 2 shows the Portuguese High Speed rail projects already approved by the government and currently under construction.

Examples of High Speed freight trains already exist in Europe. These are the postal TGV trains of Fret GV in France. The interested reader is encouraged to consult the official web site of Fret GV: http://fret.sncf.com/fret/580-high_speed_freight.html, accessed on January, 23rd, 2009.

The 2008 - 2015 vision of Fret GV is to operate "*on the Paris – Mâcon - Cavaillon line, with a processing capability of 60,000 tons, that is 2,000 trains per year of mail and express parcels. On track for 2010 with the opening of new terminals in Lyon and Marseille, 2 additional Freight TGVs a day are planed to be available on this route.*"

It has been argued that such High Speed freight services cannot operate outside France because they *lack the sort of continuous high-speed rail network that currently exists in* this country. In the coming future however, we believe that such limitations will be overcome alongside the high speed train revolution in European rail networks. High Speed freight trains running at (more than) 350 km/h will take part in future traditional practices of freight railways at European level by 2030 on Western European Rail Networks, and by 2050 on Eastern European Rail Networks.
The idea of High Speed rail systems was also born out of the need to create a transportation system that is able to compete with air. However, there is a transport market for freight in the relatively high speed conventional rail networks where the freight trains run at 150 – 200 km/h. This issue is worth mentioning because there is a middle ground between high speed rail freight and conventional rail freight that appears to be able to compete very well with trucks. This seems to be the case in many existing European rail lines. If we consider freight trains, designed to high speed standards and capable of operating on conventional routes, there would appear to be a future for the transportation of high-value, time-sensitive goods by a scheduled, conventional, relatively high speed (operating at high speed where available) service by rail in competition with trucks. The commodities being transported could be palletised goods delivered by local truck or freight tram to a railway terminal and picked up by local truck or freight tram if such a system for distributing freight in cities exists[4].

VI. Trucks on Rails

… *It is often stated, that combined transport (mainly truck-train-truck) might be a very CO_2 efficient mode. …* (Jochem and Buhler 2009, pp.1).
Trucks on rails, rolling road, rolling highway or lorries by train is a freight transportation system that combines road and rail, rendering the trucks less environmentally harmful thanks to the rail freight mode. This concept combines the line haul efficiencies of rail with the local pick up and delivery flexibility of highway. Over great distances, carriage

[4] We further comment on Rail Systems in Urban Freight in Chapter VIII. Rail Freight in Cities of this article.

of the trucks and driver, as well as the trailer is not economical. However, this concept is well-suited to short-to-moderate distance movement of trucks in bypassing congested areas of highway. The rolling road is effectively a high-capacity, high-efficiency bypass toll highway for trucks.

Rolling road technology is known as "Piggybacks" and allows the trucks to be loaded onto special low-loading wagons and then carried by rail. The service begins with the arrival of the truck at the intermodal terminal equipped with specialised ramps that allow the truck to arrive onto the "Piggyback" which is, technically, an articulated platform car. The engine of the truck can then be detached as only the (semi)trailer remains on the piggyback. This is not mandatory, so the truck can be carried complete (Figure 3). Next, the truck is secured on the Piggyback and the truck driver(s) can go and relax in the recreation wagon. On arrival, the same operation are carried out in the reverse order.

The piggybacks' services have a number of advantages encompassing efficiency, production, costs, profit, reliability, customer satisfaction, ecology. A list is provided below:

- The piggyback freight trains are made up of about 20 cars, where each one is able to carry 2 standard unaccompanied semi-trailers. This means that 40 semi-trailers are carried by one piggyback freight train;
- Trucks carried by piggyback freight trains experience a reduction of both operating costs and costs for repair/maintenance. A more rational utilisation of the trucks is thus achieved;

- Non-stop transportation service seen in freight travel towards its destination without any time loss. Waiting and idle costs are decreased;

- Totally environmentally-friendly freight transportation option: Nitrogen, CO_2, particulate matter emissions and other harmful substances released directly to the atmosphere by the trucks during their ride on the highways are decreased;

- Decongesting the highways. Less trucks on the roads impacts upon the number of accidents and fatalities on the roads are decreased.

Rolling road operation with piggyback trains is one of the freight transportation services of the 21st Century. Evidence for this is brought by a number of rolling road providers in Europe, such as:

- ÖKOMBI – ROLA generally provided rolling road services in Austria and thus significantly contributes to the general transport policy aims of the expanded European Union (the interested reader is encouraged to consult: http://www.oekombi.at, accessed on February, 3rd, 2009)

- LORRY- RAIL uses the "Modalohr" concept and operates in France on a distance of 1,050 km connecting the terminals of Bettembourg (Luxembourg) and Le Boulou (Perpignan) (for more information can be found at: http://www.lorry-rail.com, accessed on February, 3rd, 2009)

Up to now, rolling road services have received attention in Western and Central European countries and this track accompanied with adequate actions will continue in the coming future. Unfortunately, this situation appears to be different in the Eastern European countries, where such services have only been discussed but no formal actions have been taken so far.

Figure. 3 A "Piggyback" Train of ÖKOMBI company
Source: http://www.oekombi.at/index.php?lan=2 accessed on February, 3, 2009

VII. Double – Stacking

"Can Double-Stack international standard-size containers be run on European rail corridors and if so is it an economically viable option?" - Will such a question be raised in the future?

The idea of the first double stack freight car to carry one container on top of the other (Figure 4), also known as well type car, was brought to light in the early 1980's. Since then, Double-Stacking has been successfully implemented in North American railroad, in Mexico, in parts of Australia and Canada, and in China. This discussion was also initiated in India a few years ago through the introduction of the concept of running double-stack on flat cars (see Kumar 2006).

The foregoing rail systems run their freight trains mainly with diesel traction because of the flow levels of electrification. This situation allows the movement of double-stack containers because there are no overhead wires to impose height restrictions and the double-stack container trains are thus able to run where other restrictions such as clearance along bridges, tunnels and overpasses as well as load per axle are satisfied. For instance, the US rail network required some substantial work to enlarge tunnels for double stack trains. Works still remains to be carried out in order to make double-stack capable of the entire US rail network.

