DELIVERABLE 1

New Means of Transport Survey and Preselection

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prepared by

RECONNECT

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EXECUTIVE SUMMARY

Constantly growing traffic in Europe leads to increasing environmental, economical and social problems and deteriorates the competitiveness of economic activities and quality of life of its citizens. Already today transport is one of the main contributors to air pollution and climate change/CO_2 emissions, and in particular it is the fastest growing emission source. Other external costs of transport occur in terms of safety/accidents, noise, uncovered infrastructure costs and congestion. Overall, external costs are estimated to about 4 % of GDP, depending on the country and method for calculation (Rothengatter, W., 1994).

On the other hand transport services are indispensable to satisfy basic society needs on mobility and accessibility and their high standard of quality is a prerequisite and an enabling condition for European competitiveness. Moreover, the industries involved in the supply of transport equipment and services constitute a substantial part of the activity of the EU in terms of added value, employment and trade.

Transport policy makers at local, regional, national and the European level agree to a very large extent that swift action has to be taken to secure economic development in the future, to protect the environment, and to safeguard the quality of life for their citizens. The European Union took a leading role pursuing this objective in defining its Common Transport Policy as valuable strategic framework.

It seems clear that several and not only one measure have to be taken to pursue sustainable mobility and the necessary adaptations in our transport system. Basically, there are three levels of intervention to achieve the decoupling of economic development and transport demand:

- Reduction of the demand for transport
- A shift to more sustainable modes, e.g. by means of intermodal services
- Improvements of the environmental characteristics of the remaining traffic

In order to analyse the full potential of the second option, the shift to more sustainable modes, the European Commission launched an investigation in its fourth call for proposals within the transport programme of its fourth Framework Programme. This “Study of potential contribution of new means of transport to sustainable mobility” has been designed to evaluate the potential of emerging transport technologies and organisational concepts, which might improve the European transport system, its economic competitiveness and the quality of life of its citizens in the next 10 to 30 years. In addition to the ongoing efforts of European policy makers to shift traffic towards established transport modes with a higher degree of sustainability, this investigation should give important complimentary information, where new sustainable modes of transport can be expected on the market within this time frame.

The focus in the RECONNECT study has been on technical and organisational transport innovations for underground, air and ground level transport beyond traditional metro, air, road and rail transport. To assess their potential for reducing congestion as well as improving the environment, safety, reliability, efficiency and employment situation an extensive survey of existing technologies and foreseeable developments has been given taking vehicles, infrastructure and transport concepts into account.

Special emphasis has been made to their congestion and pollution reduction potential. Being one of the most populated areas in the world, Europe has to look for new, more efficient, safer and environmental friendlier solutions for freight and passenger transport consuming less energy and using less surface space. The emerging lack of space calls for exploiting the third dimension to a higher extent. Therefore improved tunnel technologies and logistic concepts, logistic and environmental advantages of airships (e.g., reduced landing infrastructure) and technological innovations for land transport on and above ground level beyond the traditional road and rail traffic have been investigated. These developments are expected to play a very important role in achieving the goal of sustainable mobility of the Common Transport Policy and to secure the competitive position of European suppliers of transport technologies and the economy as a whole.

The methodology for the present RECONNECT Deliverable 1 has been to structure all gathered information in such a way that concepts are clustered into a set of classes with a few common core characteristics. The full description of the concepts are in the annex. The description of the class in the main part aims to evaluate the class as a whole and to assess the information on the basis of experience and expertise of the RECONNECT partners. Chapters in the main part are concise (1-2 pages) and sum up the characteristic key points of the state of development of the class. The annex provides detailed information on all concepts and relies more on information received by companies and promoters.

The partners agreed that the comprehensive investigation of selected concepts in WP5 should still give an overview on all groups of options (classes) at stake. Therefore D1 identifies the most interesting technologies within each class and compares them in detail in WP5. This preselection is a personal opinion of the partners of the RECONNECT consortium and based on their experience in transport research. It is no formal recommendation and does not necessarily coincide with the opinion of the European Commission.

WP 3 was included in D1 in the following way: Annex B covers general infrastructure information corresponding to task 3.1, 3.2 and 3.3 of WP3. In addition there is a chapter on infrastructure requirements of each class in the main part concentrating on the concept(s) selected for further investigation in WP5.

The structure of the class descriptions in the main part addresses the following issues:

- Congestion reduction potential
- Sustainable mobility potential
- Role in existing transport system (intermodality, interoperability, replacement, coexistence)
- Technical and financial feasibility
- Infrastructure issues
- Representative system

The information for Deliverable 1 has been gathered mainly by literature screening, questionnaires and interviews. The project partners have tried to rely on direct information from companies and expert opinions from independent scientists at universities and research institutions.

The preselection of candidates is based on criteria like sustainability potential, maturity of development, adaptability of concept to existing infrastructure, financial and technical background of partners in the development as well as data availability.

The systems covered in D1 are:

Ground level vehicles (including water)

Guided people mover	(dedicated track, small vehicles, frequent service (< 40sec) or on demand)
Road based people mover	(no dedicated track)
Elevated public transport	(elevated systems with driver)
Moving walkways	(conveyor belt)
Fast water vessels	(water born transport)
Fast bike	(bicycle related)
Man wide car	(narrow shaped vehicles)
Individual public transport	(Transport on demand. Vehicles on a rental basis. Alternative propulsion)
Small individual cars	(most promising small and light weight individual cars)
Automated vehicle guidance/ Automated Highway systems	(automated passenger transport on roads)
Dual Mode	(alternating guided and unguided transport)
Multifunctional urban vehicles	(adaptable chassis)
Technical innovation for logistics	(hard ware innovation for freight transport)

Underground transport vehicles and logistics

Driverless guided public transport	(automated passenger transport in vehicles bigger than people movers)
High speed guided systems	(high speed guided vehicles on dedicated track)
Automated freight-train and -road concepts	(automated guided freight transport on road or rail)
Microtunnels	(freight transport in microtunnels beyond traditional pipelines)

Airships and hypersonic transport

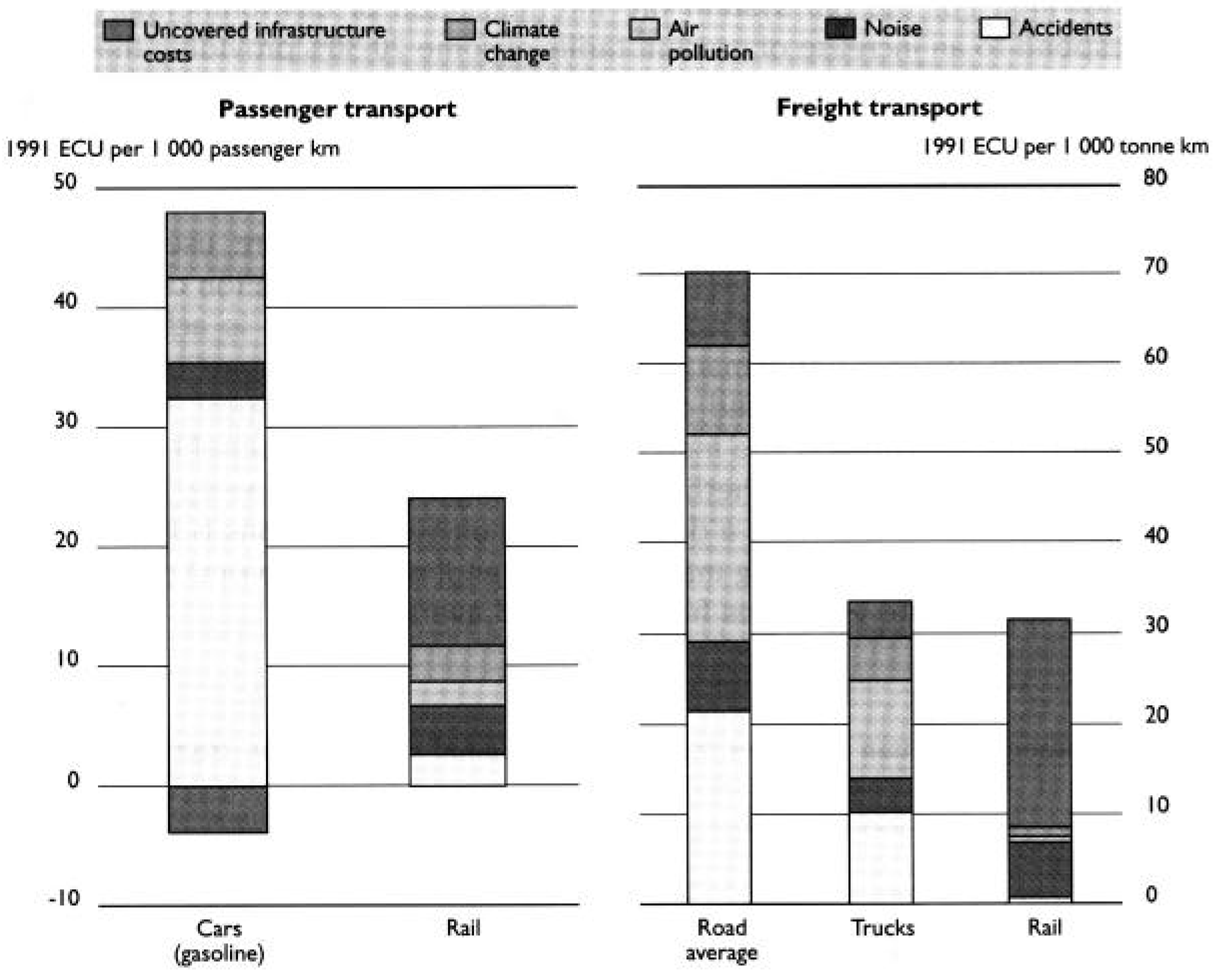
Airships	(dirigible lighter-than-air craft)
Super/Hypersonic Transport	(air transport in planes quicker than sound)

1. INTRODUCTION

Congestion on road and in the air is, at present, possibly the greatest single problem of transport policy in Europe. The economy is growing and transport is growing in parallel, even slightly faster. This has consequences for the volume and the quality of transport, is threatening the environment and is entailing risks for safety. In addition, the Union is one of the most densely populated areas in the world and a lack of space is emerging. Congestion is producing intolerable costs and problems. This situation is calling for a reflection on possibilities to find new ways of transporting, using less surface space, safer, environmentally friendlier, consuming less energy and more efficient. Modern society is requiring high tech solutions characterised by a high degree of reliability. Industry and technology are developing new ways of transporting, in particular underground logistic systems, responding to most of the requirements mentioned.

Already today transport is one of the main contributors to air pollution and climate change/CO_2 emissions, and in particular it is the fastest growing emission source. Other external costs of transport occur in terms of safety/accidents, noise, uncovered infrastructure costs and congestion. Overall, external costs are estimated to about 4 % of GDP, depending on the country and method for calculation (Rothengatter, W., 1994).

Figure 1: Average external costs of passenger and freight transport in the first half of the 1990ies



Source: ECMT (1998)

On the other hand transport services are indispensable to satisfy basic society needs on mobility and accessibility and their high standard of quality is a prerequisite and an enabling condition for European competitiveness. Moreover, the industries involved in the supply of transport equipment and services constitute a substantial part of the activity of the EU in terms of added value, employment and trade.

Transport demand continues to grow, and especially in the vicinity of large agglomerations, congestion costs are high. But also long-distance transport seems to reach the capacity limits on roads, rails and airports. This situation will become even worse with the accession of new Member States, in spite of efforts to build new and improve existing infrastructures.

Between 1970 and 1993 passenger transport in the 15 European Union countries grew at an annual rate of 3.2 %, whereas the average growth rate in the GDP (in real terms) was 2.4 % (CEC, 1995). The average distance travelled every day by each European citizen has increased in that period from 16.5km to 31.5km. The growth in demand for transport has been met largely by increased use of private cars, which now account for more than 75 % of kilometres travelled. Ownership of cars in the EU has increased between 1975 and 1995 from 232 per 1,000 people to 435 per 1,000.

The increasing demand for mobility and growth in car ownership have, combined with limits to the provision of more road infrastructure, produced an enormous increase in congestion, notably in urban areas and key transit routes. According to estimates, vehicle speeds have declined by 10 % over the last 20 years in major OECD cities (OECD, 1995). Even a rather cautious estimation of costs of congestion regarded them in the range of 2 % of the GDP, which implies that congestion costs in the European Union are about 120 billion EUR. That is four times more than is spent on public passenger transport across the European Union (CEC, 1995).

But negative impacts of the European transport system go far beyond congestion and its reduced economic and social opportunities. The environmental consequences of traffic (emissions of atmospheric pollutants and noise, use of space and segregation effect of transport infrastructures) are of general importance. Already in the beginning of this decade it was estimated (Corinair 1990) that transport causes 62 % of carbon monoxide (CO), 50 % of oxides of nitrogen (No_x), 33 % of hydrocarbon and 17 % of carbon dioxide (CO_2) emissions.

Environmental considerations have given rise to claim for a comprehensive internalisation of the external costs of transport which will contribute to an increase of transport costs (CEC, 1998). This increase still depends on future policy decisions on pricing and taxation, but a full internalisation would raise transportation costs significantly. Recent studies estimate external costs of transport to about 4 % of European GDP, of which about 40 % are assigned to environmental impacts and about 60 % to accidents (OECD, 1998).

Especially congestion costs seem to have a “hidden” cost dimension beyond direct operation costs and time losses. For freight transport, the indirect costs in terms of delays represent a key problem for industrial logistics. They favour an organisation of supply and distribution chains, which reduces the dependence on timely delivery. In other words, the risk of delivery failure represents a form of availability costs, which is playing a growing role for organisational and location decision in the economy.

The integration of central and eastern European countries (CEEC) in the European economy represents an additional challenge. While the extension of transport and other public interest service infrastructures may improve the access to these countries, it is rather doubtful whether the infrastructures in the centre of the Union can absorb further increases of demand. Indirect congestion costs as well as direct environmental costs of enlargement-related transport are difficult to assess but will contribute to the trend towards decentralisation of production.

Counter-arguments have also been raised that the congestion issue will soon be solved by the move towards an information-based society. It is assumed that the replacement of physical transport by information would help avoid the growth of availability costs from transport. However, empirical research, e.g. from the field of teleworking, is far from conclusive on this point. It is rather uncertain whether higher information intensity will actually lead to a reduction of physical flows, or not. Similarly, the move towards a service-based economy will probably reduce parts of bulky freight transport in Europe, but many services are still grounded in the use of physical goods. Moreover the efficiency gains of a service-oriented approach can be easily outweighed by a growth of demand (“rebound effect”).

It seems clear that several and not only one measure have to be taken to pursue sustainable mobility and the necessary adaptations in our transport system. Several important trade-offs have to be taken into account between environmental impacts and socio-economic benefits of transport, exemplified by the fact that transport demand has been growing until now more or less proportionally to GDP. The key issue is thus to achieve a decoupling of this relationship, or more precisely a decoupling of the growth of negative externalities of transport from growth. Different scenarios can be imagined in which this might be achieved but it can not be expected that a significant reversal of this trend will take place over the next ten to fifteen years. However, in order for this decoupling to have at least first effects by then, the appropriate measures would have to be taken now.

Basically, there are three levels of intervention to achieve the decoupling:

- Reduction of the demand for transport
- A shift to more sustainable modes, e.g. by means of intermodal services
- Improvements of the environmental characteristics of the remaining traffic

In order to analyse the full potential of the second option, a shift to more sustainable modes, the European Commission launched an investigation in its fourth call for proposals within the transport programme of its fourth Framework Programme. This “Study of potential contribution of new means of transport to sustainable mobility” has been designed to evaluate the potential of emerging transport technologies and organisational concepts, which might improve the European transport system, its economic competitiveness and the quality of life for its citizens in the next 10 to 30 years. In addition to the ongoing efforts of European policy makers to shift traffic towards established transport modes with a higher degree of sustainability this investigation should give important complimentary information, where new sustainable modes of transport can be expected on the market within this time frame.

A general and detailed foresight of technical and socio-economic developments has been already undertaken by the FANTASIE project (Forecasting and Assessment of New Technologies and Transport Systems and their Impacts on the Environment). Its main goal is to identify and assess the impact of transport technologies that are expected to have a major socio-economic impact. It has 4 main elements:

- Identification and forecasting of new technologies which are expected to have a major impact on transport systems in the attainment of Common Transport Policy (CTP) objectives;
- Development of a methodology of technology assessment and forecasting for the European context, covering environmental, safety, efficiency, socio-economic, market and other factors;
- Quantitative assessment of the potentials and impacts of new technologies for improving future European transport systems;
- Identification of options to support the introduction of new technologies, and implications for the CTP.

To analyse the results of this broad investigation more in detail with respect to new modes of transport beyond traditional road, rail, underground and air traffic DG VII assigned the RECONNECT consortium with the present study. Four partners of the consortium are already co-operating in the FANTASIE project, which will be finished in 1999.

In addition, some partners are involved in the project UTOPIA. UTOPIA is a study for Urban Transport Options for Propulsion systems and Instruments for Analysis. The key objectives that are useful in the RECONNECT project are

- Development of guidelines on the best ways of introducing new (propulsion) systems based on findings of demonstration projects, and
- Development of software to help decision-makers in both comparative testing of different sites where new systems are being introduced, and in finding appropriate technological solutions for specific urban situations.

RECONNECT aims to provide a comprehensive analysis of the potential contribution of new means of transport beyond traditional transport means like cars, trains, aeroplanes, ships and metros to sustainable mobility. To assess their potential for reducing congestion as well as improving the environment, safety, reliability, efficiency and employment situation an extensive survey of existing technologies and foreseeable developments will be given in the following chapters taking vehicles, infrastructure and transport concepts into account. These developments are expected to play a very important role in achieving the goal of sustainable mobility of the Common Transport Policy and to secure the competitive position of European suppliers of transport technologies and the economy as a whole.

2. METHODOLOGY

The focus in the RECONNECT study has been on technical and organisational transport innovations for underground, air and ground level transport beyond traditional metro, air, road and rail transport. Special emphasis has been put to the investigation of underground systems and airships as congestion on road and in the air is a mayor problem of transport policy in Europe, deteriorating not only its environmental situation but in addition jeopardising its economic development. Being one of the most populated areas in the world, Europe has to look for new, more efficient, safer and environmental friendlier solutions for freight and passenger transport consuming less energy and using less surface space. The emerging lack of space calls for exploiting the third dimension to a higher extent. Therefore improved tunnel technologies and logistic concepts for freight and passenger transport, logistic and environmental advantages of airships (e.g. reduced landing infrastructure) and technological innovations for land transport on and above ground level beyond the traditional road and rail traffic have been investigated.

Many synergy effects have been obtained by the involvement of four partners of the consortium in the FANTASIE (Forecasting and assessment of new technologies and transport systems and their impacts on the environment) project. This extensive research study for DG VII is the first Europe-wide integrated and multimodal assessment of the whole transport system and the socio-economic basis of its demand structure. Its preliminary results for underground, air and ground level transport served as input for RECONNECT.

RECONNECT relied heavily on the experience, assessment methodology, structuring complex material and technical results of FANTASIE. New concepts of transport to be dealt within RECONNECT are composed of innovative ground based concepts, underground logistics systems and tunnelling technologies due to the great potential of the space available, airships and hypersonic transport. RECONNECT considers already realised promising concepts as well as planned ones.

The consortium structure guarantees that the survey and preselection have been made by independent scientific institutions. In an objective and neutral way, the main partners at the same time secure the inclusion of industrial, municipal and academic institutions as information sources contacted by consortium partners, which have already contact with many of the promising concepts of new means of transport.

To secure full coverage of all relevant developments the consortium as well relied on the extensive perspective of the ESTO-network, the European Science and Technology Observatory of the European Union managed by IPTS, giving access to scientific and industrial information in all 15 member states.

As can be seen in the following description of workpackages, in a first stage RECONNECT covers vehicle concepts and infrastructure independently. Especially in the case of tunnelling, where the diameter is the key cost parameter, infrastructure is the main barrier for financial feasibility and hence for associated transport concepts. The separate evaluation of infrastructure is expected to help significantly in final recommendations not being bound to possible non-optimal combinations of infrastructure with specific vehicle concepts.

Workpackages and Subtasks:

WP 1 Management, co-ordination, dissemination
Task 1.1 Management, co-ordination
Task 1.2 Dissemination

WP 2 New means of transport survey and preselection
Task 2.1 Ground level vehicles (including water)
Task 2.2 Underground transport vehicles and logistics
Task 2.3 Airships and hypersonic transport

WP 3 New infrastructure survey
Task 3.1 Ground level infrastructure
Task 3.2 Tunnelling technologies
Task 3.3 Airship and hypersonic takeoff and landing sites

WP 4 Assessment framework and methodology guideline
Task 4.1 Impact criteria
Task 4.2 Criteria for improved services (role in the global European transport logistic system)
Task 4.3 Framework for legislation and standardisation
Task 4.4 Cost benefit methodology

WP 5 Targeted assessment database
Task 5.1 Ground based transport concepts
Task 5.2 Underground transport concepts
Task 5.3 Transport concepts lighter than air and hypersonic transport

WP 6 Impact assessment and cost benefit analysis of new transport concepts
Task 6.1 Impact assessment (environment, safety, reliability, efficiency, employment)
Task 6.2 Identification of legal barriers and standardisation gaps
Task 6.3 Cost benefit analysis of the new transport concepts

WP 7 Policy and market synthesis
Task 7.1 Sustainable mobility potential of new transport concepts
Task 7.2 Options to eliminate legal and financial barriers and to improve market penetration
Task 7.3 Identification of further RTD needs

The starting point is the present parallel survey of most promising new transport concepts and appropriate infrastructure as well as the definition of the assessment framework and criteria and the set-up of a methodology guideline based on the experience of the FANTASIE project.

Milestone 1 List of most promising concepts, methodology and assessment framework.
Following the criteria and conducting a series of interviews and workshops, a uniform targeted database for the most promising concepts will be established. At this stage data have been prepared on the transport concept level and are no longer split in infrastructure and vehicles.

The following steps are:

Milestone 2 A complete set of data necessary for impact assessment and cost-benefit/ multi-criteria analysis.
All concepts will be assessed for their advantages and disadvantages by performing an impact assessment as well as a cost benefit/ multi-criteria analysis.

Milestone 3 Comparison of concepts on a common basis.
The policy and market synthesis results in the sustainable mobility potential of the new means of transport, the options to eliminate legal and financial barriers and the identification of further RTD needs. In general answers to the particular objectives of chapter 1.

Milestone 4 Concepts potential, policy options, RTD needs.
The final assessment will analyse the policy implications and will give recommendations for the introduction of new and sustainable concepts.

The workpackage structure follows a mixed strategy to cover on the one hand the range of different new concepts of transport in three subdivisions, namely underground systems, airships and ground based concepts and on the other hand the scientific steps to answer the variety of questions that result from particular objectives.

The scope of the study is defined as follows:
- The time horizon envisaged is the next few decades (10 to 30 years from now).
- The focus on new concepts planned or realised so far is on underground logistic systems including new tunnelling technologies, airships and other innovative ground based concepts.

The main objectives of the study are:
- To give an overview of the possibilities of the most promising new transport concepts planned or realised so far and their contribution to sustainable mobility;
- to show the technical and financial feasibility of the new concepts;
- to identify how new transport concepts can play a role in the global European transport logistic system;
- to identify suitable geographical areas/corridors for optimal function;
- to identify optimal service characteristics;
- to identify interconnection with existing systems;
- to assess the impacts of the new concepts on the environment, safety, reliability, efficiency, acceptability and employment, and
- to identify the technical, legal and financial requirements for realisation and the need for adaptation of existing laws and standards.

A fair and non-biased comparison of advantages and disadvantages of the new concepts can be performed by a consortium that is independent from concept proposers and stakeholders. The aim of the RECONNECT partners has been not to involve stakeholders as subcontractors. All required additional data have been obtained by direct contacts with those actors or from other (independent) sources.

The methodology for the present RECONNECT Deliverable 1 has been to structure all gathered information in such a way that concepts are clustered into a set of classes with a few common characteristics. The full descriptions of the concepts are in the annex.

The order of classes in the annex is structured as far as possible corresponding to WP 2.1, 2.2 and 2.3 for ground, underground and air transport although a clear-cut allocation is not always possible as some concepts can be applied above, on and under ground level.

The description of the class in the main part aims to evaluate the class as a whole and to assess the information on the basis of experience and expertise of the RECONNECT partners. The chapters in the main part are concise (1-2 pages) and sum up the characteristic key points of the state of development of the class. The annex provides detailed information on all concepts and relies more on information received by companies and promoters.

The partners agreed that the comprehensive investigation of selected concepts in WP 5 should still give an overview on all groups of options (classes) at stake. Therefore D1 identifies the most interesting technologies within each class and compares them in detail in WP 5. Instead of the general judgement "people movers are better than moving walkways" and consequently dropping all walkways and analysing all people movers in detail, D1 aims to identify the most promising concept in each class. If this was not possible due to incomparable differences among concepts, more than one concept was proposed as representative of a class in WP 5.

WP 3 was included in D1 in the following way: Annex B covers general infrastructure information corresponding to task 3.1, 3.2 and 3.3 of WP 3. In addition there is a chapter on infrastructure requirements of each class in the main part concentrating on the concept(s) selected for further investigation in WP 5.

The structure of the class descriptions in the main part addresses the following issues:

- Congestion reduction potential
- Sustainable mobility potential
- Role in existing transport system (intermodality, interoperability, replacement, coexistence)
- Technical and financial feasibility
- Infrastructure issues
- Representative system

The information for Deliverable 1 was gathered mainly by literature screening, questionnaires and interviews. The consortium partners tried to rely on direct information from companies and expert opinion from independent scientists at universities and research institutions at the same time.

The preselection of candidates is based on criteria like sustainability potential, maturity of development, adaptability of concept to existing infrastructure, financial and technical background of partners in the development as well as data availability.
An argumentation is given with class descriptions.

3. LIST OF CLASSES

Clustering identified concepts with relevance for RECONNECT and definition of core characteristics for each class.

(Note The following data have been collected by the RECONNECT partners in order to establish a comprehensive survey. Due to limited resources, however, the consortium had to confine itself to systems it considered especially relevant for this project and with sufficient information available to expect adequate assessment later on.)

Ground level vehicles (including water)

Guided people mover (dedicated track, small vehicles, frequent service (< 40sec) or on demand):
Cable Liner, Poma-Otis, Odyssey, Intamin, American people mover, Raytheon, Cable tracks for inner-city transport, Cabinentaxi, Ultra, Soulé SK; other guided people movers

Road based people mover (no dedicated track):
Parkshuttle, Rivium, Serpentine, Horlacher Taxlwurm, Parry People Mover

Elevated public transport (elevated systems with driver):
Wuppertaler Schwebebahn, Safege, Aerobus, Alweg-Monorail

Moving walkways (conveyor belt):
Trans 18, Passenger conveyor system, Trax

Fast water vessels (water born transport):
High speed water bus or taxi, Fast ships

Fast bike (bicycle related):
Sky bikes–bike trains, High speed bikes, New bike infrastructure, BTS TransGlide 2000

Man wide car (narrow shaped vehicles):
Man wide car in general, V2P, BMW Scooter, Light weight cabin vehicle

Individual public transport (Transport on demand. Vehicles on a rental basis. Alternative propulsion):
Praxitèle, Tulip, ICVS, Station Car, Domobile, CityCar

Small individual cars (most promising small and light weight individual cars):
Smart, LEM, Aixam 300/400

Automated vehicle guidance/Automated Highway systems (automated passenger transport on roads):
Automated systems in general, Flexitrain

Dual Mode (alternating guided and unguided transport):
Ruf, Monomobile, Carmeleon, U-Bus, Spurbus Essen, DMT, Road-Train

Multifunctional urban vehicles (adaptable chassis):
NT Systèmes

Technical innovation for logistics (hard ware innovation for freight transport):
TMC, Salami Container, Lech TGZS

Underground transport vehicles and logistics

Driverless guided public transport (automated passenger transport in vehicles bigger than people movers):
Meteor, Metro Lyon, VAL, Small Metro, M-Bahn, H-Bahn Dortmund, Dorfbahn Serfaus

High speed guided systems (high speed guided vehicles on dedicated track):
Swissmetro, Maglev, Transrapid, MLU, HSST, Seraphim, Eurotunnel

Automated freight -train and -road concepts (automated guided freight transport on road or rail):
Underground transport and tube systems, MetroFreight, Automated freight trains, Combi-Road

Microtunnels (freight transport in microtunnels beyond traditional pipelines):
Unit transport by pipe, Mail tube system, Sumitomo cement capsule liner, Slurry pipeline

Airships and hypersonic transport

Airships:
CargoLifter, Hamilton Airship, Rigid Airship Design, RosAeroSystems, Aeros, Zeppelin NT, Airship Technologies, American Blimp, Global Skyship, Goodyear, WDL, Coopership, Aérospatiale

Super/Hypersonic Transport (air transport in planes quicker than sound):
HSCT, HyperSoar, Sänger

4. CLASS DESCRIPTION

4.1 Ground level vehicles (including water)

4.1.1 Guided people mover

Automated people movers aim to provide several advantages of individual car traffic: flexibility by frequent service, high degree of privacy by small vehicles as well as low operating costs for the provider due to driverless operation. The major advantage of a quick service without interference with other traffic on a dedicated track makes the service reliable and attractive and reduces congestion but has the draw back of high infrastructure costs and possible visual intrusion of elevated structures. The concepts of this class described in annex A cover a large variety of systems with on- or off-board propulsion systems, offline stations or with stops at intermediate stations, elevated or ground level infrastructure, mono- or dual rail, supported or suspended vehicles, point to point service or regular public transport service.

Congestion reduction potential

People movers have a major potential to reduce congestion due to their frequent service and segregated lane which does not interfere with existing traffic flows if installed off-ground. However most of them are adapted to low to medium transport flows and can't compete with the capacity of a metro.

Sustainable mobility potential

All covered people movers use electric motors either on board or for drawing the vehicle by cable. Therefore they are rather silent and without emissions at the point of use. Visual intrusion can be minimised by careful adaptation to the surroundings.

Role in existing transport system

Especially suited for regular but moderate transport flows within relatively short distances. At distances of a few kilometres moving walkways are too slow and buses or trams have too long service intervals and are expensive in operating costs. Along these corridors it makes sense to invest in dedicated infrastructure for a driverless transport system which does not interfere with existing ground level traffic.

Technical and financial feasibility

A range of people movers with different characteristics have already demonstrated their technical feasibility. Promoters stress advantages of their systems arguing for on-board or off-board propulsion systems, mono- or dual rail, supported or suspended vehicles. In general the question of best available technology among these options can still be regarded as open and depends very much on local conditions. The major drawback are high installation costs compared to a simple bus service. Application can therefore be expected for the time being mainly on targeted places described above.

Infrastructure issues

Dedicated lanes for people movers (mostly elevated) make these systems expensive. The guide-way with its supporting structures, foundations and stations normally accounts for about 70 % of the total investment (KFB, 1998). Opposition against these systems in urban settings emerges mainly from visual disturbance or for monumental protection reasons.

