Sustainable port development and technological innovation - Case study Port of Antwerp

Willy Winkelmans
Emeritus Prof. Dr. University of Antwerp,
ITMMA – Keizerstraat 64 -2000 Antwerpen
willy.winkelmans@ua.ac.be

Abstract

A growing imbalance between demand for freight mobility (in terms of ton and tkm) and the supply of transport (in terms of lanes of infrastructure) in and around seaports is jeopardising the sustainability of its future development. Given the ever growing globalisation of the maritime industry any shortage in (trans-port) capacity is negative. In addition to cost-effective pricing and management application of technological improvements in the field of transport and transhipment will make port development more sustainable. New (underground) modes of transport could help, the more because transport capacity extensions on the earth surface are more and more affected by limitations in speed and size as a function of density of population and the existence of biotopes, especially around (port)towns. Moreover improved surface transport systems such as lash, pushing convoys and double-stack trains are not applicable everywhere in the BNL. Of course expansion of trans-port capacity can be realised in various ways: by using bigger vehicles, by re-organising transportation spatially and timely, etc., but by creating new "ways" or modes of transportation a much greater extension in capacity will be achieved.

The feasibility of any new transport mode however depends upon cost recovering. An in-depth study of the situation in Antwerp and Rotterdam has been performed in order to acquire correct understanding of technical, economical and commercial consequences. It includes travel time and reliability analyses and a cost analysis. UCM (Underground Container Movers) as a pilot project demonstrates that "Underground Tubular Transport" contains interesting features to avoid congestion and to increase the efficiency of terminal operations in seaports confronted with congestion due to constant growing truck volumes. The volume to be transported through the UCM-system must be high enough to cover all costs (more than 2 million TEU in the business case).

Application in due time of the UCM-system in the port of Antwerp might also alleviate the congestion on certain hinterland connections, especially on high ways, which together with life-cycle considerations increases the degree of sustainability of this new way of transportation.

Keywords:
Containerisation
Port and hinterland
Road traffic congestion
UCM: underground container mover
UTT: Underground tubular transport

MAIN TEXT

Hinterland Connections
Sustainable port development and technological innovation
Case study Port of Antwerp

1. Introduction

Today more than ever one should realise that mobility is not just a question of transportation! A good transport policy pro mobility also must include measures regarding sound country planning, healthy environment and safety, in other words development of a sustainable mobility is determinant for our daily living and working conditions. In order to achieve a sustainable development in the field of transport and ports application of sound macro-economic considerations and goals in combination with healthy micro-economic concerns and objectives is required. A coherent and internal consistent long term vision on transport mode development is of great help too, certainly when it includes conceptual and technological innovation and long term planning.

2. Formulation and analysis of the current mobility issue

Transportation is one of the most rapid growing activities since globalisation of production and consumption is taking place. Since then it is striking that freight transport (in tkm) has been growing constantly at higher pace than the underlying economic determinants such as the GDP, which demonstrates how important mobility has become nowadays. [1]

---

[1] The reasons are simple and straightforward:
- growth of world population and income per head
- growth of economic activity due to globalisation and liberalisation
- growth in terms of specialisation and diversification including growth in flexibility as regards localisation (shifts), production (quantities) and consumption (habits). The influence of worldwide containerisation,

However, a growing number of regions all over the world are confronted with increasing traffic congestions, which are no longer accidental but mainly structural. The social cost of congestion in terms of pollution and time lost is enormous. Simultaneously the transport capacity is shrinking whereas the demand for mobility both in terms of passengers and freight is further growing. No wonder that in and around growth poles such as seaports queuing has become a standard phenomenon, including waiting times, anxiety, accidents and many other detrimental consequences.

Technically saturation on highways occurs when speed of all vehicles is declining to less than 50 km/h, i.e. when more than 2000 vehicles per hour per lane are moving, but queues emerge already at 1500 vehicles/hr/lane. One and another can be measured accurately by means of GSM or GPS signals. In this way it has been observed that in Antwerp for instance the number of km highways confronted with structural congestion increased by 8 times since the last 20 year! By means of random sample surveys it could be demonstrated that travel time and speed on Flemish highways are really becoming inconstant variables: between 2007 and 2008 e.g. speed during congestion times diminished by 35% and travel time increased by 55%. This situation is worsening given the fact that traffic jams are becoming wider and longer, whence travel time becomes uneasily volatile (PWC, 2009, pp. 19/21).