A question that comes to mind here is '*Is it possible to run double-stack container trains with electric traction and if so, is there any evidence for such a practice*? There is evidence that the Chinese Railways already run Double-Stack container (DSC) trains with electric traction by using well type wagons. It was reported in JICA (2007, pp. 17), as follows: …" *the JST has visited China to observe the DS container operation under wire and concluded that this* *indeed was a proven technology. The analysis carried out in the JICA Study concludes that from the aspect of economics and transport demand needs, double stack container operation adopting the well type wagon was verified to be superior*." More specifically, the Chinese Railways currently operate DSC trains under 25kV OHE by using $8^{1/2}$ ft height ISO standard size containers. In the coming future the challenge will be how to run their DSC trains under the catenary wire by using $9^{1/2}$ ft height ISO standard size containers.

There have been arguments that Double-Stack container concept cannot be implemented in Europe because of loading gauge restrictions. But *is this the case all over Europe*?

Figure 4: A Double-Stack Car owned by the TTX Company
Source:
http://en.wikipedia.org/wiki/Double-stack_car, accessed on January, 25, 2009.

According to the best of our knowledge, the recently constructed rail corridor from Rotterdam to Germany heartland, called Betuweroute, is engineered in a way that allows Double-Stack container trains to run subject to tunnels, electrification and other technical characteristics of the corridor. However, there are no DSC trains in operation yet.

It should be noted that Double-Stack is not an automatic route to direct efficiency. It depends greatly on distance for transport and on the nature of the shipments. Nevertheless, we believe that the double-stack container services with electric traction by rail may prove economic, environmental, safety and customer benefits such as:

- A possible reduction of the Number of container trains for the same throughput;
- A possible increase of the Payload capacity of the container train;
- A possible reduction in the container terminal congestion;
- A possible reduction in the Dwell time of containers at terminals and ports;
- A possible reduction in the Cost of unit transportation;
- A possible increase of the rail freight Market share with the same rolling stock;
- A possible reduction in the Overall transit time of containers;
- A possible reduction of the number of Lorries on the highways;

- A possible reduction of damage and theft in transit due to the unique design of the well type freight cars which do not allow the doors of the lower containers to be open, when the containers are on the well wagon (Figure 4);

- A possible increase in the shipping productivity for customers.

We are well aware of the fact that European railways were not constructed to fulfill Double-Stack container operations, and reengineering of the systems will have to be launched which will not come without costs. Quite the contrary! It should be noted that we do not insist that double-stacking ought to be implemented on every single European rail corridor. Instead, we wish to suggest a programme to determine specific routes for double stack container trains in order to identify and develop plans for the fulfilment of such services on specific routes which will further prove double-stack container operations to be an economically and environmentally viable option over time (e.g. by 2040 – 50). During the lifetime of such a programme, it may be that in many cases modifying the existing infrastructure for longer freight trains may be economically superior vs. modifications for double-stack. This also relates to the nature of well-type freight cars. A well-type freight car is substantially longer than the container in order to accommodate the trucks as well as articulation. Therefore, it may be necessary to modify the infrastructure for longer freight trains in order to run a DS train of economical length.

A double length container train still has twice the containers, but the rail infrastructure would also benefit other commodities. It would also be useful in the instances where double stacking is not a sound economic or service alternative to trucks, particularly where the delay involved in accumulating containers overcomes the benefit because of the length of haul and nature of the shipments.

VIII. Rail Freight in Cities

Urban freight transportation and city logistics is an area of intensive discussion today. For our purposes, we shall restrict the current presentation by focusing only on how the rail systems are seen within urban freight transportation areas. More specifically, what systems have been in existence, what has happened and what is the future of rail in urban freight transportation.

Robinson and Mortimer (2004a) concluded; "*there is no doubt that rail no longer commands a prominent place in urban freight activities. There are some grounds for believing that rail can rebuild market presence, but this will need to be done with a much greater recognition of the market's needs and requirements and how these continue to evolve.*
Shippers are now accustomed to slick, sophisticated, road-based logistics services and are very unlikely to be prepared to sacrifice these for a less capable and more costly alternative."

Such conclusions sound unpromising for the future of rail systems in urban freight transportation. However, this is the literal truth. Over the last decades we have been witnesses to the downfall of the rail freight systems in many European cities. There was a time where rail passenger stations of medium and large dimensions were planned and built with areas explicitly dedicated for freight services. The first wagon in any passenger train composition was normally a freight car used for transporting merchandises. In many rail passenger stations in the bigger cities personnel were employed to deal specifically with freight services that were once provided by the rail systems.

Nowadays the picture is different. We observe abandoned rail lines and neglected sidings, rail freight facilities and workshops in a wretched state, rail freight cars left somewhere in the network rusting and deteriorating day by day, pieces of rail infrastructure that were once in use, but no one is interested in their exploitation any more.

Regardless of all the advantages that it possesses (a typical freight train removes 50 HGVs from our roads, and tonne for tonne; rail produces less than one-tenth of the carbon monoxide, 5% of the nitrogen oxide, and 10% of the volatile organic compounds; lorries are also involved in a significant percentage of road deaths) the traditional rail freight transport mode is not as flexible as the road (trucks) mode, and the market has kicked rail freight systems out. Rail systems may have had a product to sell, however it appears that they have failed in the strategic positioning of this product in the marketplace.

There have been efforts to revive rail systems for urban freight services (see e.g. Robinson and Mortimer 2004b). Interested parties have looked at possibilities for providing inter-urban and intra-urban freight operations by rail systems. They have focused on:

- **The capability of rail to service flows of freight traffic into and between urban areas** – this initiative requires a well deployed rail network within the cities in order for rail to be able to compete against road haulage. In many cities the rail suffers accessibility problems because of lack of infrastructure. Therefore, this matter is dependent upon strategic decisions and policies favourable to rail that are part of the integral planning process of the city development. The city infrastructure must be thought of to provide a strong non-discriminative physical and economical platform to the freight transport modes for their businesses;

- **The capability of underground /metro systems to service commodity flows within the city** – arguments for such an initiative have occurred arguing that the incorporation of freight into the existing underground/metro systems requires the development of an entirely new logistic concept, pilot projects for innovative thinking as well as significant work accompanied with significant investments for the invention of underground rolling stock to carry different types of commodities. *Is it worth the trouble?*

- **The capability of tram and light rail to service commodity flows within the city** – this initiative is about urban freight trams and light rail city freight trains that are to run on existing city infrastructure in off-peak hours according to urban passenger/public traffic. These freight trams and city freight trains will have to be equipped with modern freight cars/vehicles specified to carry different categories of commodities. There have been some experiments in Germany and as a result Dresden has successfully deployed modern cargo trams in an innovative logistics application shuttling between two automotive plants.

based on the 'Pull Concept[5]', rail systems for transporting freight to, from, within and though cities will become reliable players/providers in this market and their positive role will be on the increase. CityCaro appears to provide evidence for this to be true (consult the official web site of CityCargo: www.citycargo.nl , visited on January, 26, 2009).