Representative system

Due to the variety of technical solutions in this class and its high potential to reduce environmental problems and congestion of our transport system it is proposed to analyse three rather different systems in WP 5 in more detail: Doppelmayr's Cable Car for a cable drawn system, the Intamin monorail with on-board engine in a new project of point to point service in the USA and the vertically and horizontally moving elevator Odyssey.

4.1.2 Road based people movers

Road based people movers are passenger-van to small passenger car sized vehicles, which can hold up to about 16 persons. These systems operate on normal pavement and run on rubber tires. In general the propulsion system is electric with either batteries (Parkshuttle, Rivium People Mover, Personal Rapid System), flywheel (Parry People Mover) or contactless (inductive) transmission of energy by a magnetic track (Serpentine). Navigation and driving of these systems is done automatically. Vehicles know their position due to transponders (i.e. identification points) and are managed by a central computer (except Taxlwurm and Parry People Mover). For users, the operation of these systems should be comparable with a lift. These systems are therefore also referred to as 'horizontal' lifts. Generally, the basic operation of the system is as follows: A passenger presses a button to request a vehicle at a 'stop'. After the vehicle has arrived, the passenger gets in and presses a button to indicate his/her destination. The vehicle travels automatically to the requested destination under supervision of the central computer. At the place of destination, the vehicle stops automatically.

The system can be seen as an alternative to conventional public transport, mainly by urban buses. The system is capable to offer better services than conventional public transport for the same price. Improved service is mainly concerned with demand driven operation and the possibility for high frequency. Costs improvements are attained by the concept of automated driving.

At present these systems operate at low speed (up to 20 km/h) and on dedicated lanes. Higher speed and mixed traffic use (i.e. with bikes and passenger cars) may be possible within a short to medium term period.

The best known examples are the Schiphol Parkshuttle and the Rivium People Mover in the Netherlands (technically identical systems by FROG Navigation Systems B.V.) and the Serpentine Horizontal Elevator in Switzerland (by CN Serpentine S.A.).

Congestion reduction potential

The maximum capacity per lane for road based people movers is about as high as for passenger car transport or train services, about 15.000 to 20.000 persons per hour. However, the lanes of these systems are narrower than normal lanes. The main congestion reduction potential is the fact that these systems allow economical and feasible public transport at low volume transport links. The systems are therefore best used for access and egress transport to and from public transport junctions, large parking places and city centres. Thus, these systems stimulate public transport use, which could by itself result in congestion reduction.

Sustainable mobility potential

Given present day energy use of passenger cars, urban buses and railway systems, the road based people movers can be much more energy efficient. In addition they reduce the space that is needed for transportation. The amount of gains in energy and land use efficiency of these systems are however still unclear in practice.

Role in existing transport system

Supplementary to other modes of transport, mainly to public transport, due to required demand volumes. Systems are designed to operate in low volume passenger flow situations, such as in business areas, suburban areas, etc. Road based people movers are ideally suited for access and egress transport in a broad sense.

Technical and financial feasibility

At low speed and dedicated infrastructure, these systems are already in operation. At higher speed and mixed traffic, technical feasibility has still to be proven. For that, similar technical functions are needed as for Automated Vehicle Guidance systems. Much research is done in this field.

The existence of these systems in public transport proofs that they are already financially feasible. Costs can be compared to normal urban buses that operate at much lower frequencies. Further cost reductions may be obtained if vehicles and systems can be mass-produced and if these systems require less supervision by human operators for incident handling.

Infrastructure issues

At present these systems require a dedicated track (comparable to bike lanes). Infrastructure changes in comparison to normal pavement are minor and not very costly. They mainly concern the transponders and a central computer system, or in case of the Serpentine a magnetic track for energy transmission. In the future, mixed traffic operation is likely to be possible, which reduces special infrastructure requirements.

Representative system

Due to its innovative nature, high quality of services for passengers, relatively low costs and potential for improvements, these systems are very interesting for solving urban congestion problems. Systems that can be considered for further research are the Parkshuttle at Schiphol Airport, the Netherlands, the Rivium Automated People Mover in Rotterdam, the Netherlands, the Serpentine in Switzerland, the Personal Rapid Transit system at the campus of West Virginia University, United States, the Parry People Mover in Bristol, England, the Horlacher Taxlwurm in Switzerland, the Mitsui Vehicle of the New Age in Komaki, Japan and the Niigata New Tram in Kobe, Japan. One of the most interesting systems from a transport policy point of view is the Rivium People Mover. It is already in operation and serves as part of the urban public transport system. The Rivium People Mover will therefore be considered more in detail in the remaining of the RECONNECT project.

4.1.3 Elevated public transport

In this class systems are collected which are characterised by an elevated structure of the guide-way and stations. The operation is mainly with a driver, but with future developments an automatic operation is possible.

The Representative system of this class are

- Wuppertaler Schwebebahn which was built around 1900 and which is still the backbone of public transport in the German city of Wuppertal; renewal of the complete infrastructure 1995-2000.
- SAFEGE-Monorail, proposal and test facility around 1960 near Orleans in France
- Aerobus, proposal and test facility around 1970 near Zurich in Switzerland; 3.1 km system in operation during a garden fair in 1975 in Mannheim, Germany
- Alweg-Monorail, development and test facility in 1956/57 near Cologne in Germany; several systems in operation around the world, e.g. Tokyo-city-airport 13 km since 1963/64, Disney World, Florida, 5.4 km
- Von Roll-Monorail, development since 1964; about 20 systems in operation till now, mostly in theme-parks; Sydney Harbour System: 3.6 km, Newark Airport: 2.9 km

The first three systems have in common that the vehicles are hanging on a suspended "track" (single rail, hollow beam or cable) whereas the Alweg-Monorail and the von Roll-Monorail is straddling on an elevated beam.

Congestion reduction potential

Like all elevated systems, the systems of this class have a high potential to reduce congestion because they can be operated without interference with surface traffic. Depending of the vehicle size/train length and the train intervals they can have a high capacity (up to 25,000 pass./h). Car traffic will be reduced after acceptance of the system by the public.

Sustainable mobility potential

Due to the potential to shift the modal split from car traffic to new modes of transport, the emissions and nuisance from car traffic are reduced. The systems in this class are all electrically driven, which means that no local emissions are produced. Systems with rubber tires have a low noise level.

Role in existing transport system

The systems can play a key role in public transport like the Wuppertaler Schwebebahn or can have an important function in exhibition areas, fair grounds etc. They can have a complementary or replacing function in public transport. Transfer facilities can be installed at stations as they are needed. The systems are operated preferably on single lines due to the fact that switches are (much) more complicated than for a conventional rail system.

Technical and financial feasibility

The Aerobus and the SAFEGE-Monorail have found little acceptance in practice. The Aerobus in Mannheim was dismounted because the system of suspension (vehicles hanging on and travelling along a cable) has proven to be difficult for maintenance and repair. The von Roll-Monorail is in operation mainly in theme-parks.
The Wuppertaler Schwebebahn and the Alweg-Monorail have proven to be a reliable part in public transport. Where there is considerable transport demand and the need to use an additional level other than the surface level, these systems are technically and

financially feasible. The support and guidance system of the Wuppertaler Schwebebahn is simpler (double flanged steel-wheel on a mono steel-rail) than for the Alweg-, SAFEGE- and von Roll-Monorail, which need supporting wheels as well as guiding wheels.

Infrastructure issues
The route sections need space on the surface level for columns only. At stations staircases, lifts etc. have to connect the elevated platforms with the surface level.
The main problem of all elevated systems – especially those in this class with larger vehicles and bigger stations – is that of integration into the landscape of a city. Whereas there may arise severe problems in existing cities or parts of a city – especially with ancient buildings – there can be less reservation in a new city or when the transport system and the neighbouring structures are built at the same time.

Representative system
The Wuppertaler Schwebebahn is recommended as a representative system of this class for further studies. Despite its age, it still has a modern concept and has proven to fulfil its tasks in public transport with all positive consequences for reducing congestion and adding to a sustainable mobility. There is a long experience in operation, cost issues etc. which gives a sound basis for further analysis.

4.1.4 Moving walkways

Conveyor belts would be in theory ideally suited to cover a gap in transportation for distances too long for walking but too short to invest in expensive vehicle and infrastructure technologies of traditional public transport. But to get on and off a moving pavement the entry and exit speed should not exceed 3 km/h. For extended distances like those mentioned above this low speed is not attractive. Therefore moving walkways with increasing speed at the beginning, constant speed at least 4 times higher than at the entry in the main part, and deceleration at the end are under development.

Congestion reduction potential
The lack of attractive feeders and links in public transport are a major reason for excessive car use in cities. Accelerated walkways could play an important role in extending public transport services and making them more attractive.

Sustainable mobility potential
Moving walkways are driven by electric energy and free of emissions at point of use. They are rather efficient in energy use compared to traditional vehicles, as there are few moving parts. Conveyor systems in addition directly increase the attractiveness of walking and give this most sustainable transport mode a new appeal.

Role in existing transport system
Especially suited for short, unidirectional traffic flows like linking stations of public transport or terminals in larger stations as well as star-shaped distribution of passengers from stations or traffic in pedestrian zones.

Technical and financial feasibility
Moving walkways at constant speed have proofed their high reliability already at airports building upon the maturity and high percentage of availability of escalators. Conveyor belts with changing speed are under development and have still to proof their feasibility

in permanent use. It can be expected that in well-selected cases of application the investment for this moving pavement is very reasonable. Most likely this improvement of the (urban) transport system however has to be for free and financed by public funds, as ticketing would too much complicate the use.

Infrastructure issues
Advantage is the easy access without entering a vehicle or extended station. Disadvantage is in the case of crossing traffic the need for bridges or subways or segregated lanes for the conveyor system below or above ground, what makes the investment much higher and in most cases too expensive compared to more comfortable systems in public transport, with weather protection and seats.

Representative system
As the metro provider in Paris RATP is not only investing in the development of an accelerated walkway but has already decided to install this system until next year, TRAX is proposed for further analysis within RECONNECT.

4.1.5 Fast water vessels

In the RECONNECT project, the transport systems that are water based can be included in the class of fast water vessels. Their main advantage over traditional water based transport is the reduction of travel time, due to new or upgraded propulsion systems and improved techniques for loading and unloading. The systems therefore imply improved services and, more important, become alternatives for congested transport modes.

Congestion reduction potential
The use of water as an alternative means of transport has high potential in reducing congestion in places where rivers, canals, lakes or seashores are available. A traditional problem of water based transport is the loading time. With high speed water buses or taxis and for Fast Ships that operate in short sea shipping, the travel time becomes competitive, while congested roads are avoided. For Fast Ships that are used in deep-sea transport, the congestion at airports is avoided.

Sustainable mobility potential
There are not many environmental advantages to be expected from fast water vessels. With conventional fuels, the propulsion systems are characterised by a high level of fuel consumption and emissions. Only when the transport of passengers and goods becomes more efficient than that of the present day alternatives by road or rail, there will be some potential for sustainable mobility.

Role in existing transport system
The fast water vessels can mainly substitute congested road, rail and air transport at appropriate places, but they have to be made suited for high volumes of transport.

Technical and financial feasibility
The Fast water buses and taxis are already in operation and can therefore be considered both technically and financially feasible. The jet engine technique for Fast Ships has been proven and can be considered technically feasible as well. However, the Fast Ships concept needs a complete adaptation of the loading and unloading infrastructure, which may be financially unattractive.

Infrastructure issues

For the fast water buses and taxis there is a need for passenger stops along the waterways, which can be attained at relatively low costs. Part of the Fast Ships concept is a method for quick loading and unloading of the vessel, which demands much higher investments in new terminals.

Representative system

The class of fast water vessels includes two alternatives that may be used as substitution for congested road, rail and air transport. Most congestion takes however place in urban areas, especially when waterways limit the number of roads. In those cases, the fast water buses and taxis may be an ideal way of transport that reduces overall congestion. Since some examples of fast water buses and taxis are already in operation, like in Rotterdam, the Netherlands, this system can be used as a representative of this class for further research in RECONNECT.

4.1.6 Fast bike

Fast bikes are vehicle or infrastructure improvements of bicycles of all kind. The general aim of all the innovations is to increase the application possibilities and speed of human powered vehicles. This can happen by improving the layout of the vehicles regarding the aerodynamic drag or weather protection. The design ranges from simple windshields to full bodies, which give full weather protection. In addition to ordinary bicycles other innovative frame designs are used, like 3 or 4 wheeled vehicles and recumbents which allow cruising speeds of about 35 km/h or more, even for untrained users.
The fast bikes are mainly used for passenger transport and are mainly single or double seated, but freight delivery is possible to some extent with special designed vehicles. Examples are HPVs, recumbents, bicycle lifts, bike lanes, TransGlide 2000 and Skybikes.

Congestion reduction potential

In general the congestion reduction potential is high. Due to the low speed and the smaller vehicles the existing road infrastructure can be used much more efficient. The small vehicles also need smaller parking space.

Sustainable mobility potential

The energy efficiency is very good because the only "external" energy is needed for production of human powered vehicles. HPVs also produce no emissions in the usage, no exhausts and are operated very silently. They also produce a very low potential risk for pedestrians, due to the relatively low speed. On the other hand the passive safety is also low due to the rigid structure of the vehicle bodies, which can be improved by dedicated infrastructure and regulative safety measures like speed limits for motorised traffic.

Role in existing transport system

Globally, the human powered vehicles are niche products, because even with improvements they only reach limited speed and therefore the range is limited. Such vehicles also demand some kind of physical effort and fitness, and not everybody is willing to pay that effort.
On the other hand these vehicles are very well suited for inner city or short range transport due to the absence of local emissions and the limited consumption of space.

Technical and financial feasibility

Recumbents and other aerodynamically improved human powered vehicles are technically state of the art and many innovative market ready products are already existing. Research is only working in the direction of further improvements to make vehicles even lighter and more durable. The financial feasibility for the vehicles is high because they are, compared to other innovations, very low priced.

Infrastructure issues

In general all fast bikes can be operated on ordinary street infrastructure. A net of special, dedicated infrastructure (bike lanes) is well suited to increase the number of vehicles.

Several technical innovations regarding HPVs infrastructure have been made already. The main aims are protection from other traffic and improvement for the user by facilitating the way of operating the HPV.

One innovation already under operation is the bicycle lift in Trondheim, Norway. It helps the cyclists to climb up a steep hill in this city and functions like a mixture of ski lift and moving walkway. The user puts one foot on a plate which "pushes" him or her uphill.

Where space is very limited cycle lanes can also be built elevated. An American innovation aims at the HPVs to form some sort of bike train on special infrastructure to further reduce air drag by use of the slipstream.

Other special infrastructure named TransGlide 2000 has fans as wind generators, which allow users to always use the advantage of "tail wind".

Representative system

Because the vehicle design relates very much to personal preferences of bicycle users, further research will lay its focus on infrastructure issues. The bicycle lift in Trondheim will be dealt with as a good example of already existing systems and the concept of infrastructure with "tail wind" generators (TransGlide 2000) will also be researched in detail.

4.1.7 Man wide car

A man wide car is a small vehicle for one or two persons. The car is narrow (about one meter wide, half the size of an ordinary car) and the passengers sit in a row. Some man wide cars originate from scooters or motorcycles and were designed by simply adding a vehicle body but still keeping the 2-wheel set-up. Others are cars with reduced width and have a 3 or 4 wheel chassis. The intention has been to combine the advantage of swift movement through congested areas and the limited space of motorcycles or scooters with the comfort and weather independence of normal all-purpose cars. Examples are the BMW Scooter, DC, Light weight cabin vehicle and V2P.

Congestion reduction potential

The man wide cars only need reduced parking space and can park, like motorcycles, in between cars. The man wide cars can also bypass congestion on roads, where it is allowed. For this they need to be considered legally equal to motorcycles.

Sustainable mobility potential

The sustainable mobility potential depends to some extent on the propulsion system. The systems listed are mainly based on combustion engines. Hybrid or battery powered electric versions are only mentioned as a perspective for the future. These vehicles are more energy efficient than ordinary cars because they weigh less, but are still less en-

ergy efficient than scooters or motorbikes designed for urban usage (which are also available in electric powered version now).
It has also be taken into account that these man wide cars are likely to be bought as second or third car and are, like the small individual cars, likely to come into operation in areas where a mainly good developed public transport is existing as an alternative.

Role in existing transport system
The role of these vehicles is the individual transport in conurbation areas. They offer the advantages of scooters or motorcycles with some kind of improved comfort and weather protection.

Technical and financial feasibility
The vehicles are technically feasible and several prototypes already exist but the mass production has not started yet. It is also questionable whether the market share can become very large in the short term, because due to the motorcycle boom nowadays many potential buyers have already covered their demand for a way of transportation with limited need for parking space.

Infrastructure issues
No special infrastructure is needed for small individual cars, they can be operated on normal road infrastructure. The parking regulations have to be adapted to allow parking between cars like motorcycles. An allowance to passing through or by the lanes in case of congestion would be a further improvement. On intersections before traffic lights a special dedicated lane for vehicles with a small width would enable them to line up in front of the waiting queue.

Representative system
For further research one vehicle that originates from scooters (2-wheel set-up) and one vehicle that originates from cars (3 or 4 wheels) will be researched in detail.

4.1.8 Individual public transport

Car sharing with low emission vehicles combines the flexibility, comfort and privacy of the individual car with the low space requirements and pollution of public transport. All concepts in this class use electric vehicles on a rental basis. Driving force is the shortage of (parking) space in the urban environment and the urgent need to reduce pollution in inner cities. In these high population density urban areas the decentralised car sharing system is profitable and offers a much more attractive service than traditional rental schemes. Compared to sharing an electric vehicle the use of private cars in cities is not only more polluting but rather inefficient during use (congestion) and due to the fact that a high investment is used only a small fraction of the day and consumes tight space during parking.
The systems Praxitèle, Tulip, CityCar and ICVS from different car manufacturers are similar and in test operation in France and Japan. Station Car in the USA tries to provide commuters at public transport at stations with an intermodal offer of individual public transport. Domobile goes beyond the electric cars of the other concepts in this class as the vehicle with an extremely adaptable body can be integrated in the apartment furnishing at home or fulfil additional functions during parking in the street.

Congestion reduction potential

Car sharing has the potential to reduce need for parking space considerably as on average 10 to 15 participants in the system use one car.

Sustainable mobility potential

The system tries mainly to attract private car drivers and less public transport users. Analysis of car sharing experiments with combustion engines in the past showed that car sharing reduces congestion and reduces as overall effect exhaust gases. Electric vehicles have the additional benefit to be emission free locally or totally in the case of renewable energy sources. Reduction of required parking space improves as well the urban environment beyond the ecological aspect.

Role in existing transport system

Individual transport complements public transport beyond main urban traffic corridors where it is hardly profitable due to high operating costs for drivers. By intermodal alliance with car-sharing public transport could still provide area-wide service. Taxis are more expensive especially over short distances.

Technical and financial feasibility

The demonstration projects have shown the technical feasibility of electric cars with automatic access operated on a rental basis. Economic profitability of the system has still to be demonstrated on a larger scale and depends much on local conditions like social site structure, congestion frequency and supply of public transport. Development efforts are now concentrated to achieve assisted driving of vehicles and their automated redistribution after use.

Infrastructure issues

Special parking lots have to be reserved for this kind of individual public transport, preferably near public transport stations. Video supervision aims to discourage vandalism. Recharging of cars there during off-use time (mostly inductive) demands for electric power supply. Extensive wireless communication between car/user and central unit for reservation, accounting and assistance is foreseen. Domobile needs additional infrastructure (e.g. elevator to shift car to apartment) but has on the other hand the potential to satisfy some other urban infrastructure requirements beyond transport.

Representative system

The Praxitèle system is recommended as representative of this class for more detailed analysis in WP5 as it is based on an extended demonstration project of committed partners and aims at advanced innovations in automated vehicle guidance.

4.1.9 Small individual cars

Small individual cars are small vehicles (mainly 2 seated) especially designed and suited for the use in urban environment. They originate from the light electric vehicles, which took the fact into account that the ordinary car trip covers only a short distance with seldom more than 2 people in the car and ordinary cars are over-dimensioned in most cases. These LEM have a low weight (about 300 kg) and a range of about 100 km with one battery load. Due to the shortage of parking space in conurbation areas the main car manufacturers also started to launch small car projects. They have mainly small combustion or - to some extent - hybrid engines and have driving characteristics, which are sufficient for the use in conurbation areas. A special brand of these vehicles is limited in speed to a certain amount and can therefore be operated without a driving licence.

The size of these vehicles is about half the size of an ordinary car in length; the two passengers are seated besides each other, like in normal cars. The space for luggage is usually limited but big enough for the ordinary shopping. Examples are Smart, LEM and Aixam 300/400.

Congestion reduction potential

The main advantage of small individual cars is the lower space consumption regarding parking spaces. Two of these cars can be parked on a parking space for an ordinary car.

For the congestion on roads the reduction potential is limited because these vehicles can not bypass the congestion like a motorbike or bicycle and still need a full lane on the road. The shorter length of these vehicles influences the congestion only marginally.

Sustainable mobility potential

The sustainable mobility potential regarding exhaust emissions and noise for small individual cars depends to some extent on the propulsion system used. Now the trend goes more in the direction of using small combustion engines than using battery powered electric vehicles. These vehicles also tend to have high safety standards which is in fact very good for the users but on the other hand increases the weight of the vehicles which leads to bigger engine dimensions and in the far end the small individual cars have weight and emission characteristics which are comparable to small ordinary cars.

It has also to be taken into account that many of these vehicles are bought as second or third cars and are used for mobility in high density areas that can be much better served with public transport and where individual motorised mobility is less desirable.

Role in existing transport system

The small individual cars are mainly used in inner-urban transport or in conurbation areas.

Technical and financial feasibility

Small individual cars are market ready products and affordable for the private user. The technical innovation goes in the direction of improving the passive safety of the vehicle body and of further improving the emission characteristics.

Infrastructure issues

Small individual cars are used on normal road infrastructure. The only improvements regarding infrastructure are special parking regulations for this special kind of cars. The implementers try to legalise the parking in right angel in areas where ordinary cars have to park parallel to the traffic flow.

Representative system
Several systems of this group are market ready products already. In the further process of RECONNECT one conventionally propelled car and one alternative propelled car will be researched in detail.

4.1.10 Automated Vehicle Guidance (AVG), Automated Highway Systems (AHS) and Advanced Driver Assistance Systems (ADAS)

Automated Vehicle Guidance (AVG), Automated Highway Systems (AHS) and Advanced Driver Assistance Systems (ADAS) are all collective names for systems which automate or support all the drivers' task in full or partly. In this description, only driver support systems for passenger cars and freight trucks are considered. Essentially, AVG has the following objectives:

- Increase comfort for drivers;
- enhance safety by supporting the driver;
- increase capacity by reducing longitudinal and lateral distances between vehicles;
- reduce air pollution by harmonising traffic.

AVG systems use

- Radar and sensor technology to monitor the surrounding of the vehicle;
- information and (geographical) database technology to plan trips;
- vehicle--infrastructure communication to improve the use of infrastructure capacity and safety;
- vehicle--vehicle communication to harmonise traffic, to increase infrastructure capacity and to improve safety.

Systems can be used in urban areas, like the urban drive system (traffic light-vehicle communication to harmonise traffic and increase capacity of urban roads as well as in interurban roads such as AHS (USA) or AHSRA (JAPAN)). Many systems partly support the driver.

The state of the art of AVG applications within the area of passenger car transport is characterised by two developments. The first development consists of market ready systems, which take over certain driving tasks from the driver. The market ready systems include Intelligent Cruise Control (ICC) systems, which maintain a vehicle's speed while keeping a safe distance to a predecessor, and Collision Warning (CW) systems, which warn the driver for danger for a collision. ICC and CW systems are already for sale in Japan and are likely to be introduced in Europe soon. The second major development is the development of several prototypes, which are capable of fully automated driving. The prototypes are developed with the NAHSC and AHSRA activities. The technical feasibility of these systems was demonstrated at DEMO' 97 in San Diego within the context of NAHSC and at demonstrations held in Japan in 1995 and 1996.

AVG application for freight trucks involve the previously mentioned ICC and CW systems and lane departure warning systems. The latter are important for safety problems due to fatigue of truck drivers. The Chauffeur project couples two trucks automatically. The leading truck is manually driven. The towed truck is automatically driven and follows at short intermediate distance.

Congestion reduction potential
The systems that support the driver are mainly introduced for comfort and safety reasons. Direct capacity increase will range up to 5 to 10 %. However, there is also a possibility of a capacity decrease of up to 10 %. Indirect capacity increases are possible due to a reduction in the number of incidents. For illustration, about 20 % of all queues in the Netherlands are caused by incidents.

The fully automated systems have an enormous potential of improving road capacity. Maximum capacity increase is estimated to about 200 % for interurban highways. Possible bottlenecks may occur at on and off ramps of highways, especially near urban areas. Capacity increases in electronic tow truck systems (Chauffeur) and vehicle infrastructure or traffic light systems are considerably. Further capacity increases are possible due to reduced lane width. Present lane width of 3.5 m may be reduced to a minimum of 2m. Thus, a theoretical capacity increase of 75 % is possible.

Sustainable mobility potential
By harmonising traffic and reducing vehicles' headways (reducing air resistance), vehicles have to operate at less varying speeds which reduces power needs. This results in a direct reduction of energy use. The reduction of power needs may open the possibility for using more energy and environmental friendly engines, which would otherwise not be accepted by customers.

Role in existing transport system
AVG systems are to be introduced in present or similar passenger cars and freight trucks. Thus, the position of AVG is similar to the present position of passenger cars and freight trucks.

Technical and financial feasibility
The systems which only support or take over driving tasks partly are financially and technically feasible. The market introduction has recently taken place. The main item is customer acceptance of these systems and willingness to pay for these systems by customers.

For more complex AVG systems, especially fully automated driving, both technical and financial feasibility is under investigation. Point of concern is safety. Even if AVG systems are ‘statistically’ safer, people may find it unacceptable that a system causes an accident. At present, humans cause accidents.

Infrastructure issues
Costs of possible adjustment of the infrastructure and the introduction phase of the systems are important issues. The latter follows from the fact that infrastructure may need to be present before the AVG systems can be used, while infrastructure providers are probably only willing to invest if enough AVG systems are already sold.

Representative system
Due to the certain market introduction of at least some systems and its potential of customer acceptance and capacity increases, a further general evaluation of this concept will be included in the RECONNECT study.

4.1.11 Dual mode

The core characteristic of this class is that it sums up vehicles alternating between a guided mode of locomotion and independent movement. The vehicles link for a certain period of their trip to a dedicated infrastructure providing them with electricity as propulsion energy (either direct or indirect by a dragging unit) to avoid pollution in highly populated urban areas or to save environmental sensitive nature-sanctuaries. A second reason is that along major transport corridors with high traffic flow it makes sense to invest in infrastructure which facilitates automatic long distance driving and could save operating costs for drivers. A positive impact of automation on road safety is expected as well.

Another driving force for these systems is the limited range of electric vehicles, which can be largely extended by a grid of this infrastructure. In addition batteries can be recharged during connection with the external power source of the grid.

Systems covered in this class are Ruf, Monomobile, Carmeleon, U-Bus, Spurbus Essen, DMT and Road-Train.

Congestion reduction potential

The congestion reduction potential is expected to be only moderate. However there is some potential to achieve rather short headways of vehicles during automatic driving at guided locomotion increasing the capacity of these highway corridors. The exact guidance of the Spurbus Essen reduces strongly the vehicle clearance profile and as a consequence as well use of urban space and congestion.

Sustainable mobility potential

The electric vehicles are emission-free locally or totally in the case of renewable energy sources connected to the grid and in case of batteries as well off-grid.

Role in existing transport system

Combining the quick and high capacity function of rail transport and the flexible autonomy of buses, lorries or cars, dual mode systems provide direct services without need to change the transport mode.

Technical and financial feasibility

Most systems are still only concepts, while the Spurbus Essen is in operation. A guided bus line in Adelaide, Australia is operated with diesel buses. High investments for infrastructure are major obstacles to financial feasibility.

Infrastructure issues

Infrastructure costs are substantial. Additionally they are competing with investments for traditional rail infrastructure. However flexibility to switch between guided and unguided operation avoiding change of vehicle and transport mode and enlarging the range of electric vehicles are a major advantage of dual mode systems.

Representative system

The RUF System as advanced passenger concept and the Road-Train as relatively quickly operational and hardly disruptive system for freight transport without need to change the whole vehicle fleet are recommended for more detailed analysis in WP5.

4.1.12 Multifunctional urban vehicles

The vehicles of this class are characterised by a traction unit complemented by exchangeable car-body modules for different applications. The only concept in this class is NT Systèmes linking different public services like garbage collection, mail distribution, street cleaning, removal of industrial waste and public passenger transport.
The system uses a basic vertical transverse chassis called "ANNO", which receives its power supply (VNG, Electricity, Aquazole, etc.) via the roof and uses electric wheel motors. This traction unit is coupled with a professional compartment designed according to the operator's specifications. A coupling-uncoupling device facilitates changing the professional compartment during daily operations, so that, for example, the vehicle can be changed in total cleanliness from collecting industrial waste to collecting domestic waste, or in the transportation field from carrying a 100-capacity bus with 20 seats at peak periods to a 70-capacity bus with 50 seats during off-peak periods, all of these using the same chassis.

Congestion reduction potential
Decentralised, flexible and quick exchange of car body should reduce traffic demand for public services in inner cities and congestion. Need for parking space for public vehicles will be reduced.

Sustainable mobility potential
Electric wheel motors with several options of power supply (LPG, electricity, aquazole) aim at reduced pollution. Reduction of mileage for providing services by combination of services and decentralised car-body exchange is anticipated.

Role in existing transport system
Provision of transport based public services represents a niche where urban authorities could play an active role as service provider or orderer and could pursue in addition public interest (sustainable urban environment).

Technical and financial feasibility
The technical feasibility of the concept seems likely. The economic profitability has to be investigated in the demonstration project. Public authorities could use their dominant role in public services to enforce application of the vehicles in their communities.

Infrastructure issues
The places of car-body exchange have to be chosen carefully to avoid unnecessary traffic. Space saved by avoiding parking lots for public service vehicles should not be compensated by widespread, complicated and expensive exchange infrastructure. The missing technical know-how of employee's of public service utilities for the exchange operation can be a major barrier.

Representative system
NT Systèmes as only representative of this class is recommended for further investigation in WP 5.

4.1.13 Technical innovation for logistics

The key issue of all container based transport innovations is to use a container of standardised size to make the switch between transportation modes easy and efficient. The change between different modes is useful to be able to use for every area of application the proper and most efficient mode. Also collection and distributive traffic is made much easier if the goods haven't to be reloaded piece by piece but the whole container can change from one mode to another.
Some innovations take the fact into account that the size of a container is too big for several applications and therefore offer containers with standard outer dimensions but several smaller interior compartments. These compartments can be taken out of the original container and be used for further sub-distribution with smaller vehicles.
Although container based transport systems are mainly used in freight transport it is planned to use some sort of container transport for passengers too. The container, the word capsule seems more applicable in this context, is of standardised size and has an inner trim like normal cars with four seats and space for luggage. These capsules can be mounted for road use on chassis propelled by combustion or electrical engines, for further distance they can be mounted on railway carriages for example.
Examples are the Transmodular Capsule Concept TMC and Salami container.

