The Use of Pipelines and Tunnels for the Solution of Future Transport Problems

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CargoCap represents the fifth transportation alternative. It is designed to carry bulk goods in built-up areas quickly, reliably and punctually. This innovative concept is the outcome of inter-disciplinary collaboration in research and development at the Ruhr University Bochum.

1. Motivation

Even in the age of telecommunications, the efficiency and development potential of an industrial location is largely governed by the capacity of traditional means of Transport - road, rail, air and water.
In the Federal Republic of Germany, roads as a means of Transport have reached their limits so that traffic bottle-necks and delays lead to un-duly high costs and friction. Today, tailbacks and delays cost the German economy around € 100 billion per annum [source: ADAC].

Urban conurbations, which already have been densely built-up, and possess a high share of traffic areas, are particularly affected by this increasing negative development. Their traditionally grown traffic infrastructure can only be adapted to in-creasing demands on traffic performances either to a limited extent or not at all on account of competition in utilising available space, financial constrictions on the part of the state or a lack of acceptance by the general public.

This conflict situation between required mobility and local restrictions will continue to be exacerbated as the number of vehicles is growing considerably faster than the road network. Developments by industrial enterprises on the just-in-time and just-in-case sector, which call for reliable and effective production logistics backed by widely-branched, flexible and efficient transport systems,
which are capable of safely transporting the necessary amounts of goods from one place to another in a certain time, especially contribute towards this.

The outcome of such developments is reflected in chaos that affects traffic on a daily basis to varying degrees. This leads to a fall in performance on the part of the affected region with a corresponding effect on the attractiveness of the location for both the population and companies.

Given the impasse presented by this situation, the interdisciplinary research association "Transport and Supply Systems under the Earth" was set up at the Ruhr University Bochum in 1998 with the backing of the Ministry of Education, Science and Research of North Rhine Westphalia. Its task is to come up with a novel, efficient, environmentally compatible alternative transport system with a lasting effect that can be realized in the short term.

The outcome is the innovative CargoCap concept by means of which goods can be carried speedily, reliably and punctually through underground running tubes (Fig. 1).

figure 1: CargoCap transport unit in DN/ID running tube
2. The CargoCap concept

CargoCap is devised as an independent and efficient system, fulfilling operational profitability demands that can be expanded with ease. It can be set up quickly in technical terms without violating citizens' interests and coordinated with traditional transportation systems and logistics concepts without any problems.

Transportation as such is effected on the basis of individually driven, computer-controlled transport units (Caps), each of which has a capacity of 2 Euro pallets in accordance with CCG 1 (B X DX H = 800 X 1,200 X 1,050 MM).

The application of the Euro pallet as a standardized means of transportation that has proved itself in practice ensures that CargoCap can be easily implemented in existing material flow chains and conventional transport systems. As a Cap unit carries only 2 Euro pallets, this caters for high flexibility for distributing products and freight (Fig. 2).

The goods that can be carried by CargoCap range from consumer and investment items, bulk goods, production components, parcel and express freight as well as food and allied products. Around two-thirds of all the goods of this nature transported in the Federal Republic of Germany fit into the CargoCap freight hold without any need for consignments to be divided up any further.
The technical and legal feasibility as well as the economy of CargoCap was investigated within the scope of a joint research project concentrating on a regional scheme involving a twin east-west route passing through the Ruhr District with a total length of 75 km. This “Ruhrgebiet route” mainly passes under public property in the direct proximity of the A 40 federal motorway from Unna via Dortmund, Bochum, Essen and Oberhausen to Duisburg that is chronically affected by congestion. Inner urban areas, industrial estates, business centres, logistics parks, the locations of industrial enterprises, airports as well as selected “combined traffic” locations were identified and taken into consideration as areas that should be linked to the system (Fig. 3).

The objective of the “Ruhrgebiet route” is to ensure that goods are carried by truck to the edge of the built-area. Transportation to industrial estates and city centres is then accomplished underground independently and undisturbed by possible bottlenecks affecting surface traffic. At the same time, the system ensures high operational and transportation safety as well as an extremely low risk of endangering third parties.

