Modular Automated Individual Transport for a transport revolution

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Abstract

Modular Automated Individual Transport (MAIT) is an innovative ground transportation concept for passenger and light freight that combines the flexibility of the automobile with the advantages of public transport. This revolutionary concept is based on the automated transport of passengers or freight in small container-like pods and provides driverless, 24h on-demand, non-stop, door-to-door transportation. Applying state-of-the-art computer and control technology, MAIT offers a highly efficient individual transport which is safer, more environmentally friendly and available to everyone, in contrast to the present transport systems.

1 Why do we need MAIT ?

Hardly a day passes without an item in the media about transport problems. We are told that road traffic will increase inexorably for the foreseeable future. Millions of people yearn for an end to the traffic congestion, stress, noise, fumes and danger outside their front doors, and opposition to road developments increases. The door-to-door convenience provided by car transport is not available to important parts of the society, but those who have it do not want to give it up. On top of this, scientists say that there is an urgent need to reduce dramatically the use of fossil fuel to stop global warming.

Modular Automated Individual Transport (MAIT) , which is realizable with todays technology, has the potential to improve this situation considerably, contributing to a better life quality for the entire society.

2 What is MAIT ?

The three "ingredients" of MAIT are:

1. *cabins*, containing passengers or freight
2. *carriers*, moving cabins along tracks and
3. *tracks*, capable of guiding carriers along a path.

The MAIT *vehicle* consists of a cabin attached to one carrier. The *novel feature is that the carrier can be exchanged automatically*.

Like the shipping container, the *cabin is a box without wheels or motive power*. The carrying capacity would be similar to a car or small van, where the internal design will be appropriate to their various functions. Cabins will have attachment points by which they can be transferred from one carrier type to another by a variety of means. But, unlike shipping containers, these attachments are designed so that automatic transfer can be performed efficiently, rapidly and safely. Cabins will generally be moved under computer control and journeys will be made by transferring them automatically from one carrier type to the next and by routing to the specified destination. At the start and end of trips, cabins would be branched into off-line stops or placed on a stand, allowing goods to be loaded or passengers to take their time alighting without affecting the movement of other vehicles.

Cabins for passenger and freight can be available for hire or be owned by the user. Passenger cabins are large enough to accommodate four seated adults with baggage and long enough to allow an adult to lie down in, and will be able to provide a private space for sleeping on long journeys. The furniture inside passenger cabins can be designed for various circumstances, for example to accommodate a person in a wheelchair, shopping trolleys or prams, and provision made to allow these to be rolled in easily. Cabins for longer journeys can be provided with access to entertainments, the Internet and telephone connections. A cabin management system will be needed to supply the right sort of cabin, to provide efficient re-use of cabins for hire and parking for privately-owned cabins. *Freight cabins* can be variously designed for automatic loading and unloading with industrial pallets, for carrying liquids or refrigerated for carrying foodstuffs.

A *carrier is any vehicle with motive power, dedicated to carrying cabins*. Carriers will generally be electrically-powered, quiet and pollution-free. In the established system a particular carrier will automatically move on a specific type of *track, which can be either a suspended- or supported-type guideway, or a*

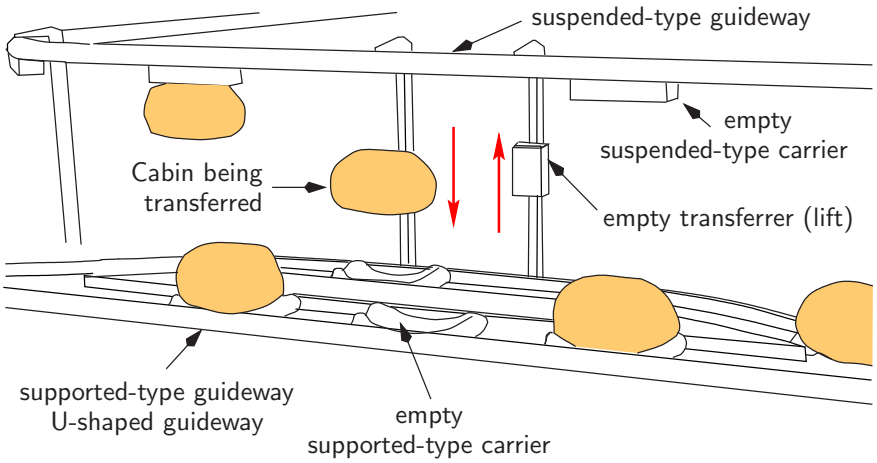


Figure 1: Vertical transfer between supported and suspended type carriers with a transferrer lift occurring between the two.