Figures 5 & 6: City Cargo in Amsterdam
Source: www.citycargo.nl, accessed on January, 26, 2009

We believe there is a future for rail systems in urban freight. It appears that Londoners do as well. According to TfL London Rail (2007, pp. 6) "... *TfL believes it is important for rail freight to flourish alongside a developing passenger railway in London. Rail freight also makes an increasingly successful contribution to the economy and quality of life of Londoners and people throughout the UK",* this is a very good example which should be followed by many other cities. With both some political pressure based on the 'Push Concept' for encouraging the shift from road to rail and solid measures of interventions into the sector

More specifically, CityCargo distributes freight in Amsterdam by using the existing tram network within the city. Freight to be transported is received in warehouses on the outskirts of Amsterdam, where it is shipped in cargo trams. Cargo trams travel to locations inside Amsterdam due to the fact that they may use alternative routes on the existing tram network. This means that the routes of cargo trams are not explicitly fixed and can be specified subject to demands, congestions, peak and off-peak times. The purpose of using different routes is also not to intervene with the passenger tram services. After arriving at the desired location inside the city, the cargo trams are met by "Green" vehicles (also called E-Cars, see Figures 5 & 6) that transport the freight from the

[5] On "Pull and Push" Concepts the interested reader is advised to consult Hopp and Spearman (2004).

cargo trams to its final destination, i.e., "*door delivery to the customer*".

Transporting freight within cities by rail systems such as trams (both conventional and wireless[6,7]), metros and light rails contributes a number of benefits to the city environment and to the citizens as a whole. These benefits are seen in:

- A significant reduction in lorry kilometres in cities;
- A significant reduction of air pollution in the cities;
- A significant reduction of noise;
- A significant reduction of congestion;
- A significant reduction of cost for city roads' maintenance;
- A significant reduction of fatalities and injuries caused by road traffic because of an increase of road traffic safety.

Our prognoses are that in the coming future more and more cities will be grasping the concept in order to satisfy their freight transportation needs by rail systems. Similar concepts such as "City Cargo" will be widespread and implemented broadly for the sake of an economic and environmentally sustainable future (e.g. by 2035 – 45).

As far as our knowledge goes, there are successful inner city goods' distribution operations that involve the use of a lorry from distribution centres to locations on the edge of the city. The distribution scheme is well suited to cities within which the streets are narrow and operation of large trucks is difficult. The scheme is as follows:
Lorries carry several small delivery vehicles from a distribution centre situated in the outskirts of the city to a location deep inside the city where these small delivery vehicles are unloaded from the lorry. Then, the small vehicles make their distribution rounds to the customers' doors and once this operation is completed they return to the lorry again for the trip back to the distribution centre. We believe this could also be achieved through a rolling road operation as one would make the best use of abandoned and old rail infrastructure in cases where this were possible. In this way, neglected sidings, abandoned rail freight storages and workshops in a wretched state could be revived and turned into inner city station locations for a distribution service of this nature. It should also be noted that the advantage of rolling road in urban freight and city logistics is that many more distribution vehicles could be handled by a train than by a lorry. Once a freight train carried the distribution vehicles and unloaded them, this train could then serve other distribution vehicles or be used for other services instead of remaining parked on the station platform.

IX. Rail Freight System of the Future

In the spirit of stimulating discussion and action we have exposed our prognoses and suggestions for the future development of rail freight systems.

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6 www.alstom.com/home/news/news/business_news/56752.EN.php?languageId=EN&dir=/home/news/news/business_news/ (accessed on 23rd March, 2009)

7 For further information, consult ALSTOM Transport: http://www.transport.alstom.com/home/, (accessed on 2nd August, 2009)

Alongside the foregoing suggestions, we favour frequent, scheduled freight service by rail with passenger-type punctuality which appears to be another missing part for bridging the gap between the rail freight past and the rail freight future; comprehensive discussion of which should be open hereinafter. Seamless operating processes with freight trains and frequent services fulfilled on optimised strict-fixed schedules multiply the utilisation and the efficiency and hence the level of production of the rail freight systems. These operational and management issues are crucial for the success of the rail freight systems of the future and must be always on the agenda. The rail freight systems must fulfil their service with freight trains as a perfect timepiece. Let us not forget that we can develop rail freight systems that are the envy of the world but they shall be unprofitable; they shall not bring the desirable benefits to society in the forms of reduced fuel consumption, emissions, congestion, and reduced cost of highway accidents if we do not exploit them properly.

We shall bring this discussion into an end and provide our formula of the rail freight system of the future, as follows:

[**AROF** + **HSRF** + **ToR** + **DS** + **CCC**]^ **FSPrfs** = **<u>Rail Freight System of the Future</u>**

Where;

AROF = **A**lternative **R**ail **O**perating **F**orms
HSRF = **H**igh-**S**peed **R**ail for **F**reight
ToR = **T**rucks on **R**ails
DS = **D**ouble - **S**tacking
CCC = **C**ity **C**argo **C**oncept

FSPrfs = **F**requent, **S**cheduled, **P**unctual **r**ail **f**reight **s**ystem

Now we shall stay tuned to find out whether our prognoses will come true or not!

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Density Delusion?
Urban form and sustainable transport in Australian, Canadian and US cities

Dr. Paul Mees

INTRODUCTION

The relationship between population density and the share of travel by different modes has been a mainstay of the transport and urban planning literature, with mode split generally regarded as an outcome of density. As a result, the most popular recipe for mode shift away from the automobile is the 'compact city', or 'smart growth' as it is called in the United States. This paper questions the assumptions behind the compact city recipe for mode shift, by re-examining the historic and contemporary evidentiary basis for it. Interestingly, increasing city densities was originally advocated as a way to facilitate, rather than reduce, the dominance of the car.