Congestion reduction potential
The private freight companies have, due to competition reasons, to take all advantages they can, the freight transport is already rather well organised and innovations are rather targeted at cost cutting than to congestion reduction.

Sustainable mobility potential
The vehicle, which transports the container, can be chosen according to the area of application. Therefore always the most energy efficient mode can be used. The usage of containers allows quick mode changes in intermodality. Further subdivision of the existing standard container size helps to reduce empty runs which would result out of oversized containers.
Some innovations try to adapt these advantages for passenger transport. The individual users still can use their own private vehicle but the mode changes due to the application.

Role in existing transport system
The innovative container logistics are an improvement of the existing container freight delivery.
The usage of intermodal capsules for passenger transport is a new "all-over" solution, which is designed to replace or improve ordinary individual traffic.

Technical and financial feasibility
Containers for freight transport are a wide spread product. Technical innovations like the smaller compartments for containers are easily feasible. The containers for passenger transport are technical state of the art too, but the standardisation issue has to be solved first. The costs for such systems can, due to standardisation, be kept reasonable in the long run, as it is now for the ordinary containers.

Infrastructure issues

The track infrastructure is different for each different mode used for the container transport and is not dealt here in detail. For the reloading facilities the key issue is that the dimensions of the containers are standardised.

Representative system

Due to the new approach of standardised capsules for freight and passenger transport the TMC system will be further researched in the RECONNECT study.

4.2 Underground transport vehicles and logistics

4.2.1 Driverless guided public transport

In this category systems are described which provide an automated passenger transport in vehicles bigger than those for people movers:

- METEOR: a new line for the Paris Metro taken into operation in 1998 (first section of 7 km length, further extension under construction); totally underground.
- Metro Lyon, line D: taken into operation 1991/92; totally underground.
- VAL-System Lille: a medium capacity system, vehicles smaller and lighter than for a classical metro; first line taken into operation 1983/84, second line 1994/95, extensions under construction; mainly underground, otherwise elevated.
- Small metro: proposal 1980/83 for a metro system with smaller vehicles to reduce costs of tunnels; totally underground.
- H-Bahn: system of about 1.8 km route length and four stations in operation on a university campus in Dortmund, Germany since 1984 (first section); totally elevated, but underground solution is possible.
- M-Bahn: magnetic levitation system; small/medium capacity; a demonstration facility with approval as a public transport system was in operation in Berlin, Germany from 1986 until 1989; totally elevated, but underground solution is possible.
- Dorfbahn Serfaus: small to medium capacity system; 1.3 km system with four stops taken into operation in 1985 in Serfaus, Austria; vehicle support by air cushions, propulsion by cable; totally underground.

Congestion reduction potential

Due to automated, driverless operation, which allows short intervals between trains, the size of the vehicles and the use of underground/aboveground level which allows a reliable operation with a high speed and a high overall quality the potential of the systems in this class to reduce congestion is very high. In some cases of existing systems it has been proved, that car traffic was reduced, in other cases it can be assumed as sure taking the high level of patronage in account.

The kind and size of the effects depend on the transport needs on the one hand and on the capacity of the system and the modal split on the other. But the example of Serfaus shows, that also a "small" system, adjusted to the local conditions, can result in very positive effects.

Sustainable mobility potential

The high capacity systems in this class are very suitable to attract people from the car and shift the modal split in favour of public transport. Related to this effect, the emissions and nuisance from car traffic are reduced.

The systems in this class are all electrically driven, with the consequence, that no local emissions are produced.

The use of the underground implies all benefits of this solution: no noise emission, no interference with the townscape, fast and reliable service, use of the surface level for other purposes etc.

Role in existing transport system

The systems can have a mainly complementary function like the additional lines of a metro system or a function where other services like buses are substituted. In most cases in practice there will be a mixture of both.

With the exception of the cable driven Dorfbahn in Serfaus all systems can have switches in their track, so that a network can be created. Interchange facilities to other lines of the system or other modes of transport can be built according to the demand and the local conditions. High capacity systems can be fed by buses and park-and-ride.

Technical and financial feasibility

The technical feasibility must be split between the aspects related to the system itself like construction and operation of the track, the vehicles etc. and the issues implied in the use of the underground space.

From the pure system point of view all systems – with the exception of the proposal "small metro" – have shown their technical feasibility and reliability in daily operation – some of them for several years. Technical and financial data are available to evaluate their performance.

Infrastructure issues

Regarding the construction of tunnels, underground stations and other facilities, the aspects of tunnelling technology discussed in detail in Annex B must be taken into account. The methods and machines for driving tunnels and creating other underground installations are fully developed, so that there exists no reason not to use the underground space for transport facilities in any kind of ground conditions and in any situation of the above ground use. But generally speaking the use of underground suffers from high costs of tunnelling and other related building activities. Systems which need a smaller volume of underground structures (e.g. tunnels with a smaller cross section) have advantages compared to systems with a larger volume of structures – provided that the systems have a similar capacity. All efforts must have the aim to develop methods of underground construction which are cheaper and more effective than existing ones. This could lead to a more intensive use of the underground space for transport systems with all the benefits related to this.

Representative system

Among the whole scale of new modes of transport discussed in this project the systems in this class have the biggest capacity for urban transport. As a representative for this group the Metro Lyon, Line D is recommended. Automated operation is an aim for metros worldwide. The system is in operation since 1991/92 which gives a sound basis of experience of operation, cost issues etc. for further analysis.

Because characteristics of those systems are very different, the H-Bahn – as a second representative for a medium capacity concept – is recommended for further studies.

4.2.2 High speed guided systems

Several systems, developments or proposals have been found, which aim at long distance, interurban transport with high maximum speeds of 400 to 500 km/h. All systems have guided vehicles on a dedicated track. To reach the mentioned speed range it is necessary to use magnetic based contactless technologies for levitation, guidance, propulsion and breaking.

The representative systems of this class are:

- High speed Ground Transportation – Maglev Trains: a US proposal for a demonstration link of 32 km length in Florida, USA
- SwissMetro: Proposal for a fully underground system in Switzerland with a total length of 680 km. A concession for a pilot connection with a length of 60 km has been applied for.
- Transrapid: The German variant of Maglev-Systems. A connection between Hamburg and Berlin is planned (290 km) which could be taken into operation in 2005 if construction work could be started in 1999.
- MLU: The Japanese Railways are engaged in this development. A connection Tokyo – Osaka (515 km, 35 km in tunnel) is planned. Part of this (43 km) will serve as a test track.
- HSST: This is a development of the Japanese Airlines with a maximum speed of 200 km/h. Several demonstrations with passengers on fairs and exhibitions. Airport link in Hiroshima planned.
- SERAPHIM: A development in USA underway since 1994. New technologies for the guideway and the propulsion system are proposed.
- Eurotunnel: A proposal in 1985 for a high-speed metro-system on a European scale. Total route length around 2700 km, fully underground.

Congestion reduction potential

The systems of this class aim at a speed range and an average travel distance where they have advantages in total journey time compared to high-speed trains with conventional wheel-rail technology, to air transport as well as to the individual car traffic.

This is why in feasibility studies and for planned projects a high acceptance and impressive numbers of passengers are predicted. This change in modal split could lead to a remarkable reduction of congestion on streets and in the air, followed by a corresponding decrease of emissions like fumes, noise etc. For the Swissmetro project it is taken into account furthermore, that freight transport will be shifted from the road to the conventional rail because there will arise free capacities, when the Swissmetro will be in operation. It has been predicted that the operation of the Swissmetro would save between 190 and 350 million liters of fuel in Switzerland per year.

It should be mentioned that not a few experts take the forecast numbers of passengers as to optimistically.

Sustainable mobility potential

Under the assumption that the predicted number of passengers would not be far beyond reality, the Maglev-Systems have a huge potential to change the modal split for interurban traffic. The systems do not produce local emissions due to their electro-magnetic propulsion technology. For the Transrapid it has been proved, that the noise level at 300 km/h is lower than for a conventional regional train at 80 km/h. If the system is put underground like it is proposed for Swissmetro and Eurotunnel this implies all benefits of this solution: no noise emission, no interference with the landscape and the townscape, fast and reliable service independent from weather conditions, use of the surface level for other purposes etc.

Role in existing transport systems

Maglev-systems will usually have a mixture of a complementary function and a substitution. The share of both may change over time. It is possible e.g. that parallel flight connections will be cancelled when the Maglev-system shows sufficient advantages.

In densely populated areas like Western Europe or Japan the relation between average journey speed (as high as possible !) and distances of stations (as short as possible !) must be well balanced, to gain the relative optimum. It is furthermore very important that intermodality is guaranteed.
The need for Maglev-systems in Western Europe must be carefully analysed that there does not arise a situation of competition with the High Speed Rail Systems, which are in operation and in further development. From an overall economical point of view this would be a waste of money.

Technical and financial feasibility
The German and the Japanese systems seem to be technically feasible, demonstration connections of several hundred kilometres length are planned in both countries. Experts in this field sometimes say that the development of the Transrapid is somewhat like five years ahead of the Japanese systems.
The SERAPHIM-system seems to be in an early stage of development.
Swissmetro and Eurotunnel do not imply own developments of Maglev-technology.
For the Berlin–Hamburg line of the Transrapid and for the Swissmetro it is planned, that they are – at least partly – financed privately. This would underline the confidence of the industry and the operator in these systems. It is unlikely, that these systems will be financed by public funds alone.

Infrastructure issues
If a system should be put underground, there arises the problem to optimise the cross section of the route tunnel. A train travelling with a speed of 400 km/h or more through a tunnel suffers from a high air resistance. That is why the Swissmetro-system proposes to evacuate the tunnels (this will require further intensive studies to develop a reliable and cost effective technology for this task).
The diameter of tunnels (5 m for the Swissmetro, single-track tunnel) does basically not imply any problems for tunnel construction. But due to the high volume of underground construction work it must be recommended to develop methods of tunnel driving which are cheaper and more effective than existing ones.
If the system or parts of it are placed at surface level or on elevated structures the space needed can be compared with any conventional railway systems.
In existing cities it will be difficult to insert elevated structures into a townscape.

Representative System
It is recommended to choose the Transrapid as a representative for this class. Tunnelling options should be included.

4.2.3 Automated freight-train and -road concepts

Automated freight train and road concepts are systems for freight transport that do not necessarily make use of a driver. The systems can be implemented on:

- *the urban level*, for example the Tokyo Linear-Motor-Network and London Metro Freight, based on fully automated small vehicles making use of tunnels and the metro rail network respectively, especially meant for reducing congestion problems between the major post-offices in Tokyo and in the City of London;
- *the interurban, long distance level*, for example the Automated Underground Tube Network Tokyo and the SST concept of the Deutsche Bahn, which are based on unmanned freight trains and are meant to increase the capacity of the railway infrastructure and to save costs;

- *seaport-hinterland connections*, for example the Combi Road concept which is based on unmanned trucks carrying sea containers and driving on dedicated tracks with active longitudinal guidance from the seaports to inland-terminals;
- *the (inter-)national network level*, like for example the TSF programme in Belgium and the IPOT programme in the Netherlands in which (in the conceptual phase) a design is created for a national Underground Transport & Tube system of about 10000 kilometres with 14 major junctions for both general cargo purposes as for liquids and gases.

Congestion reduction potential
The congestion reduction potential of these concepts depends on the actual level of congestion and the modal shift that can be attained by introduction of the new concept. In the IPOT programme the reduction in congestion costs is estimated for four designs of an underground Transport & Tube System. This effect is shown in the table below.

Table 1: Congestion reduction potential of four different designs of an underground transport and tube system in the Netherlands

Design	Length of network (km)	Reduction in congestion costs (million EUR) per year
One city	123	-3
Randstad (regional network)	1,055	-42
National	4,000	-160
National extended	10,000	-350

Sustainable mobility potential
Evaluation of London Metro Freight has shown a greater energy efficiency and therefore less emissions and noise. The environmental effects of the SST concept and Combi road are unclear. The evaluation of the IPOT programme has shown a substantial reduction in emissions. Moreover a reduction in visual and noise nuisance can be reached by an underground system.

Role in existing transport system
For both London Metro Freight and the STT concept existing infrastructure can be used. For Combi-Road, the IPOT programme, the Automated Underground Tube Network Tokyo, the Tokyo Linear-Motor-Network and the TSF concept, additional (dedicated) infrastructure is necessary. All systems are able to substitute conventional road and rail based systems. However, the long distance underground systems like IPOT and TSF concepts may offer complementary services.

Technical and financial feasibility
Feasibility studies of all concepts mentioned do not indicate technical nor financial unfeasibility. For most concepts costs are known, however revenues are yet uncertain.

Representative system
Both from a congestion reduction potential as a possible contribution to sustainable mobility the designs of the IPOT programme seems the most promising option in this class. Moreover, the Dutch Ministry of Transport has planned serious investments in further elaborating this concept in the next years. Therefore, this concept will be evaluated further in the remainder of the RECONNECT study.

4.2.4 Microtunnels

The transport of liquids and gas in pipes and tubes is a widely used technology. For underground tubes one speaks of microtunnels, which may have a diameter of somewhat like 0.5 m up to around 2-3 m.
There have been efforts since a lot of years to use microtunnels for the transport of freight beyond the traditional pipelines.

Systems described in this category are:

- Ondergronds Logistiek Systeem - OLS (Unit Transport by Pipe U T P): a proposal in the Netherlands for freight transport based on a train concept in a tube.
- Mail Tube System: pneumatic driven capsules in an underground tube (diameter 0.45 m); in operation 1962-1973 in Hamburg.
- Sumitomo Cement Capsule Liner: pneumatic driven train of three capsules in a pipe (diameter 1.0 m, mainly elevated); in operation in Japan since 1973; proposals/plants with a similar technology around the world: Airapid (Japan), BHRA (UK), Transprogress (GOS), TUBEXPRESS (USA), Subtrans (USA).
- Slurry Pipelines: transport of fine-grained coal or ore in slurry through pipes (diameter up to 500 mm); several plants in operation around the world.

A proposal from Japan, the "Automated Underground Tube Network Tokyo" (see chapter 4.2.3), is designed to use underground tubes or tunnels with a diameter of 5.5 m in which electrically driven automatic guided freight wagons will travel. Its dimensions and operations are more similar to a metro for passengers than to a microtunnel system.

Congestion reduction potential

Freight transport in microtunnels can complement existing transport systems on road or rail or even substitute them. If the systems are optimised according to the task they can work efficiently and effectively. Depending on the layout and the size of a system, it can have a very high capacity. Transport on the road can be avoided with the positive effect of a reduction in congestion.

Sustainable mobility potential

Microtunnel systems can have a high capacity with automatic operation. They are especially suited to serve high volumes of uniform goods between two points e.g. a production plant and a distribution site. They do not produce any local emissions due to their environmental friendly support and propulsion system (e.g. rubber tires, electrical or pneumatic propulsion).
The use of the underground implies all benefits of this solution: no noise emission, no interference with the townscape, continuous and reliable transport, use of surface level for other purposes etc.

Role in existing transport system

The systems have a complementary function, if they serve a two-point connection only. If they are extended to a network they can have a substitution function.

Technical and financial feasibility

The development of machines for driving microtunnels has made tremendous progress in the last few years due to the large demand of this technology for sewers, fresh water tubes etc. This helps to reduce interference with the use of the surface compared to cut and cover methods during the construction phase.
Practical existing examples and feasibility studies show, that the systems can be financial successful.

Infrastructure issues

Most of the systems in this category are designed to be located underground. Basically there exists the technology to drive the necessary route tunnels (diameter: 0.8 m up to 5.0 m) and to construct the necessary infrastructure for stations etc. But if the systems shall be used on a broader scale in the future it has to be recommended to develop the methods of underground construction, that driving tunnels becomes cheaper and can be made quicker than today without a reduction of safety.

Representative system

The most recent proposal for the type of microtunnels is the Unit Transport by Pipe (UTP) from the Netherlands. It has a high potential of technical development compared to the existing or already dismantled systems. The Tokyo proposal does not really fit in the category microtunnels, a lot of principles for construction and operation of a metro system for passengers can be transferred.

4.3 Airships and hypersonic transport

4.3.1 Lighter-than-air craft

Airships can be in general described as aerodynamically shaped, dirigible (controllable) lighter-than-air craft using a lifting gas for permanent buoyancy and a propulsion system for moving and manoeuvring. The airship's envelope design further adds an aerodynamic component to the lifting capacity.
Airships are not dependent of a lift force like all types of heavier-than-air vehicles and owe their capabilities to the use of lifting gas lighter than the surrounding air.
A dirigible is defined as a vehicle capable of manoeuvring and cruising against wind forces (though there are distinct limitations) in comparison to aerostats.
Airships shaped other than a teardrop or a cigar can be in principle considered lighter-than-air lifting bodies.
Hot-air or gas filled balloons are per se non-steerable lighter-than-air vehicles, even though circumnavigating the globe in a balloon – as just recently achieved by the 'Breitling Orbiter III' – implicates the impression of steerability.
Sub-categories are defined in the following, focusing on truly steerable vehicles.

Rigid airships

Most complex design of airship providing a stiff skeleton structure to maintain the outer aerodynamic shape. The non-pressurized lifting gas is contained in several gas cells, which ensure the buoyancy of the vehicle. All components like flight deck, gondola or interior passenger compartments, engines, fuel tanks and tail unit are attached to the rigid skeleton.
Even in the event of loss of gas, the structural integrity and as well sustaining control of the craft is guaranteed; the rigid structure prevents flexure and combined with reinforced envelopes allows for significant speed advantage over non-rigid airships. The largest pre-war built airships so far have been of the rigid type, better known as zeppelins. The majority of new concepts for medium and large size airships rely on rigid structures for providing a maximum of payload capacity, safety and efficiency.

Semi-rigid airships

A cross over between non-rigid and rigid airships, these vehicles have a solid continuous keel on the lower side serving as a kind of spine to the construction. The pressurised lifting gas is contained in inner gas cells split to several compartments, which are covered by multi-layer foils to prevent the loss of gas.
Similar to the design of a rigid airship, major components of the vehicle (flight deck, gondola, passenger or freight compartments, engines, fuel tanks and tail unit) are attached to the rigid keel, so the vital integrity of the crafts structure is maintained even if damage to one or several gas cells occurs.
Due to the introduction of new lightweight and extremely strong materials (e.g. carbon fibres, kevlar) a double hull system with a stiff outer envelope itself can add significantly to the structural strength of the whole system, whereby the most promising improvement compared to similar all rigid airships is the reduction of the overall empty weight of the vehicle, thus increasing payload.
At least one project for a large size cargo airship in an advanced design phase is based on the semi-rigid airship concept.

Non-rigid airships
The simplest type of airship is the non-rigid airship, which owes its shape completely to the (relatively low) pressure inside the envelope. To maintain a constant pressure inside the hull, multiple ballonets (air containing bags) are used to balance the varying pressure of the lifting gas. Gondola or flight deck and tail unit are directly connected to the airships envelope, whereas the engines are typically attached to the gondola.
Due to their less complex design, non-rigid airships – most commonly referred to as blimps – are very cheap to operate and have proven very independent of weather conditions, but the possibility of loosing the structural integrity when lifting gas is leaking, limits size and payload capacity of this type of airship in general and its potential for passenger and freight transport. (The largest US navy blimps provided payloads of approximately less than 15 tons for military surveillance.)

Other lighter-than-air craft
Recently proposed concepts include a dirigible freight balloon that would be capable of lifting up to 250 tons. The concept basically relies on a double hull design, with an outer air filled hull that is meant to compress and decompress the inner helium compartments, thus accommodating the craft to different altitudes and payloads. Attached to the underside freight container are the steering system and the flight deck. A different approach is offered by the proposal of deltoid lifting bodies, e.g. composed of multiple spheres containing the lifting gas and covered by an outer rigid hull structure. Those concepts are thought to enable for useful lifts of up to 1000 tons, applicable for passenger or cargo transport.

Congestion reduction potential
Airships take advantage of a low cruising altitude – normally between 1000 and 2000 meters above sea level – which, to a large extent, helps avoid interference with other air transport modes, because only helicopters might operate on this flight level. In conjunction with a lean ground infrastructure, in general independent from airports, but with the option for linking to other transport modes where appropriate, lighter-than-air craft could contribute to reducing congestion in specific areas.

Sustainable mobility potential
Using a marginally biased part of air space, thereby not releasing emissions at a higher level, could mean that airships evolve into an efficient and environmental friendly means of transport, supplementary to existing ground transport concepts.

Role in existing transport system
As stated above new airships could supplement existing transport modes if interoperability is properly addressed. Especially for inter-urban passenger and freight transport airships may be an integral part of a sustainable traffic.
Larger vehicles targeting heavy and bulky freight transport might even substitute existing modes, like slow transport by ship or extremely expensive and limited transport by cargo aircraft.

Technical and financial feasibility
All current and future airship concepts can in principle rely on a long experience in building and operating those vehicles. Considering remarkable improvements in the understanding of aerodynamic and structural design criteria for airships and the introduction of light weight materials derived from state-of-the-art aircraft, the technical aspects of developing next generation (semi-)rigid airships are calculable. Larger airships tar-

geting at unique market segments like bulky and heavy freight transport will apparently require innovative solutions addressing logistic aspects of the transport concept.
While expenditures for constructing small to medium size airships are relatively comprehensible, bringing up a system like CargoLifter might actually mean overall development costs in the range of a large turbo-prop or medium size regional jet aircraft, thus reaching some 300 or 400 million EUR. In addition ground infrastructure requirements for large airships might further contribute to 'system costs'.
However it has to be pointed out, that concepts contributing to the main theme of the study – reducing congestion – can only be expected to evolve in the rigid and semi-rigid airship. With respect to the limited scope of the survey it has to be stated, that those revolutionary designs – leaving aside the classic airship design experience – will identify the need for further basic research on conceptual problems.

Infrastructure issues

Ground infrastructure for airships does not have to be attached to congested airports but may offer advantages for smart connection to existing transport modes. Technical approaches incorporating logistic features into the vehicle concept will further reduce the need for extensive additional infrastructure, however hangars at an airship's home base constitute significant new infrastructure.

Representative system

The preselection for the airship class includes two promising projects, which display significant congestion reduction potential by their payload capacity, manoeuvrability and vehicle speed (independence from weather conditions):

- CargoLifter ‘CL 160’ as an example for a large semi-rigid freight airship, incorporating a new logistic and operational approach and
- Rigid Airship Design ‘NL-1’ as a modern successor to classic rigid zeppelin-type airships, applicable for passenger or freight transport.

As a baseline reference for the following assessment work within RECONNECT the Zeppelin NT concept will be included, because it represents the only new (semi-)rigid airship design with a prototype already flying, thereby helping to comment on feasibility, safety issues, developing and operating costs and the general problems related to the implementation of new means of transport.
(However, it is not intended to include the reference project in the subsequent database, which will stick to the study’s main theme of reducing congestion – which the Zeppelin NT does not apply to!)

4.3.2 Hypersonic transport

By definition, hypersonic implicates speeds exceeding Mach 5 or some 5300 km/h at high altitudes, whereas supersonic in general means speeds above the speed of sound (Mach 1).
When looking at super- and hypersonic transport vehicles, a distinction has to be made according to the operating speed of the vehicle and the type of propulsion system used. While supersonic aircraft cruising at Mach 2 or Mach 3 might still be powered by conventional turbo jet engines or a combination of jet and ramjet engines, all aircraft approaching speeds of Mach 5 have to use ramjet or scramjet engines or even combined propulsion concepts integrating rockets as well.
A ramjet engine can simply be described as an air-breathing jet engine operating with no major moving parts, relying on forward motion and a specially shaped intake passage to compress air for combustion. Hydrogen on-board the aeroplane may be used

as fuel, with the combustion being self-sustaining after ignition and the boundary condition of airflows travelling at subsonic speeds through the engine. In comparison, a scramjet excels on the effect of airflow through the turbine exceeding supersonic speeds.
Air-breathing engines using air as oxidator and hydrogen as fuel promise to be very emission friendly. With noise emissions significantly down from current supersonic aircraft, those concepts could be a promising alternative, when it comes to long range or even round the globe travel.

Advanced supersonic transport
Considering a next generation supersonic transport – as a successor to the Concorde, now flying for 30 years – bridges a gap between current conventional subsonic aircraft and future true hypersonic transport means. For this reason the idea of advanced supersonic aircraft has been included in the study, with respect to the time horizon covered.

Hypersonic transport
Focusing on future aircraft travelling at hypersonic speeds, two sub-classes have to be defined, due to the fact, that aerodynamic problems as well as the choice of propulsion systems will be key criteria for the targeted operative range.
The entry to hypersonic transport will be vehicles limited to the speed range of Mach 5 to 7 with ramjet engines being the dedicated propulsion system.
The final step will be transport concepts aiming at the Mach 10 to 12 speed range, using scramjet or combined rocket/scramjet propulsion systems for travelling at high altitudes.

Congestion reduction potential
Long-range travel capability of hypersonic aircraft could help avoid stopovers that contribute significantly to airport congestion on international hubs.
Flying on the edge of the Earth's atmosphere would in the same way establish a flight level previously not occupied by other aircraft, thus helping to relieve intercontinental air routes.

Sustainable mobility potential
The use of air-breathing engines would introduce a remarkably emission friendly propulsion concept, much advanced to current jet engine systems. If noise regulations could be met, hypersonic travel may become a valuable alternative for the business community.

Role in existing transport system
High-speed travel by aircraft is considered basically complementary to existing air transport modes, limited to a few large international airports, which offer interconnection with continental and regional services. Due to the sheer size of the development, hypersonic aircraft will supposedly be designed as multi-role vehicles, which to some extent would help address intermodality in the transport chain.

Technical and financial feasibility
At the moment developing and introducing a truly operational hypersonic transport constitutes the ultimate challenge in aircraft design. Though a couple of components, e.g. ramjet engines or structural components, have been successfully tested, integration into a vehicle concept remains difficult and points to the need for further R&D. Especially

structural heating is identified as a fundamental obstacle to efficient and reliable hypersonic transport.

Overall development costs for a full-scale project are estimated to be several billion EUR, comparable to those for an all-new large size subsonic passenger aircraft like the Boeing 777.

Infrastructure issues

As stated above, hypersonic aircraft would have to use existing airport (hub) infrastructure with no extra requirements – compared to next generation subsonic wide body aircraft – concerning the tarmac. All adaptation needed with ground infrastructure would be related to the aircraft's fuel (liquid hydrogen) and of course special flight check resp. maintenance procedures would lead to accommodations on dedicated apron sections.

Representative system

For further investigation within this study the focus will be on:

- the US ‘HyperSoar’ project that proposes a Mach 10 multi-purpose hypersonic transport relying on a so-called rocket based combined cycle engine.

5. OUTLOOK

The preselection of candidates in chapter 4 is based on criteria like sustainability potential, maturity of development, adaptability of concept to existing infrastructure, financial and technical background of partners in the development as well as data availability. Due to this selection a comprehensive assessment of the most promising technical options can be pursued within the limited financial resources of the project. The way of selecting the representative system(s) of each class secures in addition that all large categories of the RECONNECT project and all modes of transport are still considered in the deeper analysis of workpackage 5. They will be represented by those concepts, technologies and systems in the class, which the partners of the consortium estimate to be the most interesting and promising options for the future. That estimation is based on their experience and the assessment criteria defined in workpackage 4 and laid down simultaneously in Deliverable 2.

The partners have agreed to include any new arising concept idea in this database to keep track of newest developments. So Deliverable 1 will be open for attachments during analysis of representative systems in workpackage 5 and these new concepts will be assessed with the same set of criteria as in Deliverable 1, to estimate their potential contribution to improve the transport system of the future.

6. BIBLIOGRAPHY

AERO INTERNATIONAL (1997-99): Several volumes.

AIR&COSMOS/Aviation Magazine International (1998-99): Several volumes.

A.N.A.E. (L'Académie Nationale de l'Air et de l'Espace, 1990): Proceedings of the European symposium on future supersonic/hypersonic transportation systems.

ARCHBOLD, Rick and MARSHALL, Ken (1994): Hindenburg. An illustrated history (German edition, 1997: Luftschiff Hindenburg und die grosse Zeit der Zeppeline)

AVIATION WEEK & Space Technology (1998-99): Several volumes.

AVIATION WEEK & Space Technology: Aerospace Source Book 1999 (Vol. 150).

CARGOLIFTER AG (1998-99): Internet homepage. (Invest, concept, technology, model, media)
(URL http://www.cargolifter.com)

CEC, European Commission White Paper (1998): Fair Payment for Infrastructure Use: A phased approach to a common transport infrastructure charging framework in the EU, CEC: Brussels

CEC, European Commission Green Paper (1995): The citizen's network: Fulfilling the potential of public passenger transport in Europe (COM(95) 601 final)

CEC, European Commission (1993): Transport in the 1990, Europe on the move

DELFT University of Technology (1995): Delft Outlook 94.3 - Ancient but safe technology revives supposedly long dead competitor.
(URL http://www.bu.tudelft.nl./diec/outlook/94_3/h1.htm)

ECMT (ed.): Efficient Transport for Europe. Policies for Internalisation of External Costs, European Conference of Ministers of Transport, OECD: Paris 1998

FAG (Flughafen Frankfurt/Main AG, 1995): Vision 2000 plus (Masterplan 1995). History of masterplan 1938.

FLIGHT INTERNATIONAL (1997-99): Several volumes.

FLUG REVUE (1998-99): Several volumes.
(URL http://www.flug-revue.rotor.com)

KFB Rapport: PRT – a sustainable transport system for Urban areas in Sweden? (Sweden 1998)

LLNL (Lawrence Livermore National Laboratory, 1998): Internet homepage.
(URL http://www.llnl.gov)

OECD (1995): Urban Travel and sustainable development, Paris 1995

OECD (1998): Efficient Transport for Europe. Policies for Internalisation of External Costs, OECD: Paris

RAD N.V. (Rigid Airship Design N.V., 1999): Internet homepage. (Company profile, the business concept, benefits, markets, 1st airship, FAQs, press page, history)
(URL http://www.rigidair.com; http://www.tradezone.com/tradesites/rigid.html)

ROTHENGATTER, W. (1994): Do external Benefits compensate for external costs of transport?, *Transportation Research*, 28A(4), pp. 321-328. European Conference of Ministers of Transport (1998): Efficient Transport for Europe. Policies for Internalisation of External Costs, OECD: Paris.

SCIENCE NEWS (Science News Online, 1998): Internet homepage.
(URL http://www.sciencenews.org/sn_arc98/9_19_98/Fob5.htm)

STORM, Martje G.A. and PEETERS, Paul M. (1996): Revival of the airship?

