

## 21<sup>st</sup> Century Supply Chains for Europe : the fifth transport mode for freight

Congestion is strangling the supply chains of Europe and adding to the major issues of climate change, dwindling oil reserves, air pollution, noise and safety. A major contributor to all these issues is road freight, which has become the dominant mode of freight transportation in all European countries.

Over the last 50 years the major investments in the transport infrastructure have failed to meet the ever increasing demands for freight transport. Much development work has been done, and investments made, in transferring freight from the road network to the more socio-environmentally friendly transport modes of rail and water. Yet these modes were designed in different ages and are invariably a poor fit with the road dominated 21<sup>st</sup> century supply chains. Supply chain optimization through intermodal and co-modal (multimodal) solutions is considered today a top priority both by the business community and the institutions [EIRAC, 2005]<sup>1</sup> in the Strategic Intermodal Research Agenda 2020, '*It would benefit by the introduction of a "fifth" freight transport systems with features very different from the traditional modes and showing intrinsic characteristic of sustainability*'.

Research groups in Belgium, Germany, Italy, the Netherlands and the United Kingdom, are united in *the International Society for Underground Freight Transportation*, which focuses on this "fifth" transport system. Their joint ambition is to develop and to implement a very sustainable, cost effective way of moving goods, based on automated transport, electrically powered and using capsules or other specific vehicles in dedicated underground tubes or routes, which would address all the issues of EU *White Paper*<sup>2</sup> concurrently: decrease oil dependence, congestion and greenhouse gas emissions.

Today, throughout Europe, large volumes of chemical and petrochemical products are transported between ports, industrial complexes and retail outlets in pipelines safely, reliably, cost effectively and with minimum environmental impact and in the most energy efficient manner possible. And, of course nearly every domestic and business property throughout Europe is connected by pipeline for drinking water and sewage. It is unthinkable that these goods would be transported by any other means. Examples of underground pipeline systems to transport solid goods were developed in the 20<sup>th</sup> century (e.g. London's Mail Rail system and Japan's system in Kuzzu) and recent studies have shown that all the essential technologies exist to develop an operational system fit for the demands of the 21<sup>st</sup> century.

A wide range of applications for freight pipelines have been studied including:

1. In urban areas, for the purpose of provisioning post offices, retail trade, catering establishments, hospitals, offices, and consumers. This application is designed for the transportation of load-units of pallet size.
2. Internal or between industrial complexes, logistical centers, and multi-modal terminals, such as airport and harbor complexes.
3. Collection or long distance transportation of agricultural products, aggregates and solid waste.

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<sup>1</sup> European Intermodal Research Advisory Council (EIRAC) in the *Strategic Intermodal Research Agenda 2020* (2005).

<sup>2</sup> *WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system* (COM/2011/0144 final)

#### 4. Inland or cross-country transportation of maritime containers.

These transport systems combine the social advantages of taking the traffic movements away from the road infrastructure and applying electrical propulsion, with the economic advantages of unimpeded automated transport over a dedicated infrastructure that is separated from passenger traffic. The economic advantages are to be found in an almost direct delivery (no more need for roundtrips with mixed cargo), twenty-four hour service, low variable and exploitation costs, flexible batch dimension, and short turn-around times, and last but not least a much lower life-cycle cost. The social advantages concern the low (local) environmental impact, resulting in reduction of noise, visual pollution, and emissions, reduction of congestion problems, reduction of energy use, and a related reduction in CO<sub>2</sub> emissions, more intense use of available space and an increase in traffic safety.

The key questions that need to be addressed are:

- What supply chain markets are applicable?
- What is the nature and size of the economic, social and environmental benefits?
- What is the optimum specification for an international pipeline system?
- What is the optimum blend of proven technologies?
- What direct and indirect costs are incurred in achieving the benefits?
- What is the optimum development route?
- How should the development be funded?
- What legal and governance issues must be addressed?
- What other 'Barriers to change' will arise and how best to lower the 'Barrier'?