Believing that less mobility could present a kind of solution is dangerously underestimating the contribution of transport in a societal context. In fact congestion is a kind thermometer of the imbalance between supply and demand, jeopardizing the good working of the economy. In other words solving the problem of congestion is mainly a question of maintaining equilibrium between supply (of infrastructure) and demand (of mobility in terms of vehicles and displacement). The fact that the intensity of the use of for instance the Belgian road network increased by more than 300% over the last 30 years, whereas the total length of its road network only increased by 125% dramatically demonstrates the gap between both parameters (PWC, 2009, p. 18).

Once the imbalance between demand (for mobility) and supply (of transportability) becomes serious, a kind of vicious circle starts to work: the ever growing demand leads to more and more transport units, whence the limited infrastructural capacity in confrontation with the unlimited number of vehicles engenders more queues, more losses, more pollution, more nuisances, etc… As such our mobility problem clearly is connected with the limitation of supply (costs?) and a rather unlimited level of demand (prices?).

Since this is not a problem limited to one specific country it is reasonable to demand how the EU transport policy considers the situation. The first white paper on European transport policy: “2010: time to decide” promoted the idea to decoupling the link between economic growth and transport, which proved to be a mission impossible. The current degree of mobility is minimally to be maintained for reasons of welfare, whence the EU changed their

telecommunication and internet must not be denied! Better transportation made delocalisation and/or relocation of plants and or industrial firms more feasible than ever.

objectives toward "not more, but another growth of mobility". This is well formulated in the forthcoming next white paper: "2020 A sustainable future for transport: towards an integrated technology-led and user-friendly system".
Unfortunately a clear strategic long term vision and strategy still is totally absent, plus no word is said about the possibility to create new ways of transportation. Nevertheless UTP (Unit Transport by Pipeline) or UTT (Underground Tubular Transport) is in fact fully in line with the principal objectives in the current green paper[2].

Indeed, underground transportation as a new mode of transport guarantees:

- An almost perfect internalisation of all external effects, including as such a serious lowering of the carbon footprint of transport
- Very good performances regarding capacity, rotation time, transport costs (cf. the total absence of bad weather conditions, of congestion, of route problems), whence highest energy efficiency can be obtained
- Moreover: UTT represents corridor transportation by definition and is ideal for public private partnerships, whereas important additional advantages are to be mentioned, such as the small space intensity together with the preservation of aboveground alternative use of space and the resulting higher degrees of performance as regards damage prevention, frequency, speed, reliability and punctuality.

As such it should become clear that the two other original principal goals of the EU, viz. promotion of modal shifts towards environmental friendly transport modes and support of technological progress and innovation in the field of transport, are definitively in favour of the introduction of new ways of transportation too. First, modal shifts so far have not been a real success; plus even if inland water and railway transport could double their degree in the modal split - which is very unlikely - then still road transport volumes increase! Second, new transport modes are undoubtedly technological and innovatively driven.

*3. **Towards problem solving actions***

Transport capacity can of course be improved and enlarged in different ways. That is not the real problem. The bottom-line question is to get it acceptable or affordable in a sustainable way. Constructing new roads in densely populated areas is no longer that obvious, neither is the introduction of bigger surface vehicles. Dislocating the faster passenger transportation from rather slower freight transportation in terms of infrastructure is basically a very good idea, but apparently too late to realise. For aboveground transport there is indeed no extra "room" anymore.[3] Surface transport capacity extensions are indeed practically always

[2] Main objectives mentioned are: decarbonisation of transport, internalisation of the external cost of transport, higher energy efficiencies, development of transport corridors or "priority freight lines" and further promotion of PPP's for financing transport infrastructures.

[3] The political and economic feasibility of "double stacking (highways?)" and/or of the so-called "Eco Combis" (vans of 25 m and more) in Europe can hardly be taken for granted. Interesting transport innovations such as barge pushing convoys and double-stack trains are not fully executable in Europe due to lack of space and non-adapted superstructures such bridges.

confronted with severe limitations in speed and size given the density of population and specific natural circumstances, especially in and around towns and natural parks. Moreover further increase in surface transport capacity goes ahead with plenty of negative effects. The

Eco-combi e.g. will not only increase CO^2 emissions but also take away from the more environmentally friendly railways large volumes of high-valued commodities and last but not least increase the maintenance cost of many roads.