DENSITY AS DESTINY

When automobiles began to appear in large numbers in the 1920s, urban planners were unsure how to respond. The most radical proposal came from the French architect Le Corbusier. In his 1924 book *The City of To-morrow and Its Planning*, Le Corbusier argued:

> In Paris… the combined superficial area of the vehicles using the roads is actually greater than that of the roads themselves… And where do all these motors go? To the centre. But there is no proper superficial area available for traffic in the centre. It will have to be created. The existing centres must come down (Le Corbusier, 1971, pp. 116-7).

'We must decongest the centres of our cities', Le Corbusier said, 'by increasing their densities.' Skyscrapers would be built on stilts so the ground could be covered with car parking, served by elevated freeways. 'Running north and south, and east and west… there would be great arterial roads for fast one-way traffic built on immense reinforced concrete bridges 120 to 180 yards in width and approached every half-mile or so by subsidiary roads from ground level.' Underneath the roads and parking, railways would run in tunnels, but trams would be abolished. 'The tramway has no right to exist in the heart of the modern city' (pp. 164-5).

By the end of the Twentieth Century, the argument had been reversed. The low-rise city came to be seen as intimately linked with the car, and public transport – especially light rail – with high densities. By the 21st century, the Le Corbusian skyscrapers invented to make room for cars were routinely presented as the antidote to automobile dependence.

An important step in this process came with the Chicago Area Transportation Study 1956 (CATS), the first major computerised transport and land-use study. CATS was directed by Dr. J. Douglas Carroll Jr, a sociologist from of the University of Michigan, and ran from 1955 to 1962. The study began with an 'inventory', or survey, of land use and transport in the greater Chicago region in 1956. The analysis of urban form found that population densities declined with increasing distance from the city centre. The analysis of travel revealed that a quarter of regional trips were by public transport and three-quarters by car (the study did not count walking or cycling), with public transport's share of the market also declining with distance from the CBD.

'This evidence', the study team concluded, 'partially destroys the idea that people choose their mode of travel' (CATS, Vol. 1, p. 74). Public transport mode share could be predicted using an equation in which the variables were density and car ownership (p. 119). Having established the equations relating traffic to land use for 1956, the study used them to predict travel patterns for the design year of 1980. The starting point was a prediction of future land use patterns. CATS assumed that the historical trend towards a more spacious city would continue, leading to a continued decline in density. The consequence, according to the CATS equations, would be a further reduction in public transport's share of the market, from 24 per cent of trips in 1956 to 14 per cent in 1980.

Given these trends, CATS recommended that 92 per cent of investment should go to highways and the remaining 8 per cent to public transport (half of this was for car parking at stations). Anticipating criticism that planning for public transport decline would be a self-fulfilling prophecy, the study team responded: 'The conditions of land use and density… are the major determinants of the travel market. If demand is constrained by these factors, it is unlikely that changes in supply will have any great effect on the number of users' (vol. 2, p. 53).

In fact, CATS claimed, regular public transport could not operate at all at the densities found in Chicago's suburbs in the 1950s, densities that were predicted to become the norm in future decades. The inventory had established that most bus trips occurred within the boundaries of the City of Chicago or adjacent inner suburbs. 'The explanation', according to the study team, 'lies in the density of land use, and car ownership. Bus service can be provided only where there are enough passengers to pay operating costs… There are enough passengers only in districts which have a certain minimum density [which] appears to be about 25,000 persons per net residential square mile.' Below this figure, which is equivalent to 96.5 per hectare, 'buses apparently cannot operate economically' (vol. 1, pp. 43-4).

This finding was picked up by other writers and so widely disseminated that it has become a truism. The British economist Colin Clark took the CATS figure, halved it to allow for non-residential uses, and concluded that 'a population density of 12,500 per gross sq. mile (48 persons/hectare) in a predominantly residential area is likely to be the limit below which 'bus services will be un-remunerative without a subsidy.' This suggested public transport did not have a long-term future, since 'residential densities in modern cities... are tending to stabilize well below this limit' (Clark, 1967, p. 366). Clark's assumption that half of developed land was residential was incorrect: CATS actually found that only a third was, so

Clark's density threshold should have been 32 per hectare, not 48.

The Australian transport planners Peter Newman and Jeff Kenworthy took Clark's figure, reduced it again on the basis that most public transport systems now receive some subsidy, and arrived at a minimum density of 30 persons per hectare below which public transport cannot be provided (Newman & Kenworthy, 1989, p. 131). The supposed minimum density of 30 per hectare – which would have been 20 if the starting-point of 32 had been used instead of 48 – has been widely accepted by urban planners in Australia and North America.

Nobody seems to have taken the trouble to examine the original CATS figures to see if they really prove that bus services could not have been provided in Chicago's suburbs. In fact, the lack of suburban bus service in Chicago was the result of politics, not density (Yago, 1984, chapter 6; Flink, 1988, pp. 362-4). Public transport was provided for many decades by private franchisees, operating on a similar system to that employed for British Rail services in the UK, and trains and trams in Melbourne. Despite strong support for public ownership, demonstrated in a series of plebiscites beginning in 1902, Chicago's private transit franchisees held onto their properties until they went bankrupt during the Depression. More than a decade of indecision and decline followed before the banks, acting as receivers, sold operations to the Chicago Transit Authority, a body created by state legislation in 1947.

The CTA was financially hamstrung by the need to rehabilitate the dilapidated systems it inherited, and cut costs by replacing ageing trams with buses. There were no funds available for significant service extensions or improvements. An attempt in 1956 – the very year CATS officially commenced – to use state fuel tax funds to finance modernisation and extension of CTA services was defeated by vigorous lobbying by a coalition of highway interests.

Suburban municipalities could choose whether to join the CTA, and given its parlous state most did not: they were served by private commuter railroads and may not have seen a great need for buses. These municipalities had no bus services, and therefore no bus passengers. A few closer-in suburbs did join the CTA, and were provided with bus service. These were the suburbs CATS observed as having bus passengers. Density had nothing to do with it, as the density map in the CATS report shows they were all well below the supposed minimum (vol. 1, p. 21).

So the Chicago density threshold was a pseudo-scientific rationalization for a state of affairs that had arisen through public policy failures. Even Carroll's assistant Roger Creighton later acknowledged that the treatment of public transport had been the weakest part of CATS: 'the answer was never considered satisfactory… In retrospect, one looks at these arguments with mixed emotions… But this was the fault of the times' (Creighton, 1970, pp. 303-4). Nobody apparently noticed, however, and the Chicago density threshold has been used ever since.