It is proposed that a pan-European study team be formed from the various European study groups to research the answers to these questions. If the answer to these questions confirms the preliminary findings that freight pipelines are indeed feasible and economically, socially and environmentally justifiable then the team should prepare a European development plan aimed at producing a world leading freight transport system designed for the needs of the 21<sup>st</sup> century.

The pan-European study team consists of:

Mole Solutions, United Kingdom (Roger Miles, Mole Solutions Ltd)

Foodtubes, United Kingdom (Noel Hodson, Foodtubes)

Pipe\$Net, Italy (Prof. Franco Cotana and Prof. Ing. Federico Rossi, University of Perugia)

CargoCap, Germany (Robert Stein, CargoCap GmbH)

UCM, Belgium (Em. Prof. dr. Willy Winkelmanns, ITTMA & Johan van Wassenhove, Denys)

OLS, The Netherlands (dr. Ir. Johan Visser and dr. Rob Konings, OTB TU Delft)

This study team is member of the International Society on Underground Freight Transportation by Capsule Pipelines and Other Tube/Tunnel Systems (ISUFT). ISUFT is a global network of researchers and consultants from universities, consultancies and engineering companies. The members of ISUFT carry out projects on underground freight transportation in Europe, the USA, Japan and China.

Automated freight transport, electrically powered and using capsules or other specific vehicles on a dedicated network, in particular underground is a very sustainable, cost effective way of moving good. These systems contribute to a modal shift towards sustainable freight transport.

More information can be found on:

[www.isuft.org](http://www.isuft.org)

[www.cargocap.com](http://www.cargocap.com)

<http://www.molesolutions.co.uk>

[http://www.noelhodson.com/index\\_files/Foodtubes-pipelaying-1dec09.pdf](http://www.noelhodson.com/index_files/Foodtubes-pipelaying-1dec09.pdf)

<http://www.pipenet.it>

<http://www.denys.com/projects/index/nl/1/1>

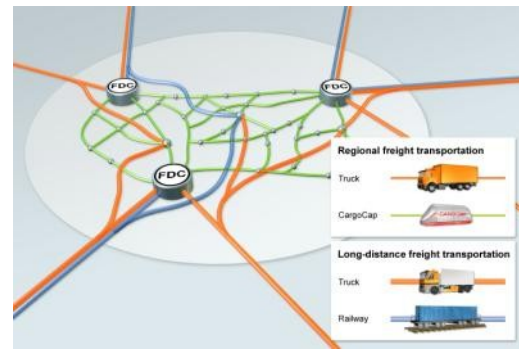
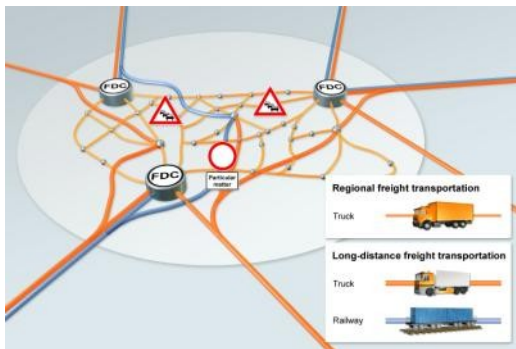
Dr. ir. Johan Visser, President ad Protem of ISUFT

## CargoCap

### Automated underground transportation of cargo: the 5th transportation alternative for the transport of goods in congested urban areas

CargoCap is the 5th transportation alternative to roads, rails, water and air to transport goods fully automated through underground transport pipeline systems in congested urban areas rapidly, economically, reliably and eco-friendly.

Fully automated transport vehicles, the so-called Caps, travel in underground pipelines with a diameter of only 2.00 metres, loaded with two euro-pallets each. For direct connection, the cargo will be delivered directly to the recipient, or to the immediate vicinity of a station by means of connection logistics with delivery vehicles. Only these stations provide connection to the surface. They may be located either right in the city centres near huge stores, or immediately at the assembly line of a factory.