The bottom line for introducing new ways of transportation however is precisely the possibility to recover from the market any increase in costs. In due course regularly new modes of transport have come into existence. Why should this no longer be possible in an era of high technological and innovative thinking? Although one cannot know with certainty what the future will bring, the long lasting existence of business cycles learns us that several technological innovations have found place during last centuries creating regularly new modes of production and transportation: in the 19th century both railroads and pipelines were invented as new transport ways; in the 20th century we god the motorization of road transport and air transport, so in total 4 new modes of transport over a good 100 years! During the second half of the XXth century no other real new mode of transport was created and this none-withstanding the very high conjuncture wave at that time. Only in the field of telecommunication some major inventions were produced. Strange, why? Investments in infrastructure nevertheless determine the functioning of an economy, whence infrastructures are needed in parallel with economic innovation! (Noels, 2008, chapter 3, pp. 347/358).

Anyhow, any new transport mode should possess the following qualities: interconnectivity with standard surface transport modes, very low spatial intensity, optimal market segmentation and/or dislocation of passenger and freight transportation, high safety and security standards, high velocity whenever required, and very high energy efficiency. In this relation it is useful to make a clear distinction between tunnel transport and tubular transport. A tunnel is the underground continuation of a surface road, whereas traditional pipelines aboveground or underground are “vehicles” to transport liquids or gases. Tubular transport on the contrary uses tubes as an infrastructure, as a kind of “road” underground, which means that inside these tubes dedicated “vehicles” are to be brought into operation for transportation needs. This shows how fundamentally different tubes are to be considered from pipelines and tunnels in terms of transportability. Tubes represent in this respect truly a new kind of infrastructure, allowing newly adapted vehicles to operate fully underground. Pipelines are to be considered as vehicles rather than as infrastructure, which explains why commonly this mode of transport resorts under “Economic Affairs” and not under the department of “Mobility” or “Public Works”! As such this explains why in many countries “transport by pipeline” unfortunately is not part of a coherent transport policy!

Knowing that space definitively is in short, that “space” is becoming a luxury on our globe, makes that “space” no longer primarily can be used for transportation and related business logistics, especially not in and around seaports! This is another good reason to “build underground”, where space is abundantly present at least at low depths.
Thanks to new tunnel boring machines, especially the ones using “pipe-jacking”, going

underground poses no problem any longer neither technologically nor construction wise. Also maintenance of underground infrastructures is not a problem. Several types of such TBM's (Tunnel Boring Machines) exist which can drill and build auto guided tubes underground in the range from 1 to 7 meter without incurring any nuisance worth mentioning aboveground. Only every two kilometres a "construction pit" is to be built, from where the pipe-jacking will create fully finished tubes at a speed of around 1m per hour.

Finally, the different modes of transport can be compared objectively, showing that tubular transport ranks highest both in terms of macro- or socio-economic characteristics and the many operational or micro-economic conditions. Typical transport modal split conditions such as speed, accessibility, flexibility and penetration are commonly considered as inferior in case of transport by pipelines, but in reality much depends upon the quality of the network. Eventually if a life-cycle assessment - through which all kind of cost implications are taken in consideration – is followed, it can be proofed that UTT ranks definitely highest in class thanks to an absolute low negative externality in combination with lower operational and maintenance costs.

4. ***The case of UCM in the Port of Antwerp***

The port of Antwerp consists of two sections, one on the right bank (RSB) and the other on the left bank (LSB) of the river Scheldt. These two port sections serve growingly the same hinterland, which creates traffic problems due to ineffective interconnection between both sides of the river Scheldt[4].
Many containers loaded or unloaded at the Deurganck dock[5] (LSB) are coming from or going to the northern and eastern hinterland of the port of Antwerp, in other words these traffic streams need to cross the river Scheldt in one or another way. Today about 60% of the container traffic at that dock is done by trucks, whence some 3 million vans per year or about 8200 trucks per day are joining the already very heavy road traffic around Antwerp. Altogether this increases of course the already existing severe congestion on these high ways.
In 2012 it is expected that the Deurganck dock will run at full capacity, whence more than 4.5 million container boxes will run over the port's roads (Vernimmen, et.al., 2007, pp. 298/300). The "road system" in and around the port of Antwerp therefore needs urgently serious expansion and or reconsideration.