road with the appropriate navigation equipment. Depending on the local traffic situation, parts of the track can be either on street level, overhead or underground (for examples see Section 3). The elevated guideways are slim and similar to walkways for pedestrians because payload of MAIT vehicles is limited to $500\,kg$. The carriers and the tracks can be designed with any transport technology as long as it adheres to the MAIT *standard specifications* (see below). The carrier-track technology could cover a wide range of speeds, carrying capacities and propulsion systems, for example:

- *guideway carriers* with hard rubber tires, running in a suspended-type guideway or on a U-shaped supported-type guideway. Depending on the guideway design, such a carrier has medium to high carrying capacities and speeds of up to $130\,km/h$. Suspended-type carriers are particularly suitable for indoor transport because they do not require on-floor guideway structures.

- *road carriers* with wheels designed to run on ordinary roads. For navigation, induction loops are embedded in the road. Energy could be stored by a small battery or a flywheel which is recharged at each stop. This carrier type is flexible and the induction loops are cheap to implement, but it would be slow and suitable only for short distances. However, there are areas such as narrow streets in historic towns where elevated guideways will be unacceptable and ground-level operation is unavoidable.

- *magnetic levitated (MAGLEV) carriers* using electrical linear synchronous motors. These carriers have high carrying capacity at a high speed. They are suitable for inter-city connections with low branching.

A definitive requirement is that cabins are transferable from and to other carrier types by means of *transferrers*. Fig. 1 shows an example where the active part of the transferrer is a lift which engages with the cabin and moves it up to the suspended guideway or down to the supported guideway. Fig. 2 shows how a cabin might be transferred from one supported-type carrier to second supported-type carrier or stand. Such a horizontal movement of a light weight cabin requires little power, allowing the transferrer mechanism to be built into the carrier.

MAIT has a vital capacity to evolve and adapt. Each individual city is different and will present specific problems, requiring tailor-made solutions. The city planner will be able to draw on many different automated carrier technologies, each with their own strengths and weaknesses, and combine them using each to the best advantage to provide a seamless transport system. Most types of guideway could be installed or removed with far less upheaval and damage to the fabric of the city than that caused by roads. Overhead carrier guideway and supports would be made in prefabricated sections mounted on minimal foundations. MAIT will be quiet and non-polluting and, with a limited maximum loading and small loading gauge, can be comparatively easily routed over, under and through existing city structures. The essential features of the above described system are:

- *driverless, on-demand and 24h origin-to-destination transit in individual cabins without intermediate re-embarkation*—the entire cabin is transferred.

- the carrier-track technology can be adapted to *operate cost-effectively in all transport environments*. Therefore, using different carrier types,

the MAIT network could reach city centres, low traffic density residential areas, or even manufacturing machine inside factories.

- carriers and tracks could be used to *transport passenger cabins during daytime* and *freight cabins during the night*. This means that the parts of the system with high capital investment can be in use for a greater proportion of the time. Spreading the load more uniformly throughout the day means that the system cost can be lower for a given total capacity.

- the heart of MAIT is a *specification of open standards* defining: envelope volume of cabin; electro-mechanical interface between cabin, carrier and transferrer; communication protocols which are used to coordinate cabins, carriers and tracks; safety, security and comfort criteria.

- *new carrier designs can be added to the system* provided only that they adhere to the abovementioned standard specification.

- the *components and operators of the system can be owned by individuals, private companies or public authorities*.