The objective of the Ruhr district route is to ensure that goods are carried into industrial parks and city centres, which are brought by train or long-distance
truck only up to the freight handling facilities of the conurbation. Transport in the underground then takes place independently and undisturbed by aboveground traffic bottlenecks.

At the same time, the system guarantees a high operational and transportation safety as well as an extremely low risk of endangering third parties.

The “Ruhrgebiet route” essentially represents the smallest network size that can operate with an economic profit. Every expansion of the network - either regionally or inner-urban - results in additional economic success so that CargoCap can be assessed as a worthwhile investment for the future.

The possibilities and potentials of extending the system into the Rhineland have been considered in this context so that especially the three airports, Dortmund, Düsseldorf and Cologne-Bonn - as the largest freight hub in North Rhine Westphalia - can be integrated into the CargoCap scheme in order to respond to developments on the logistics sector.

Investigations undertaken so far reveal that CargoCap is in the position to lastingly support the economic development and enhancement of competitiveness of industrial locations in an environmentally friendly manner.

3. Transport Technology

The Caps are designed aerodynamically with running wheels taking over the bearing function and guide rollers at the sides controlling the course. The required bearing and course guidance elements are integrated directly in the running tube line.

Caps are zero emission vehicles, which are driven electrically via conventional three-phase motors, which are fed by frequency converters. They are robustly built with high operational safety, low energy consumption, low procurement costs as well as a long service life while needing relatively little maintenance.

A board computer is responsible for the individual steering of the Caps that travel autonomously, which can be grouped to travel more closely together if the capacity has to be increased although they are not coupled by rnechanical means. The minimum distance amounts to 2.0 m and is controlled and regulated via radar-supported monitoring systems.

This small gap in conjunction with individual control of the Caps prompted the development of a novel branching system, in which the set of points is itself the
passive element and the Transport unit actively steers the transfer procedure into and out of the grouping without reducing speed. As a result, the seemingly low speed of 36 km/h given a constant flow leads to a considerable reduction in transport time compared to lorries in a built-up area. Available parts and components that are tried-and-tested in practice were essentially made use of for developing the CargoCap system in the interests of its speedy and economic realization. In this connection, care was taken to ensure that the system would not preclude future developments, as e.g. in the field of linear motor and magnetic levitation technology as well as contactless energy transfer can be applied without any difficulty.

4. Transportation Pipelines

It is possible to lay the DN/ID 1600 circular-shaped transportation pipelines in public traffic areas alongside, below or above existing infrastructural installations such as e.g. supply and disposal lines, power and telecommunication cables, Underground or road tunnels by means of trenchless technology using the pipe jacking principle without affecting the surrounding structures (Fig. 4).

![Figure 4: Planned „Ruhrgartstrasse“ for CargoCap and potential extension into the Rhineland](image)
When pipe jacking is applied, prefabricated driving pipes are thrust from a starting shaft through the subsoil towards a target shaft with the aid of a main jacking station. The in situ soil or rock is removed by mechanical means at the face and transferred above ground via the column of pipes that has been driven. A steerable shield machine, which is in front of the first pipe, ensures that the drive can be undertaken either in a straight or curved line.

An effort is made to attain a major driven length from a starting shaft in the interests of an economic excavation. The creation of shaft structures in particular represents a substantial cost factor when lines are being laid. At present, propulsion lengths of more than 1000 m will be realised, 3 kilometers are targeted at the near future.

5. Legal situation

CargoCap impresses by its legal enforceability in practice. The legal investigations showed that for the realisation of the CargoCap system little legal obstacles have to be overcome. This is due to its innovative character and the resulting qualification to function neither as conventional means of transport nor as a supply line.

No project approval has to be accomplished for the establishment of the plant and no building or construction permission has to be given for the underground transfer of the transportation tube.