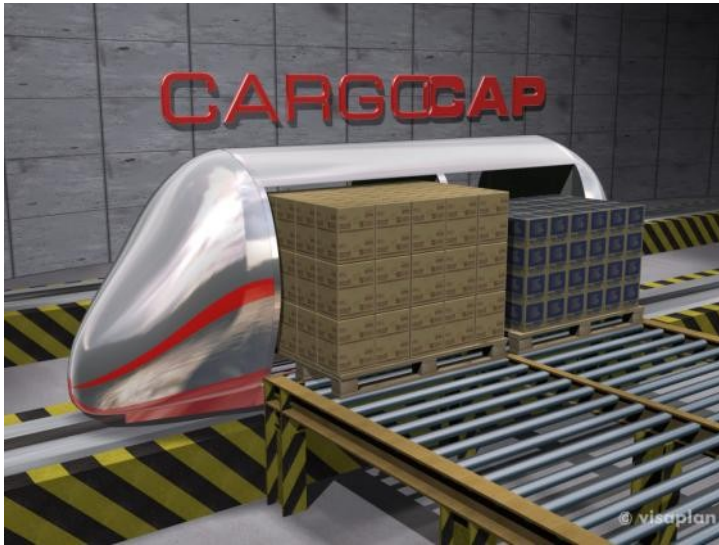


the present situation: the road as a transportation route has reached the limit of its capacity. Serious traffic jams and delays combined with noise, emissions, or particulate matter emissions and constitute a high risk potential.

the solution: goods are transported underground rather than on the road, without the negative side effects of truck traffic.

### Logistics System

Due to its underground transport pipeline system, CargoCap is independent of, and unaffected by, other traffic infrastructure, traffic jams and weather conditions. Transports are performed via computer-controlled Caps with a holding capacity of two euro-pallets each. The euro-pallet is a standardised, tried and tested load carrier. Its use guarantees an easy implementation of CargoCap into already existing supply chains. A high freight- and allocation flexibility is warranted by loading only two euro-pallets onto a Cap. Consumer and investment items, bulk goods, cargo, production components, building material, parcel and express freight, as well as food and allied products rank among the goods that may be transported via CargoCap.



Length	4000 mm
Width	1400 mm
Height	1600 mm
Weight empty	800 kg
Payload max.	1500 kg
Maximum speed	11 m/s (39,6 km/h)
Average speed	10 m/s (36 km/h)
Track gauge	800 mm
Slope	max. 3%

### Vehicle technology

The aerodynamically optimised Caps travel on rails through the underground transport pipeline system, fully automated and autonomically. They are driven by electric motors at a speed of 36 km/h. This transportation speed is kept constantly, resulting in a considerable reduction of transport time compared to a truck in the congested urban area. Energy supply of Caps is contact-free, and therefore maintenance-free. In sections of the CargoCap transport network with heavier traffic, several Caps are aligned to travel one after another in close intervals (platoon). This is made possible through an innovative switch concept and special design of passive junctions. Caps feature an active switch module and define the driving direction autonomously.

**“You cannot see, hear or smell CargoCap.”**


#### Advantages Operation

- Automated
- Eco-friendly
- Energy-saving
- Efficient
- Flexible
- Precise, just-in-time and just-in-case
- Independent of weather conditions
- Safe
- Autonomous and independent of scarce traffic capacities above ground

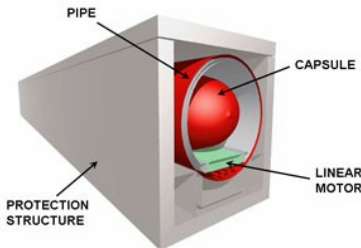
#### Advantages Construction and Realisation

- Immediately realisable
- Expandable
- Eco-friendly
- Space-saving
- Innovative

More Information [www.cargocap.com](http://www.cargocap.com)