ZLT (Zeppelin Luftschifftechnik GmbH, 1997-99): Zeppelin NT – product information brochure; internet homepage. (FAQ, gallery, company, descriptions)
(URL http://www.zeppelin-nt.com)

ANNEX A NEW MEANS OF TRANSPORT SURVEY

Characterisation of identified transport concepts
Following the methodology outlined in RECONNECT, the identified new means of transport are clustered to several classes which exhibit a number of common core characteristics and are considered relevant for the project.
Afterwards, each class is subdivided into a comprehensive number of transport concepts which are characterised in detail.

The main part of Deliverable 1 includes a description and evaluation of transport classes according to the experience of RECONNECT partners.
As a complement, this section presents a full description of all the transport concepts identified in this phase of the project.

For each transport concept, the information provided is organised as follows:

- A descriptive table with 20 generic attributes of the technology is systematically included and completed to the extent allowed by the information available.
- Whenever possible, additional information is included. A more extended description comprises, for example a discussion on the system's mechanics, the power source, the main applications and the status of development.

At this level of the project, the description of transport concepts is mainly based on information obtained from developing companies, providers or promoters. However, the RECONNECT partners have tried to complement this information, as far as possible, by directly inquiring after independent experts from universities and research organisations.

A1 Ground level vehicles (including water)

A1.1 Guided people mover

A1.1.1 Cable liner

1	Project, development, concept	**Cable Liner**
2	Type of transport	Passengers
3	Transport or logistic concept	Elevated rails
4	Type of vehicle concept	Funicular drawn by continuously moving cable loop, running on rubber tyres on elevated rails
5	Type of propulsion system and fuel	Electric / drawn by cable
6	Geographical scale	short (500m – 4km, in the shuttle mode 300m – 1.6km)
7	Technical or organisational innovations	No individually powered vehicles with complex drive components or complicated power feeding devices. Intervals of only 30 seconds between vehicles eliminate waiting times.

8	Short description	The CABLE Liner is a detachable funicular railway with vehicles running on rubber tyres drawn by a continuously moving cable loop integrated into the guideway elevated at 5 to 8m above ground level or in tunnels. A detachable grip assembly, integrated into the bogie of the passenger vehicle, forms the mechanical connection between the vehicle and the haul rope. Driverless cabins (capacity: 30 passengers) arrive every 30 seconds at stations and reach 6-10m/s (22-36km/h), transporting a maximum of app. 4,000 pass./h on their route up to 4 km with up to 5 stations.
9	Underlying problem or objective	It is difficult to serve efficiently regular but moderate transport flows within relatively short distances. At distances of a few kilometres moving walkways are too slow and buses or trams have too long service intervals and are expensive in operating costs. Along these corridors it makes sense to invest in dedicated infrastructure for a driverless transport system which does not interfere with existing ground level traffic.
10	Place in transport system	Complementary
11	Advantages for accessibility	Segregated alignment of infrastructure does not interfere with traffic on ground level.
12	Advantages for transport service	No more timetables or waiting time due to regular service every 30 seconds. Quick short distance service on dedicated routes without crossing especially suited for moderate and regular transport demand along corridors. Low (=driverless) operating costs.
13	Environmental advantages	Electric propulsion system without any local atmospheric emissions and low noise emissions (52dBA on track and < 65dBA inside vehicle)
14	Expected transport volume	Each line app. 4,000 pass./h and direction. Estimation of worldwide market: app. 150 MEUR/year.
15	Comparable projects or developments	Leitner AG (Alto Adige, Italy, Mr. Seeber) and Pomagalski/Otis (France)
16	Contact	Doppelmayr Cable Car, Rickenbacherstraße 8-11, Postfach 20, A-6961 Wollfurt/Austria Tel.: ++43 5574 / 604 Fax.: ++43 5574 / 75590 email: dcc@doppelmayr.com, Hr. Tino Immhaeuser, Ing. Sellge
17	Partners in project	Doppelmayr GmbH, Siemens AG
18	Planning of project or development	Cable shuttle in Las Vegas in construction with scheduled inauguration in April 1999. Start of construction of Cable Liner in shopping city near Vienna scheduled for May 1999 with termination in November.
19	Financial information	25 MEUR for track in shopping city near Vienna.
20	Donors	Austrian Fund for Innovation and Technology.
21	Additional information	

Mechanics

The Cable Liner is a detachable funicular railway with vehicles drawn by a continuously moving cable loop integrated into the guideway.

A detachable grip assembly, integrated into the bogie of the passenger vehicle, forms the mechanical connection between the vehicle and the haul rope. The spacing between vehicles is defined by the grips and cannot change outside the stations.

Cable Liner vehicles therefore do not require any complex drive components such as drive/gearbox/brakes, no complicated safety spacing or power feeding devices for operation of the vehicles on line as would be required for individually powered vehicles.

The tractive force generated by the moving haul rope ensures optimal running characteristics on gradients and in curves, irrespective of climatic conditions.

The main haul rope drive can be located in any of the final control centres or in a station, where it is protected against mechanical and structure-borne noise.

In the area of the stations, the vehicle grips detach from the haul rope. The vehicle is decelerated to creep speed (0.28 m/s) and slowly moves along the platform as passengers get in and out.

In the station, the generously dimensioned double door automatically slides open to provide level access for both foot passengers and wheelchair users.

Two vehicles, i.e. one arriving and one departing are always within sight of the station.

According to the permanent movement system of continuous monocable gondolas vehicle intervals of approx. 25 seconds can be reached with the Cable Liner. timetables therefore not necessary any more.

Electrical equipment

The electrical equipment of the Cable Liner is designed to meet high demands in terms of safety and availability, a feature that is achieved by the application of modular technologies.

The system is characterised by its overall-digital technology where Programmable Logic Controllers (PLC's) and microprocessor-controlled frequency converters with serial data coupling aim at efficiency and functionality.

This technology has been developed by Siemens Industrial Electronics and is being successfully applied in numerous projects all over the world.

For any Cable Liner application the standard software is adapted to the individual requirements of each installation, however, no special components or assemblies are used.

Close co-operation with the Siemens Traffic Engineering Department and the experience gained in recent years with the realization of various urban ropeway projects (funicular in Barcelona, Spain, air-cushion underground in Serfaus, Austria) led to an electrotechnical solution which is tailored to the special requirements of a public transport system. Know-how and experience from the fields of Ropeway Engineering and Traffic Engineering are combined with Siemens' experience in the field of drive and control technology.

Sophisticated project planning and realization based on and in combination with a consistent quality assurance system is essential in order to achieve the required high degree of system availability and thus greatly emphasised throughout the entire project.

In combination with important system functions executed partially redundant, an efficient diagnostics and visualisation system as well as the application of technologies which make the system easy to repair, such quality assurance aim at a high degree of system availability which is imperative in public transport.

The drive technology applied in the case of the Cable Liner is based on a uniform three-phase current technology with voltage source converters. It is easy to maintain and highly reliable.

Long-distance equipment diagnosis is possible by means of teleservice data coupling. It reduces the time required for maintenance even further.

Applications of the Cable Liner system

- As a feeder, where the Cable Liner links up with existing public transport systems such as railways, subways etc. Here the Cable Liner has both a „channelling“ as well as a distributing function.
- As part of a park and ride system, where the Cable Liner not only forms a link between an out-of-town car park and areas in the city centre but also provides a service to suburban stops along the route.
- As a direct transfer system between two points where there is a requirement for frequent, high-volume transport (e.g. airports, exhibition centres).
- As an additional attraction in tourist resorts where the Cable Liner can also contribute towards reducing traffic volumes in the centres of resorts.

Current status of the Cable Liner development

The technical development of the Cable Liner system is the joint project of Doppelmayr Seilbahn-Vertriebsgesellschaft m.b.H. and the Innsbruck branch of Siemens AG Austria. Over the past 20 years Doppelmayr and Siemens, both individually and jointly (particularly in Austria), have been developing ropeway systems available on the world market with high transport capacity and system availability.

After several years of groundwork, the two corporations decided to collaborate on the future development of the Cable Liner, whereby Siemens AG Austria would be able to draw on the experience gained in urban transport applications.

As far as rope technology and vehicle development were concerned, Doppelmayr contributes the required know-how thanks to their long-standing business relationships with the relevant suppliers.

After initial in-depth studies of the assembly groups (bogie carriages, vehicle frames, electric drive technology, electronic control systems), Doppelmayr and Siemens set up a development team. Once the technical specifications had been updated, the mechanical and electrical design engineers were able to go ahead with the construction of a pilot installation.

In March 1996, passenger transport system Cable Liner was taken into operation at the Doppelmayr test-centre in Wolfurt. Ever since then, intensive testing and research has been carried out.

A1.1.2 Poma-Otis

1	Project, development, concept	**Poma-Otis**
2	Type of transport	passengers
3	Transport or logistic concept	rail
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	mainly cable propelled
6	Geographical scale	short
7	Technical or organisational innovations	driverless, cable propelled transportation systems
8	Short description	Manufacturer, several products in operation: incline elevators, urban funiculars, shuttles and mini-metros. E.g. the mini metro in Serfaus was built by Otis
9	Underlying problem or objective	
10	Place in transport system	complementary
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	zero-emission vehicle
14	Expected transport volume	
15	Comparable projects or developments	People movers
16	Contact	Jaques Weiler (Sales Manager Europe) Tel.: ++33 450 22 53 69, email: 106000.2210@compuserve.com
17	Partners in project	
18	Planning of project or development	several systems in operation
19	Financial information	
20	Donors	
21	Additional information	

A1.1.3 Odyssey

1	Project, development, concept	**Odyssey**
2	Type of transport	passengers
3	Transport or logistic concept	advanced elevator
4	Type of vehicle concept	elevator cabin
5	Type of propulsion system and fuel	electric
6	Geographical scale	short distances (within buildings, connecting neighbouring buildings)
7	Technical or organisational innovations	elevator able to move vertically and horizontally
8	Short description	Odyssey is an integrated building transit system that will make possible the next-generation of super-tall or super-wide buildings. The system will utilise vehicles capable of moving both vertically and horizontally.
9	Underlying problem or objective	
10	Place in transport system	
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	www.otis.com
17	Partners in project	
18	Planning of project or development	since 1996 in conceptual stage
19	Financial information	
20	Donors	
21	Additional information	

A1.1.4 Intamin

1	Project, development, concept	**Intamin**
2	Type of transport	passengers
3	Transport or logistic concept	rail
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	electric / powered through infrastructure
6	Geographical scale	short
7	Technical or organisational innovations	monorail systems
8	Short description	Intamin is a manufacturer of monorail systems (e.g. monorail Stuttgart)
9	Underlying problem or objective	
10	Place in transport system	
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	zero-emission vehicle
14	Expected transport volume	
15	Comparable projects or developments	peoplemovers
16	Contact	Intamin AG, Verenastraße 37, Postfach 95, CH-8832 Wollerau, Tel.: 01/786 91 11
17	Partners in project	
18	Planning of project or development	market ready products, several in operation
19	Financial information	
20	Donors	
21	Additional information	

A1.1.5 American People Mover

1	Project, development, concept	**"Peoplemover": C-45, Skyway, Miami Metromover, Morgantown Group Rapid Transit System**
2	Type of transport	Passengers
3	Transport or logistic concept	elevated rails
4	Type of vehicle concept	car / bus linked together
5	Type of propulsion system and fuel	electric / powered through infrastructure
6	Geographical scale	short / urban
7	Technical or organisational innovations	automatically driven, elevated guideway
8	Short description	Automated peoplemover system, driverless operation, line and stop bound
9	Underlying problem or objective	ordinary PT too expensive - cutting cost through driverless operation and cheaper infrastructure
10	Place in transport system	Substitution
11	Advantages for accessibility	
12	Advantages for transport service	convenient way of driving, not impeded by ground traffic
13	Environmental advantages	zero-emission vehicle
14	Expected transport volume	
15	Comparable projects or developments	Peoplemovers
16	Contact	http://weber.u.washington.edu/~jbs/itrans/lascol.htm http://weber.u.washington.edu/~jbs/itrans/jack.htm http://weber.u.washington.edu/~jbs/itrans/miami.htm http://weber.u.washington.edu/~jbs/itrans/morg.htm
17	Partners in project	
18	Planning of project or development	several operational systems, market ready
19	Financial information	
20	Donors	
21	Additional information	

A1.1.6 Raytheon PRT

1	Project, development, concept	**Raytheon PRT 2000 Personal Rapid Transport System**
2	Type of transport	Passengers
3	Transport or logistic concept	elevated rails
4	Type of vehicle concept	Capsules
5	Type of propulsion system and fuel	electric / powered through infrastructure
6	Geographical scale	short / urban
7	Technical or organisational innovations	automatically driven, elevated guideway, direct stop to stop operation
8	Short description	Network of elevated rails and offline stations, the small capsules bring the passengers without stop to the destination, high number of capsules keep the waiting time short.
9	Underlying problem or objective	eliminate the need to interchange
10	Place in transport system	Complementary
11	Advantages for accessibility	
12	Advantages for transport service	no need to interchange
13	Environmental advantages	zero-emission vehicle
14	Expected transport volume	
15	Comparable projects or developments	personal rapid transit
16	Contact	http://weber.u.washington.edu/~jbs/itrans/PRT/PRT2000_Concept.html
17	Partners in project	
18	Planning of project or development	concept only
19	Financial information	
20	Donors	
21	Additional information	

A1.1.7 Cable tracks for inner-city transport

1	Project, development, concept	**Cable tracks for inner-city transport**
2	Type of transport	mainly passengers, perhaps freight
3	Transport or logistic concept	cable
4	Type of vehicle concept	cabin
5	Type of propulsion and fuel	electric mechanical by cables
6	Geographical scale	urban
7	Technical or organisational innovations	organisational: to use existing technology of cable transport, known from ski-cable-tracks, in urban areas
8	Short description	use of cable cabins for transportation of passengers (and perhaps freight) in urban areas
9	Underlying problem or objective	congestion: transportation by cable cabin through the air is an alternative for ground level transport
10	Place in transport system	substitution of ground level traffic, complementary as access and egress transport
11	Advantages for accessibility	on a local scale the cable cabin offers an additional transport mode through air
12	Advantages for transport service	fast and reliable transport in inner-cities
13	Environmental advantages	advantages in terms of local emissions and noise, disadvantages from the visual intrusion of the city atmosphere
14	Expected transport volume	
15	Comparable projects or developments	Parking Shuttle at Rossy Airport (F) Concepts in the cities of Nijmegen and Arnhem (NL)
16	Contact	manufacturer of cable tracks, city of Nijmegen
17	Partners in project	
18	Planning of project or development	system operational at Rossy Airport and ski-areas, conceptual phase in Nijmegen and Arnhem (NL)
19	Financial information	
20	Donors	
21	Additional information	

A1.1.8 Cabinentaxi

1	Project, development, concept	**Cabinentaxi**
2	Type of transport	Passengers
3	Transport or logistic concept	guided vehicles; mainly elevated structure, underground possible
4	Type of vehicle concept	cabin, 2-3 seats
5	Type of propulsion system and fuel	electric, powered through infrastructure, asynchronous short stator linear motor
6	Geographical scale	short distance/urban
7	Technical or organisational innovations	driverless small cabins, nearly door-to-door service
8	Short description	Car size cabins with rubber tired wheels for support and guidance; one direction straddling on, the opposite direction hanging from an elevated beam; operation on demand; relative breaking distance; distance of stations 300-800 m; the destination should be reached without stops at intermediate stations;
9	Underlying problem or objective	service offer with characteristics similar to a taxi
10	Place in transport system	Complementary
11	Advantages for accessibility	short distance to stations; no interference with traffic on ground level
12	Advantages for transport service	service on demand without stop at intermediate stations; average speed 36 km/h; no timetables or waiting time due to steadily available cabins
13	Environmental advantages	electric propulsion system without any local atmospheric emissions and low noise emission
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	
17	Partners in project	DEMAG Fördertechnik, Wetter
18	Planning of project or development	R&D since 1970; test facility near Hagen since 1972: 1.4 km, 6 vehicles, 3 stations; the taxi-concept was stopped later on, because feasibility studies showed an extremely high demand of cabins especially in peak hours; furthermore the operation with a relative braking distance was not allowed by German authorities; a shuttle system (length 600 m/with one larger cabin) was installed at a hospital in 1976.
19	Financial information	
20	Donors	R&D and test facilities partly financed by German Ministry of Research and Technology
21	Additional information	

A1.1.9 Ultra

1	Project, development, concept	**Ultra**
2	Type of transport	Passengers
3	Transport or logistic concept	Elevated rails
4	Type of vehicle concept	Small cabin with up to 4 seats
5	Type of propulsion system and fuel	Electric power via insulated rail fixed in the guideway
6	Geographical scale	Urban
7	Technical or organisational innovations	Driverless small vehicles on segregated lane, stations off main line for unhindered traffic, nearly door-to-door service
8	Short description	Frequent service of small vehicles for up to 4 persons allows for flexibility and privacy. Speed 64-80 km/h on expressways, 32-40 km/h on feeders. Swiping a smart card through an on-board reader the user informs the central computer on the desired destination.
9	Underlying problem or objective	Service offer with characteristics similar to a taxi
10	Place in transport system	Complementary
11	Advantages for accessibility	Short distance to stations; no interference with traffic on ground level
12	Advantages for transport service	Driverless service on demand without stop at intermediate stations; no timetables or waiting time due to steadily available cabins
13	Environmental advantages	Electric propulsion system with low noise emission and no local atmospheric emissions. Single 1.5 m track has only reduced visual intrusion compared to other systems.
14	Expected transport volume	
15	Comparable projects or developments	Cabinentaxi
16	Contact	Martin Lowson, Univ. of Bristol, Advanced transport Group, University Walk, Bristol BS8 1TR, Tel.: (+44) 117 928 76 94, email: Aero-transport@bris.ac.uk. Web: http://atg.fen.bris.ac.uk
17	Partners in project	
18	Planning of project or development	Concept
19	Financial information	
20	Donors	
21	Additional information	

A1.1.10 Soulé SK

1	Project, development, concept	**Soule SK**
2	Type of transport	Passenger
3	Transport or logistic concept	Elevated rails
4	Type of vehicle concept	Cable-pulled vehicle
5	Type of propulsion system and fuel	Electric / drawn by cable
6	Geographical scale	200 – 2,000 m
7	Technical or organisational innovations	The SK Noria consists of vehicles running, at regular intervals. The Noria offers a quasi-continuous transport with waiting times of less than 30 seconds. The vehicles are driven by a succession of different systems: cables, friction wheels and revolving platforms. When nearing a station, the clamp releases the main cable, the vehicles are slowed down by a decelerating cable or horizontal friction wheels, then slide by the platform at a speed of 0.3 m/s (1 km/h), more slowly than a moving walkway. In the end stations, the vehicles change track in minimum space, by the mean of a revolving platform, and immediately start on their way back.
8	Short description	The SK is an automated transport system with vehicles with steel wheels driven by a cable at 20 – 30 km/h (max. 36 km/h). The vehicles ride on rails in a segregated right of way. A clamp located under the chassis of the vehicle grips the cable. A single engine that can be redundant moves the cable. Rollers, fixed between the two rails guide it, which allows any line configuration.
9	Underlying problem or objective	It is difficult to serve efficiently regular but moderate transport flows within relatively short distances. At distances of a few kilometres moving walkways are too slow and buses or trams have too long service intervals and are expensive in operating costs. Along these corridors it makes sense to invest in dedicated infrastructure for a driverless transport system which does not interfere with existing ground level traffic.
10	Place in transport system	Complimentary
11	Advantages for accessibility	The SK system targets on residential, industrial, commercial or recreational areas badly or not at all served by public transport or other areas cut by ways impossible to cross at level: waterways, railways, highways etc.
12	Advantages for transport service	No more timetables or waiting time due to regular service every 30 seconds. Quick short distance service on dedicated routes without crossing especially suited for moderate and regular transport demand along corridors. Low (=driverless) operating costs.

13	Environmental advantages	The small gauge of SK system requires only a narrow right of way. It can run levelled on a viaduct or in a small gauge tunnel. The stations are small: the SK can adapt to complex configurations: maximum slope of 10 %, minimum radius of 50 m. It is an electrical system, pollution free at point of use. The engines are located in soundproof buildings and quiet.
14	Expected transport volume	
15	Comparable projects or developments	Cable Liner
16	Contact	M. Lomberty, email: soulest@compuserve.com, Web: www.Bigorre-st.fr Bigorre Systèmes de Transport 33, avenue du Général Leclerc, R.C.S. F-Bagnères
17	Partners in project	
18	Planning of project or development	
19	Financial information	Development costs 10,800,000 FRF
20	Donors	
21	Additional information	

A1.1.11 Other guided people mover

A variety of other concepts have been developed which correspond to the definition of this class (guided small vehicles on segregated lane with frequent service or on demand):

Culor: System idea from Lycoming College, USA, suspended vehicles under pipe-shaped beam coupled electro-magnetically into trains, decentralised control system

Fly Way: Swedish elevated system with suspended vehicles that can be lowered at stations making elevated stations unnecessary.

Pathfinder: Suspended, battery-operated vehicles which can be lowered at stations. Batteries charged at stations. Model built at Seattle.

PRT 2000: Raytheon and Chicago Regional Transit Authority invested 300 million SEK in development. Concept based on patent from Prof. Anderson (Univ. Minnesota). Test track near Boston.

Sky Cab: Battery driven vehicles on rubber wheels from Sweden.

Ultra-Wave PRT: Linear motor-driven suspended vehicles with rubber wheels. Electricity supplied inductively from the beam. 3 small loops in UK. Very slender guide-way.

AEG Transit Systems PM C 1000: Electrical driven wagon following a guided rail driving on a concrete road with a speed up to 90 km/h.

Arrow Dynamics: Mainly for amusement parks with non-automatic monorail.

Bombardier Disney Monorail: Electrically driven monorail, rubber wheels, concrete track, up to 112 km/h.

Bombardier UM Monorail series: Electrically driven monorail, rubber wheels, up to 32 km/h.

GEC/Alstom's Light Railway: Light rail electrically moved by a motor inside the vehicle, up to 80km/h.

Kawasaki's CVS: Each vehicle has own motor, up to 27 km/h.

Kawasaki/Kobe Steel Portliner: Vehicles with rubber wheels on a steel track, motor inside vehicle, up to 60 km/h, operating in Japan (Kobe).

Otis Cable Shuttles: Levitated by hovercraft-technique, vehicles moved by cable pulled electrically by a motor, speed up to 48 km/h.

Otis LIM Shuttle III: Vehicles moved by linear induction motor inside vehicle up to 48 km/h.

PRT Systems: Suspended system moved by rotary current motor inside vehicle on rubber wheels, up to 35 km/h. Operational in UK and Ireland.

A-Train CAT: Train system with steel on rubber wheels moved by rotary current motor inside vehicle up to 120 km/h.

Eurotrain-Monoviga PM: Monorail up to 120 km/h.

Inductran PM: Vehicles with rubber wheels moved by linear induction motor inside track.

Mitchell Transit System: Vehicles with rubber wheels moved up to 100 km/h (goal 390 km/h) by rotary current motor in the steel track. Money for test facility requested from National Science Foundation.

Von Roll Seilbahnen 3-S-Systems: similar to suspended tram of Soulé System.

Titan PRT system: Elevated vehicles moved in intervals of 7.3 seconds up to 72 km/h by linear induction motor with rubber bands.

A1.2 Road based people movers

A1.2.1 Parkshuttle

1	Project, development, concept	**Parkshuttle**
2	Type of transport	passengers
3	Transport or logistic concept	road
4	Type of vehicle concept	automated vehicle with the size of a small passenger van
5	Type of propulsion system and fuel	electric and batteries
6	Geographical scale	short distance / urban
7	Technical or organisational innovations	automatic guidance, needs no additional track infrastructure
8	Short description	The Parkshuttle is a low-capacity automatic navigating vehicle that operates without any physical guidance. It finds its way automatically and travels on a simple ground-level asphalt track. This innovative form of passenger transport is ideally suited for short-distance feeder transport to public transport stations. The Parkshuttle operates at Schiphol airport between the main terminals and the parking facilities
9	Underlying problem or objective	access to parking places that are not close to main terminal at Schiphol airport, where manned buses are expensive
10	Place in transport system	complementary
11	Advantages for accessibility	better and faster individual access at lower costs
12	Advantages for transport service	frequent service, easy access
13	Environmental advantages	zero emission vehicles
14	Expected transport volume	
15	Comparable projects or developments	RIVIUM Automated People Mover
16	Contact	http://weber.u.washington.edu/~jbs/itrans/parkshut.htm
17	Partners in project	ZWN Group (largest public transport company in the Netherlands), IC Holding (investment company in technology), Hollandia Kloos (steel construction).
18	Planning of project or development	in operation
19	Financial information	
20	Donors	
21	Additional information	

A1.2.2 RIVIUM Automated People Mover

1	Project, development, concept	**Rivium Automated People Mover**
2	Type of transport	passengers
3	Transport or logistic concept	road (at the moment dedicated road, restriction may be relaxed in the future)
4	Type of vehicle concept	automated vehicle with the size of a small passenger van
5	Type of propulsion and fuel	many are possible, rechargeable batteries are used in test pilots
6	Geographical scale	urban
7	Technical or organisational innovations	technical: unmanned vehicles controlled by computers and supervised by humans and sensors to detect other traffic
8	Short description	fully automated vehicles with the size of a small passenger van that can drive on a road that is suited for automated vehicle guidance; mainly used for access and egress transport
9	Underlying problem or objective	costs: manned buses are expensive to be used for access and egress transport with low transport volumes; with automated people movers, the frequency can be much higher and more adjusted to the transport demand
10	Place in transport system	complementary to long distance (public) transport
11	Advantages for accessibility	reduction of overall travel time for multi-modal trips
12	Advantages for transport service	higher quality public transport and in case of electric propulsion no local emissions and noise
13	Environmental advantages	only in case of electric propulsion no emissions and noise
14	Expected transport volume	
15	Comparable projects or developments	Parkshuttle at Schiphol Airport (NL)
16	Contact	Ir. P.H.F. Peteri, FROG Navigation Systems BV, Cartesiusweg 120, 3534 BD Utrecht (NL), Tel: +31-30-2440550
17	Partners in project	ZWN Transport Company and Municipalities of Capelle a/d IJssel and Rotterdam
18	Planning of project or development	the system is operational in Capelle a/d IJssel (RIVIUM) and will be monitored after 6 months
19	Financial information	3.7 million EUR
20	Donors	ZWN Transport Company FROG Navigation Systems Ministries of Economic Affairs and Transport Municipalities of Capelle a/d IJssel and Rotterdam

A1.2.3 Serpentine

1	Project, development, concept	**Serpentine**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	"horizontal elevator"
5	Type of propulsion system and fuel	contactless (inductive) transmission of energy
6	Geographical scale	Urban
7	Technical or organisational innovations	Coils in the road surface are used for a contactless (inductive) transmission of energy, and serve in the same time as a reference for the automatic guiding
8	Short description	Small vehicles (1.2 m broad) with up to 5 standing rooms move automatically at 15 km/h to the selected destination. The magnetic track (on car lanes, pavement or cycle paths) supplies the vehicle with electric energy for the driveline, guides and controls of the vehicle and provides an information interface. The coils are installed in a conventional road in an unobtrusive way. Regular service of 1 vehicle per minute. Continuous chain capacity up to 15,000 people per hour.
9	Underlying problem or objective	To combine flexibility and privacy of individual transport with space and fuel economy of public transport. Major advantage of Serpentine is low infrastructure installation costs (lower than for a trolleybus line).
10	Place in transport system	Complementary
11	Advantages for accessibility	Real network operation possible instead of traditional transport service on crossed lines.
12	Advantages for transport service	High safety with light vehicles at moderate speed. In addition laser obstacles detector and instantaneous engine break.
13	Environmental advantages	Central co-generation uses heat and electricity. No local emissions. Inventors claim a consumption equivalent of only 0.1 l/100km. Reduced need of space for vehicles and lanes.
14	Expected transport volume	
15	Comparable projects or developments	Park shuttle
16	Contact	CN Serpentine SA, Ch. Primerose 27, CH-1007 Lausanne, M. Bernard Saugy, Tel.: (+41-21) 617 17 66. Fax: (41-21) 617 17 80
17	Partners in project	Swiss Federal Institute of Technology, Epitaux Electronique SA, Leclanché SA, Electricité Romande, City of Lausanne
18	Planning of project or development	Prototype, demonstration project planned
19	Financial information	Project 1996-98: 3,005,000 CHF

A1.2.4 Personal Rapid Transit

1	Project, development, concept	**Personal Rapid Transit**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Automated vehicle with the size of a small bus
5	Type of propulsion system and fuel	
6	Geographical scale	Urban
7	Technical or organisational innovations	
8	Short description	The Personal Rapid Transit system or Morgantown People Mover consists of 71 cars that can carry approximately 16 people. The cars move along a 5.2 kilometre track over the campus of West Virginia University, with 5 stops. They have rubber wheels and are driven electrically by a guide rail, but an update of the system could make it find its own way on the concrete track. The system was designed by Boeing and was originally almost 14 kilometres long, but technical support was stopped by Boeing in 1979. It's maximum speed is 48 km/h
9	Underlying problem or objective	Connection between buildings that are standing far apart, but with high transport volumes only at some times each day. The system therefore combines demand dependent services at low costs by the absence of a driver
10	Place in transport system	Complementary
11	Advantages for accessibility	Variety in services depending on demand
12	Advantages for transport service	Fast services at low costs
13	Environmental advantages	
14	Expected transport volume	Currently 16,000 people per average school day
15	Comparable projects or developments	
16	Contact	
17	Partners in project	
18	Planning of project or development	In operation at West Virginia University campus
19	Financial information	Investment costs were 131 million US$ in beginning of 1970ies
20	Donors	West Virginia University
21	Additional information	

A1.2.5 Parry People Mover

1	Project, development, concept	**Parry People Mover**
2	Type of transport	Passengers
3	Transport or logistic concept	Rail
4	Type of vehicle concept	Tram
5	Type of propulsion system and fuel	Flywheel
6	Geographical scale	Inner city
7	Technical or organisational innovations	Ultra-light tram powered by flywheel charged by on-board D.C. electric motor through railside contact only at passenger stops. Direct mechanical transmission. Small vehicles, frequent service, extremely cheap and unobtrusive infrastructure without continuous power supply and need for stray current protection or dedicated track.
8	Short description	Vehicles 2m broad, 2.5m high, up to 6m long and max. weight of 6t. Low speed flywheel with 500 kg, low voltage charging, storage capacity > 1 kWh. Speed 32-48km/h. 35 passengers (20 seated). Applicable also in closed space.
9	Underlying problem or objective	Lack of easy accessible low-cost, short-distance transport means in inner cities with minimum infrastructure costs.
10	Place in transport system	Complementary. Especially suited in inner city and pedestrian zones with limited space, small distances and frequent stop requirements and without tolerance for visual intrusion by transport infrastructure.
11	Advantages for accessibility	Low-floor and good acceleration (1m/sec^2) of vehicle. Reduced curve radii (min. 15m) allow flexible adaptation of track to local situation. Frequent stops at least every 500m.
12	Advantages for transport service	Infrastructure is very cheap and quick to install. The very low weight of vehicles reduces rail wear and allows for shallow foundation without need to displace existing underground infrastructure.
13	Environmental advantages	Emission-free at point of use and quiet. Energy recuperation by regenerative braking. Low rolling resistance on rail. No visual intrusion by overhead wires or elevated tracks.
14	Expected transport volume	Capacity is 500-1,000 passengers per direction per hour with a 2-5 minutes headway and 2,000 for a two car set.
15	Comparable projects or developments	
16	Contact	Paul Truelove, Tel.: +44 121 359 36 21, email: P.F.Truelove@aston.ac.uk
17	Partners in project	
18	Planning of project or development	More than one year of operational testing. Commercial system is being put into place in Bristol.