3 How would MAIT be introduced ?

No advanced new technology is needed to introduce MAIT ; the innovative aspect of MAIT is a clever synthesis of control technology (used for robotics or aviation), networking logistics (used for organizing data packages on the Internet), and conventional mechanical, electrical, and civil engineering. There is a lot of development in progress in a variety of advanced, usually automated, transportation technologies such as *Personal Rapid Transit (PRT)* [1] The new features specific to MAIT , namely the transferrer mechanism and the necessary logistics, will be an extra development added to the already substantial body of automated transport technologies.

A small MAIT network could be installed first and tested on private property, serving initially as a flexible on-demand light-weight freight transportation system, possibly within a larger industrial complex. This would provide a realistic *proof of concept* and allow an early profit. As soon as the system satisfies all expected performance and safety criteria, it could be made available for passenger transport inside the industrial complex. The test track could then be extended to surrounding residential areas and activity centres in order to study the reaction of people to the novel transportation system.

The next logical step would be its deployment in urban areas, with the objective of providing access for MAIT to all premises in limited areas of towns, which may include the major activity centre(s). Since city centres are characterized by high traffic density and little space, medium- to high-capacity carriers would be required, running on overhead or underground guideways for total separation from pedestrians and road traffic. Flexible, suspended-type guideway loops would be added to take cabins automatically to and even inside individual establishments in town centres. In some cases it should be possible to place this guideway at the back of rows of premises with a stop or transferrer for each delivery point. This will allow car traffic to be greatly reduced or even eliminated in these areas, thus providing an immediate tangible benefit. The regime in the areas fully served by MAIT will be similar to a large building served by lifts (elevators), which people use to move about within a building, leaving their cars or other transport outside. In city centres people will move about in MAIT cabins with the same ease as they do using lifts, and it will become as inappropriate to bring cars into the central area as to bring them into a large building.

In these early stages, *travel outside the areas served by MAIT will continue to depend on roads and rail*. There are several options, allowing a coexistence during that phase:

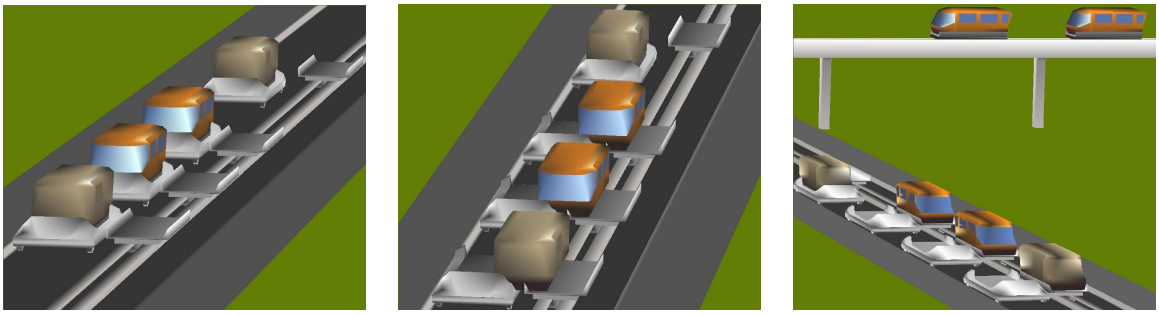
- Park&Ride (P&R) places could be provided at the major arterial roads of towns, where people have the choice of transferring from car to MAIT .

- the local MAIT network could serve as a feeder for railway stations.

- it would be feasible for passenger and freight cabins to be carried by conventional transport (vans, trucks or rail) for most of the journey, transferring them to automated carriers only for the last leg into the centre of towns. The cabin is a passive container and can therefore be cheap to use in this way. The cabin transfer from conventional transport to MAIT could be automated and the organisation of vans or trucks put under the logistic control of the MAIT system, resulting in a better traffic coordination.

As the system develops, the car-traffic-free area will expand to connect all activity centres and spread into adjacent residential areas with low traffic density. An effective solution for residential areas would be the road carrier, because it has low infrastructure costs and is flexible enough to stop in front of any front door. During a transient phase people should have the option to use either MAIT or their own car. As the

[1] J. Schneider's Web site (`http://faculty.washington.edu/~jbs/itrans`) contains a large collection of links to information about innovative transportation technologies.