A legal immission control permit or a permission according to § 19 A WHG is not necessary either. Only a legal water permit or appropriation has to be obtained according to § 2 WHG. Concerning the use of roads for the transfer of the driving pipelines in a closed type of construction the conclusion of a permission contract under private law with the road construction load carrier is sufficient in principle. Additionally, within the range of federal highways, an extension permission must be given.

However, due to the small impairments on the traffic by the underground transfer it is safe to assume that the necessary permission will be obtained. Also from the environmental point of view, few problems occur concerning the groundwater. This is due to the small emissions and the isolation of the underground tube.
6. State of progress

The theoretical research and development work has been almost concluded with the formulation of the transport concept. The project team believes it is advisable to realise the CargoCap scheme in three stages so that the experienced gained can be put properly into practice.

During the first stage, the basic technical components for the transport units have to be tested on a model installation. Towards this end, a model section is being set up on a 1:2 scale in which the bearing and guidance components in particular should be examined and optimised. Furthermore, the model section will be used to test the newly developed branch device and the initial designs for the control and monitoring components as well as data and energy transfer. This development phase is already being supported by industrial partners. Thus, the necessary pilot plant was made available by the RWE power AG. SEW-Eurodrive, well-known as one of the prominent enterprises on the field of propulsion technology, supports the project by means of a free supply of the engines and the control components for the Caps as well as a contact-free working and thus almost maintenance-free energy transfer system. This system supplies the vehicles with energy by means of electromagnetic induction via an air gap. With the help of an industrial WirelessLAN system communication between the vehicles and the route sections takes place contact-free and permanently.

The second stage relates to the construction and operation of a test section on a 1:1 scale. In conjunction with this, all the components for the construction process technology, engineering technology, electro as well as control and information technology must be tested and improved prior to being used in practice. In this context, locations of industry with demanding logistic requirements are suitable, e.g. airports.

The third stage, which will be carried out parallel to the construction and operation of the fest section, foresees the translation of CargoCap into an open
or closed solution. The above-mentioned “Ruhrgebiet route” will serve in part or in its entirety as a reference facility for the open solution. The closed solution is to be implemented in the internal operational logistics of an industrial or mail order company, with the same principles still essentially applying for the system as for the “Ruhrgebiet route”. The dimensions of the running tube diameter and the Caps will, however, be flexibly adapted to the specific requirements along with other parameters.

7. Summary / Outlook

The reduction of goods traffic on our roads represents an urgent objective of North Rhine Westphalians transport policy and the CargoCap project. The related research and development work carried out at the Ruhr University Bochum have confirmed the technical and legal feasibility as well as the economic advantages. Such a wide-branching, effective transportation system in the Ruhr District, in other built-up areas or metropolises is in a position to improve the accessibility of production plants, trade centres and also relatively out-of-the-way locations, by providing the quality of transport for the amount that has to be carried. CargoCap is not only an interesting transport alternative but also an economically attractive investment object. Given the lack of availability of public funds, it is up to the private economic sector to take the initiative. However, public interest will not be neglected, as a corresponding operator model will be established on the basis of a public-private-partnership. Nowadays, it is self-explanatory that electricity, water, gas, distant heating and waste disposal networks are available for all households, commercial and industrial enterprises. CargoCap offers the chance to ensure that sometime in the future, underground transportation pipelines will not only connect city centres but will be able to open up an entire built-up area in the form of a network. It will be possible to deliver goods directly to every household in low diameter transportation pipelines so that the vision of all-embracing electronic buying can become reality.
literature:


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5 Stein, Klemmer, Kersting: „CargoCap – wirtschaftliche Gütertransportalternative im Ballungsraum“, 2004

figures:

fig. 1 CargoCap transport unit in DN/ID running tube

fig. 2 Automated trans-loading of the CargoCaps via conventional roller conveyors

fig. 3 Accomodating CargoCap running tubes in public traffic areas alongside existing infrastructural installations

fig. 4 Planned „Ruhrgebietstrasse“ for CargoCap and potential extension into the Rhineland