THE COMPACT CITY

Cars and suburbs seemed to have developed together in the United States, while public transport held its own mainly in European cities, which remained much denser. The contributions made by different urban transport histories and policies, including the European tradition of public ownership of public transport, have been largely forgotten. Even critics of automobile dominance accepted the overwhelming importance of urban form, with the result that the ‘compact city’ has emerged as the most popular prescription for planning ‘sustainable cities’.

The idea is not new. The Chicago Area Transportation Study canvassed it half a century ago, citing unnamed writers who ‘argue that the suburban dweller should be prevented from stretching out into quarter acre lots because a high density, compact city would be more efficient’. So ‘why not control land use and density so as to control the level of mass transportation usage?’ The study team’s answer was that people prefer dispersed living and would be unlikely to accept measures to restrain densities. ‘A more reasonable position is that people, acting in their own interests in a relatively free society, are gradually evolving their desired environment’ (vol. 2, pp. 73, 53-4).

As concern about the environmental and others problems of automobile dependence grew, the reasonableness of this position was increasingly questioned. Contemporary advocates of the compact city have the opposite view of car dominance to the Chicago transport planners of the 1950s, but their recipe for change accepts the same logic, namely that unless densities are substantially increased, alternatives to the car are impossible. Environmentalists who argue in this manner can unintentionally provide support for the continuation of unsustainable transport policies.

This problem can be seen in the United Kingdom today. Outside London, urban public transport is extremely unattractive and offers no serious competition to the car, for reasons discussed in Mees (2009). But many British advocates of sustainable transport seem more interested in higher-density housing than in fixing public transport. The dominant view is presented in *Building the 21st Century Home*, a widely-used guidebook published in 1999:

> We may lament the decline in public transport and the effects of deregulation and reducing subsidy. However it must be recognised that the dispersal of development and the reduction of housing densities has also played its part. The Local Government Management Board estimates that densities of 100 persons per hectare are required to support a viable bus service and 240 persons per hectare for a tram service, whereas the average density of new housing development is just 22 units to the hectare [or] around 50 people (Rudlin & Falk, 1999, p. 158).

So transport policies are not the main barriers to improved public transport; density is the problem. Apparently, development densities need to double just to make bus services possible, and to increase five-fold before Britons can think about trams. Quite simply, this is never going to happen. This is an argument for giving up on alternatives to the car.

So where do the density figures come from? The report cited as the source, published by the Local Government

Board but written by academics from the University of the West of England in Bristol, does specify 100 residents per hectare as the minimum density for buses, but I could find no reference in it to a minimum for trams (Barton et al, 1985, p. 80). The report did not 'estimate' the bus figure, however; it simply cited White (1976) as the source. White's only mention of a specific density threshold comes in a sceptical discussion of the then-new concept of 'dial-a-bus', which refers to un-named American consultants who believe it requires 'about twenty to forty persons per acre' (50 to 100 per hectare). White omitted the figure from later editions of the book, noting that dial-a-ride was a high-cost mode and most services have been withdrawn (White, 1976, p. 112; cf. White, 2002, p. 97). So the supposed density requirement for buses is not the result of estimation or calculation at all, while the higher figure for trams seems to have emerged from thin air.

In the process of migrating to the UK, the CATS/Clark figure mysteriously doubled for buses and increased five-fold for trams. It also became gospel, and is now cited in almost any discussion of sustainable cities in the UK. For example, the Commission for Architecture and the Built Environment endorsed the 100 for bus and 240 for tram figures in 2005 Better Neighbourhoods, even arguing that 275 people per hectare is a 'sustainable urban density' – bad news for the City of Paris, with only 250 (CABE, 2005, p. 7).

Britain is not the only place where low densities are said to create insuperable problems for public transport. The American architectural historian Robert Bruegmann writes in his 2005 book *Sprawl*: 'It appears that 10,000 people per square mile [39 per hectare] is a threshold for the extensive use of public transportation systems'. Although Bruegmann never mentions CATS in his book, he derives his threshold from the gross density of the City of Chicago, on the basis that it and New York are the only US cities where public transport is used extensively (Bruegmann, 2005, p. 55). Alan Moran, from the Australian free-market think-tank the Institute of Public Affairs, offers the highest figures of all. 'A rule of thumb is that rail-based systems require 40,000 people per square kilometre [400 per hectare] to be viable. … Express bus systems need 26,000 per square kilometre [260/ha]' (Moran, 2006, p. 15). No source is cited for these figures.

Arguments that densities many times current levels are needed before transport trends can change are really arguments for continuing with automobile dependence. Bruegmann and Moran intend us to draw this conclusion, and while other commentators seek to encourage higher-density development, the main effect of their arguments is to provide support for the advocates of autopia.

THE DENSITY DEBATE IN AUSTRALIA

The leading academic advocates of the compact city as a response to automobile dependence are Professors Peter Newman and Jeff Kenworthy, based for many years at Murdoch University, but now at Curtin University. Their pioneering study of cities and transport began after the oil shock of the 1970s and culminated in 1989 with publication of *Cities and Automobile Dependence* and supporting papers in planning journals. *Cities* and its 1999 update *Sustainability* *and Cities* set the terms for the debate over density in the last two decades, coining the term 'automobile dependence', reviving the idea of the compact city as the response, and establishing the multi-city comparison of transport and urban form as the methodology for investigating the issue (Newman & Kenworthy, 1989; 1999; Kenworthy et al, 1999; 2001).

Compared with Moran and the British density enthusiasts, Newman and Kenworthy are moderates, suggesting the critical threshold is around 30 per hectare, rather than 100 or more. This figure was, as we have seen, derived from the Chicago Area Transportation Study via Colin Clark, but Newman and Kenworthy corroborated it with their comparison of densities and automobile use across a range of cities and countries. The comparison was expressed as a much-reproduced graph showing a hyperbolic relationship in which car use increases exponentially once densities drop below about 30 per hectare. Hong Kong had the highest density and lowest energy use; Houston the lowest density and highest energy use. Interestingly, an almost identically-shaped graph, comparing car trip-making and density in different parts of Chicago, appears in the first volume of the CATS report (p. 61).