19	Financial information	Cost estimate for a 5km loop with 6 vehicles and 10 stops is less than 3 million EUR. Vehicle cost 150,000 EUR. PPM will offer one third of capacity of a tram for one fifth of the cost.
20	Donors	
21	Additional informa-tion	The disadvantage of costs for the driver’s salary can be compensated by lower infrastructure costs and easier accessibility than for automated people movers on segregated lanes. Low energy density but frequent stops allow recharging. Energy storage on board in a flywheel needs less weight than batteries and quick recharging is no problem, whereas batteries are difficult to recharge with high power and during braking. Safety: predictable path of vehicle is important in crowded and multifunctional inner-city spaces. Safe multiplate design of flywheel breaking into large number of small fragments in case of failure.

A1.2.6 Horlacher Taxlwurm

1	Project, development, concept	**Horlacher Taxlwurm**
2	Type of transport	passengers
3	Transport or logistic concept	road
4	Type of vehicle concept	car
5	Type of propulsion system and fuel	electric / batteries
6	Geographical scale	short
7	Technical or organisational innovations	multiple unit train with very high manoeuvrability
8	Short description	Multiple-unit train - for the public transport of persons and goods over large areas of open ground, and travels at walking pace only (8-12 km/h). Absolute tracking stability of the individual trailers behind the towing cabin unit, which allows even narrow passages to be negotiated without problem.
9	Underlying problem or objective	objective: providing higher capacities without extra infrastructure
10	Place in transport system	complementary
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	zero-emission vehicle
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Horlacher AG CH-4313 Möhlin http://www.horlacher.com/defaulte.htm
17	Partners in project	Swiss Federal Office of Energy
18	Planning of project or development	prototype
19	Financial information	
20	Donors	
21	Additional information	

A1.3 Elevated public transport

A1.3.1 Wuppertaler Schwebebahn

1	Project, development, concept	**Wuppertaler Schwebebahn**
2	Type of transport	passenger
3	Transport or logistic concept	asymmetrically suspended elevated rapid transit system, double-flanged steel wheels on one steel monorail
4	Type of vehicle concept	train, articulated vehicles, length: 24 m, capacity: 204 passengers
5	Type of propulsion system and fuel	electric, powered through infrastructure
6	Geographical scale	short distance / urban
7	Technical or organisational innovations	First system in the world with vehicles hanging from a suspended rail
8	Short description	suspended rail on elevated structure, vehicles with bogies on the roof; route length 13.3 km, 19 stations
9	Underlying problem or objective	The city of Wuppertal is situated in a valley along the river Wupper. There was no space for a railbound system at grade. The Schwebebahn was built from 1898 to 1903 as an elevated system mainly above the river (10 km length)
10	Place in transport system	Complementary
11	Advantages for accessibility	Urban rapid transit system without interference with road traffic; train headways in peak hours: 2.5-3.5 min
12	Advantages for transport service	Smooth ride; max. speed 60 km/h, av. speed 27 km/h; high level of reliability and safety
13	Environmental advantages	no local emissions
14	Expected transport volume	16.9 million passengers per year (27.3 % of the total passenger volume of public transport in Wuppertal)
15	Comparable projects or developments	Aerobus, SAFEGE-Monorail
16	Contact	Wuppertaler Stadtwerke AG, Bromberger Str. 39-41 D-42281 Wuppertal, http://www.wsw-online.de/
17	Partners in project	Inventor: Eugen Langen, Cologne
18	Planning of project or development	Opening of the system: 1901-1903; renewal of the complete infrastructure: 1995-2000
19	Financial information	Renewal: funds from the state government, the federal government and the city of Wuppertal
20	Donors	
21	Additional information	

A1.3.2 SAFEGE-Monorail

1	Project, development, concept	**Safege-Monorail**
2	Type of transport	Passengers
3	Transport or logistic concept	guided vehicles hanging on suspended track
4	Type of vehicle concept	single vehicle (bus size); length: 17.3 m; capacity: 123 passengers
5	Type of propulsion system and fuel	electric, powered through infrastructure
6	Geographical scale	short distance, urban
7	Technical or organisational innovations	low weight structure and vehicles
8	Short description	Bogies on top of the vehicle travel in an overhead suspended hollow beam; Supporting and guiding wheels with rubber tires
9	Underlying problem or objective	High cost of underground systems
10	Place in transport system	Complementary
11	Advantages for accessibility	
12	Advantages for transport service	Planned max. speed: 100 km/h, planned headway: 90 sec
13	Environmental advantages	no local emission, low noise
14	Expected transport volume	capacity: 25,000 passengers/h
15	Comparable projects or developments	Wuppertaler Schwebebahn, Aerobus
16	Contact	
17	Partners in project	Société Anonyme Francaise d'Etudes des Gestion et d'Enterprises (SA FEGE)
18	Planning of project or development	Test facility (length 1.3 km) near Orléans, France, 1960
19	Financial information	
20	Donors	
21	Additional information	

A1.3.3 Aerobus

1	Project, development, concept	**Aerobus**
2	Type of transport	Passenger
3	Transport or logistic concept	Guided vehicles hanging on suspended cable
4	Type of vehicle concept	bus like articulated vehicles, length: 19 m, capacity: 100 passengers
5	Type of propulsion system and fuel	electric, powered through infrastructure
6	Geographical scale	short distance, urban
7	Technical or organisational innovations	The cable on which the vehicles are hanging is suspended in such a way, that the vehicle is travelling horizontal between the columns
8	Short description	Shuttle service between two stations, route length 3.1 km; elevated structure: 4.5-20 m above surface level
9	Underlying problem or objective	Connection of two areas of the garden fair in Mannheim in 1975
10	Place in transport system	Complementary
11	Advantages for accessibility	additional service without interference with road traffic
12	Advantages for transport service	smooth ride; max. speed 20 km/h
13	Environmental advantages	no local emissions, low noise, "light" infrastructure; energy consumption: 127 Wh/to km
14	Expected transport volume	Max. 22,000 passengers per day (9 hours operation)
15	Comparable projects or developments	Wuppertaler Schwebebahn, SAFEGE-Monorail
16	Contact	
17	Partners in project	Inventor: Gerhard Müller, Dietlikon/Zürich; City of Mannheim
18	Planning of project or development	A test track near Zürich (length 1 km) existed since 1970. The system in Mannheim was in operation during the garden fair (04-10/75); It was disassembled afterwards
19	Financial information	Costs for the Mannheim system (1975): infrastructure: 12 million DEM; per vehicle: 400,000 DEM; total operating costs (185 days): 1.8 million DEM
20	Donors	
21	Additional information	

A1.3.4 Alweg-Monorail

1	Project, development, concept	**Alweg - Monorail**
2	Type of transport	passengers
3	Transport or logistic concept	Vehicles straddling on a guideway, supporting and guiding wheels with rubber tires, mainly elevated, at grade and underground sections possible.
4	Type of vehicle concept	train, articulated vehicles, capacity 100-500 passengers
5	Type of propulsion system and fuel	electric, powered through infrastructure
6	Geographical scale	short distance / urban
7	Technical or organisational innovations	vehicles straddling on an elevated monorail
8	Short description	Elevated system with vehicles straddling on a monorail; System Tokyo Airport: length 13 km, 4 stations
9	Underlying problem or objective	Fast shuttle service in Tokyo; shorter systems on fair grounds, exhibitions etc
10	Place in transport system	Complementary
11	Advantages for accessibility	Tokyo: shuttle service airport - city centre
12	Advantages for transport service	Tokyo: fast travel, max. speed 100 km/h
13	Environmental advantages	no local emissions, low noise level due to rubber tires
14	Expected transport volume	Florida system: capacity 10,000 pass./h
15	Comparable projects or developments	Several shorter system in Japan and USA (e.g. Disney World, Florida, 5.4 km)
16	Contact	
17	Partners in project	Tokyo: Tokyo Monorail Co. Ltd.
18	Planning of project or development	Development started in Germany - test track in Cologne in 1956/57; Construction of Tokyo Airport system: 1963/64
19	Financial information	
20	Donors	
21	Additional information	

A1.3.5 Von Roll Monorail

1	Project, development, concept	**Von Roll Monorail**
2	Type of transport	passengers
3	Transport or logistic concept	vehicles riding on rubber wheels on an elevated concrete beam
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	electric, powered through infrastructure
6	Geographical scale	short distance / urban
7	Technical or organisational innovations	Vehicles straddling on an elevated monorail (concrete beam).
8	Short description	Elevated system with vehicles riding on a concrete track; vehicles electrically driven (rotary motor); mostly non-automatic, automatic operation of the system at Sydney Harbour since 1991.
9	Underlying problem or objective	Use of elevated structures to avoid interference with surface traffic; most systems in theme parks.
10	Place in transport system	Complementary
11	Advantages for accessibility	local service in theme-parks;
12	Advantages for transport service	Maximum speed: 60 km/h; vehicle intervals: 60 sec.
13	Environmental advantages	no local emission
14	Expected transport volume	
15	Comparable projects or developments	Alweg-Monorail
16	Contact	
17	Partners in project	AEG (has bought the company von Roll)
18	Planning of project or development	About 20 systems from 1964 till now; most of them in theme-parks; Sydney Harbour: length 3.6 km; Newark Airport 1995: length 2.9 km
19	Financial information	Investment costs Sydney Harbour: 65 million Australian dollars; Newark system: 143 million US$
20	Donors	
21	Additional information	

A1.4 Moving walkways

A1.4.1 Trans-18

1	Project, development, concept	**Trans-18**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Conveyor system
5	Type of propulsion system and fuel	Electric
6	Geographical scale	Urban
7	Technical or organisational innovations	Varying broadness of conveyor belt allows for adaptation of speed up to 20 km/h (development target: 60km/h).
8	Short description	Using the Bernoulli law for liquids the conveyor belt reduces its width like an extensible moving walkway in accelerating. The principle is an extensible chain of flexible and interconnected bars, covered by metallic scale.
9	Underlying problem or objective	To get on and off a moving pavement the entry and exit speed should not exceed 3 km/h. To offer attractive cruising speed the conveyor should accelerate in between to a velocity at least 5 times higher.
10	Place in transport system	Complimentary for distances too long for walking but too short to invest in expensive vehicle and infrastructure technologies of traditional public transport. (e.g. linking of terminals).
11	Advantages for accessibility	Advantage is the easy access without entering a vehicle or extended station. Disadvantage is in the case of crossing traffic the need for bridges or subways or segregated lanes for the conveyor system below or above ground. Therefore especially suited for short, unidirectional traffic flows.
12	Advantages for transport service	No operating costs for a driver and lower investment costs as most alternatives if installed on ground without crossings.
13	Environmental advantages	System without local emissions, enhanced appeal of walking.
14	Expected transport volume	
15	Comparable projects or developments	Passenger Conveyor Systems
16	Contact	Centre d'études et de recherches sur l'aménagement urbain. 147, avenue Victor Hugo, F- 75016 Paris, Tel: 704 34 70 – 553 97 18
17	Partners in project	Centre d'études et de recherches sur l'aménagement
18	Planning of project or development	Project is proposed for Paris (La Défense)
19	Financial information	
20	Donors	

A1.4.2 Passenger Conveyor System

1	Project, development, concept	**Passenger Conveyor System**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Conveyor system
5	Type of propulsion system and fuel	Electric
6	Geographical scale	Short distances
7	Technical or organisational innovations	Increasing conveyor speed during cruising from 3km/h to 15 km/h by relative sliding platforms.
8	Short description	Rectangular Al-platforms move parallel to their short sides and slide across one another, resulting in the platforms moving end to end at right angles to their original direction.
9	Underlying problem or objective	To get on and off a moving pavement the entry and exit speed should not exceed 3 km/h. To offer attractive cruising speed the conveyor should accelerate in between to a velocity at least 5 times higher.
10	Place in transport system	Complimentary for distances too long for walking but too short to invest in expensive vehicle and infrastructure technologies of traditional public transport. (e.g. linking of terminals).
11	Advantages for accessibility	Advantage is the easy access without entering a vehicle or extended station. Disadvantage is the impossibility of crossings demanding for bridges or subways for crossing traffic or segregated lanes for the conveyor system below or above ground. Therefore especially suited for short, unidirectional traffic flows.
12	Advantages for transport service	No operating costs for a driver and lower investment costs as most alternatives if installed on ground without crossings.
13	Environmental advantages	System without local emissions, enhanced appeal of walking.
14	Expected transport volume	Capacity 10,000 people/h.
15	Comparable projects or developments	Trans-18
16	Contact	J.K. Todd, Passenger Conveyor Systems, Dunlop-Angus Belting Group, Uxbridge, UK
17	Partners in project	Dunlop
18	Planning of project or development	Proposals for demonstration projects in a business area redevelopment in Paris and the London Bridge.
19	Financial information	
20	Donors	

A1.4.3 Trax

1	Project, development, concept	**Trax**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Conveyor system
5	Type of propulsion system and fuel	Electric
6	Geographical scale	Short distances (up to 400 m)
7	Technical or organisational innovations	Increasing conveyor speed during cruising from 3 km/h to 12 km/h. Conveyor belt has a synchronous handrail and can change direction.
8	Short description	The speed is changed from 0.75 to 3 m/s within 10 m at the beginning and end of the moving walkway by overlapping rolls turning at different speed.
9	Underlying problem or objective	To get on and off a moving pavement the entry and exit speed should not exceed 3 km/h. To offer attractive cruising speed the conveyor should accelerate in between to a velocity at least 4 times higher.
10	Place in transport system	Complimentary for distances too long for walking but too short to invest in expensive vehicle and infrastructure technologies of traditional public transport. (e.g. linking of metro stations and terminals).
11	Advantages for accessibility	Advantage is the easy access without entering a vehicle or extended station. Disadvantage is in the case of crossing traffic the need for bridges or subways or segregated lanes for the conveyor system below or above ground. Therefore especially suited for short, unidirectional traffic flows.
12	Advantages for transport service	No operating costs for a driver and lower investment costs as most alternatives if installed on ground without crossings.
13	Environmental advantages	System without local emissions, enhanced appeal of walking.
14	Expected transport volume	10,000 persons per day. Maximum capacity 10,800 people/h.
15	Comparable projects or developments	Passenger conveyor system, Trans 18, Mitsubishi (Japan) and Loderway (Australia).
16	Contact	M. Duranton, CNIM, Port Brégaillon, F-83500 La Seyne sur mer, Tel: (+33) 494 10 30 32 M. Pierre Patin, S.A.2P No operating costs for a driver and lower investment costs as most alternatives if installed on ground without crossings., 11,rue Carnot; F-94270 Le Kremlin; Tel.: (+33) 01 46 71 94 45
17	Partners in project	CNIM (Constructions Industrielles de la Méditerranée) and RATP (Subway in Paris)
18	Planning of project or development	160 m walkway will be installed in the subway in Paris until end of year 2000.

19	Financial information	Development cost shared by CNIM and RATP.
20	Donors	
21	Additional information	

A1.5 Fast water vessels

A1.5.1 High speed water bus or taxi

1	Project, development, concept	**High speed water bus or taxi**
2	Type of transport	passengers
3	Transport or logistic concept	water
4	Type of vehicle concept	boat
5	Type of propulsion and fuel	several possible, diesel and electric are most common
6	Geographical scale	urban and interurban
7	Technical or organisational innovations	organisational: organisation of fleet of water vessels as public transport or taxis with required infrastructure for passengers
8	Short description	small high speed boats are used as buses or taxis in urban areas
9	Underlying problem or objective	congestion: in highly congested areas, the presence of waterways can be used more efficient for the transportation of passengers
10	Place in transport system	mainly substitution for road traffic in congested areas
11	Advantages for accessibility	dependent on the presence of waterways, which may reduce the accessibility
12	Advantages for transport service	reduction of travel times due to use of non-congested waterways; ideally suited for inner-city tourism
13	Environmental advantages	none
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Dutch Ministry of Transport
17	Partners in project	local public transport operators
18	Planning of project or development	two systems in use, one between Amsterdam and Velsen, one between Rotterdam and Dordrecht
19	Financial information	
20	Donors	Dutch Ministry of Transport
21	Additional information	

A1.5.2 Fast Ships

1	Project, development, concept	**Fast Ships**
2	Type of transport	freight
3	Transport or logistic concept	water
4	Type of vehicle concept	boat
5	Type of propulsion and fuel	waterjets on diesel
6	Geographical scale	coastal shipment to transatlantic
7	Technical or organisational innovations	Technical: jet engines applied to a ship and shape of body to deal with waves; Organisational: just-in-time delivery and transfer infrastructure for new method of quick loading and unloading of vessels
8	Short description	The Fast Ship/Alicon concept consists of a high-speed cargo carrier with jet engines and a method for quick loading and unloading of the vessel. In this way, the sailing time between the east coast of the United States and Western Europe can be shortened from 8 to 3.5 days, with a maximum turn-around time for the ship of 6 hours. The large ships can carry up to 10,000 tons with a speed up to 38 knots (70 km/h).
9	Underlying problem or objective	Conventional ships can carry large amounts of freight, but are slow and unsuitable for many logistic concepts like just-in-time delivery; Fast Ships make this possible
10	Place in transport system	Fast Ships are characterised by a high level of fuel consumption and emissions. This doesn’t make the vessel a good alternative for cargo transport by road. When the ship is compared to a full freighter Boeing 747 however, the Fast Ship turns out to be more fuel efficient and environment-friendly. Stimulating the use of Fast Ships in deep-sea transport as an alternative to airplanes is therefore more convenient than stimulating the use in short sea shipping as an alternative to road transport. When more efficient and cleaner engines become available, Fast Ships might also become interesting for short sea shipping. Exploitation of Fast Ships in for example the port of Rotterdam would not cause any extra problems to congested inland transport by road, only for more inland transport by rail, which is no problem for the rail infrastructure.
11	Advantages for accessibility	
12	Advantages for transport service	reduced transport times, higher reliability
13	Environmental advantages	none

14	Expected transport volume	in the short term four ships of 10,000 tons
15	Comparable projects or developments	
16	Contact	Fastship Atlantic Inc. (USA) or Mr. Kjartansson, Tel: +31-71-439-62008
17	Partners in project	
18	Planning of project or development	unknown
19	Financial information	terminal costs: 75 million US$
20	Donors	The Delaware Port Authority, Philadelphia
21	Additional information	Reference: Ing. A.C. van Holk (1996) Fast Ships in Cargo Shipping, an impact analysis of the Fast Ship/Alicon concept, Technical University Eindhoven

A1.6 Fast bike

A1.6.1 Sky bikes – Bike trains

1	Project, development, concept	**Sky Bikes - Bike Trains**
2	Type of transport	passengers
3	Transport or logistic concept	elevated rails
4	Type of vehicle concept	recumbent bike
5	Type of propulsion system and fuel	human powered / auxiliary electric or gas engine
6	Geographical scale	short / urban
7	Technical or organisational innovations	human powered recumbent bikes are used and form "trains" to reduce air resistance
8	Short description	Guided Bicycle Rapid Transit is a conceptual combination of the characteristics and advantages of bicycles and guided rapid transit systems. Due to the low weight and size of bicycles the cost for the necessary infrastructure for the transit system infrastructure can be minimised. Higher speeds and distances can be covered with the bicycle due to the infrastructure. The whole system is just a conceptual idea until now.
9	Underlying problem or objective	bicycle usage for longer distances
10	Place in transport system	substitution
11	Advantages for accessibility	
12	Advantages for transport service	improvement of speed for cyclists, own elevated track
13	Environmental advantages	zero or low emission vehicles
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	http://weber.u.washington.edu/~jbs/itrans/skybike.htm
17	Partners in project	
18	Planning of project or development	concept only
19	Financial information	
20	Donors	
21	Additional information	

A1.6.2 High speed bikes

1	Project, development, concept	**High speed bikes**
2	Type of transport	passengers
3	Transport or logistic concept	road
4	Type of vehicle concept	bicycle
5	Type of propulsion and fuel	human powered
6	Geographical scale	short to medium distance
7	Technical or organisational innovations	technical: more efficient bicycles by reduction of air resistance
8	Short description	improved bicycles and reduction of air resistance, for example by putting riders in horizontal instead of vertical position or use of cabin
9	Underlying problem or objective	bicycles are relatively slow in comparison with passenger cars, but can offer reduced congestion and less emissions and noise
10	Place in transport system	substitution of existing bicycles and passengers cars on short distances
11	Advantages for accessibility	bicycles use less road and parking space capacity and may therefore reduce congestion
12	Advantages for transport service	more reliable, less comfortable
13	Environmental advantages	less energy use, noise and emissions
14	Expected transport volume	
15	Comparable projects or developments	similar to light weight cabin vehicles which are in general not humanly powered
16	Contact	Brian Wilson, HPVA, P.O. Box 1307, San Luis Obispo, CA 93406-1307 (USA), http:\\www.ihpva.org\ or Flevobike, Lelystad, the Netherlands or manufacturers and dealers of these bicycles
17	Partners in project	
18	Planning of project or development	development of high speed bicycles in progress; many types of high speed bicycles are for sale
19	Financial information	cheapest high speed bicycle costs about 1000 Euro
20	Donors	
21	Additional information	

A1.6.3 New bike infrastructure

1	Project, development, concept	**New bike infrastructure**
2	Type of transport	passengers
3	Transport or logistic concept	road
4	Type of vehicle concept	bicycle
5	Type of propulsion and fuel	human powered, possibly with external power supply
6	Geographical scale	short to medium distances, urban
7	Technical or organisational innovations	technical: lift to support a bicycle up-hill, covered bicycle lanes with air support (wind always from the back)
8	Short description	bike infrastructure to actively or passively support cyclists to attain higher speeds with less effort
9	Underlying problem or objective	bicycles are relatively slow in comparison with passenger cars, but can offer reduced congestion and less emissions and noise
10	Place in transport system	substitution of existing bicycles and passengers cars on short distances
11	Advantages for accessibility	bicycles use less road and parking space capacity and may therefore reduce congestion
12	Advantages for transport service	more reliable, less effort and more comfort
13	Environmental advantages	less energy use, noise and emissions
14	Expected transport volume	
15	Comparable projects or developments	Bicycle Lift, Trondheim (N) High Speed Bike Lanes (NL)
16	Contact	City of Trondheim (N) ENFB, Woerden, the Netherlands
17	Partners in project	
18	Planning of project or development	the bicycle lift in Trondheim is operational; high speed lanes are in conceptual phase
19	Financial information	
20	Donors	
21	Additional information	

A1.6.4 BTS TransGlide 2000

1	Project, development, concept	**BTS TransGlide 2000**
2	Type of transport	Passengers
3	Transport or logistic concept	covered lanes for bicycles with tailwind generators to minimise air resistance
4	Type of vehicle concept	bicycle
5	Type of propulsion system and fuel	human powered - electric fans
6	Geographical scale	short (urban)
7	Technical or organisational innovations	Fans provide permanent tailwind for cyclists and allow speeds up to 40 km/h
8	Short description	The BTS TransGlide 2000 is a new infrastructure for cyclists. These cycle lanes are mostly built elevated and are full covered. Running through the center of the System is a dividing wall with twelve-foot (3.65 m) wide traffic lanes on each side to accommodate bicycle traffic moving in opposite directions. Fans move the air through the System in the same direction as the bicyclists are riding. This technology increases the efficiency of the bicycle by providing an environment within which bicyclist can ride comfortable at average speeds of 25 mph (40 km/h).
9	Underlying problem or objective	Improvement of cycling speed and efficiency
10	Place in transport system	Complementary
11	Advantages for accessibility	Elevated infrastructure does not interfere with traffic on ground level.
12	Advantages for transport service	cycling will be made much more efficient
13	Environmental advantages	No emissions (human powered), low energy consumption (only for the fans)
14	Expected transport volume	
15	Comparable projects or developments	Bicycle Lift Trondheim
16	Contact	Bicycle Transportation Systems, Inc., 3377 South Willow Court, Denver, Colorado 80231, USA, (303) 671-5000, FAX (303) 671-5388, email: info@biketrans.com http://www.biketrans.com/index.html
17	Partners in project	
18	Planning of project or development	Paper concept
19	Financial information	
20	Donors	
21	Additional information	

A1.7 Man wide car

A1.7.1 Man wide car in general

1	Project, development, concept	**Man wide car**
2	Type of transport	mainly passengers, dedicated freight transport (small, light, high delivery speed required) is possible
3	Transport or logistic concept	road
4	Type of vehicle concept	car
5	Type of propulsion and fuel	any propulsion system that can be used for a passenger car, motor or scooter
6	Geographical scale	all distances
7	Technical or organisational innovations	technical innovation: narrow (man wide) cars; organisational innovation: (dedicated) lanes and parking spaces narrower than regular lanes and parking spaces
8	Short description	passenger car with two seats in line; vehicle width is half of that of regular car;
9	Underlying problem or objective	congestion and lack of parking space: with constant capacity per lane and parking space, more lanes and parking spaces can be created without increasing land use if the width of cars is reduced;
10	Place in transport system	substitution: man wide car is essentially a normal passenger car with limited seating capacity
11	Advantages for accessibility	if the infrastructure is adjusted accordingly, an increase in capacity, throughput and parking of 100 % can be achieved
12	Advantages for transport service	the smaller vehicles are likely to be less comfortable than present ones
13	Environmental advantages	smaller vehicles consume less energy due to less air resistance and therefore have lower emissions
14	Expected transport volume	
15	Comparable projects or developments	BMW Scooter (regular scooter with cabin to increase comfort and safety)
16	Contact	Mr. G. van der Zanden, Buro A+, Godswerdersingel 87, 6041 GK Roermond (NL), Tel: +31 4750 17400 and DaimlerChrysler, Stuttgart (D)
17	Partners in project	
18	Planning of project or development	DaimlerChrysler has developed similar car, which they position as fun-car and not as a man wide car
19	Financial information	

A1.7.2 V2P

1	Project, development, concept	**V2P (Véhicule Urbain 2P)**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Car
5	Type of propulsion system and fuel	Petrol (optional electric propulsion)
6	Geographical scale	Urban
7	Technical or organisational innovations	Narrow vehicle with 3 wheels for 2 passengers in tandem position and light body offering inclining possibilities to the driver during turning at high speeds. During parking and low speed the chassis can be fixed to improve stability.
8	Short description	Max. length: 2.2m. Max. Width: 0.8m. Height: 1.6m. Max. speed: approx. 110 km/h. Weight < 200kg. Price < 46,000 EUR. Consumption < 3 l/100km.
9	Underlying problem or objective	Attempt to combine high comfort, stability and safety of a car with low weight consumption and needed space of a single-track vehicle.
10	Place in transport system	Complementary
11	Advantages for accessibility	Vehicle can bypass congestion similar like bikes or bicycles.
12	Advantages for transport service	Traffic lanes might be redimensioned or increased on already existing infrastructure.
13	Environmental advantages	Low weight V2P will reduce consumption and most likely pollution by exhaust gases as well.
14	Expected transport volume	Inventors expect a market of 800,000 to 2.5 million vehicles during 10 years in France and 9 millions in California in 2015.
15	Comparable projects or developments	Lean Machine (Citons General Motors); Stream (Honda); C1 (BMW); Concept of Edmund Jephcott, DC; Light weight cabin vehicle
16	Contact	S.A.2P; M. Pierre Patin; 11,rue Carnot; F-94270 Le Kremlin, Tel.: (+33) 01 46 71 94 45
17	Partners in project	
18	Planning of project or development	Realised prototype
19	Financial information	
20	Donors	
21	Additional information	

A1.7.3 BMW Scooter

1	Project, development, concept	**BMW Scooter**
2	Type of transport	passengers
3	Transport or logistic concept	road
4	Type of vehicle concept	scooter with a cabin
5	Type of propulsion and fuel	all that are possible for scooter
6	Geographical scale	all distances, with long distances mainly for recreational purposes
7	Technical or organisational innovations	technical: a cabin is added to the scooter; organisational: roads and parking lots may be adjusted to width of scooter to allow for higher capacity
8	Short description	normal scooter with a cabin to protect driver against weather conditions and accidents
9	Underlying problem or objective	congestion and parking space: small scooter needs less road and parking space than normal passenger car; comfort and protection against accidents: scooter with a cabin offers more comfort and protection again accidents
10	Place in transport system	both substitution for passenger cars and complementary for recreational purposes
11	Advantages for accessibility	with dedicated lanes with corresponding width, these scooters may have easier access to congested areas
12	Advantages for transport service	lower costs in comparison to normal passenger car with more comfort and safety than normal scooter or bike
13	Environmental advantages	reduced energy use by reduction of air resistance and weight of vehicle
14	Expected transport volume	
15	Comparable projects or developments	Man wide car
16	Contact	BMW
17	Partners in project	
18	Planning of project or development	the BMW scooter will soon be on sale
19	Financial information	
20	Donors	
21	Additional information	

A1.7.4 Light Weight Cabin Vehicle (TWIP)

1	Project, development, concept	**Light Weight Cabin Vehicle (TWIP)**
2	Type of transport	passengers
3	Transport or logistic concept	road
4	Type of vehicle concept	small light vehicle with characteristics and capabilities between a scooter and a car
5	Type of propulsion and fuel	electric, ICE and human
6	Geographical scale	medium and short distance, mainly urban
7	Technical or organisational innovations	technical: development of light weight vehicle that is comfortable and cheap enough to replace a normal passenger car
8	Short description	small light vehicle with characteristics and capabilities between a scooter and a car
9	Underlying problem or objective	congestion and parking space: small vehicles use less road and parking space than normal passenger car; environmental: small light weight vehicles use less energy and produce less noise and emissions than normal passenger car
10	Place in transport system	mainly substitution for passenger car and scooter, but may be used complementary as well
11	Advantages for accessibility	small vehicles may cause less congestion and enable more vehicles to be parked in the same space
12	Advantages for transport service	less energy use and therefore less costs than a normal passenger car, more comfort than a scooter or bike
13	Environmental advantages	less energy use, noise and emissions than normal passenger car
14	Expected transport volume	
15	Comparable projects or developments	Several vehicles are already in the market; in some places in Switzerland, for instance Mendrisio, these kind of vehicles and their organisational form (infrastructure) are tested
16	Contact	TWIP producer: TWIKE AG, Kirchrain 11, CH-4460 Gelterkirchen, Tel: +41-61-981-5408
17	Partners in project	
18	Planning of project or development	several vehicles are already on sale
19	Financial information	
20	Donors	
21	Additional information	