	<b>UNIVERSITA' DEGLI STUDI DI PERUGIA CIRIAF</b> Via G. Duranti, 67, I-06125 PERUGIA Tel. 075-5853717 Fax- 075 5853697	<b>PIPEŞNET</b> Material for Strategic Transport Technology Plan (as ISUFT) CIVITAS PLUS 2 proposal	<b>DATE</b> 19 Apr 11 <b>PAG.</b> 6 di 12 <b>VERS.</b> 1.0 <b>AUTH.</b> Andrea Marri
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## PIPEŞNET



Pipeşnet is an innovative, low environmental impact, transport system for light goods, developed by the research center *Centro Interuniversitario di Ricerca sull'Inquinamento da Agenti Fisici* (CIRIAF) at University of Perugia (Italy). The system has been included in the 2009 report of World Energy Council *European Climate Change Policy Beyond 2012* as one of the most promising technologies which could play a significant role in the mid-long term future to mitigate greenhouse effect. Pipeşnet takes part to the "RENAISSANCE" project co-financed by European Union within CIVITAS+ Initiative.

### Description of system

Pipeşnet is a transport system for light goods (50-200 Kg on a europallet volume) made of a network of vacuum-sealed pipes, where europallet-sized capsules are moved by electrical linear motors at high rate and low friction conditions. Concept of system is based upon the assumption that, for light goods, a higher transport capability can be achieved by transferring small payloads at high rate instead of slowly moving huge masses (trucks, trains). Focusing on small and light volume freight will lead to lower construction complexity and investment costs, lower impact and interference of infrastructures with the territory, more manageable safety requirements and shorter time for the system to be operative.

### Features of system:

- ✓ **high transport capacity** (through high speed and rates of launch)
- ✓ **max speed = 1500 km/h**
- ✓ **max transport capacity = 500 kg per second**
- ✓ **traffic relief**
- ✓ **lower emissions** both air and noise (-50% CO<sub>2</sub>, -80% NO<sub>x</sub> and PM in comparison to road transport using Italian electricity emission footprint)
- ✓ **lower energy consumption** (30% of road transport with energy recover during deceleration)
- ✓ **high speed delivery**
- ✓ physical and logistic **integration** with existent **infrastructures**
- ✓ **modularity, flexibility, extensibility**
- ✓ **road accidents reduction**
- ✓ shaped on **final user's needs** not on transport supplier
- ✓ it can be laid out on any floor (underground, suspended or at ground level)

### Application:

- connection between intermodal hubs or consolidation centres and city centre

- connection of industrial zones, seaports, hubs, goods distribution centres, one with the other and/or with city
- spreading logistic services supplied along a “metropolitan for goods”.

Optimization of supply chains would benefit by the introduction of a “fifth” freight transport system, with unique characteristics which would disclose in scenarios usually “difficult” for traditional systems like: environmentally fragile areas, highly dense urban zones, territory with a complex orography, valuable historical city centres and areas with growing mobility needs yet with saturated capacity.

### **Economy**

Estimated cost of the whole infrastructure (pipes, motors, pumps, etc.) is 2-3 millions euro per kilometer for a fully developed system. The cost-benefit analysis for different scenarios (urban, interregional), performed under CIVITAS+ grants and to be published in late 2012 at the end of “RENAISSANCE” project, shows that the system provides high social economic advantages even under low demand conditions provided that modal shift is sufficiently high (>20%). Under high demand conditions operating costs are even lower than most efficient road haulage, thus providing a high profile profitability investment option.

### **Status and Prototypes**

CIRIAF has developed some prototypes like the electrical linear motor, which is the project’s *core subsystem*, complete of controls, vacuum testing and mechanical experiments. A prototype tube (length = 80 m, see picture) is being completed at Terni’s facility labs of University of Perugia, Faculty of Engineering, where experimentation of launching stations and airlocks will be performed.