The compact city thesis has been debated for more than two decades, and the debate may have produced more heat than light. David Banister (2005, p. 98 & chapter 6) offers a comprehensive review of the literature, observing that much of the analysis has been 'very simplistic in its approach', and concluding that 'the situation is very much more complex than is often argued.'

Some compact city critics have questioned the quality of Newman and Kenworthy's data, generally without offering anything better to replace it – the principal exception here is the American transport and planning critic Wendell Cox (see his website www.demographia.com). With each successive edition of the database, now in its third iteration, Newman and Kenworthy have corrected errors and omissions as well as expanding the range of cities reported. Interestingly, over time their figures have converged with those of Cox.

Not all critics of the compact city are advocates of the automobile. Professor Ian Lowe is President of the Australian Conservation Foundation, and author of *Living in the Hothouse* (2005), a plea for serious action to combat climate change. But Lowe also understands the attractiveness of leafy suburbs, and the equity issues involved:

This comparatively uncrowded urban form is one of the aspects of Australian urban lifestyle which appeals to those of us who have lived in the northern hemisphere. I live in a Brisbane suburb, ten minutes bicycle ride from Griffith University and near an express bus route which takes twelve minutes to the city centre, but in a quiet street backing onto bush. I am more likely to be awakened by rainbow lorikeets than traffic. Few of the world's cities offer such a lifestyle to any but the very rich (Lowe, 1994, p. 30).

Lowe acknowledges that the current transport pattern in Australia 'fails on all three criteria of sustainability.' Change is needed, but Lowe would like it to happen without depriving ordinary Australians of quiet streets backing onto bush. He seems unsure about how this might be accomplished.

Other Australian urbanists share Lowe's concerns. Pat Troy of the Australian National University penned *The Perils of Urban Consolidation*, a swingeing rebuttal which indicts the compact city on efficiency, equity, environmental and democratic grounds. The economic historian Hugh Stretton shares these concerns and adds a political argument. 'Australians would rather lose their cars than lose their cars and their houses. However hard it may be to get them to trade their big cars for little ones... or to give them up altogether, it would be harder still to get them to do it by first giving up their houses and gardens and neighbourhood parks and playing fields' (Stretton, 1993, p. 136).

Stretton advocates a modern version of Ebenezer Howard's 'garden city' – 'poly-centred conurbations in which land is used generously for housing but more densely for many public and commercial uses' (Stretton, 1975, pp. 5-6), with efficient public transport connecting the centres. This alternative version of the sustainable city is championed as an antidote to global warming by Gleeson (2008), but it appears to be a minority taste among 21st-century urban planners.

Troy's most telling criticism of compact city advocacy is that correlation is not the same as causation. Walking and public transport use tend to be higher the closer one comes to the city centre, for a variety of reasons: the share of trips made to the centre (the best-served destination by public transport and the hardest to reach by car) increases; municipally-provided public transport is usually better in the central municipality (as in 1950s Chicago); and radial public transport routes converge, reducing walking distances to stops and stations. Car use rises with distance from the centre even in cities with uniform densities, such as Canberra. Since density also declines with distance from the centre in most cities, then there will appear to be a relationship between density and car use. But this correlation does not prove causation: the number of fire engines sent to a fire correlates strongly with the amount of damage done by the fire, but sending fewer crews will not reduce the damage bill.

There is no doubt that very large differences in density do affect transport patterns. It would be impossible for the car to dominate travel in Hong Kong or Manhattan, no matter how much effort was devoted to the task. Conversely, in spacious cities like Houston and Canberra, it is possible to plan on the basis that cars will dominate. So the general relationship shown in Newman and Kenworthy's famous graph is undoubtedly correct. But Houston is never going to become Hong Kong or anything like it: that would require demolition and rebuilding on a Corbusian scale. The question is whether achievable changes in density are likely to make a significant difference, and here the evidence is less compelling.

ANOTHER LOOK AT THE DATA

In 2004, a team of Israeli researchers re-examined the Australian and US cities in the original *Cities and Automobile Dependence* data-set. Their analysis, replete with a reproduction of the famous hyperbola, found no correlation between density and energy consumption: the US cities had similar densities to the Australian cities, but much higher car and energy use (Mindali et al, 2004). The Newman and Kenworthy graph actually shows that Australian cities' car use rates are closer to those of the European cities than to the US cities, despite the large differences in density.

More recently, Rickwood and Glazebrook (2009) analysed the relationship between density and public transport's share of work trips in Australian cities at the census collection district (CD) scale (CDs are the smallest units for which the Australian Bureau of Statistics reports census data). They concluded that 'moderate increases in local area densities, without changes to transport infrastructure, will result in no change in transit use' (p. 185), but that larger changes in the long term may have an impact. One interesting aspect of the Rickaby and Glazebrook study was the development of a different methodology for estimating urbanised areas, and therefore densities, from that used by Newman and Kenworthy. Kenworthy estimated the urban areas of Australian cities from maps and satellite images, but Rickaby and Glazebrook aggregated all CDs with a density of 5 or more persons per hectare.

The Australian Bureau of Statistics has employed a similar methodology to delineate urbanised areas since the 1960s, based on Linge (1965). The main differences are that the ABS methodology uses a lower threshold of 2 persons per hectare, and also includes non-residential CDs that are surrounded by, or contain land uses that relate closely to, residential CDs (ABS, 2005). Rickaby and Glazebrook did not use the ABS methodology, as it necessarily involves the inclusion of some non-residential land (p. 174), but it has the advantage of enabling international comparisons. The reason for this is that Statistics Canada and the US Census Bureau employ a similar methodology to that of the ABS for delineating urbanised areas (Puderer, 2009; US Census Bureau, 2007), although with a higher density threshold of 4 persons per hectare (in the US, 1000 per square mile, or 3.86 per hectare).

Newman and Kenworthy actually used the 'urbanized area' data from the US Census Bureau to estimate the densities of US cities for their database, but did not use the equivalent Canadian or Australian figures, as the land areas of these units were not published until the 2006 censuses. It is now possible to compare the densities of urban areas across the US, Canada and Australia on a consistent basis – subject to the qualifications that the US figures are from the 2000 census, while the others are from 2006, and that the lower threshold for Australian cities under-states densities somewhat relative to the North Americans. As each country's census also includes a question about the mode of travel for the journey to work, it is also possible to compare mode shares across the three countries. Although each country's census reports the mode share data slightly differently (for example, the US figures include taxis in 'public transport'), more detailed data is available which allows these differences to be corrected for, producing figures that can be compared. While work trips only account for a minority of travel, they provide a consistent basis on which a wide range of cities can be compared: by contrast, surveys of overall travel are conducted in different years, often using different methodologies.