A1.8 Individual public transport

A1.8.1 Praxitèle

1	Project, development, concept	**Praxitèle**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Car
5	Type of propulsion system and fuel	Electric (batteries)
6	Geographical scale	Short (several hundred meters to several kilometres)
7	Technical or organisational innovations	Combination of electric vehicles with inductive charging, operated in the car sharing mode and equipped with sophisticated ICT (GPS, automated driving, contactless access control, video surveillance and optimised distribution among car parks)
8	Short description	INRIA and INRETS designed this concept for urban mobility between public and individual transport. Renault converted more than 50 Clio to electric vehicles with Ni/Cd batteries. EDF responsible for inductive recharging. INRIA developed sophisticated information technology tools for driver's access to cars and for the central control unit to assist and observe drivers, to manage efficiently the distribution of vehicles among rental stations and with the final goal of fully automated driving of vehicles and their redistribution after use. Emphasis on intermodal connection to public transport.
9	Underlying problem or objective	Reduced attractiveness of public transport by lack of flexibility, individuality and comfort. Deteriorating urban environment by pollution and occupied space of individual cars. Inefficient and slowing traffic by congestion. No profitability of public transport beyond main urban traffic corridors. High operating costs for drivers in taxis and public transport.
10	Place in transport system	Complementary
11	Advantages for accessibility	Car sharing in decentralised rental stations ("praxiparcs") provides better accessibility complementary to public transport.
12	Advantages for transport service	Car sharing reduces congestion. Own driving complements public transport in peripheral regions with low profitability. Taxis lack competitiveness for short distances.
13	Environmental advantages	Electric Praxitèle cars eliminate emissions at point of use and reduce congestion and land-use operating in the car-sharing mode.
14	Expected transport volume	Estimated market share: 3-5 % of motorised urban transport
15	Comparable projects or developments	Tulip, CityCar

16	Contact	http://www-rocq.inria.fr/Praxitele/welcome-angl.html
17	Partners in project	RENAULT, EDF, CGEA, Dassault Electronique, INRIA, INRETS, (EPA,SAN locally in St. Quentin)
18	Planning of project or development	Large scale pilot project in Saint-Quentin-en-Yvelines near Paris fully operational since June 1998.
19	Financial information	Depending on time and frequency the user has to pay for 30 minutes 10-50 FRF.
20	Donors	
21	Additional informa-tion	

A1.8.2 Lisélec / Tulip

1	Project, development, concept	**Lisélec / Tulip**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Car
5	Type of propulsion system and fuel	Electric (batteries)
6	Geographical scale	Short (several hundred meters to several kilometres)
7	Technical or organisational innovations	combination of electric vehicles with inductive charging, operated in the car sharing mode and equipped with sophisticated ICT (personal remote control, guidance by infrared beacons, journey invoicing)
8	Short description	Within the LISELEC project the partners (PSA-Peugeot Citröen, ISIS, Cegelec-CGA, Via Transport) developed a concept for urban mobility bridging public and individual transport. Application of electric vehicles in the car sharing mode to overcome lack of space, pollution and congestion in inner-cities. PSA developed the Tulip, a vehicle especially designed for electric propulsion, inductive recharging and urban traffic.
9	Underlying problem or objective	Reduced attractiveness of public transport by lack of flexibility, individuality and comfort. Deteriorating urban environment by pollution and occupied space of individual cars. Inefficient and slowing traffic by congestion. No profitability of public transport beyond main urban traffic corridors. High operating costs for drivers in taxis and public transport.
10	Place in transport system	Complementary
11	Advantages for accessibility	Car sharing in decentralised rental stations provides better accessibility complementary to public transport.
12	Advantages for transport service	Car sharing reduces congestion and own driving complements public transport in peripheral regions with low profitability. Taxis lack competitiveness for short distances.
13	Environmental advantages	Tulip cars especially designed for electric vehicle demands with low consumption eliminate emissions at point of use and reduce congestion and land-use operating in the car-sharing mode.
14	Expected transport volume	
15	Comparable projects or developments	Praxitèle, CityCar
16	Contact	M. Noel Bureau (Fax: +33 141 36 39 47)
17	Partners in project	PSA-Peugeot Citröen, ISIS, Cegelec-CGA, Via Transport
18	Planning of project or development	Before introducing its special designed Tulip vehicles PSA wants to test the self-service concept with converted electric cars already marketed by the company within the Lisélec

		demonstration project. Start in La Rochelle end 1999.
19	Financial information	Experiment cost: 120,000-150,000 FRF/vehicle. User will pay 40 FRF /20 minutes plus annual subscription.
20	Donors	
21	Additional information	

A1.8.3 ICVS

1	Project, development, concept	**ICVS (Intelligent Community Vehicle System)**
2	Type of transport	passengers
3	Transport or logistic concept	road
4	Type of vehicle concept	car
5	Type of propulsion system and fuel	electric and batteries
6	Geographical scale	short distance / urban
7	Technical or organisational innovations	rental with smart-card, caravan drive redistribution of parked vehicles, automatic charging
8	Short description	Small purpose built EVs, rental service with smart card, automatic charging and possibility of automatic operation for redistribution
9	Underlying problem or objective	Space shortage in inner cities or main activity centres
10	Place in transport system	complementary
11	Advantages for accessibility	Improvement of individual feeder or distribution trips to PT
12	Advantages for transport service	convenient and fast rental, individual mobility without owning a car
13	Environmental advantages	zero-emission vehicles, less space consuming
14	Expected transport volume	
15	Comparable projects or developments	station car, praxitele
16	Contact	Honda Motor Co Ltd., http://www.honda.co.jp
17	Partners in project	Honda
18	Planning of project or development	test operation in 1998 in Japan
19	Financial information	
20	Donors	
21	Additional information	

A1.8.4 Station car

1	Project, development, concept	**Station Car**
2	Type of transport	passengers
3	Transport or logistic concept	road
4	Type of vehicle concept	car
5	Type of propulsion system and fuel	electric and batteries
6	Geographical scale	short distance / urban
7	Technical or organisational innovations	reserved parking spaces at the stations
8	Short description	Car sharing system: Commuters use small battery-powered electric cars between home and a mass transit station or a mass transit station and work. They also use the vehicles for errands during the day or for short trips on evenings and weekends. For longer trips a conventionally propelled vehicle is available
9	Underlying problem or objective	bad access to PT-stations
10	Place in transport system	complementary
11	Advantages for accessibility	better individual access to PT-stations
12	Advantages for transport service	
13	Environmental advantages	zero-emission vehicles, less space consuming, modal-shift to PT because of better accessibility
14	Expected transport volume	
15	Comparable projects or developments	ICVS
16	Contact	Martin J. Bernard 963 Hillcroft Circle Oakland, California 94610 Phone: 510 839 6054 Fax: 510 832 3925, http://www.stncar.com/
17	Partners in project	National station car organisation
18	Planning of project or development	in operation / several sites in the USA
19	Financial information	
20	Donors	
21	Additional information	

A1.8.5 Domobile

1	Project, development, concept	**Domobile**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Car
5	Type of propulsion system and fuel	Electric (battery)
6	Geographical scale	Urban
7	Technical or organisational innovations	Combination of individualised public transport (car sharing) with innovation in the field of housing and construction. Valuable space in buildings for garages and on the street is not wasted any more but structured with multifunctional vehicles blending into urban architecture and matching additional requirements during parking.
8	Short description	Small electric vehicles for up to 4 persons are equipped with an extremely adaptable car body to match better the urban environment. Vehicles can be easily dismantled and reassembled and will either be used as public benches or communication terminals during parking, can be stacked densely in “domomats” for automatic rental near public transport stations, or can be integrated with a “domolift” in a private version directly as part of the apartment furnishing.
9	Underlying problem or objective	Regardless of propulsion system private vehicles are a mayor obstacle for urbanism occupying much public space. Private cars are used very inefficiently only a small fraction of the day.
10	Place in transport system	Complementary
11	Advantages for accessibility	Urban environment gets more accessible for pedestrians and domobiles could bridge the gap between the public transport network and mobility needs originating in private or apartments or office environment.
12	Advantages for transport service	Shift of space dedicated for parking to moving transport.
13	Environmental advantages	Urban public space is saved and the segregation effect of traffic infrastructure is reduced. Domobiles have as electric vehicles no local emissions and due to their compact structure consumption should be low.
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Association Voiture-Ville; 18, rue Gabrielle, F-75018 Paris, Tel.: (+33) 146 06 68 29, Fax: (+33) 142 54 30 40
17	Partners in project	

18	Planning of project or development	Project idea proposed by architect Edward Grinberg.
19	Financial information	
20	Donors	
21	Additional information	

A1.8.6 CityCar

1	Project, development, concept	**CityCar**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Car
5	Type of propulsion system and fuel	Electric (batteries)
6	Geographical scale	Urban
7	Technical or organisational innovations	Combination of electric vehicles, operated in the car sharing mode and equipped with ICT (GPS, contactless access control, communication with central unit and optimised distribution among car parks)
8	Short description	30 small cars with 2 seats (Ligier Ambra) are used in a decentralised rental scheme.
9	Underlying problem or objective	Reduced attractiveness of public transport by lack of flexibility, individuality and comfort. Deteriorating urban environment by pollution and occupied space of individual cars. Inefficient and slowing traffic by congestion. No profitability of public transport beyond main urban traffic corridors. High operating costs for drivers in taxis and public transport.
10	Place in transport system	Complimentary
11	Advantages for accessibility	Car sharing in decentralised rental stations provides better accessibility complementary to public transport.
12	Advantages for transport service	Car sharing reduces congestion. Own driving complements public transport in peripheral regions with low profitability. Taxis lack competitiveness for short distances.
13	Environmental advantages	Electric small cars eliminate emissions at point of use, use little energy and reduce congestion and land-use operating in the car-sharing mode.
14	Expected transport volume	
15	Comparable projects or developments	Praxitèle, Lisélec/Tulip
16	Contact	Anne-Marie de Andrea, Av. De France 4, CH-1951 Sion Tel. 027 327 34 47, Fax 027 322 61 26, email : deandreaa@post.ch
17	Partners in project	City of Martigny, Car Postal Suisse, EPFL
18	Planning of project or development	Testing with selected drivers until end 1999. Public demonstration starts in 2000.

A1.9 Small individual cars

A1.9.1 Smart

1	Project, development, concept	**Smart**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Car
5	Type of propulsion system and fuel	Internal combustion engine (petrol, diesel)
6	Geographical scale	Urban and regional
7	Technical or organisational innovations	The short vehicle (2 seats) was designed for urban and low occupancy traffic. Extended use of communication technologies for driver assistance and embedding in intermodal mobility concept.
8	Short description	Length only 2.5m. The electric propulsion originally foreseen by SMH has not been realised so far. Styling and the possibility to change the car body quickly to match the colour with the reason of the trip target on fashion conscious customers.
9	Underlying problem or objective	Lack of (parking) space in cities, congestion and very low occupancy rates in cars demands for smaller vehicles.
10	Place in transport system	Substitution of urban and second car traffic complementary to long distance and high occupancy car and public transport.
11	Advantages for accessibility	Short length of SMART allows for parking in spots where normal cars don't fit.
12	Advantages for transport service	Overall mobility concept of producer tries to match better the intermodal offer of transport means to the changing needs of the users.
13	Environmental advantages	Lightweight vehicle structure aims at low consumption although reducing internal combustion engines has thermodynamic efficiency limitations. Small dimensions of the vehicle will reduce parking space and congestion. The complimenting mobility concept could shift car drivers towards public transport.
14	Expected transport volume	
15	Comparable projects or developments	Small 2 seat vehicles from specialised producers in France and Spain (like MATRA).
16	Contact	Micro Compact Car smart GmbH (MCC), Mr. Kogel, Tel.: (+49) 70 31-90 47 17
17	Partners in project	DaimlerChrysler
18	Planning of project or development	Already on sale
19	Financial information	

A1.9.2 Lem

1	Project, development, concept	**Lem**
2	Type of transport	passengers
3	Transport or logistic concept	small individual cars
4	Type of vehicle concept	car
5	Type of propulsion system and fuel	electric
6	Geographical scale	medium distance
7	Technical or organisational innovations	Small individual cars with battery and electric engine. Fit for one or two persons with luggage.
8	Short description	Most cars are over-dimensioned in size and engine power. The principle for LEMs (short for Leicht Elektro Mobile – leightweight electric vehicles) is to reduce the size and characteristics of the vehicles to fit most of the daily trips. The vehicles are big enough to transport two persons with luggage and have a range of 100 km.
9	Underlying problem or objective	normal cars are unnecessarily overdimensioned in size and engine power
10	Place in transport system	substitution
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	zero emission vehicle
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Ing. Büro Muntwyler, P.O.Box 512, CH-3052 Zollikofen
17	Partners in project	
18	Planning of project or development	A large-scale test of LEMs is going on in Mendrisio (a city of 6,500 inhabitants) in Switzerland since 1994. The aim was to have 350 LEMs in operation till the year 2001. The demonstration has 3 main focus - LEM in daily use, LEM as a part of sustainable mobility concepts and supportive actions for market introduction of LEM.
19	Financial information	
20	Donors	
21	Additional information	

A1.9.3 Aixam 300/400

1	Project, development, concept	**Aixam 300/400**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Car
5	Type of propulsion system and fuel	Internal combustion engine (diesel)
6	Geographical scale	Urban and regional
7	Technical or organisational innovations	Quiet engine with low consumption (<3.5 litres/100km). Boot 600 litres. Vehicle net weight 350 kg.
8	Short description	The short vehicle (2 seats) was designed for drivers without license. Speed is limited to 45 km/h. Mainly used in urban and short distance rural traffic.
9	Underlying problem or objective	Lack of (parking) space in cities, congestion and very low occupancy rates in cars demands for smaller vehicles.
10	Place in transport system	Substitution of urban and second car traffic complementary to long distance and high occupancy car and public transport.
11	Advantages for accessibility	People without driver license have access to a car. Short length of vehicle (2.6m) allows for parking in spots where normal cars don't fit.
12	Advantages for transport service	Drivers can use smaller car when they have few or no passengers at all.
13	Environmental advantages	Low consumption (below 3.5 litres/100km)
14	Expected transport volume	In France app. 9,000 small cars with 2 seats are sold each year.
15	Comparable projects or developments	Similar cars with 2 seats from French and Spanish companies
16	Contact	Aixam-Mega, 56, route de Pugny, F-73101 Aix-les-Bains, Tel.: (+33) 479 61 42 45
17	Partners in project	
18	Planning of project or development	On sale
19	Financial information	
20	Donors	
21	Additional information	

A1.10 Automated Vehicle Guidance/Automated Highway Systems

A1.10.1 In general

1	Project, development, concept	**Automated Vehicle Guidance (AVG) or Automated Highway Systems (AHS)**
2	Type of transport	passengers and freight
3	Transport or logistic concept	road
4	Type of vehicle concept	car, truck and bus
5	Type of propulsion and fuel	all presently used for car, truck and bus
6	Geographical scale	all distances
7	Technical or organisational innovations	technical: vehicles and infrastructure that take over all or some driver tasks; organisational: all kind of problems are to be expected with the automation of driver tasks; safety and legal matters are important issues
8	Short description	automation of driver tasks which allows for shorter inter-vehicle spacing
9	Underlying problem or objective	capacity: shorter inter-vehicle spacing may increase road capacity, comfort and safety
10	Place in transport system	substitution of present driver tasks
11	Advantages for accessibility	increased road capacity may increase the accessibility to congested areas
12	Advantages for transport service	increased comfort and safety
13	Environmental advantages	none or minor (5 % reduction in energy usage)
14	Expected transport volume	potentially, all road traffic can be supported by AVG or AHS systems
15	Comparable projects or developments	Europe: Prometheus, Chauffeur, ADASE, SAVE, urban drive, etc. USA: AHS, ITS Japan: AHSRA and others
16	Contact	Dr. P.J. Zwaneveld, P.O. Box 6041, 2600 JA Delft (NL), Tel: +31-15-2696873
17	Partners in project	AI, COFI Route, TNO, RWS-AVV, INRETS, INRIA
18	Planning of project or development	development and testing of systems in progress, first systems are already on the market (Adaptive Cruise Control, Collision Warning System, Lane Departure Warning System)
19	Financial information	several billion EUR have been and will be invested
20	Donors	AI, governments and road providers
21	Additional information	

A1.10.2 Flexi train

1	Project, development, concept	**Flexi Train**
2	Type of transport	passengers
3	Transport or logistic concept	road
4	Type of vehicle concept	car
5	Type of propulsion system and fuel	mainly electric
6	Geographical scale	short and long distance
7	Technical or organisational innovations	cars are mechanically coupled on highways, intelligent power management
8	Short description	Small EVs and light vans for cartage are used. Each vehicle is fitted with a proprietary coupling front and rear, through which power and data can be transmitted. When formed into a train with other vehicles, primary controls are handed over to the lead vehicle. When the vehicles are uncoupled, these revert to individual vehicles.
9	Underlying problem or objective	energy consuming private car operation on highways
10	Place in transport system	substitution
11	Advantages for accessibility	
12	Advantages for transport service	automatic car operation on longer distances
13	Environmental advantages	zero-emission vehicle, energy efficient
14	Expected transport volume	
15	Comparable projects or developments	automated highways
16	Contact	http://camdek.com
17	Partners in project	
18	Planning of project or development	concept only
19	Financial information	
20	Donors	
21	Additional information	

A1.11 Dual Mode

A1.11.1 Ruf System

1	Project, development, concept	**RUF System**
2	Type of transport	passengers and freight
3	Transport or logistic concept	dual mode road / monorail
4	Type of vehicle concept	car / bus
5	Type of propulsion system and fuel	electric with batteries or hybrid / powered through infrastructure
6	Geographical scale	short and long distance
7	Technical or organisational innovations	Dual mode car - uses own infrastructure (monorail) for longer distances, also larger vehicles for public usage
8	Short description	Dual-mode system where the vehicles are small electric cars (RUFs) or larger Automatic People Mover units (MAXI-RUFs). The vehicles can go directly from road to a triangular monorail at 30 km/h. The RUFs can be closely coupled on the monorail. The RUFs take current from the rail or from small batteries when it is driving by itself on the roads. The batteries can be charged during rail driving. The range on roads - 50 km. Speed on road - 80 km/h; rail up to 200 km/h. Rail switching takes places without moving rail. The dual-mode principle is used for automatic guidance of a RUF from one rail - via road - to another rail or to the ordinary road network. The RUFs can be privately owned or public.
9	Underlying problem or objective	short range of electric cars
10	Place in transport system	substitution
11	Advantages for accessibility	
12	Advantages for transport service	combines the advantages of car and public transport
13	Environmental advantages	zero-emission vehicle, energy efficient
14	Expected transport volume	
15	Comparable projects or developments	all dual mode projects
16	Contact	RUF International, 155 Roedovre Centrum, DK 2610 Roedovre, Demark, Phone: ++45 36 70 88 95, Fax: ++45 36 70 88 66, email: pallerj@inet.uni-c.dk
17	Partners in project	
18	Planning of project or development	concept only
19	Financial information	

A1.11.2 Monomobile

1	Project, development, concept	**Monomobile**
2	Type of transport	passengers
3	Transport or logistic concept	dual mode road / suspended rail
4	Type of vehicle concept	car
5	Type of propulsion system and fuel	electric and batteries / powered through infrastructure
6	Geographical scale	short and long distance
7	Technical or organisational innovations	uses own infrastructure (suspended rail) for longer distances
8	Short description	Small electric car that attaches to a suspended monorail for long distance trips and is capable of running independent of the track for local trips.
9	Underlying problem or objective	short range of electric cars
10	Place in transport system	substitution
11	Advantages for accessibility	
12	Advantages for transport service	combines the advantages of car and public transport
13	Environmental advantages	zero-emission vehicle, energy efficient
14	Expected transport volume	
15	Comparable projects or developments	all dual mode projects
16	Contact	ARD, Inc. 26 East 6th Street Cincinnati, Ohio 45202 (51 3) 651-5553, e-mail:ard@iac.net; http://www.iac.net/~ard
17	Partners in project	
18	Planning of project or development	concept, prototype tested on a short section of tracks
19	Financial information	
20	Donors	
21	Additional information	

A1.11.3 Carmeleon

1	Project, development, concept	**Carmeleon**
2	Type of transport	passengers
3	Transport or logistic concept	road or rail / suspended
4	Type of vehicle concept	car
5	Type of propulsion system and fuel	electric / cable propelled
6	Geographical scale	short
7	Technical or organisational innovations	capsule can be used on roads (mounted on an electric drive unit) and on a cable railway
8	Short description	System for touristic cities, capsules can be used for inner-city transportation (mounted on electric drive units) and also for transportation up to the mountains (as a cable car on the existing cables from existing lifts).
9	Underlying problem or objective	need to interchange, traffic problems in touristic cities
10	Place in transport system	substitution
11	Advantages for accessibility	better access to e.g. ski-lifts
12	Advantages for transport service	no need to interchange
13	Environmental advantages	zero-emission vehicle
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	DI Christina Weiss; email: gabl.weiss@tirol.com; Austraße 11, A-6063 Innsbruck/Rum, Tel.: ++43 512 261533
17	Partners in project	
18	Planning of project or development	concept only
19	Financial information	
20	Donors	
21	Additional information	

A1.11.4 U-Bus

1	Project, development, concept	**U-Bus**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Bus
5	Type of propulsion system and fuel	Electric in inner cities. Outside standard diesel engines.
6	Geographical scale	Urban and suburban. Especially suited for medium sized cities.
7	Technical or organisational innovations	Zero emission in inner cities is combined with flexible service in low traffic flow suburban areas where infrastructure for external power grid is too expensive. Contrary to a hybrid solution trolleybus/diesel-engine no new vehicles are necessary and less dragging units than buses are required.
8	Short description	Buses are linked mechanically on selected corridors to an electric driven dragging unit, which hauls it through inner city zones. One dragging unit can haul several buses with one driver reducing operating costs. Outside the buses run on classic diesel engines and allow flexible service close to clients.
9	Underlying problem or objective	Emission reduction in inner cities without changing transport means (especially unfavourable compared to cars in medium sized cities).
10	Place in transport system	Substitution in selected areas
11	Advantages for accessibility	No need to change transport means passing from suburban to inner city environment.
12	Advantages for transport service	No need for changing rolling stock of urban public transport providers.
13	Environmental advantages	Zero emission and noise in inner cities from public transport.
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Intema Consult (Ing. Wancura), Karlauer Gürtel 24/4, A-8020 Graz, Tel.: (+43) 0676 5917 970
17	Partners in project	
18	Planning of project or development	Project idea
19	Financial information	
20	Donors	
21	Additional information	

A1.11.5 Spurbus Essen

1	Project, development, concept	**Spurbus Essen**
2	Type of transport	Passenger
3	Transport or logistic concept	Road
4	Type of vehicle concept	Bus
5	Type of propulsion system and fuel	Internal combustion engine (diesel) or electric motor (external electricity grid) like a trolley bus.
6	Geographical scale	Urban
7	Technical or organisational innovations	Guided buses avoid traffic jams by using dedicated lanes and tunnels together with light rail and trams in urban centres. Outside they still have the full infrastructure independence and flexibility of buses.
8	Short description	Exact guidance reduces strongly the vehicle clearance profile. Safety margins for steering are not necessary any more.
9	Underlying problem or objective	Guided buses try to combine the speed and punctuality of rail systems with the flexibility and low cost of buses.
10	Place in transport system	Substitution of part of public transport on lines combining segments with and without dedicated track.
11	Advantages for accessibility	Combining the quick and high capacity function of light rail rapid transit and the flexible feeder function of buses, this dual mode system provides direct services without need to change the transport mode.
12	Advantages for transport service	Increased attractiveness of public transport
13	Environmental advantages	Changing from diesel engine buses to trolley buses allows for locally emission free transport.
14	Expected transport volume	
15	Comparable projects or developments	Spurbus in Adelaide, Australia
16	Contact	Essener Verkehrs-AG, Zweigertstr. 34, D-45130 Essen
17	Partners in project	BMFT
18	Planning of project or development	Already in operation
19	Financial information	
20	Donors	
21	Additional information	

A1.11.6 Dual Mode Truck system

1	Project, development, concept	**Dual Mode Truck system (DMT)**
2	Type of transport	freight
3	Transport or logistic concept	road and dedicated road
4	Type of vehicle concept	truck
5	Type of propulsion and fuel	electric propulsion and electric power cable
6	Geographical scale	short distance, between cities (urban distribution centres)
7	Technical or organisational innovations	under surface or medial strips of (new) highways, vehicle spacing using laser-radar
8	Short description	DMT comprises two transport modes. Drivers drive the electric trucks on normal roads, but on dedicated highways the trucks move automatically without a driver (automated vehicle guidance). While moving on dedicated highways the batteries are recharged via an electric power cable. Automated vehicle spacing is done using laser-radar. Terminals are urban distribution centres
9	Underlying problem or objective	decrease in accidents, air pollution, energy consumption and congestion
10	Place in transport system	substitution of normal freight trucks
11	Advantages for accessibility	direct connections between distribution centres
12	Advantages for transport service	freight transport becomes faster and more reliable
13	Environmental advantages	less emissions and noise
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Yamada Harutoshi, Japan
17	Partners in project	
18	Planning of project or development	track for experiments has been built between Tokyo and Kobe
19	Financial information	
20	Donors	
21	Additional information	

A1.11.7 Road train

1	Project, development, concept	**Road-Train**
2	Type of transport	Freight
3	Transport or logistic concept	Road
4	Type of vehicle concept	Truck
5	Type of propulsion system and fuel	Electric (or CNG) in environmental sensitive areas. Outside standard diesel engines.
6	Geographical scale	Continental with environmental sensitive segments taken into account by corridors with non-polluting power supply.
7	Technical or organisational innovations	Heavy-duty vehicles are linked mechanically to an electric driven dragging unit, which hauls it through the sensible area. The dragging unit is attached to an overhead cable for electricity supply with possible recuperation. The transport in the sensitive area is sustainable without requiring a system change outside this area.
8	Short description	Along an existing highway an electric overhead cable is installed above the right lane. The heavy-duty vehicles are gathered at the entrance of the sensitive area. Three to four of these units are linked together to a "*road-train*". At each highway exit an area is foreseen for a reorganisation of the *road-trains*. Trucks can leave the system and continue with their tour individually.
9	Underlying problem or objective	Relief for sensitive regions suffering heavily from freight transit offering in the same time goods traffic a quick, flexible and cheap solution without changing rolling stock.
10	Place in transport system	Substitution in sensitive areas
11	Advantages for accessibility	Restrictions for polluting and noisy trucks already in place on some transit corridors can be avoided.
12	Advantages for transport service	Shifting trucks and trailers on trains causes problems for their rails not adjusted for excessive weight and is more disruptive than coupling them quickly to road-trains.
13	Environmental advantages	Zero emission in sensitive areas and reduced noise
14	Expected transport volume	Potentially high if applied in selected high flow transit corridors.
15	Comparable projects or developments	
16	Contact	Intema Consult (Ing. Wancura), Karlauer Gürtel 24/4, A-8020 Graz, Tel.: (+43) 0676 5917 970
17	Partners in project	
18	Planning of project or development	Project idea submitted to DG VII (P. Mercier-Handisyde)
19	Financial information	
20	Donors	

Road-Train – Ways of alternative transport for heavy duty vehicles through environmental sensitive areas

Problem description

The problems connected with freight transport are well known. Despite the progress on the individual vehicle level, the cumulative transport volume is growing so fast; the effects on the environment are going from bad to worse. Especially in sensitive areas (e.g. the Alps) the environmental awareness is growing and therefore the acceptance of the negative side effects of transportation is decreasing.

Many solutions have been presented so far to solve the problem. Nevertheless, the introduction of an innovative concept for heavy freight transport into the existing transport system meets with strong opposition, mainly from industry. One reason is that most of the systems require a total replacement of the vehicle stock as well as the rearrangement of the infrastructure.

Therefore the introduction in a small-restricted area, which suffers tremendously with the side effects of freight transportation seems impossible.

One alternative heavily promoted is the rolling road; heavy-duty vehicles are loaded on trains, having several disadvantages as well. Most of the existing tracks are not suitable for the heavy weights and require a renewal. Furthermore such trains are rather inflexible, as getting on and off along the line is not possible.

Objective

The objective is to find a system for the transport of heavy-duty vehicles, which combines the following advantages:

- The system is suitable for a regionally restricted area; no repercussion on the transport outside of this area is given. This means, that the normal vehicle stock can be used and no or only small additional installations on the vehicles are needed.
- The system is built on already existing components; the innovation is the combination of these systems, which have not been used before.
- The demand for additional infrastructure has to be kept small. Existing roads shall be used.
- The system avoids the monopoly of a certain system provider; it supports the mechanism of the free market among vehicle suppliers and carriers.
- The system itself allows a high flexibility.
- The interface to the traffic system outside the system is easy and flexible. Therefore, logging in and out of the system is fast and can be done wherever required. No infrastructure for loading and unloading is needed.
- The smooth interface allows an intelligent extension of the system where requested.
- The system has environmental benefits compared to the existing system, e.g. a lower energy demand, the usage of cleaner drive-line technologies, etc.
- The costs of the new system are comparable to those of the existing system.

Idea

A solution combining the advantages listed above is the following:

The heavy-duty vehicles are gathered at the entrance of the sensitive area. Each truck is linked mechanically to an electric driven Dragging unit, which hauls it through the sensible area. Three to four of these units are linked together to a *"road-train"*. The first Dragging unit is a tractor. This tractor has an electric motor strong enough to carry the train and is attached to an electric overhead cable for electricity supply. Another option is to use clean fuels such as CNG.

The transport in the sensitive area is sustainable without requiring a system change outside this area. The *road-train* system is flexible and comfortable for the users.

System Description

a) Adaptation of the infrastructure

Along an existing highway an electric overhead cable is installed above the right lane.
At each highway exit an area is foreseen for a reorganisation of the *road-trains*. Trucks can leave the system and continue with their tour individually.
As the tractor is driven electrically, the motor can be used as a generator when going downhill, in this way the system allows a recuperation of energy.
At the border of the sensible area terminals are installed which allow a gathering of vehicles as well as a reloading of the freight if wanted.

b) Tractors

There are three different types of tractors:

- Tractor unit: It is driven electrically and is the leading vehicle of the road-train. The tractor unit can draw one truck, but has the capacity to guide up to four dragging units, which are connected to the road-train, each one carrying a truck. The trucks have to be adapted only slightly to allow the mechanical linkage to the tractor.
- Dragging unit: The dragging unit is a unit, which has an electric motor and an electronic guiding system on board. It can be steered from the Tractor unit via a remote control system. The Dragging unit has different purposes.
  - It can be coupled in a road-train between two trucks as an additional dragging machine or
  - It can replace the motor car of the truck and take over the semi-trailer or
  - It is designed as plateau-car, which can take over the container of the trucks.