Runner up in the 2008 St. Andrews Prize for the Environment. Member of ISUFT.

### FOODTUBES™ – Goods In & Waste Out – Low Cost , Low Pollution Transport.

Cargos can be packed into inexpensive, lightweight cargo-capsules, approx. 1 metre x 2 metres (about the size of a large man) or 1.57 cu metres, each carrying up to 2 tonnes of freight, propelled through underground, undersea and over-ground pipelines by electricity. Wire “Cages” of about this size are loaded into supermarket vehicles, carrying goods between their warehouses and retail shops.



The Capsules will be precisely controlled by software – to travel through numerous interlinked, open-architecture Foodtubes Circuits, each of about 100 km; eventually forming **The Transport Internet™**.

In cities, dense-urban & urban areas, Foodtubes Circuits will be installed using No-Dig technology; reducing surface disruption. Pipeline-Circuits infrastructure will last for 50 to 100 years.

**Foodtubes Commercial Models** show 70% profits; charging less than equivalent lorries and trains. [http://www.noelhodson.com/index\\_files/ftubesfinancials\\_28Sep07\\_v15.xls](http://www.noelhodson.com/index_files/ftubesfinancials_28Sep07_v15.xls)

Foodtubes has calculated that today 92% of the fuel or energy used to transport freight is wasted on moving the vehicles. Only 8% is used to move the goods or cargos.

**Water, oil and gas** are transported efficiently through pipelines. There are more than 300,000 km of large diameter pipelines in Europe, including undersea pipelines; operating continuously, day and night, transporting huge vital cargos, unseen and unheard by most citizens.

Many cargos could be transferred into Foodtubes, saving 90% of the diesel used today and reducing man-made CO<sub>2</sub> and other pollutants by 8% to 16%, annually saving billions of litres of diesel.

After water, food is the largest vital daily cargo. The food transport industry now utilises 25% to 30% of all freight vehicles. Foodtubes will transport goods from farm to supermarket, including recycling food & waste.

Carrying food, and **other suitable cargos**. FOODTUBES Circuits are capable of removing 50% of all the commercial transport vehicles from city streets, main roads and railways – and replacing a significant proportion of sea and air freight transport.

If it wins this EC Grant Application (Apr 2011), Foodtubes plans a Demonstration Circuit for city transport managers to consider installing Foodtubes. <http://www.noelhodson.com/Ftubes/12APR11-FOODTUBES-EC-e7M.pdf>

Google “FOODTUBES” for CONTACTS - Engineering, Team and State of the Art papers.

## UCM (Underground Container Mover) <sup>®</sup> (Denys NV) a technological and transport-economic solution for sustainable development of seaports

For the last decades container transport has become very popular and several studies have shown that this transport will rise even further. To meet the market requirements with regard to container movements within the harbour, additional intraport –transport facilities will have to be foreseen beside the existing transport infrastructure such as motor-roads, railways and inland navigation waterways.

The underground container transport system UCM (Underground Container Mover) is a new automated intraport system which offers the ability to transfer containers most efficiently within a harbour area. The transport system UCM has a large number of advantages regarding to the existent transport modi in the harbour:

- Independent of the existing transport infrastructure
- No influence of weather conditions
- 24 h on 24 h
- Almost unlimited transport capacities
- Inexpensive and reliable
- Durable technological development

UCM provides displacement of containers by means of transport chains (see [Figure 1](#)) running within underground tubes of a diameter of 4.2 m at lower speed. At a speed of 7km/hr it counts down already 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 more than 4 million boxes per year.