The results are set out in table 1, which is at the end of this paper. Urban areas have been arranged in order from most to least densely-populated. Because there are so many cities in the United States, only the largest have been included.

The results cast serious doubt on the idea that density determines transport patterns, because the urban area with the highest density of all – even allowing for the understatement of the Australian figures – is Los Angeles, the archetype of automobile dependence. Brisbane, with barely a third Los Angeles' density, has three times as much public transport use, and more walking and cycling. The lowest rate of car use is in New York, which has a relatively high density, but one considerably below Los Angeles, San Francisco and San Jose. However, if taxis (counted in 'other' and used extensively in New York) are included with cars, then Ottawa has the lowest car use. But Ottawa's density is not particularly high, being lower than Sydney's, and probably about the same as Melbourne's when allowance is made for the different Australian density threshold.

Another surprising city is Portland, Oregon, hailed among urban planners as a model of 'smart growth' and 'transit-oriented development'. Its density is barely half that of Los Angeles, and lower than Adelaide's, although its public transport mode share, at 6 per cent, is higher than the City of the Angels. Although Portland showed the largest increase in public transport mode share of any US city between the 1990 and 2000 censuses (a full percentage point), its 2000 performance shown in Table 1 is lower than any Canadian or Australian city, even Canberra and Hobart. It is not clear why Portland should be regarded as a model of either smart growth or successful public transport in Canada or Australia.

The US density figures in Table 1 are similar to those reported by Kenworthy et al (1999; 2001), which is unsurprising, since they come from the same source. The Australian figures in Table 1 are significantly higher than Kenworthy's, because the census methodology counts less non-residential land as 'urban'. The biggest difference comes with the Canadian cities, where the census densities are much lower than those reported by Kenworthy et al. The reason for this appears to be that Kenworthy's Canadian figures were 'net' or 'residential' figures that excluded non-residential land mixed in with residential land. This can be seen clearly from their map of Toronto (Kenworthy et al, 1999, p. 375), which shows parks, cemeteries and Toronto and York Universities as 'non-urban' land.

The census data confirms Newman and Kenworthy's finding that US cities are the most automobile-oriented, followed by the Australians, with Canadian cities least auto-oriented. The Canadian cities have the highest rates of walking and cycling, as well as public transport use, the US cities the lowest. But the census data does not show a similar pattern with densities: the three countries' cities are surprisingly similar, with the largest differences being between cities in the same country. And importantly, the differences in density do not correlate closely with differences in mode share: there is a very weak relationship between density and public transport mode share, and no relationship at all between density and walking/cycling.

Brisbane and Boston have relatively high rates of public transport use despite very low densities; Victoria, the capital of British Columbia, has surprisingly low automobile use despite its low density, thanks to a combination of respectable public transport use with high rates of walking and cycling.

It has not been possible to include European cities in this comparison, because that country's statistical agencies do not publish comparable data on urban densities. However, it can be observed that most of the European figures covered in the Newman-Kenworthy databases appear to be for central cities only, rather than entire urban areas, because of the difficulty of obtaining data for the true urban area (Kenworthy et al, 1999, pp. 27-32). Since central cities are usually denser than their suburbs, this means the apparent large difference between European urban densities and those in Australia, Canada and the USA is at least partly an illusion. Kenworthy and his colleagues were able to obtain density estimates covering the entire urban region for some European cities, but these figures – 28.5 per hectare for Copenhagen and 24.0 for Oslo – are not that different from cities like Los Angeles, Toronto and San Francisco, and probably Sydney as well (allowing for the under-statement of the Australian figures).

CONCLUSIONS

The idea that urban density is the main determinant of the share of travel made by different modes, and that public transport cannot be operated effectively below a minimum density somewhere between 30 and 100 persons per hectare, rests on a very weak evidentiary base. It appears to have originated from the discussion of suburban bus services in the Chicago Area Transportation Study, but that discussion erroneously attributed to density a problem that was really the result of planning and policy failures. The more recent trans-national comparison by Newman, Kenworthy and colleagues appears to have under-estimated the densities of Australian and US cities relative to those in Canada and Europe. More recent Australian, Canadian and US census data suggests that, when measured accurately, population density is only very weakly related to public transport's share of work trips, while there is no link at all for walking and cycling.

The data used in this paper has multiple limitations, arising from the following factors:

- The US figures date from 2000, while those for Australia and Canada date from 2006
- The three countries do not employ exactly the same definitions of urban areas, which means the Australian figures are under-stated relative to the other countries
- Densities have been calculated for the principal urbanised area within each statistical region, whereas ideally 'satellite' areas should also be included; and
- Mode share figures are for the journey to work only, rather than for all travel.

Nevertheless, despite the limitations, the data in Table 1 suggests the need for a serious re-examination of the 'compact city' solution to mode shift. This will require additional work to address the limitations mentioned above, and will become easier once data from the 2010 US census and 2011 Australian and Canadian censuses becomes available. The additional work is important, because transport policies are much easier to change than the urban densities of large cities, which alter only slowly and with great disruption and controversy. If transport policy is more significant than density in effecting change (Mees, 2000; 2009), then the environmental problems of urban transport may be easier to solve than has been widely believed. Alternatively, the more 'backyard-friendly' path to urban sustainability advocated by Stretton and Gleeson may prove more effective than the compact city.