  The dragging units are fully equipped with the drive train and the motor; the overhead cable secures the energy supply. The dragging unit is either driven manually or automatically (if installed mechanically in a road-train).
- Hybrid lorry: The lorries can also have a hybrid engine, which is driven conventionally outside the sensitive area and electric in the area. The hybrid lorry can be imagined like a diesel-electric-locomotive. As the overhead cable secures the energy supply, the lorries need no on board batteries.

c) Logistic

One of the key parts of the system is the switch from the regular road traffic to the *road-train* system. In praxis a mixture of the following cases will have to be handled:

- Trucks are linked to a road-train and continue driving, while the driver stays on board.
- Semi-trailer are handed over to dragging units, the motor car takes over a semi-trailer from the opposite direction.
- Containers are shifted.
- Hybrid lorries are linked into the system by attaching them to the overhead cable, they can continue driving.
- For each of these different types a different procedure is necessary.
- The linking of the lorries to a tractor unit is fast and easy. Incoming trucks are redirected to waiting units and linked to them.
- The dragging units await lorries, which want to reload the semi-trailer or the container. For reloading the semi-trailer, it is lifted mechanically, the motor car drives away, and a dragging unit drives under the semi-trailer, which is lower to it.
- Shifting of containers is done with an automatic shifting station.
- Hybrid lorries just change their mode and drive on electrically

Each of these procedures require a few minutes only, and the truck can go on within the system.

Advantages

One of the main advantages of the system is the great flexibility in many aspects:

- The tractor units and dragging units can be owned by different transport organisations, which allow the system to stand the free market.
- The trucks can be attached and detached at any highway exit.
- As linking in and out of the systems requires a few minutes only, the trucks can arrive all day long and continue their tour immediately. The relatively small number of four trucks per road-train guarantee minimal waiting times.
- The drivers can either stay on board of his truck and rest, while the truck is transported, or take over another trailer and drive back immediately.
- Once the overhead cable infrastructure is installed, it can be used at any time. Regulative measures, such as shifting the transport peak away from rush hours, can be set achieved by different fees for usage.

European Relevance

The system is suitable for many different areas all over Europe, which suffer the same environmental problems due to heavy freight traffic. Developing the system parameters in an EC project allows coming up with a common solution for all this sensitive areas. This increases the acceptance among the truck owners and drivers. Manufactures can adapt the trucks once for all these areas.

A1.12. Multifunctional urban vehicles

A1.12.1 NT Systèmes

1	Project, development, concept	**NT Systèmes**
2	Type of transport	Passenger/ freight
3	Transport or logistic concept	Road
4	Type of vehicle concept	Car
5	Type of propulsion system and fuel	To choose (CNG, electricity, diesel etc.)
6	Geographical scale	Urban
7	Technical or organisational innovations	Standardised traction unit can be adapted with exchangeable car-body modules for different use.
8	Short description	Project allows a flexible adaptation of a special designed vehicle to different kinds of urban public transport needs like garbage collection, mail distribution, street cleaning, removal of industrial waste and public passenger transport.
9	Underlying problem or objective	The frequent need of access for a variety of specialised public service vehicles in urban centres is hampered by congestion and creates congestion itself. Multifunctional, intermodal and interoperational use of one traction unit with several exchangeable car-bodies is pursued.
10	Place in transport system	Substitution of several urban public transport services
11	Advantages for accessibility	Decentralised, flexible and quick exchange of car body should increase accessibility.
12	Advantages for transport service	Investment costs and operating costs can be reduced by achieving public services by multifunctional use of adaptable vehicles.
13	Environmental advantages	Electric wheel motors with several options of power supply (LPG, electricity, aquazole) and reduction of mileage for providing services by combination of services and decentralised car-body exchange.
14	Expected transport volume	Target is to obtain part of garbage collection vehicle market (around 1.2 billion EUR per year in Europe).
15	Comparable projects or developments	
16	Contact	NT Systèmes. 14, grand rue, F-78490 Les Mesnuls. Tel.: (+33) 01 34 86 87 88. Email: rdind@rd-industries.com
17	Partners in project	NT Systèmes, CGEA, SITA, EDF, GDF
18	Planning of project or development	Preparation of demonstration project
19	Financial information	
20	Donors	

NT Systèmes architecture has been developed as a result of an analysis of the town environment and the provision of urban services, particularly in the fields of public transport, cleanliness and handling. In-depth studies of both the manner in which these services could be provided and the necessity for providing clean, suitable vehicles led R&D Industries to suggest to Cgea and Sita that they combine their efforts to set up a Research and Development program for urban vehicles (Buses, Domestic waste collection vehicles), their design, their role in the town and the conditions governing their use.
The initial results of this work have led to:

- the definition of a vehicle architecture which is quite different from that of existing products;
- the creation of NT Systèmes which is to produce demonstration vehicles using this architecture within 18 months.

The principle:
The principle distinguishes the source of energy, the type of traction and the professional compartment to:

- Provide a choice of clean energies;
- use standard traction technology;
- enable a variety of vehicles to be based on this standard.

The unit uses a basic vertical transverse chassis called *"ANNO"*, which receives its power supply (VNG, Electricity, Aquazole, etc.) via the roof and uses electric wheel motors. This *Anno* is coupled with a professional compartment designed according to the operator's Specifications.
A coupling-uncoupling device facilitates changing the professional compartment during daily operations, so that, for example, the vehicle can be changed in total cleanliness from collecting industrial waste (IW) to collecting domestic waste (DW), or in the transportation field from carrying a 100-capacity bus with 20 seats at peak periods to a 70-capacity bus with 50 seats during off-peak periods, all of these using the same chassis.
A patent, which is being extended internationally, protects the design.

The project's qualities:

- It will help to improve urban traffic management;
- The basic module takes advantage of the use of electric motorization and provides an architecture which is ideal for the urban environment : inter-modularity (for example containers full of goods or other products can be moved from one vehicle to another, or one mode of transport to another) and inter-operability (the same chassis can be used to collect IW during the day, traditional domestic waste in the morning and evening and be used for street washing at night);
- Simultaneous improvement in immediate profitability with the following advantages:
  - Refuse collection trucks: improved productivity,
  - Urban deliveries: efficient organization of bodies and extension to an organization using suspended bodies,
  - Interchangeability of the drive units,
  - Modular battery exchange (for electrical energy);
- Expansion towards new types of industrial alliance in terms of structures, motorization and urban experiments;
- The project, oriented towards sustainable development and customized production, promotes employment since it gives various industries the chance to make small production runs using technological engineering (which is the heart of the system) provided in a standard system;
- Various non-polluting energies can be used on the same basic module.

Development organization:
The NT Systèmes program is essentially a multi-partner program and typically uses Network organization. NT Systèmes does not pretend to have universal expertise but on the contrary, under the terms of durable development, considers that others should be involved in such a project, including:

- operators and local authorities to define applications and choose experimental sites;
- town planners and logistics engineers to design and finalize the development of the urban landscape which will lead to a new organization of services;
- expert industrialists for field applications, whether to produce vehicles such as Buses, express delivery service trucks, handling systems and refuse collection trucks, or developing special vehicles (civil security, public works).

In this way, NT Systèmes is currently building and developing a network of partners in France and in Europe, to coordinate fields of experimentation and develop an industrial network based on ANNO which will develop and market the appropriate vehicles.

Handling application:
In the field of container handling, NT Systèmes proposes town delivery applications using container trucks. The *ANNO* technique produces very interesting performances:

- Non-polluting chassis (standard hybrid pull chain, electric wheel motors, energy source: electricity, Natural Gas, Aquazole, etc.)
- lateral displacement of vehicle (turning angle when manoeuvering: 90°)
- exceptional manoeuvrability (standard steering angle: 60°)
- container lifted from the top
- active suspension
- kneeling (to pick up the containers)
- performances on public or private roads (up to 70km/h)

Technical Characteristics (Europe) **- *ANNO* Chassis:**

Characteristics	Data
Overall width	2350 mm to 2550 mm extensible according to option
Height	1900 to 3300 mm
Internal passage	900 to 1100 mm
Ground clearance	variable from 150 to 270 mm kneeling option
Steering	Steering angle on the road: 60° Turning angle for manoeuvres: 90°
Energy	VNG, Electricity, Aquazole, Clean diesel
Traction	Standard hybrid electric
Electric wheel motor	50 kW per wheel (2 motors per *ANNO*)
Chassis mounts for professional compartment	Standardized

Technical characteristics of the generic vehicle (Europe) **- Bus:**

Characteristics	Data
Electrical transmission	Front-wheel drive
Tires	2 large diameter front wheels 4 rear tandem wheels
Steering	Front steering angle: 45° 4-wheel steering
Overall length	8 to 12 m
Overall width	2350 to 2500 mm
Overall height	3300 mm
Ground clearance	150 to 270 mm
Seats	15 to 35
Handicapped seat	1
Standing capacity	34 to 86
Loaded weight	10.5 to 16 tonnes
Maximum speed	70 km/h

Refuse collection truck:

Characteristics	Data
Electrical transmission	Front wheel or 4-wheel drive
Tires	2 large diameter front wheels 6 rear tandem wheels
Steering	Front steering angle: 60° Option: 90° 4- to 6-wheel steering
Overall length	7 to 10.5 m
Overall width	2350 to 2500 mm
Overall height	3300 to 3500 mm
Ground clearance	150 to 270 mm
Load capacity	10 to 23 m^3
Loaded weight	11 to 22 tonnes
Maximum speed	70 km/h

A1.13 Technical innovation for logistics

A1.13.1 TMC

1	Project, development, concept	**TMC Transmodale Capsule Concept**
2	Type of transport	passengers / freight
3	Transport or logistic concept	all
4	Type of vehicle concept	capsules
5	Type of propulsion system and fuel	all
6	Geographical scale	short and long distance
7	Technical or organisational innovations	a standardised capsule is used on several transportation platforms
8	Short description	A standardised capsule is used with several transportation modes e.g. on an electric car chassis for suburban use, a conveyor network for use in centre cities, a tunnel or tube for intra-regional trips, an airplane for cross-country trips and a ship or ferry when needed. There are capsules for freight and people transport.
9	Underlying problem or objective	an "all over solution"
10	Place in transport system	substitution
11	Advantages for accessibility	
12	Advantages for transport service	covers the whole door to door transport chain with one vehicle
13	Environmental advantages	depending to the vehicle used, mainly zero-emission vehicles
14	Expected transport volume	
15	Comparable projects or developments	RUF
16	Contact	http://weber.u.washington.edu/~jbs/itrans/tmcap.htm
17	Partners in project	
18	Planning of project or development	concept only
19	Financial information	
20	Donors	
21	Additional information	

A1.13.2 Salami Container

1	Project, development, concept	**Salami Container**
2	Type of transport	Freight
3	Transport or logistic concept	Container
4	Type of vehicle concept	All kind of vehicles
5	Type of propulsion system and fuel	All kind of propulsion systems or fuels
6	Geographical scale	Long distance
7	Technical or organisational innovations	Combination of advantages of containers in long distance freight transport with the ability of dispersed local distribution of the container content without any reloading
8	Short description	"Salami Containers" dispose of outer dimensions of a standard container but consist of several compartments with a cross section equal to the standard container dimension. However these compartments are shorter than the container length and can be taken out by folk lift trucks.
9	Underlying problem or objective	Use of containers for smaller or mixed freight quantities entails the disadvantage of loosing time by transshipment and creating additional traffic to and from temporary stores.
10	Place in transport system	Complementary
11	Advantages for accessibility	Temporary stores are not needed. Higher accessibility in the logistic chain without reloading.
12	Advantages for transport service	Logistic chains without additional transshipment for local distribution
13	Environmental advantages	Reduction in traffic demand by direct delivery
14	Expected transport volume	Potentially great with increasing market potential as piece goods get continuously more important
15	Comparable projects or developments	DB Logistikbox
16	Contact	Intema Consult (Ing. Wancura), Karlauer Gürtel 24/4, A-8020 Graz, Tel.: (+43) 0676 5917 970
17	Partners in project	
18	Planning of project or development	Project idea
19	Financial information	
20	Donors	
21	Additional information	

A1.13.3 Lech TGZS

1	Project, development, concept	**Lech - Tunnel Gueter Zustell Service**
2	Type of transport	freight
3	Transport or logistic concept	underground
4	Type of vehicle concept	freight-cart
5	Type of propulsion system and fuel	electric vehicles
6	Geographical scale	short distance, urban
7	Technical or organisational innovations	freight logistic in tunnel
8	Short description	During wintertime Oberlech is a car-free village and only a funicular can reach this touristic village. The hotels of the village and the funicular station of Oberlech are connected by an underground tunnel system to an underground hall. The goods for the hotels are delivered to the underground hall by trucks and stored there. On their way back the trucks dispose of the village's refuse. The funicular delivers the luggage of the tourists. All the goods and the luggage are distributed through the tunnel system by electric driven carts. These carts also do the garbage-transport to the underground hall.
9	Underlying problem or objective	The objective of the tunnel system is to transport all necessary freight invisible for the tourists and independent from weather conditions.
10	Place in transport system	complementary
11	Advantages for accessibility	independence from weather conditions (especially snow)
12	Advantages for transport service	
13	Environmental advantages	electric vehicles have no local emissions and create almost no noise; due to the underground operation the streets of the village are free of cars and trucks;
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Oberlecher Wege und Garagengesellschaft, Oberlech 266, A-6764 Lech am Arlberg; Ing. Fridolin Lucian (Burg-Hotel Oberlech), Tel.: ++43 5583 2291 0; Fax: ++43 5583 2291 120
17	Partners in project	owners of the hotels in Oberlech
18	Planning of project or development	already in operation
19	Financial information	
20	Donors	

A2 Underground transport vehicles and logistics

A2.1 Driverless guided public transport

A2.1.1 Meteor

1	Project, development, concept	**Meteor**
2	Type of transport	passengers
3	Transport or logistic concept	guided vehicles with rubber tires (Paris metro system), underground
4	Type of vehicle concept	train, 6 vehicles, total capacity: 722 passengers
5	Type of propulsion system and fuel	electric, DC-motors powered through infrastructure
6	Geographical scale	urban
7	Technical or organisational innovations	fully automatically driverless operation
8	Short description	New line for the Paris metro; total length planned: 20 km / 18 stations, opened 1998: 7 km / 8 stations
9	Underlying problem or objective	Need for new metro capacity in Paris
10	Place in transport system	Complementary
11	Advantages for accessibility	more stations in the urban metro network, better service for urban areas
12	Advantages for transport service	average speed: 40 km/h, better service on metro network, less congestion on other rapid transit lines
13	Environmental advantages	no local emission, low vibration level due to rubber wheels
14	Expected transport volume	Headway in peak hours: 85-105 sec; capacity: 40,000 pass./h; expected volume: 96 million pass./year
15	Comparable projects or developments	Metro Lyon, VAL Lille
16	Contact	Regie Autonome des Transports Parisiennes (RATP)
17	Partners in project	RATP, MATRA
18	Planning of project or development	1990 decision to built the new metro line; 1998 opening of the first 7 km with 8 stations
19	Financial information	Infrastructure costs: 6.9 billion FRF (1996)
20	Donors	43.8 % Region Ile de France / 30.3 % French State Government / 18.5 % RATP (loans) / 7.4 % Départment Paris
21	Additional information	

A2.1.2 Metro Lyon, Line D

1	Project, development, concept	**Metro Lyon, Line D**
2	Type of transport	passengers
3	Transport or logistic concept	guided vehicles with rubber tires (metro stile), underground
4	Type of vehicle concept	train, 4 double units, total capacity: 528 passengers
5	Type of propulsion system and fuel	electric, DC-motors powered through infrastructure
6	Geographical scale	urban
7	Technical or organisational innovations	fully automatically driverless operation
8	Short description	Fourth line of the Lyon metro system, length: 11.5 km / 13 stations, mainly underground
9	Underlying problem or objective	Need for a new metro line in Lyon
10	Place in transport system	Complementary
11	Advantages for accessibility	Additional line in the metro network; average distance of stations (whole metro network): 700 m
12	Advantages for transport service	Max. vehicle speed: 75 km/h, headway 6 min, 2.5-4 min in peak hours
13	Environmental advantages	no local emissions, low noise and vibration levels due to rubber tires
14	Expected transport volume	
15	Comparable projects or developments	METEOR Paris, VAL Lille
16	Contact	Société Lyonnaise de Transports en Commun SEMALY/ TLC; 19, Bd Vivier Merle, F - 69212 Lyon Cedex
17	Partners in project	SEMALY (planning), MATRA (automatic operation) GEC Alstom (vehicles)
18	Planning of project or development	Planning of metro network up to 1970; opening of line A-C: 1978-1984, line D: 1991/92
19	Financial information	
20	Donors	
21	Additional information	

A2.1.3 VAL

1	Project, development, concept	**VAL (Vehicules automatiques légères)**
2	Type of transport	passengers
3	Transport or logistic concept	guided vehicles with rubber tires, mainly underground, elevated if possible
4	Type of vehicle concept	train, 2 articulated vehicles, total capacity: 308 passengers
5	Type of propulsion system and fuel	electric, DC-motors, powered through infrastructure
6	Geographical scale	urban
7	Technical or organisational innovations	fully automatically driverless operation, vehicles smaller and lighter than for a classical metro
8	Short description	New guided urban transit system for Lille; two lines in operation; total length 28.5 km (15.8 km in tunnel) / 41 stations (26 underground)
9	Underlying problem or objective	Need for an medium capacity transport system cheaper than a conventional metro
10	Place in transport system	Complementary
11	Advantages for accessibility	New guided urban transport system, average distance of stations 738 m
12	Advantages for transport service	Max. operating speed 60 km/h; headway 3-6 min, 1.5 min in peak hours
13	Environmental advantages	no local emissions, low noise and vibration levels due to rubber tires
14	Expected transport volume	55 million passengers / year (1993)
15	Comparable projects or developments	A VAL-System is in operation (first line) and under construction respectively (second line) in Toulouse
16	Contact	Communauté Urbaine de Lille, (CUDL), 1 rue du Ballon, F - 59034 Lille Cedex
17	Partners in project	CUDL, MATRA
18	Planning of project or development	Development and tests 1972-74, 1974 decision to built the system in Lille, 1983/84 opening of the first line (13 km), 1994/95 opening of the second line (15.5 km), an extension of the second line is under construction (13 km)
19	Financial information	Total costs: line 1: 3.9 billion FRF, line 2: 3.4 billion FRF;
20	Donors	funds: 60 % loans, 20 % State Government, 20 % Transport Tax
21	Additional information	

The system VAL (Vehicules Automatiques Legeres) is operated fully automatically and without drivers. The first line was opened in Lille, France, with a length of around 13 km and 18 stations. A second line, 12 km long was taken into operation in 1989. Further lines are still under construction; the total network will have a length of 45 km.

The development of the VAL at the beginning of 1970ies involved close collaboration between the Lille Urban Community, the Council of Lille Est (a new part of the town) the University and MATRA, the manufacturer of the system.

The main object of what was at the beginning no more than a research and development programme was to try to find an innovative rail solution which could prove to be economically viable when applied to the planned link.

The 110,000 residents along the corridor linking up the centre of Lille was not enough to justify the cost of a "heavyweight" underground railway and even less the recurrent expenses involved operating it. This corridor represents an area that is 600 metres wide and through which the line runs.

The Urban Community set itself three goals when it undertook the project:

- Reduce the physical size of the system, both rolling stock and infrastructure in order to satisfy a demand of 10,000 passenger-trips per hour. This was compared with approximately double that demand for heavier, larger systems in service in high-density corridors. It had to be done at a reduced capital expenditure compared to larger systems.
- Provide the highest possible quality of service in order to attract customers who had abandoned public transport in favour of private cars. In 1971, the number of trips made on public transport per inhabitant per year in the region was far below the national average.
- Provide for efficient management and operation to allow operating costs to be reduced in order to succeed in or, at least come close to, balancing revenue from the fare box with normal operating and maintenance expenses.

A fully automated system was identified as the solution able to meet these ambitious goals.

The key facts were:

- The high frequency of trains allowed by the full automatic control meant that the size of the rolling stock could be reduced. In this way in Lille, two cars with a total length of 26 metres and a width of 2.06 metres operating every minute could move up to 10,000 passengers per hour per direction. Reduction in the rolling stock size meant that capital expenditures could be reduced by 15 to 20 % when compared to a standard rail system.
- Quality of service was measured using several criteria, but the principal ones were: waiting time, travel time, comfort and safety. Automatic control offers a high performance to improve the quality of service. Its possible to offer short waiting times throughout the service period even including public holidays, at the lowest possible costs. Waiting time can be adapted to demand at all times by mere remote control by an operator at the central control room.
- Due to train stopping precision obtained when using automatic control – to within 15 cm – stations can be fitted with platform edge doors. This door system ensures a high level of passenger safety. In addition, platform width can be reduced, thereby reducing the capital costs of stations, including real estate acquisition.
- Automatic control combined with the systematic use of remote monitoring produces radical changes in the way a system can be operated and maintained.

Other features can be described as follows:

- Wheels with tires
  In addition to the comfort it provides for passengers, the running of trains on tyres ensures a reduction in noise level. On sections of the line running above ground level, the noise level generated by VAL trains is lower than the ambient noise, system vibrations are not noticeable. Rubber tyres allow in-service acceleration and braking rates of 1.35 m/s². This performance allows VAL vehicles to maintain a scheduled speed of 35 km/h, including stops.

- Light-weight / Energy saving
  VAL vehicles, which are made of aluminium alloy and equipped with simple axles, have an empty weight of no more than 31 metric tons, or 624 kg per square metre of floor space compared with 865 kg for a classic modern urban rail train.
- Safety
  Since May 16th, 1983, when the first line was opened until 1993, 350 million passengers have been transported without any accident due to the system. No failure involving safety aspects has occurred during the system's 75,000 operating hours. The provision of platform doors is an additional safety feature: it is impossible for anyone to fall onto the line.
- Availability and reliability
  From the moment it entered service, the VAL demonstrated an availability rate of 0.986 which was an excellent result during the starting-up phase and, indeed, better than the contractually specified performance. At present (in 1993), over a year's time, the average annual availability rates have stabilised at 0.995.
  In real terms, this means that for a passenger making two 10-minute journeys per day:
  - There will be a delay of more than four minutes only once every four months;
  - Emergency braking will be applied once every three months;
  - A train will fail to stop at that passenger´s station once every five years.
- Security
  The frequent train arrivals helps to deter crime in stations and the surveillance provided by close to 400 CCTV cameras ensures rapid response to any threatening passenger situation.
  The absence of corridors and the small stations also help to reduce crime opportunities. Passengers have easy access – both in stations and in the cars – to a two-way communication system with central control.
  In addition roving teams are present throughout the day.
  A survey conducted in Lille showed that users felt more secure in the VAL system than in the districts it serves.
- Endurance
  The average distance covered by rolling stock without any failure is more than 4,500 km, which represents 67 days in service in Lille. The average repair time is half a day. Certain trains, which have been run intensively, have travelled more than 800,000 kilometres.
  The equipment's high performance means that the vehicles can run for 15,000 km without requiring any maintenance operation.
  Other cities in France and around the world use the VAL-System too or are planning it. In Toulouse, France, e.g. a line of 10 km length and with 15 stations was opened in 1993.

A2.1.4 Small metro

1	Project, development, concept	**Small metro**
2	Type of transport	passengers
3	Transport or logistic concept	metro style, mainly underground
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	electrical, powered through infrastructure
6	Geographical scale	urban
7	Technical or organisational innovations	vehicles with a smaller cross section to reduce tunnelling costs
8	Short description	A metro with vehicles with a smaller cross section was proposed; vehicles width: 2.45 m, total height: 2.65 m; floor height 350 mm above rail level; length of double unit: 34.52 m; total capacity of one unit: 160 passengers; train with up to three units; headway down to 90 sec. Single track tunnel with a diameter of 3.60 m (circular cross section) compared to 4.60 to 4.90 m for a conventional metro tunnel.
9	Underlying problem or objective	Public transport needs in medium sized cities; high costs of conventional underground systems
10	Place in transport system	complementary
11	Advantages for accessibility	Improvement of public transport in medium sized cities where a conventional metro system is not justified.
12	Advantages for transport service	short headways, high average speed
13	Environmental advantages	no local emissions due to electrical propulsion, no noise emission outside the tunnel
14	Expected transport volume	max. capacity: 14,400 pass./h
15	Comparable projects or developments	VAL
16	Contact	
17	Partners in project	Prof. Dr.-Ing. H. Bugarcic (retired); TU Berlin, Institut für Fahrzeugtechnik, Sekr. SG 14, Carnotstr. 1, 10587 Berlin
18	Planning of project or development	Proposal in 1979; 1:1 vehicle model and feasibility study 1980-83
19	Financial information	Cost reduction of about 30 % per m tunnel compared to a conventional metro.
20	Donors	
21	Additional information	

A metro system with a smaller cross-section was proposed in Germany at the beginning of the 80ies (Bugarcic, 1979; Keudel 1983). The background was, that an independent track – preferably in a tunnel – was thought to be necessary to guarantee a high capacity and reliability on the one hand but that the high cost of tunnelling for a classical metro were prohibitive for its application in medium sized cities with inhabitants between 200,000 and 600,000. In these cities at grade systems often cannot fulfil their tasks properly due to congestion, building density etc. A metro with a smaller cross-section of the vehicles and due to that with narrower tunnels could be a solution to overcome these problems.

The vehicle had a width of 2.45 m and a total height of 2.65. The wheels had a diameter of 600 mm, that made it possible to put the floor of the passenger compartment on a height of 350 mm above the rail level. The gauge was proposed to be only 1,000 mm compared to the usual one of 1,435 mm. If compatibility is a necessity, a gauge of 1,435 mm is possible to. The ceiling of the vehicle was rounded to fit better in a tunnel with a circular cross-section. In accordance with the philosophy that in case of an emergency the train should not stop in the route tunnel but should go on into the next station where passengers could leave the train easier, there was no emergency walkway along the train in the running tunnel. Additionally it was foreseen that people could leave the train through doors at the front and at the end if a complete breakdown of a train occurred so that it could not reach the next station. The current collector is at the side of the vehicle in contact with a third rail and not on top of the ceiling with an overhead wire system. This also helps to reduce the necessary tunnel cross-section.

This concept resulted in a tunnel cross-section with a diameter of 3.60 m for a circular tunnel compared to a tunnel diameter of around 4.6 to 4.9 m for a single-track tunnel of a conventional metro. This could lead to a cost reduction of about 30 % per m tunnel.

A feasibility study was made for the city of Karlsruhe, in which the new system was compared with a light railway system of the same capacity (Keudel, 1983). In route sections where due to local conditions tunnels were necessary for both systems the new system was clearly less costly. But comparing the whole system with a route length of around 42 km and 76 stations resulted in 35 % higher investment cost mainly due to a higher share of elevated tracks for the new system as well as the necessary equipment for an automatic operation.

A2.1.5 M-Bahn

1	Project, development, concept	**M-Bahn**
2	Type of transport	Passengers
3	Transport or logistic concept	Guided vehicles on elevated structure; automatic operation
4	Type of vehicle concept	Train consisting of two vehicles; capacity: 80 passengers each
5	Type of propulsion system and fuel	Maglev system consisting of permanent-magnet long-stator linear synchronous motor with travelling field winding integrated in the track and embedded in stator slots and the permanent magnets installed on board the vehicle.
6	Geographical scale	Short distance, urban
7	Technical or organisational innovations	Maglev system; light weight vehicles due to the fact that the propulsion system is installed in the track.
8	Short description	The M-Bahn is a fully automatically operated system with magnetic levitation and driven by a linear motor with travelling field in the track. A demonstration facility of 1.6 km length with two stations was installed in Berlin partly on an old route section of the metro. The system was operated with a train consisting of two vehicles.
9	Underlying problem or objective	M-Bahn aims at low to medium capacity services in public transport as well as for special services (airports etc.).
10	Place in transport system	Complementary
11	Advantages for accessibility	As a small/medium capacity system, the M-Bahn is suitable to complement public transport systems or to fulfil special services on airports etc.
12	Advantages for transport service	The automatic operation allows short headways. The maximum speed of 80 km/h allows a fast transport.
13	Environmental advantages	There are not produced any local emissions, the noise levels are low.
14	Expected transport volume	Berlin: 1.7 million passengers per year (1989/90)
15	Comparable projects or developments	
16	Contact	(AEG Westinghouse Transportation Systems Int., Berlin) ABB Daimler-Benz Transportation GmbH
17	Partners in project	
18	Planning of project or development	First R&D activities for the M-Bahn concept started in 1976. A first test facility (length: 1 km, 2 stations, 4 vehicles) was built in Brunswick in 1979. A demonstration facility in Berlin was built between 1984 and 1986; an intensive testing and further development took place. In 1989 the M-Bahn was approved as a system for public passenger transport. The Berlin facility hat to be dismounted because the metro should use its route again.

