Modular Automated Transport
Frequently Asked Questions (FAQ)

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1 General Questions

1.1 Why is MAIT divided into cabins, carriers and tracks ?

A qualitative evaluation of the following *requirements for a "better" transportation system* indicate that the modularization of MAIT is likely to be the most appropriate.

Requirement 1: the new transportation system should reduce travel time, energy, pollution and land-use and improve comfort and safety. These requirements are considered common sense, this is what we all want.

Requirement 2: the transportation system should be usable by a large part of the society. This requirement, ensuring that (almost) everybody can benefit from the new transportation system, may be even part of political frame conditions.

Requirement 3: the transportation system should provided at least the same service as the private car does, such as door-to-door transport, spontaneous and 24h access, no transfer between means of transportation, e.t.c. Otherwise people will keep their car and use the alternative transport system only if there is no other choice, i.e. there is either traffic congestion or there is no parking space available [1]. Consequently, only that (small) amount of car drivers will change to the new transportation system that is necessary to cause traffic-congestion or parking problems. In other words, road and parking space will remain at their capacity limits and few people will make their trip with the transportation alternative (relative to the total amount of trips).

Therefore, if the new transportation system should not offer at least car-equivalent service then the road traffic situation will not change considerably but there would be an additional transportation system in town that is little used (which may be in contradiction with requirement 1 (land-use) and requirement 4).

Requirement 4: the transportation system should be profitable. Otherwise no one will develop, implement, operate and use it.

Requirement 5: the transportation system should be well adaptable to travel demand patterns, travel distance, street layout and architecture of a city. This requirement is important in order to offer transport solutions to cities of any character.

Requirement 6: the transportation system should be open to new propulsion technologies. If the replacement or extension of a transportation system by a new technology were too expensive then future improvements would be hampered. Furthermore, it is easier to find investors if future technological support is guaranteed.

Requirement 7: the transportation system should be able to use parts of the present infrastructure.

Requirement 8: a smooth, practicable and economic transient between the present transportation infrastructure and the new transportation system should be possible.

[1] Darmstadt, Germany 1998: In order to reduce the tremendous parking problems in the inner city of Darmstadt, the city council decided, in agreement with the students association, the local public transport companies (headed by HEAG), that the student ID-card of the Technical University of Darmstadt (TUD) is valid as ticket for all public transport in the area of Darmstadt. This means free public transport for all students!

While students who live in Darmstadt have greatly appreciated this offer and made use of it, the students from outside, who use to access Darmstadt by car, have, in general, not accepted to leave their car at the available park&ride places and to come into town by bus or tram. In consequence, the parking situation inside Darmstadt did not improve as expected.

There are essentially four concepts that are potentially satisfying these requirements. Below, these concepts are presented and their *relative systematic strength and weaknesses* are highlighted:

Concept 1: *Dual mode systems*. The currently most important example of this category is the *RUF system* [1]. RUF vehicles can either be (manually) driven on ordinary roads, just like cars, or they can be hooked onto a guideway, where they are operated automatically. The strong points of this concept are:

Requirement 7: it can immediately use the present infrastructure, but the automated part of the network needs to be built up from scratch.

Requirement 8: point 8: the roads are used (as they are) by the dual mode vehicles. The automated part of the network is predominantly build with elevated guideways that do not interfere with the present traffic.

The weaknesses of the Dual Mode concept are:

Requirement 2: people who want door-to-door access still need the driver's license and a private vehicle. However this can be compensated by a flexible taxi-like service or by a complete automation.

Requirement 4: Dual mode vehicles incorporate mechanical, electrical and navigation support for two transport modes. Therefore, dual mode vehicles, and also their guideways are heavier and more expensive compared with vehicles that are designed for a single mode.

Requirement 6: the extension or substitution with new technologies is rather difficult because Dual mode vehicles have a rather monolithic design.

Requirement 8: people who want door-to-door access need to buy dual-mode vehicles, which will be surely more expensive than conventional cars. Hence, some resistance may be expected from the user's cost perspective.

Concept 2: *Integrated transportation systems:* Concepts like *InTranSys* [2] or similar pallet type systems [3, 4] consider guideways, that can pick-up and carry pallets (with persons or freight), but also entire cars and vans. The strength of this concept are:

Requirement 7: one can immediately use the present infrastructure, but the automated part of the network needs to be built up from scratch.