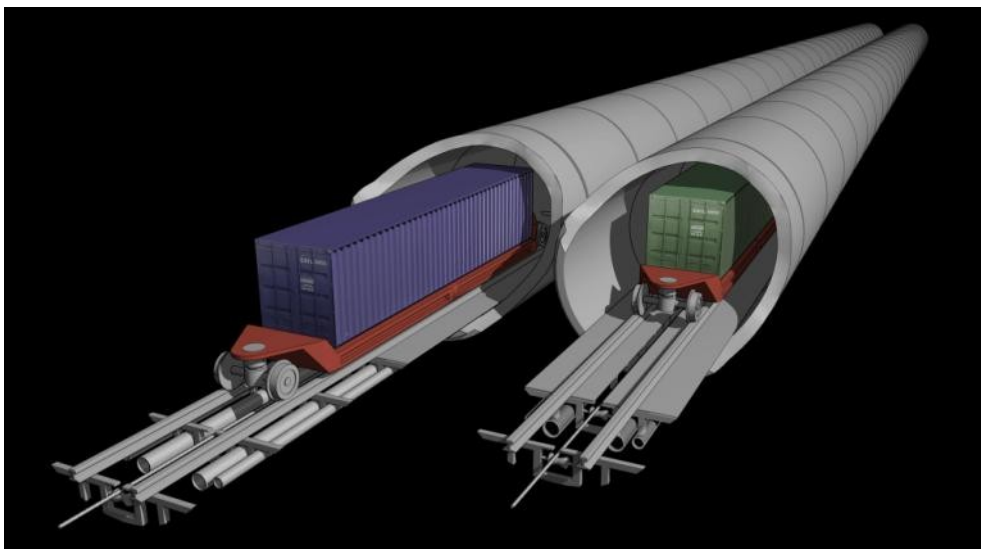


Figure 1: The UCM <sup>®</sup> (DENYS NV) or “Underground Container Mover” with transport chains in a loop, low bed trailers and electric motors.

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.

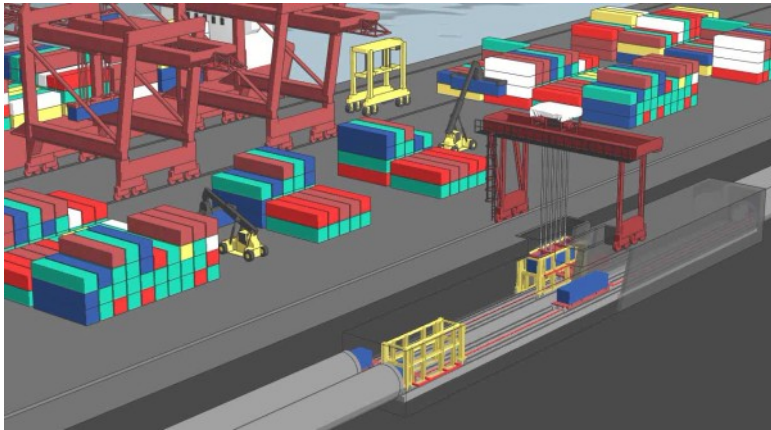


Figure 4: interconnectivity between two different UCM loops

Given that UCM allows to interconnect several terminals spread over the whole port and – why not – beyond the port's perimeter, it becomes feasible to optimise the loading and unloading of seagoing and inland waterway vessels together.

Installing UCM as a pilot project may generate competitive advantages for ports possessing over such an extra way of transport. It allows indeed to avoid or certainly to alleviate congestion on surface transport, while at the same time it increases the efficiency on terminals confronted with the issue of congestion due to the constant growing truck volumes on the roads around the seaport.