Today's chosen solution consists of building a traditional railway tunnel, which will cost more than 750 million € and needs a construction time of 4 to 5 years. Rather negative is

[4] Many seaports do have similar situations because of their location alongside streams. Given the growing threat of increasing congestion and waiting times on the "roads" in and around these seaports the question of how to cope with it becomes crucial. A cost-effective integration of the various port sections therefore is of paramount importance.
[5] The Deurganck dock has a container handling capacity between 6 and 10 million TEU/year, of which 20% is pure transshipment. Of the remaining 80% of these containers come or go for ca. 70% from or to North-Europe (the Netherlands, Luxemburg, Germany), whence it can be expected that finally much more than 3 million TEU/year must cross the river Scheldt.

that this solution is uni-modal, i.e. it will take away from the congested roads only minor parts of the growing container traffic.
The solution we propose is to install a tri-modal so-called UCM system[6]. This would cost much less - around 550 million euro for a closed loop of around 20 km - and could be constructed in less than 4 years. Given the fact that container transport is most suited to multi-modal solutions, the UCM system offers a new direct "way" to combine all transport modes at every transhipment place.

UCM involves displacement of the containers by means of transport chains (see Figure 1) running within underground tubes of a diameter of 4.2 m at a speed of 7 km/hour. It counts down to more than 100 boxes/hour either direction, i.e. about 5000 boxes/day. The total yearly transportation capacity therefore reaches some 2 million boxes per year! The speed of the belt can be increased up to 15 km/hour resulting into an extended capacity of 4 million boxes per year.

FIGURE 1: THE UCM ® (Denys NV) Underground Container Mover WITH TRANSPORT CHAINS IN A LOOP, LOW BED TRAILERS AND ELECTRIC MOTORS.

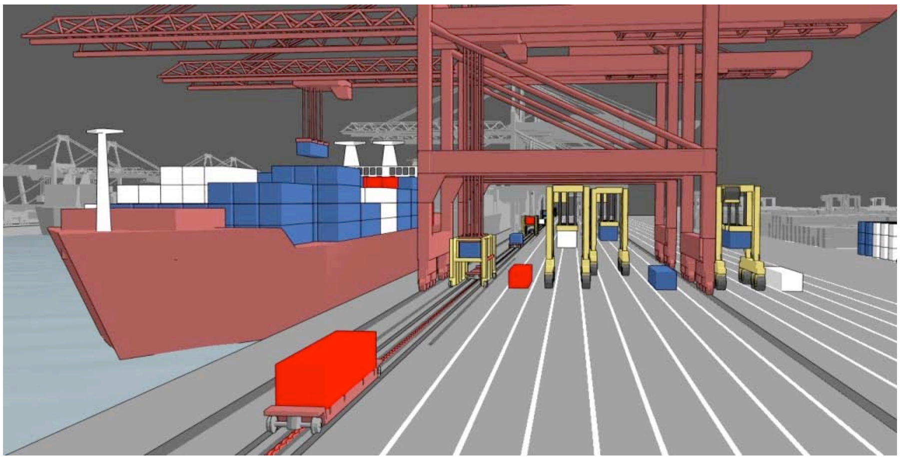
On the container terminal two kinds of transhipment are possible: either horizontally or vertically. The first approach is much too site-intensive for modern container terminals. Hence it is chosen for vertical transhipment, although the (dis)charging frequency is somewhat lower then.

[6] UCM stands for "Underground Container Mover" and is the trade-marked codeword by the construction firm DENYS Company Lt. The system allows to interconnect various (container) terminals at any dock on both sides of the river Scheldt with several transhipment zones for barges, railway and road transportation altogether, and this on a 24/24 h basis.

A free chosen number of loading and unloading platforms can be installed either at the apron on one or more of the normal lanes between the legs of the container cranes or at the rear quay, either underground or aboveground (see Figures 2 and 3). [7]