Requirement 8: the roads are used (as they are) by cars and people do not even have to buy new vehicles. The automated part of the network is build with elevated guideways that do not interfere with the present traffic.

The weaknesses of the Integrated Transportation concept are:

Requirement 1: Large guideways may not be flexible enough to be implemented within city centers with a narrow road system (as it is the case in many European cities). This means it remains pollution, congestion and parking problems that occur predominantly in city centers. However, combining the Integrated Transportation concept with other automated transport systems using small vehicles could reduce this problem.

Requirement 2: people who want door-to-door access still need the drivers license and a private car.

Requirement 4: a guide-way that is designed for vans *plus* the vehicle that is required to carry the charge (pallets, cars, vans) is very heavy. This makes the guideway and vehicles large and expensive compared with other alternatives.

Requirement 7: the existing infrastructure can be used immediately, but the required guideway (which is large and expensive) needs to be built from scratch.

Concept 3: *Intelligent Transportation Systems (ITS).* These are concepts that attempt to improve the present transport systems (car, rail, ship), using new information and control technologies. This includes the *Automated Highway Project*, inter-modal concepts, where cars can be loaded on trains or ships, improved navigation systems for cars, telematics e.t.c. (for example see [5]) The strength of this concepts are:

Requirement 7: it can immediately use the present infrastructure (roads+rails). Only on roads, where cars run under complete automatic control, navigation equipment needs to be installed, which is inexpensive compared with any kind of guideway-structure.

Requirement 8: the new and old infrastructure is the road. Cars that have the appropriate navigation equipment can access instantly the entire network.

The weaknesses of ITS concepts are:

Requirement 1: pollution in city centers will remain and where the network is not completely automated, also congestion and parking problems. The fuel or energy is not provided by the track and must be transported within the cars. However, the research for an economically attractive alternative to petrol is under way (since decades).

Requirement 2: people who want door-to-door access still need the driver's license and a private car.

Requirement 4: fully automated cars that run safely at high speeds require rather expensive navigation equipment.

Requirement 6: substitution or extension with new technologies is rather difficult since these concepts are by definition fixed on 19^{th} century propulsion technology. However, it is compatible with the integrated transportation concepts.

Requirement 8: the navigation equipment for cars can be expensive and people may not be willing to pay for this additional cost. This can delay its implementation. Another problem will be that (competing) car manufacturers need to agree on a common standard for the required navigation equipment.

Concept 4: *Modular Automated Transport.* This concept divides the entire transportation system into (small) cabins, carriers and track. The carrier-track system can be implemented with the technology that is most adapted to the local transportation problem. Only the cabin with its contents is moved automatically from one carrier to another when needed. The system is completely automated. Similar ideas have been proposed in [6, 7] The strength of the MAIT concept are:

Requirement 1: All carriers can be driven with emission-free electrical energy. Furthermore, the possibility to shift freight transport from day time to night reduces the required transport capacities during peak-hours, which may result in considerable saving of infrastructure and land use (see also point 4).

Requirement 2: nobody needs a drivers license or to own a private car, almost everybody can use it.

Requirement 4: all vehicles can be shared, the user does not need to buy one. If, however, somebody desires to travel in his own, private space, it suffices to buy an inexpensive cabin and not the entire vehicle. Carrier and track, which are estimated to represent 80% to 90% of the invested capital can be in use 24h a day. This is because carriers transport passengers in person cabins during the day and freight in freight cabins during the night. Over night delivery will become usual when also the charging and unload process of standard industrial pallets or packages will be fully automated.

Requirement 5: the transport (carrier-track) technology can be optimally adapted to solve certain (local) transportation requirements.

Requirement 6: carrier or track are modules and easily replaceable or extendable by new technologies.

The weaknesses of the MAIT concept are:

Requirement 4: the electro-mechanical interface between carrier and cabin (that allows the automatic exchange of the carrier) will add extra cost to the system with respect to a conventional car of equivalent size.

Requirement 7: most of the existing infrastructure can be used, but needs to be completed with necessary guiding and navigation equipment. Elevated guideways for light weight vehicles that are necessary in most places need to be built up from scratch.

Requirement 8: roads, rails or other infrastructure that is used by MAIT can no more be used by present transport systems. However, intersections between the MAIT road carrier and conventional cars can be organized.