(a) (b) (c)

Figure 2: Picture Sequence, showing a parallel transfer of three cabins from a road carrier to a suported-type guideway carrier. (a) The three cabins in the front are ready for transfer and are aligned with the three empty guideway carriers. (b) the transfer is in process. (c) transfer is terminated. Now the three cabins can continue their trip on the guideway—also on the elevated one as shown in the background.

car becomes increasingly unnecessary for inner town trips, conventional road traffic will decrease, which would free some of the road-lanes for the MAIT system; existing bus lanes, metro lines or trams could also provide space for the system.

The next stage will be when neighboring towns are linked together, with high-capacity guideway carriers, running at speeds of up to $130\,km/h$. This inter-town network will have fewer branches and MAIT vehicles will have time to form platoons in order to save energy. The volume of traffic that can be carried by a single bi-directional guideway would be comparable to a motorway with four lanes per direction.

Gradually, car traffic will be eliminated from towns and the city environment consequently improved. Town planning issues will become better understood and provided for by appropriate legislation. For more distant inter-city connections, cabins could be loaded onto specially designed railway carriages or ferries where passengers will be able to emerge to access toilets, refreshments and entertainments. Eventually, MAGLEV carriers could provide long-distance national or trans-national links at speeds greater than $500\,km/h$.

Finally, individual cabins will be carried anywhere by being transferred automatically from one carrier to another, providing a seamless, door-to-door journey for both passengers and goods. It will take some decades to build up a comprehensive MAIT system but tangible benefits will be obtained early on.

4 What are the attractions of MAIT ?

Any new transportation scheme that is going to supersede a substantial proportion of road traffic must provide:

- At least as good access to all types of location such as homes, shops, businesses and leisure facilities.
- Carriage both for people and most goods.
- Faster and more reliable movement from door to door.
- Accessible to all, regardless of age, driving skills, capital resources, state of health or inebriation.
- Major improvements in energy efficiency and a major reduction in total pollution.
- Near complete elimination of pollution in the vicinity of the users.
- Cheaper for users.
- Profitable for operators and manufacturers.
- Safer and quieter for users and non-users.
- The capacity to evolve; any scheme capable of making a significant difference is likely to take many decades to introduce, during which it will have to operate in parallel with existing modes of transport. It must be able to adapt to problems that will arise and technological developments that might occur.

MAIT will provide all of these.

5 Conclusions

The benefits of MAIT will become quickly obvious and available to everyone; the introduction of MAIT will allow car traffic in urban areas to be eliminated rather than diluted over a much larger area. *Life in the streets will be safer; the air will be cleaner and there will be less noise; there will be more green space, more pedestrian walkways, more bicycle tracks, more public*

places for people to meet and for children to play. People will relate to MAIT as a superior sort of lift rather than an inferior substitute for a car.

The ownership of the components of the MAIT system is flexible and could permit development by a combination of state and private enterprise. Adding the MAIT concept to the various emerging advanced transit technologies, together with parts of the existing transport infrastructure, offers the vision of a seamless transportation system with benefits far exceeding those of the parts.

Historically, improvements in transportation infrastructure have been followed by an increase in trade and wealth of a nation or continent. MAIT will usher in a transport revolution which, over some decades, will have a far wider impact than the introduction of the shipping container 40 years ago. MAIT will not only *enhance personal mobility for all ages, incomes and abilities*, but will also considerably *improve the traffic of light freight*. MAIT links indoor and outdoor transport, optimizes just-in-time delivery and allows automated overnight distribution of goods. Thus, it increases productivity by supporting the trends in modern manufacturing such as *flexible and decentralised production*, *out-sourcing* and *modular-sourcing*. MAIT is also an *ideal completion for the ever increasing e-commerce marked* as food and dry goods can be delivered automatically to private homes from stores or factories where orders are submitted by the Internet. Moreover, In itself MAIT may grow rapidly to become a major industry sector.

However, it became evident that the broad introduction of MAIT necessitates the constructive cooperation of various scientific disciplines, including industry, potential operators, political decision makers and mass media.