FIGURE 2: UCM AT THE REAR QUAY - INDIRECT TRANSHIPMENT REQUIRED

FIGURE 3: UCM AT APRON ABOVEGROUND => DIRECT TRANSHIPMENT



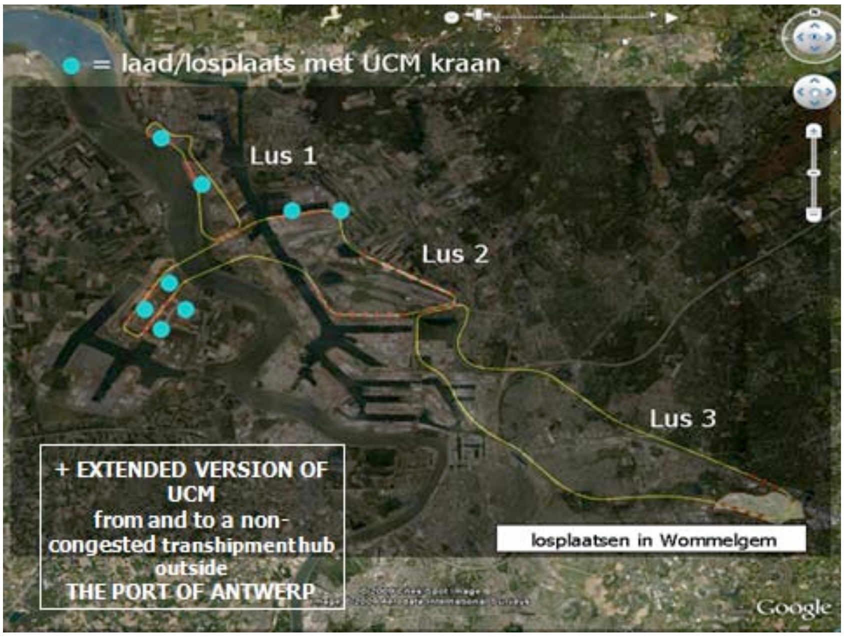
For reasons of cost price direct transhipment alongside the quay is of course to be preferred.

[7] The vertical loading/unloading platforms lead to an underground station, where over some 30 meters a double track runs next to the main chain. On this second chain a portal crane is moving over the main chain with a container lift. This crane shifts the containers from the quay (apron) to a standstill portal chariot, which can move over the main chain. Once the speed of the underlying transport chain is achieved the container is put down on the main transport chain, after which the portal chariot returns to its initial position in order to take in a new container.

An important extra advantage is that UCM makes it possible to interconnect several terminals (or quays) in an optimal way by means of a series of loading/unloading stations, which are spread over the whole length of the quays both at the left and right river bank. Such a kind of optimisation could accelerate the loading and unloading of vessels substantially while limiting the distance between gantry cranes, forklifts or straddle carriers to a minimum. Moreover, a combination of such closed loops over the port area could make all strategic container locations interconnected (cf. Figure 4 and 5).

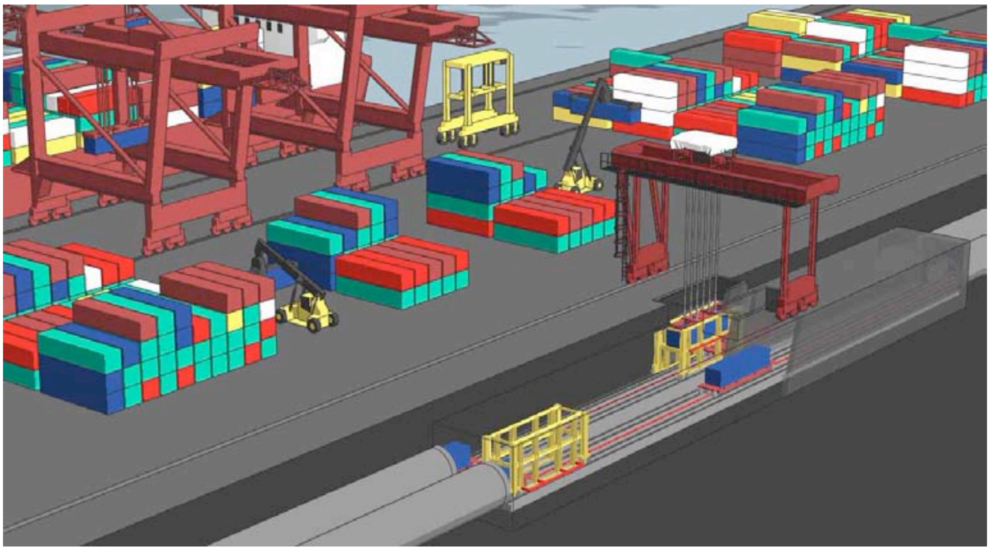
FIGURE 4: UCM CONNECTING DIVERSE PORT TERMINALS, BARGE SECTIONS AND THE SHUNTING YARD OF THE RAILWAYS IN THE PORT OF ANTWERP

FIGURE 5: UCM INTERNCONNECTING VARIOUS SECTIONS IN AND OUTSIDE THE PORT – a so-called optimal UCM TRAJECT



At the crossing points the containers can be transferred from one loop into another, which might shorten drastically the transfer time of containers within the port and increase the turnover of the quays (cf. Figure 6).