The table below is summarizing the results:

requirement	1	2	3	4	5	6	7	8	total +/-
Concept 1		-		-		-	+	+-	2/4
Concept 2	-	-		-			+-	+	2/4
Concept 3	-	-		-		-	+	+-	2/5
Concept 4 (MAIT)	+	+		+-	+	+	-	-	**5/3**

Obviously, such unweighted qualitative comparisons cannot reveal the whole truth. On the other hand, a quantification of the entire problem field is a difficult task, and there is no guarantee that results are really objective. Nevertheless, the above table shows clearly two groups of concepts, that represent in fact *two implementation strategies:*

1. *The morphogenetical strategy:* the implementation of the new transportation system is achieved by a gradual continuation or transformation of the present (car, rail) transportation system. All concepts following this strategy have their strength in the use of

present infrastructure and in the ease of implementation (requirements 7 and 8). Their weaknesses are the overall problem solving potential of the final system (requirements 1 through 6). Obviously, concepts 1 to 4 belong to this strategy.

2. *The substitutional strategy:* the new transportation system is built up in parallel to the present system and replaces it gradually as it expands. All concepts following this strategy have their strength in the problem solving potential of the final system (requirements 1 through 6), but interfere more with the present infrastructure during the implementation phase (requirements 7 and 8). Apparently, only MAIT (concept 4) belongs to this strategy.

In conclusion, non of the concepts is easy to implement and has the optimum solution to an ideal transportation system. In this context, the question which strategy to follow has a more philosophical character. The final *decision in favor of the substitutional strategy* is backed by the following reasoning:

- the performance of the final system has priority to difficulties during its installation. If there are feasible solution to overcome those difficulties then the substitutional strategy should be preferred.

  And there are solutions: the use of elevated guideways for the main traffic streams can minimize interference with present infrastructure. For local, door-to-door traffic, the conversion of present public transport lines (bus-lanes, metros, trams) and the reduction of in-town public parking space (while offering park& ride possibilities at the main arterial roads) may be solutions for the transient phase; at least from a technical and logistic point of view.

- when following the morphogenetical strategy then there is the risk that the costs to "upgrade" the existing transport structures to a constantly evolving technology will ever increase and end up in a cul-de-sac. From there, the only way out is a "gene-leap", a complete renewal of the system structure: the substitutional strategy.

  It is recognized that short-term profit oriented marketing strategies and politics will prefer this path of development, but why should we wait to get an "almost ideal" transportation system tomorrow if we can get it today ?

1.2 What have MAIT and PRT in common?

MAIT can be seen as a *superimposed, generic concept* of various PRT technologies in the sense that the carrier-track modules of MAIT may be implemented with almost all proposed PRT system. The main requirements are

1. an interface that allows to unmount automatically cabins (in which persons or freight reside) from one carrier-type and mount it on another.
2. that all carrier and track modules can communicate with the computer network that organizes the traffic on the global MAIT network.

MAIT includes therefore all properties of PRT systems (see [8], Section "What is Modular Automated Transport ?") and almost all current PRT developments could be made MAIT -compatible! Thus, MAIT is a de facto PRT network, implemented with different PRT technologies, whereby the cabins can reach any point of the network, independent of its technological implementation. Therefore, MAIT has also to deal with the same problems as any specific PRT implementation.

1.3 What is the difference between MAIT and a Dual mode systems?

Dual mode vehicles are able to switch between two transport modes; usually between driving on ordinary roads and automatic control on guideways, as it is the case for the RUF system [1].

In order to do this, Dual mode vehicles contain drives and navigation equipment for *both* modes. This is in contrast with MAIT , where the vehicles contain only a drive, engine, navigation e.t.c. (= carrier) for *one* transportation mode at a time. Hence, the technological specific part of a MAIT vehicle is concentrated in the carrier module. If the vehicle wants to change the transport mode, it will (automatically) exchange its carrier. With this respect, MAIT vehicle have the advantage that they do not have to carry two transport technologies (from which only one is in use) and are therefore lighter than comparable dual mode vehicles. This results also in a lighter and low cost guideway.

The problem of MAIT is rather a logistic one: to allocate free carriers and to organize exchange of carriers.

1.4 What is the difference between MAIT and integrated transport systems?

Integrated transport systems, as proposed by J.R. Guadagno [2] and others [3, 4], allow individuals, groups, cars or vans to accommodate in larger vehicles or platforms that run fully automated on guideways.

This can also be considered as a dual mode system in the sense that one can drive his car on ordinary roads, but when driving onto the automated platforms, one can also travel on guideways.