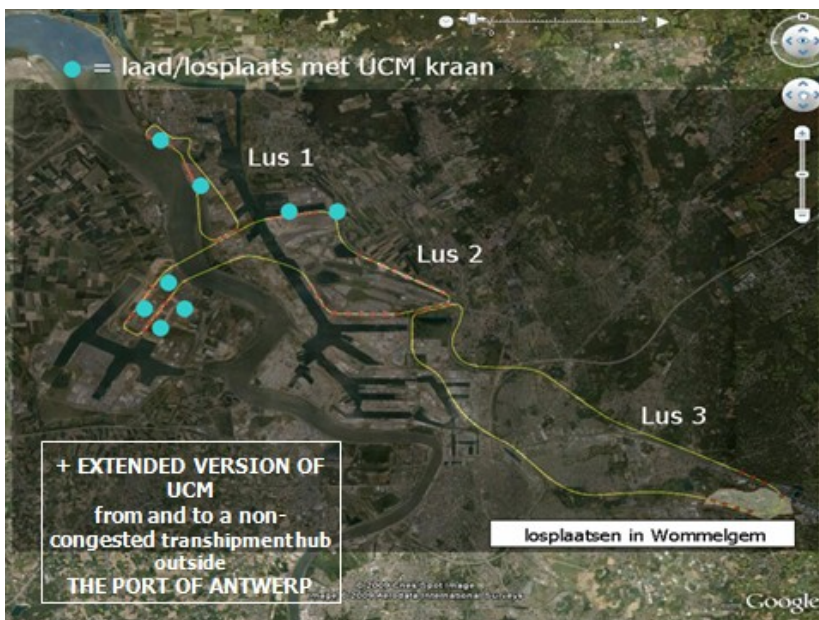


Figure 6: UCM interconnecting various sections in and outside the port

A business case also demonstrates that UCM incorporates many additional and valuable advantages, such as optimisation of the distribution of containers, optimisation of transit times and last but not least high reliability of the operations given the total absence of external impacts. In other words

UCM is perfectly inter-operational with respect to all existing transport infrastructures and transshipment and storage superstructures. Given that no interference with weather conditions is to be feared, it is perfectly suited to operate on a 24h basis, whence the system guarantees JIT container deliveries. Moreover, the transport capacity is flexible, easily expandable and very reliable, while the system is relative cheap in maintenance and energy consumption and based upon most sustainable transport technologies because no negative externalities are involved.

The question whether these potential advantages are “payable” could be answered positively by the business case provided the impact of congestion and waiting times on surface roads with respect to truck tariffs will continue to grow. One and another is worth to consider because the lower ecological footprint of UCM - which has not been taken into consideration so far – eventually might increase the internal rate of investment of the project, allowing social loans for building and installing underground transport capacities.

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 today.

Em. Prof. dr. Willy Winkelmans (ITMMA - University of Antwerp) and Ir. Johan Van Wassenhove (CEO DENYS Company Ltd)

## **Mole Solutions is...**

The concept that is at the heart of Mole Solutions was formed in the 1970's with the development of major refined oil distribution pipelines. The economic and socio-environmental benefits to be gained from using an automated transport system rather than the energy inefficient, batch process water, rail or road transport systems was strikingly evident. Subsequently, Mole Solutions Ltd was formed in 2002 by a small group of senior businessmen with the objective of developing the freight capsule pipeline concept to address the economic, social and environmental problems of freight transportation: rising supply chain costs; congestion; infrastructure resilience; carbon footprint, etc.

The team members have in-depth experience of the important business and technical disciplines combined with extensive complex change management experience. Mole Solutions has established strong partnerships with a number of universities and appropriate companies.

In 2008 Mole was invited to submit written evidence to the House of Commons Transport Committee Report on Freight Transport, entitled, 'Freight Pipelines – an innovative solution to road congestion' ([www.publications.parliament.uk/pa/cm/cmtran.htm](http://www.publications.parliament.uk/pa/cm/cmtran.htm)). In 2009 they were commissioned by the Department for Transport and the Department for Environment, Food and Rural Affairs to undertake a strategic research project, 'Assess the feasibility of using pipelines to transport aggregates in England'. The report was published in June 2010 ([www.sustainableaggregates.com/strategic\\_research/sr\\_keyarea5.htm](http://www.sustainableaggregates.com/strategic_research/sr_keyarea5.htm)) and concluded that suitable technologies existed; freight pipelines could offer major cost savings against road, rail and water freight and, in addition, provided significant socio-environmental benefits.

Mole has presented papers on freight pipelines at conferences in the UK, China and the USA.