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Table 1: *Density and method of travel to work in US, Canadian and Australian cities (2000/2006)*

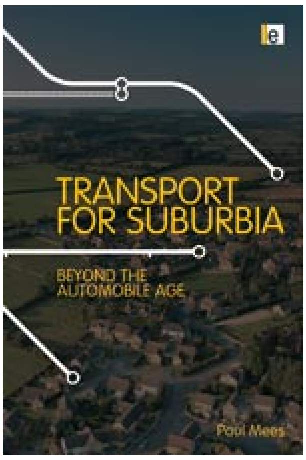
City	Country	Population	Density (per hectare)	Car %	Public transport %	Walking %	Cycling %	Other %
Los Angeles	US	16,373,645	27.3	91.1	4.7	2.7	0.6	1.1
Toronto	CA	5,113,149	27.2	71.1	22.2	4.8	1.0	0.9
San Francisco	US	4,123,740	27.0	84.2	9.7	3.4	1.1	1.4
San Jose	US	1,682,585	22.8	Included in San Francisco data.: see notes.				
New York	US	21,199,865	20.5	67.6	24.8	5.7	0.3	1.6
Sydney	AU	4,119,189	20.4	71.2	21.2	4.9	0.7	2.0
Montreal	CA	3,635,571	19.8	70.4	21.4	5.7	1.6	0.9
New Orleans	US	1,337,726	19.7	89.3	5.4	2.7	0.6	1.4
Las Vegas	US	1,563,282	17.7	91.2	4.1	2.4	0.5	1.4
Ottawa	CA	846,802	17.2	68.1	21.2	7.6	2.2	0.9
Vancouver	CA	2,116,581	17.2	74.4	16.5	6.3	1.7	1.1
Miami	US	3,876,380	17.0	92.7	3.9	1.8	0.5	1.1
Melbourne	AU	3,592,592	15.7	79.3	13.9	3.6	1.3	1.9
Denver	US	2,581,506	15.4	91.4	4.4	2.5	0.7	0.8
Chicago	US	9,157,540	15.1	83.9	11.5	3.2	0.3	1.0
Sacramento	US	1,796,857	14.6	92.3	2.7	2.3	1.4	1.0
Winnipeg	CA	694,668	14.3	78.7	13.0	5.8	1.6	0.9
Calgary	CA	1,079,310	14.0	76.6	15.6	5.4	1.3	1.0
Phoenix	US	3,251,876	14.0	93.4	1.9	2.1	0.9	1.4
Adelaide	AU	1,105,839	13.8	83.1	9.9	3.2	1.5	2.3
San Diego	US	2,813,833	13.2	91.2	3.4	3.5	0.6	1.4
Washington DC	US	4,923,153	13.1	86.5	9.4	3.0	0.3	1.0
Portland	US	2,265,223	12.9	89.4	6.0	3.1	0.8	0.7
San Antonio	US	1,592,383	12.6	93.6	2.8	2.4	0.1	1.2
Perth	AU	1,445,073	12.1	83.3	10.4	2.7	1.2	2.4
Detroit	US	5,456,428	11.9	95.3	1.7	1.8	0.2	0.5
Baltimore	US	2,552,994	11.7	Included in Washington DC data: see notes.				
Houston	US	4,669,571	11.4	93.9	3.3	1.6	0.3	1.1

Dallas	US	5,221,801	11.3	95.5	1.7	1.5	0.1	1.0
Victoria	CA	330,088	11.1	71.7	10.2	10.4	5.7	2.0
Philadelphia	US	6,188,463	11.0	86.1	8.8	4.0	0.3	0.8
Columbus	US	1,540,157	11.0	94.3	2.2	2.5	0.2	0.5
Seattle	US	3,554,760	10.9	87.7	7.0	3.3	0.6	1.4
Canberra	AU	368,129	10.8	82.0	7.9	4.9	2.5	2.7
Cleveland	US	2,495,831	10.7	93.7	3.4	2.1	0.2	0.6
Milwaukee	US	1,689,572	10.4	92.7	4.0	2.8	0.2	0.6
Hobart	AU	200,524	10.3	82.6	6.4	7.6	1.1	2.3
Minneapolis	US	2,968,806	10.3	91.8	4.5	2.5	0.4	0.6
Virginia Beach	US	1,569,541	10.2	93.7	1.8	2.7	0.3	1.6
Edmonton	CA	1,034,945	10.1	82.8	9.7	5.1	1.1	1.2
Orlando	US	1,644,561	9.9	95.4	1.6	1.3	0.4	1.1
Tampa	US	2,395,997	9.9	94.9	1.3	1.7	0.6	1.1
St. Louis	US	2,603,607	9.7	95.2	2.3	1.6	0.1	0.7
Brisbane	AU	1,763,129	9.2	78.6	13.8	3.7	1.1	2.8
Providence	US	1,188,613	9.0	93.1	2.4	3.3	0.2	0.7
Boston	US	5,819,100	8.9	85.1	9.0	4.2	0.4	0.9
Kansas City	US	1,776,062	8.9	96.0	1.2	1.4	0.1	0.8
Cincinnati	US	1,979,202	8.6	94.1	2.6	2.3	0.1	0.7
Indianapolis	US	1,607,486	8.5	96.0	1.2	1.7	0.2	0.8
Pittsburgh	US	2,358,695	7.9	88.8	6.2	3.7	0.1	0.6
Atlanta	US	4,112,198	6.9	94.2	3.6	1.3	0.1	1.1
Charlotte	US	1,499,293	6.7	96.6	1.3	1.2	0.1	0.8

Sources: Australian and Canadian Census 2006, US Census 2000
Notes:
• Population and mode share figures are for the entire census area, density is for urban area only, except for the following US regions: San Francisco Consolidated Metropolitan Statistical Area includes San Jose urban area, and Washington CMSA includes Baltimore, so Metropolitan Statistical Areas figures have been used for population (unfortunately, mode share figures were only available for the larger CMSAs).
• 'Car' includes truck; 'other' includes motorcycle and taxi (counted as public transport in some US studies).

Transport for Suburbia
Beyond the Automobile Age
By Paul Mees

The need for effective public transport is greater than ever in the 21st century. With countries like China and India moving towards mass-automobility, we face the prospects of an environmental and urban health disaster unless alternatives are found - it is time to move beyond the automobile age. But while public transport has worked well in the dense cores of some big cities, the problem is that most residents of developed countries now live in dispersed suburbs and smaller cities and towns. These places usually have little or no public transport, and most transport commentators have given up on the task of changing this: it all seems too hard.
This book argues that the secret of 'European-style' public transport lies in a generalisable model of network planning that has worked in places as diverse as rural Switzerland, the Brazilian city of Curitiba and the Canadian cities of Toronto and Vancouver. It shows how this model can be adapted to suburban, exurban and even rural areas to provide a genuine alternative to the car, and outlines the governance, funding and service planning policies that underpin the success of the world's best public transport systems.



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