FIGURE 6: THE INTERCONNECTIVITY BETWEEN TWO DIFFERENT UCM LOOPS



In short, UCM has plenty of potential advantages such as optimal distribution of containers, optimal transit times, reliability of the operations given total absence of external impact and very low energy consumption and maintenance costs. Ultimately the question is to know whether all these potential advantages are “payable” or not?

The business case carried out by PWC (2009) demonstrates that this is indeed possible, given the fact that the evolution and impact of congestion and waiting times on surface roads with respect to truck tariffs will certainly become a substantial management criterium.

The bottom-line reasoning goes as follows: in the near future truck companies will have to increase their tariffs as a consequence of lower speeds, higher fuel prices and or the impact of road pricing. More congestion indeed implies more vehicles and more personnel to “run” the same volumes per year. Finally it all results into higher costs for the company, especially because these costs can only be covered by the same number of kilometers as before.

Based upon the estimated new kilometer cost or cost per container, the business case proofed to be feasible at a discounted interest rate of around 7% only based upon the ordinary capex and opex.
However, given the various social advantages which go together with the development of UCM, and which have not been included in the calculations, it should be possible to increase

the internal rate of investment to an acceptable degree, by allowing social loans for building and installing underground transport capacities.
This is of course a political choice, but it is also to be considered whether seaports possessing an UCM system might become a specific competitive advantage in comparison to other congested ports without such a system.

Benchmarking Antwerp with UCM and Rotterdam without UCM in relation to their mutual inland hubs such as München and Duisburg, is showing that this reasoning might be correct.

5. ***In conclusion***

UTT and UCM contain an interesting number of advantages in comparison to the existing traditional transport and transhipment means in seaports:

- it is perfectly inter-operational with respect to the existing transport infrastructures and the transhipment and storage superstructures;
- no interference with weather conditions is to be feared;
- it is perfectly suited to operate on a 24h basis, whence the system could guarantee a kind of JIT containers delivery;
- the transport capacity is flexible, easily expandable and very reliable;
- it is relative cheap in maintenance and energy consumption;
- it concerns a most sustainable transport technology because no negative externalities are involved.

Today the issue of sustainable mobility is mainly a question of capacity building. Underground solutions are promising in this respect, though the social basis for it is still very weak. Starting with some intelligent pilot projects could change and positively influence these cautious or guarded attitudes. In such circumstances far-reaching changes require the collaboration of as much as possible actors. Elaborating on the creation of a broad social basis therefore is of paramount importance. The value of such a basis depends upon commitment of various stakeholders. If we want to possess a real mobile world to-morrow, we should start caring about it in very innovative ways today.

REFERENCES

- Noels, Geert (2008). Econoshock. Houtekiet, Business Contact, Antwerpen.

- PWC and Winkelmans (2009). Underground Transportation of Containers "A Business Case UCM Antwerpen", Antwerp, 9 June 2009, pp. 92 + appendices (confindential report).

- Swissmetro, (2003) c/o PricewaterhouseCoopers AG, Bern info@swissmetro.com: Technische und ökonomische Machbarkeitsstudie der Swissmetro-Strecke Basel-Zürich, Juni 2003.

- Vernimmen, Dullaert, Geens, Notteboom, T'Jollyn, Van Gilsen, Winkelmans (2007) Underground Logistics Systems: A way to cope with growing Internal container Traffic in the Port of Antwerp?, Transportation Planning and Technology, August 2007, Vol. 30, Nr.4, pp. 391-416.

- Winkelmans, Beuthe, Notteboom, Coeck, De clercq (2000). Strategic positioning of underground transportation by pipelines and tubes in the framework of a coherent transport policy, FETRAPI, Brussels, 150 pp. + appendices.

- Winkelmans, W. (2009). "Sustainable mobility: a dream or a necessity?", in: The Fifth Conference Move, The future of Mobility & Logistics in Belgium (Editor Frank Boermeester), pp. 64/65, Leuven, October 2009.

- Winkelmans, W., (2009). "Underground transport is the future" in: Vitale Steden (Editors Sven Gatz, Sas van Rouveroij, Christian Leysen), pp. 233/241, VUBPRESS, 2009.