When cars are dragged by the platforms, then there are two propulsion systems "on board": the one of the platform and the engine/wheels of the car. The main difference between MAIT and integrated transport systems is the same as for Dual mode systems: MAIT vehicles contain only one propulsion system at a time and transport less "dead weight".

1.5 What is the difference between MAIT and GRT ?

MAIT is certainly not a Group Rapid Transport (GRT), where passengers in one cabin can have different destinations. This is excluded by the programming and boarding procedure (see[8], Section How to use MAIT). However, a variety of hitch hiking should be possible if the patron (travel card holder) agrees to take other persons within his cabin who have the same destination.

1.6 Who is in charge of MAIT , is MAIT not a big monopoly?

MAIT is a concept that consists essentially of a set of standards. This standard is open and everybody can produce and sell MAIT system components. Possibly an *independent international institution is in charge of verifying if all new products confirm to the MAIT standards*. The MAIT network (track) itself consists of interconnected clusters, whereby in one area, multiple clusters (with possibly different carrier technologies) can overlap. Each cluster can be owned by different operators. Also carrier-operators, cabin operators and user-services do not need to belong to the same company. In theory each individual can buy carriers or cabins and can offer transport service on the network. The organization structure of MAIT is therefore *anti-monopolistic*.

2 Technical Questions

2.1 How much storage capacity is required for cabins and carriers?

The amount of storage depends on the network topology and the demand patterns of a certain city or region. Hence, general quantitative numbers cannot be given. However, MAIT will require less storage (or parking) space than the private car system because:

1. less vehicles are necessary to provide equivalent service (mainly due to vehicle sharing).
2. a large part of the carriers will be in operation at day (person transport) and night (transport of freight cabins).
3. cabins and carriers can be stored with a higher density than autos. This is because they do not need access-ways (can be store in a first-input-last-out line or similar), neither air conditioning.

2.2 What is if a vehicle breaks down on a line?

If a vehicle breaks down, the concerned line is temporarily blocked and the following emergency strategies are initiated:

1. the breakdown is reported to the global vehicle control center, which will no more direct vehicles into the concerned branch but route the traffic around the defect part of the network.
2. if the defect vehicle is not completely blocked, the vehicle behind will slowly approach the concerned vehicle and push it to the next off-line stop, where it can be removed from the track.
3. in the case the defect vehicle does not move any more, it needs to be repaired or removed from the track. During this operations the vehicles on the same line need to wait.

Remark: the vehicles are designed to have a high availability. This feature is desirable, because profitable: MAIT vehicles can (theoretically) be in operation 24h a day. Each breakdown will be a loss for the operator. For the same reason, the maintenance is carried out more carefully (and frequently) than it is the case for private autos.

3 Auxiliary Questions

3.1 Who cannot use MAIT ?

Principally everybody who can move themselves can use MAIT . Even an infrared communication system between customer and cabin could be installed for people who are physically not able to insert a card into the slot. However, it is a task of each government to set up laws allowing certain people to use or not to use MAIT .

3.2 What is if somebody "undesired" wants to enter the cabin while boarding?

This is an act of violence. To prevent it, different strategies are implemented:

1. The boarding of busy MAIT stops are camera-supervised, also for safety reasons.

2. There are security buttons at the platform and in each passenger cabin. If a security alarm has been initialized, the nearest security team will be automatically informed to take action.

If a friend, college or relative of the costumer has the same destination then the costumer himself, there is no reason why he should not enter the vehicle as well. With MAIT one pays for the vehicle (just as with taxis) and not per person.

3.3 What is if a passenger wants to make a break during a trip?

There is an "interrupt button" at the user-terminal inside each passenger cabin. Pressing this button, the terminal displays a list with possible stops where the current trip can be interrupted (by default the next stop). The list indicates also the facilities (restaurant, bathroom, e.t.c) and the expected arrival time for each stop. The passenger can then choose one of these stops. When the vehicle arrives at the desired stop the door opens and passengers can leave the vehicle, while the now parked vehicle is waiting. The passenger has also the possibility to lock the cabin by asking back the travel-card. After the break, the passenger opens the vehicle (with his travel card) and enters. The terminal inside the cabin displays now: "Continue voyage?" The vehicle will continue the trip if one passenger presses the "OK" button at the user terminal.

3.4 What is if the MAIT card is lost?

The costumer can call the user-service, where he purchased this card. The user-service will block his account for the identification number (ID) of this card. The costumer will then receive from the user-service a new card with a different ID.

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