19	Financial information	R&D, the test facilities as well as the demonstration facility in Berlin were partly financed by the Ministry of Research and Technology.
20	Donors	Ministry of Research and Technology
21	Additional information	

A2.1.6 H-Bahn

1	Project, development, concept	**H-Bahn Dortmund (Siemens People Mover)**
2	Type of transport	Passengers
3	Transport or logistic concept	Guided suspended vehicles on elevated structure, automatic operation
4	Type of vehicle concept	Single vehicles; capacity: 45 passengers
5	Type of propulsion system and fuel	Electrical, DC-motor or linear motor; wheels covered with hard rubber for levitation and guidance travelling in a hollow beam on an elevated structure.
6	Geographical scale	Short distance, urban
7	Technical or organisational innovations	First people mover system with hanging cabins and fully automatic operation in Germany
8	Short description	The H-Bahn is a fully automatically operated, elevated system taken into operation in 1984 on the campus of the University Dortmund. The route length is around 1050 m with two stations. In 1993 two extensions of 550 m and 180 m with two more stations at public transport stops were opened. Operation is either on schedule or on demand.
9	Underlying problem or objective	In the first stage two areas of the university were connected by the H-Bahn. Before the existence of the H-Bahn the students had to walk or drove by car. The second stage provides the integration of the H-Bahn in the public transport system.
10	Place in transport system	Complementary
11	Advantages for accessibility	Better accessibility of the university campus in stage 1, integration in public transport in stage 2.
12	Advantages for transport service	The system is operated on schedule (5/10 min intervals). A demand responsive operation is possible in times with less demand. The vehicles have a capacity of 45 passengers (16 seats, 29 standees). The maximum speed is 50 km/h.
13	Environmental advantages	The electric propulsion does not produce any local emission. Less noise compared with conventional steel wheel system. The elevated structure fits into the architectural and natural landscape of the university campus. The car traffic on the roads in the surroundings was reduced by about 20 %.
14	Expected transport volume	1991: 650,000 passengers; 1995: 1,220,000 passengers
15	Comparable projects or developments	Under construction: Connection between a railway station and the airport in Düsseldorf.
16	Contact	H-Bahn-Gesellschaft Dortmund mbH, Joseph-von-Fraunhofer-Str. 25, D-44225 Dortmund; Tel:++49 231 75755, Fax: ++49 231 759246
17	Partners in project	Siemens AG, Erlangen, DUEWAG, Düsseldorf

18	Planning of project or development	Development of the H-Bahn system: R&D since 1970, short test track with switch at DUEWAG in Düsseldorf 1974/75, large test facility (1.4 km) at Siemens Erlangen 1976/80; 1981: permit to build the Dortmund system, 05-1984 inauguration of the system; 12-1993 opening of the extensions.
19	Financial information	R&D, the test facilities as well as the first stage of the Dortmund system were partly financed by the Ministry of Research and Technology. The extension of the Dortmund system was financed like light railway systems in Germany, by 90 % from funds form the federal Government and the Land, Northrhine-Westphalia and 10 % by the city of Dortmund.
20	Donors	Ministry of Research and Technology; Siemens AG; DUEWAG; State Government; Government of Northrhine-Westphalia; City of Dortmund
21	Additional information	

A2.1.7 Dorfbahn Serfaus

1	Project, development, concept	**Dorfbahn Serfaus**
2	Type of transport	passengers
3	Transport or logistic concept	underground
4	Type of vehicle concept	metro
5	Type of propulsion system and fuel	air cushion funicular system
6	Geographical scale	short distance, urban
7	Technical or organisational innovations	first air cushion funicular system operating in a tunnel in Europe
8	Short description	The Dorfbahn Serfaus is a fully automatically operating underground air cushion funicular system. The route-length is 1.2 km. The transport capacity is 1,500 persons per hour.
9	Underlying problem or objective	Serfaus is a small touristic village in Tyrol, Austria. Since the 1970ies motor traffic was prohibited within the village-borders. The tourists were brought from the parking lot in front of the village to the ski-areas behind the village by ski buses. At the beginning this was a good solution, but as the number of guests grew, the consequent increase in bus traffic produced an intolerable situation due to noise, pollutant emissions and the danger of traffic accidents. The objective of the 'Dorfbahn-project' was, to bring the tourists from the parking lot (in front of the village) to the ski-area (behind the village) without creating extra traffic in the village and without destroying the picturesque character of the village.
10	Place in transport system	substitution
11	Advantages for accessibility	the ski-area behind Serfaus is easy accessible
12	Advantages for transport service	the vehicles reach / leave the stations in 10 minutes intervals; due to underground operation the 'Dorfbahn' is independent from weather conditions;
13	Environmental advantages	the cable of the 'Dorfbahn' is driven electrical and therefore the 'Dorfbahn' is local emission free; due to the underground operation and the air cushion system the 'Dorfbahn' creates almost no noise;
14	Expected transport volume	700,000 trips per year* (* the 'Dorfbahn' is only operating from December to April (=5 months per year))
15	Comparable projects or developments	an air-cushion cable car, which was the model for the 'Dorfbahn', was developed by OTIS and is operating between two big hospitals in Denver (USA); another system based on hoover technics but with propulsion by a linear induction motor, based inside the vehicle is the OTIS LIM Shuttle III (Durham 1980, 1 km)

16	Contact	Ing. Siegmund Tschuggmall, Tourismusverband, Untere Dorfstraße 13, A-6534 Serfaus; Tel.: ++43 5476 6239 0; Fax: ++43 5476 6813
17	Partners in project	Owner: Komperdell Cable Car Ltd., Serfaus; Planning: ILF Consulting Engineers, Innsbruck; Mechanical and Electrical Engineering: Freissler-Otis, Vienna; Cable Facilities: Waagner-Biro, Vienna; Electrical Operations Control and Telecommunication: Siemens, Austria; Car Body: Swoboda, Oberwies;
18	Planning of project or development	08-12-83: resolution of the municipal council to build the 'Dorfbahn'; 03-07-84: start of construction (excavation); 09-10-84: start lighting of the tunnel; 29-05-85: start cable-installation; 01-07-85: installation of electrical control system; 30-08-85: installation of vehicles; 23-09-85: start of test runs; 14-12-85: inauguration;
19	Financial information	capital costs: 140,000,000 ATS; operational costs: 8,000,000 ATS per year* (*operating period of the 'Dorfbahn': December - April (=5 month per year))
20	Donors	Austrian Ministry of Science: 6,500,000 ATS
21	Additional information	in operation since December 1985

The village of Serfaus in the Tirol, Austria is situated at the end of a valley at around 1,400 m above sea level. Several lifts lead to large skiing area. The road through the village ends at the upper end of the place at the valley stations of the lifts. There is no through traffic but up to 6,000 tourists per day come by car to the skiing area causing a lot of congestion, noise and pollution.

In December 1985 a new transport system was taken into operation to overcome these problems. A special cableway in a tunnel 1,280 m in length was built. The downhill station is situated near a large parking area, two stations in the heart of the village and the uphill station near the starting points of the lifts to the skiing area.

The tunnel is single way with a cross-section of 3.24 m wide and 3.52 m high.

The train, consisting of two vehicles, is operated in a shuttle service between the two terminal stations. The total length of the train is 29.1 m, it has a capacity of 270 to 360 people (standees only). A complete round of the train takes 8 min, that makes a total average capacity of 2,000 passenger per hour in each direction, it can be risen to 3,000 passengers by adding a third vehicle if this should be necessary in the future. The maximum speed is 40 km/h, the average travel speed around 20 km/h.

The vehicles do not travel on wheels but glide on air cushions which are generated by compressors on board of the vehicles. By this technique no rolling noise or vibrations are generated which could bother people living in adjacent buildings. The vehicles are guided by side wheels travelling along a rail and driven by a cable. The stationary motor is placed in the uphill station. The system is operated automatically; the platforms are equipped with doors, which open and shut simultaneously with the doors of the vehicles. Television cameras and turnstiles are installed to control the passenger flow.

The village metro in Serfaus was built within 15 month with total cost of around 5 million US$ (as of 1985). The lift company privately financed it.

Similar systems on elevated structures have been built in Tampa, Florida and in Sun City, Bophuthatswana (South Africa).

A2.2 High speed guided systems

A2.2.1 Swissmetro

1	Project, development, concept	**Swissmetro**
2	Type of transport	passengers and freight
3	Transport or logistic concept	underground
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	magnetic hoovering train driven by linear-electric-motor, which is installed in the vehicle
6	Geographical scale	long distance, interurban
7	Technical or organisational innovations	Subterranean transport concept with reduced air pressure in the tunnels enables a speed of up to 400 km/h; designed as a magnetic hovering train.
8	Short description	The Swissmetro concept defines a subterranean transport concept. Vacuum in the tunnels enables a speed of up to 400 km/h. A comfortable trip is enabled by the design as a magnetic hovering train. Aim of Swissmetro is the connection of Swiss and later European cities and regions. The transport concept is optimized in relation to trip time, frequency, cost and safety. It also fulfils the demands in relation to environmental issues and low energy use. The Swissmetro system is viewed as an additional, fast, safe, economical and non-polluting transport concept.
9	Underlying problem or objective	Due to the mountains, the high population density and the development of environmental protection in Switzerland, it becomes more and more difficult to build new streets or railways. The Swissmetro shall solve this problem by providing an additional, fast, safe, economical and non-polluting transport concept, which is independent from the crowded earth's surface.
10	Place in transport system	complementary
11	Advantages for accessibility	the Swissmetro will connect the major towns in Switzerland 3 times quicker than present connections; the Swissmetro stations will be erected at the junctions of the public transport of the regions;
12	Advantages for transport service	the interval between the trains will be about 10 minutes; the safety of the Swissmetro will be higher than the safety of existing transport concepts; the Swissmetro will need the same ticket-fares as conventional trains to operate economically;
13	Environmental advantages	The energy-consumption of the Swissmetro will be 35 Wh/passenger-kilometre; (the energy-consumption of e.g. an intercity-train is 56 Wh/passenger-kilometre); studies say, that the operation of the Swissmetro will save between 190 and 350 million litres of fuel in Switzerland per year;

14	Expected transport volume	between 4 and 8 billion passenger kilometres
15	Comparable projects or developments	
16	Contact	Swissmetro s.a., C.P. 5278, CH-1211 Geneve 11; Tel.: ++41 22 715 32 52; Fax: ++41 22 715 32 13;
17	Partners in project	
18	Planning of project or development	1974: development of the idea for Swissmetro; 1988: feasibility study; 1990: idea of Eurometro; 1992: foundation of Swissmetro AG; 1993: study confirms that Swissmetro is useful, feasible and economical; 1994: start of the main-study; 1996: application for permission to construct a pilot-route; 2005-2020: expected start of Swissmetro;
19	Financial information	the expected costs (1993 !) for the Swissmetro-net are 28 billion CHF - the construction time is estimated with 25 years; the estimated costs for the connection of Geneva and St. Gallen (320 km) are 13 billion CHF - the construction time for this distance should be 15 years; up to 07-1998 there have been 20 million CHF invested in the research for Swissmetro;
20	Donors	
21	Additional information	

Swissmetro is a proposal for a long distance, high-speed underground system with magnetic suspension, which the consortium Swissmetro S.A. intends to build in Switzerland. The concept is aiming at transporting passengers at speeds of more than 400 km/h by means of special vehicles in tunnels between the most important Swiss centres.

Swissmetro is based on a combination of the following complementary technologies:

- entirely subterranean infrastructure with single track route tunnels totalling to around 680 km tunnel length and numerous underground stations
- partial vacuum in the tunnels to reduce air-resistance (air pressure of around 25,000 pascal which means 1/4 of the regular air pressure)
- magnetic levitation and guidance system
- vehicle propulsion system using linear electric motors.

The planned underground links are intended to connect Switzerland's major cities with one another: the two main lines concerned are:

- Geneva – Lausanne – Berne – Lucerne – Zurich – St. Gallen and
- Basle – Lucerne – Bellinzona.

At its end points, the Swissmetro could join up with the high-speed railway network (ICE, TGV, etc.) to become an "Eurometro" with services to Paris, Lyon, Marseilles, Strasbourg, Frankfurt on Main, Munich and Milan.
The advantages are seen in the following aspects:

- the entire system runs underground, which would avoid noise nuisance, air pollution, damage to the ground and expropriations
- a reduction in travelling time compared with road and rail amounting to as little as a third or a quarter compared with today
- rail routes would become available on the surface rail network, which would result in a part of the existing infrastructural capacity becoming free for other purposes and

other forms of transport (e.g. partially relocating goods services from the road onto rail) and
- relocating and restricting the ever growing traffic on motorways.

It has been calculated, that Swissmetro has advantages regarding the consumption of power (see table).

Table A1: Power consumption according to form of transport

Means of transport	Wh/t·km	Wh/passenger·km
Railway		
IC	35	56
TGV	50	108
Goods train	15	–
Swissmetro	77	35
Car	930	465
Lorry	100	200

According to investigations 200 to 350 million litres of fuel could be saved annually with the proposed system fully in operation.

The vehicles have similarities to the construction principles of aircraft. Planned are vehicles with a diameter of 3.6 m and a length of 200 m, which could carry 800 seats. The total weight would be around 180 t. Vehicles of around 50 m length with a capacity of 200 passenger are possible also. Automatic locks in the stations guarantee a safe boarding and alighting of passengers. The travel time between two stations will be constant at around 12 or 15 minutes.

A study group from Lausanne Technical University carried out a pilot-study on the feasibility of the project from the end of 1989 till December 1992 on behalf of the Swiss Department for Transport and Energy. The study revealed that the project was feasible, also in economic terms and made sense. Thus

- the transport study (in accordance with models taken over from French railways (SNCF) to ascertain the transport demand on TGV lines) for the line between Geneva and St. Gallen as well as for the projected overall network with respect to relocating road traffic and the degree of utilisation resulted in an extremely favourable modal break-down,
- the economic feasibility study came up with a positive result and
- it is possible in technical terms as one or several solutions could be found for each technical problem.

In mid-1994 the main study war launched, in which the following topics have been treated:

- to evaluate and exactly determine the desired solution with respect to technical feasibility, safety and costs
- to discover how the Swissmetro will fit in the overall transport system and effects of the various solutions
- the analysis of the effects of the different solutions
- examination of the constructional regulations for the various solutions, especially regarding the tunnels, shafts, underground stations and power supply
- to ascertain the volumes of excavated material and to put forward suggestions for where it is to be stored, as well as
- to investigate the safety of the system and to determine measures for its realisation.

Problems still to be treated in further studies are e.g. to be found in the following questions:

- Will the concrete for the inner lining shell of the tunnel be able to stand up to the strain, especially resulting from the partial vacuum?
- Will the tunnel cross-section have to be enlarged even further on account of the major aerodynamic stress imposed by the vehicles?
- How will safety problems be solved given only a few cm of free space between the vehicle and the tunnel wall?

The long heading sections represent a further problem, as e.g. two tunnels which have to be driven from Basle to Zurich and from Zurich to Berne, which are 80 to 100 km in length. The allocation of construction lots is supposed to facilitate an optimal application of double-shield TBMs, something that calls for far-reaching geological advance investigations.

A pilot connection with a length of 60 km between Geneva and Lausanne could be in operation up to the year 2010. Swissmetro has asked for a concession at the end of 1997. The whole system could be available in the year 2025. The cost for the pilot connection are estimated between 3.5 and 4.3 billion CHF, for the whole system between 25 and 30 billion CHF, which should mainly be financed privately.

A2.2.2 Maglev

1	Project, development, concept	**High Speed Ground Transportation – Maglev Trains**
2	Type of transport	passengers and freight
3	Transport or logistic concept	rail
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	magnetic levitation system with AC current powered superconducting magnets
6	Geographical scale	long distance, interurban
7	Technical or organisational innovations	advanced materials in vehicle and prefabricated guideway components; superconducting magnets;
8	Short description	American Maglev Star is an inherently stable freight and passenger magnetic levitation system concept based on superconducting magnets that propel vehicles along a guideway. AC current powers the magnets, allowing cost-efficient, safe, consistent high speed.
9	Underlying problem or objective	
10	Place in transport system	Substitution
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	John J. Morena, of Maglev 2000, Florida Project Office, 335 Golden Knights Blvd., Titusville, FL 32780; Phone: (470) 267-0910; fax: (407) 267-1006; http://weber.u.washington.edu/~jbs/itrans/ammaglev.htm
17	Partners in project	AMS (American Maglev Star) Corporation; Maglev 2000;
18	Planning of project or development	A 20 miles (32 km) demonstration is planned, that would connect the Kennedy Space Centre with Cape Canaveral. In 1997 started the erection of a two mile elevated guideway for a high speed magnetic levitation system at the Space Coast Regional Airport
19	Financial information	Estimated costs for the 20-mile guideway: 225 to 500 million US$; expected total costs for the 2 mile guideway: about 32 million US$
20	Donors	
21	Additional information	

A2.2.3 Transrapid

1	Project, development, concept	**Transrapid**
2	Type of transport	passengers
3	Transport or logistic concept	guided vehicles, magnetic support and guidance; mainly elevated, at surface level or underground possible
4	Type of vehicle concept	Train, up to 10 vehicles, max. total capacity 840 passengers
5	Type of propulsion system and fuel	magnetic levitation, guidance and propulsion system
6	Geographical scale	long distance, interurban
7	Technical or organisational innovations	Electromagnetic systems; contactless support, guidance, propulsion and braking technology.
8	Short description	Transrapid is a German High Speed System with electromagnetic technology for support, guidance, propulsion instead of wheels motors etc. Propulsion with an electromagnetic travelling field in the guideway (synchronous long stator linear motor). The vehicle encloses the guideway, so that derailment is excluded.
9	Underlying problem or objective	Operating speed 300-500 km/h to close the gap between railways and short distance air traffic.
10	Place in transport system	complementary/substitution (air, car)
11	Advantages for accessibility	
12	Advantages for transport service	High speed transportation, low internal noise level, to a large extent vibration-free
13	Environmental advantages	no local emissions, low noise levels compared to conventional steel wheel/rail system
14	Expected transport volume	Transport capacity: 30 million passengers per year on double guideway (train with 10 sections, 5 min headway)
15	Comparable projects or developments	Developments in Japan and the USA
16	Contact	MVP Versuchs- und Planungsgesellschaft für Magnetbahnsysteme m.b.H., Landsberger Str. 76, D-80339 München Transrapid International (TRI), Anzinger Str. 11, D- 81671 München
17	Partners in project	MVP/Lufthansa Commercial Holding GmbH/ Deutsche Bahn AG
18	Planning of project or development	R&D in Germany since the early 70ies; test facility in the Emsland (31.5 km) since 1984; Expertise approving the technical feasibility 1991; since 1992 planning of a connection Hamburg–Berlin (292 km, 131 km elevated, 161 km at surface level), costs (1996): 9.8 billion DEM, expectations: 11.4-25.2 million pass./year 2.6-3.5 billion pass. km/year, revenues 700-950 million DEM/year, 20 min headway, total journey time 60 min, max. speed > 400 km/h, partly private financed

19	Financial information	
20	Donors	R&D, test facility Emsland: Ministry of Research and Technology/Thyssen/Siemens connection Hamburg–Berlin: State Government (?), industry, DB AG, Lufthansa
21	Additional information	

A2.2.4 MLU

1	Project, development, concept	**MLU**
2	Type of transport	passengers
3	Transport or logistic concept	guided vehicles, magnetic support and guidance; elevated, at surface level or underground
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	magnetic levitation, guidance and propulsion
6	Geographical scale	long distance, interurban
7	Technical or organisational innovations	use of superconducting magnets, electrodynamic principle, linear motor technology, U-shaped guideway
8	Short description	
9	Underlying problem or objective	
10	Place in transport system	complementary/substitution (air, car)
11	Advantages for accessibility	
12	Advantages for transport service	Max. speed > 500 km/h
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Railway Technical Research Institute, Headquarters, Hikari-cho 2-8-38, Konubunji-shi, Tokyo, Japan
17	Partners in project	Japanese National Railways
18	Planning of project or development	R&D start in 1962; 7 km test track (1975); planned: 42.8 km test track as part of a connection Tokyo-Osaka (515 km, 35 km in tunnel)
19	Financial information	
20	Donors	
21	Additional information	

A2.2.5 HSST

1	Project, development, concept	**HSST (High Speed Surface Transport)**
2	Type of transport	passengers
3	Transport or logistic concept	guided vehicles, magnetic support and guidance; mainly elevated, at surface level or underground possible
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	magnetic levitation, guidance and propulsion
6	Geographical scale	urban (HSST-100); long distance, interurban (HSST-200)
7	Technical or organisational innovations	magnetically levitation with ordinary direct-current electro-magnets; propulsion by a linear motor
8	Short description	Maglev system for urban and interurban transport, several concepts.
9	Underlying problem or objective	
10	Place in transport system	complementary/substitution (air, car)
11	Advantages for accessibility	
12	Advantages for transport service	Max. speed 200 km/h
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	HSST Development Corporation, Kokuryu Bldg. 3F 2-6-15 Shibakoen, Minatoku, Tokyo 105 Japan
17	Partners in project	Japanese Airlines, Nagoya Railroad Co. Ltd., Hazama Corporation
18	Planning of project or development	R&D start in 1972; 1989 commercial operation at Yokohama expo
19	Financial information	
20	Donors	
21	Additional information	

A2.2.6 Seraphim

1	Project, development, concept	**Seraphim**
2	Type of transport	passengers
3	Transport or logistic concept	guided vehicles
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	magnetic levitation and propulsion, energy from a gas turbine on board of the vehicles
6	Geographical scale	long distance, interurban
7	Technical or organisational innovations	segmented rail phased induction motor
8	Short description	
9	Underlying problem or objective	
10	Place in transport system	
11	Advantages for accessibility	
12	Advantages for transport service	Max. speed > 300 km/h
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Sandia National Laboratories, Albuquerque, NM 87 185-1186, USA
17	Partners in project	
18	Planning of project or development	R&D, component tests since 1994
19	Financial information	
20	Donors	
21	Additional information	

A2.2.7 Eurotunnel

1	Project, development, concept	**Eurotunnel**
2	Type of transport	passengers, freight, cars
3	Transport or logistic concept	guided vehicles, magnetic support and guidance; fully underground
4	Type of vehicle concept	train
5	Type of propulsion system and fuel	magnetic levitation and guidance, propulsion with a long stator linear electric motor
6	Geographical scale	long distance, interurban
7	Technical or organisational innovations	magnetic levitation, guidance and propulsion; concept of a metro-system on a European scale
8	Short description	Two lines with a total length of 2,700 km are proposed to link the major cities in Western Europe.
9	Underlying problem or objective	The transport needs and the density of population require an underground transport system
10	Place in transport system	complementary/substitution
11	Advantages for accessibility	Drastic reduction of travel time between major European cities
12	Advantages for transport service	
13	Environmental advantages	No local emissions, whole system underground, change of modal split from plane and car to Eurotunnel reduces consumption of energy and related emission of fumes, noise etc.
14	Expected transport volume	
15	Comparable projects or developments	Swissmetro
16	Contact	
17	Partners in project	
18	Planning of project or development	Proposal in 1985 by Helmut Hirtz, Germany
19	Financial information	Estimated costs (1985) for the German sections only: 300 billion DEM; Time for realization: 33 years
20	Donors	
21	Additional information	

A project similar to the Swissmetro but on an European scale war proposed in 1985 (Hirtz, 1985). A long distance high-speed system with an infrastructure completely underground should connect with two lines important cities in Germany and neighbour-countries:

- A line north-south from Helsingborg and Kopenhagen in the north via Hamburg, Hannover, Frankfurt to Straßbourg, Zurich, Milano and Genua in the south with a length of around 1,500 km and

- a line from London via Brussels, Bonn, Frankfurt, Stuttgart, Munich to Salzburg with a length of around 1,200 km.

These lines should consist of two single-track tunnels with an internal diameter of 7.4 m each in a depth of 100 m to 150 m below ground. The tunnels should be driven mainly by appropriate tunnelling machines and lined with prefabricated concrete elements.

The stations are situated at parallel tracks switching off from the main track. Besides passenger transport also an Express goods transport as well as transport of cars is foreseen. Due to the fact, that boarding and alighting as well as loading and unloading happen to separate tracks, through trains are possible without problems.

The vehicles will have magnetic suspension and guidance system; the propulsion system will use linear electric motors. This configuration allows for speeds up to 400 km/h. It was not proposed to evacuate the tunnel but this needs a larger cross section of the tunnel due to the need to reduce the air-resistance.

The cost for the system in Germany only (1,200 km route tunnel – 2 single-track-tunnels plus 1 service tunnel –, 12 stations with the necessary underground installations) have been calculated in 1985 to around 300 billion DEM. The total time for realization was estimated to be around 33 years.

A2.3 Automated freight transport

A2.3.1 Underground Transport and Tube Systems

1	Project, development, concept	**IPOT: Underground Transport and Tube Systems (UTTS)**
2	Type of transport	freight
3	Transport or logistic concept	underground
4	Type of vehicle concept	unmanned vehicles
5	Type of propulsion and fuel	many possible, hybrid in study
6	Geographical scale	in conceptual phase, four spatial concepts are defined: • one city, distance of 123 km • Randstad area, 1,055 km • Netherlands with 14 junctions, 4,000 km • Netherlands with 14 junctions extended, ca. 10,000 km
7	Technical or organisational innovations	technical: automation of transshipment; organisational: standardisation of load units
8	Short description	a sophisticated new Underground Logistic System for general cargo and the extension of the traditional pipeline networks for liquids and gases to offer an alternative mean of transport
9	Underlying problem or objective	to reduce the increasing pressure of freight transport on spatial policy, to increase economic possibilities and to reduce the burden on nature and the environment
10	Place in transport system	substitution of road transport to tubes
11	Advantages for accessibility	reduction in congestion costs per year for each concept: • one city: 3 million EUR • Randstad area: 39 million EUR • Netherlands with 14 junctions: 152 million EUR • Netherlands with 14 junctions extended: 337 million EUR
12	Advantages for transport service	improved reliability and safety of transport services
13	Environmental advantages	reduction in emissions and visual and noise pollution
14	Expected transport volume	in 2020 for each concept: • one city: 0.03 billion tonne-km • Randstad area: 0.65 billion tonne-km • Netherlands with 14 junctions: 6.67 billion tonne-km • Netherlands with 14 junctions extended: 21 billion tonne-km
15	Comparable projects or developments	

16	Contact	Dra. F.J.P. Heuer, Voorzitter Stuurgroep Ondergronds Transport en Buisleidingen, P.O. Box 20904, 2500 EX Den Haag
17	Partners in project	Dutch Ministries of Transport, Economic Affairs and Spatial Planning
18	Planning of project or development	potential projects are defined for the traditional bulk goods and the non traditional general cargo systems; potential pilot projects are: • ULS Schiphol: design phase to reduce congestion around Schiphol, 1999 - 2000 • ULS South Limburg: preparatory phase, development of intermodal transshipment with inland shipping and rail, mid-1999 • ULS for one city: preliminary study for urban distribution
19	Financial information	Investments and exploitation costs per year: • one city: 0.85 and 0.09 billion EUR • Randstad area: 6.68 and 0.58 billion EUR • Netherlands with 14 junctions: 24.89 and 2.02 billion EUR • Netherlands with 14 junctions extended: 54.13 and 4.17 billion EUR
20	Donors	private and public parties
21	Additional information	

A2.3.2 MetroFreight

1	Project, development, concept	**MetroFreight**
2	Type of transport	freight
3	Transport or logistic concept	underground or surface level road (on dedicated tracks with external conductors for power and therefore some characteristics of rail)
4	Type of vehicle concept	trucks (4.5 meters long)
5	Type of propulsion and fuel	electric and or diesel (hybrid)
6	Geographical scale	urban and interurban
7	Technical or organisational innovations	technical: automated vehicles with automated routing and vehicle control; organisational: automated vehicle routing and toll system.
8	Short description	fully automated freight transport system; the infrastructure is composed of asphalt roads; the system can be used either underground or above the ground; it consists of small vehicles which are able to transport standardised units; the vehicles are electrically moved by rechargeable batteries and by means of external conductors; they can choose and follow their own route and can follow each other at short intervals; their maximum speed is 100 km/h;
9	Underlying problem or objective	problems with distribution of freight in the congested London region, especially in the City of London
10	Place in transport system	substitution of trucks and lorries and complementary to the current freight transport services
11	Advantages for accessibility	easier access to areas in the central district of London
12	Advantages for transport service	improved punctuality and reliability as compared to ground level transport (metro system is dedicated); other advantages are the low logistic and transport costs, higher reliability, lower labour costs, lower social costs and increased safety
13	Environmental advantages	greater energy efficiency and therefore less emissions and noise
14	Expected transport volume	
15	Comparable projects or developments	
16	Contact	Mr. D. Bliss, Head of Road Transport Services, Royal Mail and Mr. M. Clarke, Cranfield School of Management
17	Partners in project	
18	Planning of project or development	project is in planning phase and developed especially for mail although other sorts of freight are possible; MetroFreight can be operational within 5 years and will reach its final market share within 25 years

19	Financial information	investments are 400,000 US dollar/km for surface-development and 1.6 million US dollar for underground development; the project will be privately financed and the system will be subject to toll
20	Donors	
21	Additional information	

A2.3.3 Automated Freight Train

1	Project, development, concept	**Automated Freight Train, SST concept**
2	Type of transport	freight
3	Transport or logistic concept	rail
4	Type of vehicle concept	train
5	Type of propulsion and fuel	diesel and overhead power supply
6	Geographical scale	long distance, interurban transport
7	Technical or organisational innovations	technical: automated systems to control vehicle, for communication with infrastructure systems and to prevent accidents
8	Short description	fully automated freight trains for which no driver is required
9	Underlying problem or objective	limited capacity of railway system: automated trains can increase the flexibility and capacity of the railway system with a possibility of cost savings
10	Place in transport system	substitution: automated trains can replace existing trains or trucks
11	Advantages for accessibility	increase of capacity of railway track, improved quality of services and lower costs may stimulate the use of rail instead of road
12	Advantages for transport service	more flexibility in services and therefore higher punctuality and reliability
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	Combi-Road
16	Contact	Dipl.-Ing. Peter Faber, Deutsche Bahn AG
17	Partners in project	Deutsche Bahn, Alcatel, Institut für Fördertechnik und Schienenfahrzeuge (IFS)
18	Planning of project or development	start of testing in 1993; end of testing in April 1996; currently there are new tests in Salzgitter and Wolfsburg
19	Financial information	
20	Donors	
21	Additional information	

A2.3.4 Combi-Road

1	Project, development, concept	**Combi-Road**
2	Type of transport	freight
3	Transport or logistic concept	road (on dedicated tracks and therefore some characteristics of rail)
4	Type of vehicle concept	truck (automated on dedicated tracks with passive lateral and active longitudinal guidance)
5	Type of propulsion and fuel	all possible, tests are with hybrid electric diesel
6	Geographical scale	medium to long distance, interurban up to 200 km
7	Technical or organisational innovations	technical: development of automated vehicle and dedicated infrastructure; organisational: containers are transported one by one over dedicated track, for which access and egress transport must be organised
8	Short description	fully automated transport of containers with automated (but not necessarily driverless) trucks on dedicated tracks; the vehicles have an extra guide rail and place recognition is based on a special infra-red system; the maximum speed is 50 km/h
9	Underlying problem or objective	transport costs: automated vehicles can be cheaper than manned vehicles; congestion: the capacity of the road (or dedicated tracks) can be increased by use of automation
10	Place in transport system	substitution of trains, ships and perhaps some trucks, complementary for present truck
11	Advantages for accessibility	depends on implementation of dedicated tracks, but capacity of the road (or dedicated tracks) can be increased by the use of automation, therefore the costs of transportation are reduced in comparison to for example trains
12	Advantages for transport service	the system consists of individual trucks which offers more flexibility in transporting freight from one place to the other than trains for lower costs than trucks
13	Environmental advantages	
14	Expected transport volume	capacity can be 3800 containers a day
15	Comparable projects or developments	Automated Freight Train
16	Contact	F.J. Melcherts, Projectbureau Combi-Road, P.O. Box 114, 2920 AC Krimpen a/d IJssel (NL), Tel: +31-180-550982, fax: +31-180-550874, e-mail: box@combi-road.nl, http://www.combi-road.nl
17	Partners in project	Centrum voor Transport Technologie
18	Planning of project or development	a test track has been build and tests have been carried out; future of project is uncertain
19	Financial information	investment costs will be 15 million NLG/km (about 7 million EUR/km)
20	Donors	Dutch government through the ECIS project

A2.3.5 Automated Underground Tube Network Tokyo

1	Project, development, concept	**Automated Underground Tube Network Tokyo**
2	Type of transport	freight
3	Transport or logistic concept	underground rail
4	Type of vehicle concept	train
5	Type of propulsion and fuel	electric linear induction engine
6	Geographical scale	urban with a network of approximately 300 km and with 150 stations
7	Technical or organisational innovations	technical: automated vehicles and automated transport into lifts that bring containers up to ground level terminal; organisational: linking of department stores, wholesale houses, printing-offices, truck-terminals etc. directly with the underground network
8	Short description	electrically driven automatic guided freight wagons will move containers in tunnels, which will lie approximately 40 to 50 meters underneath the surface, between underground stations; there the containers will be transported automatically into elevators which will bring them up to a ground-terminal; the wagons can follow each other at intervals of 30 seconds and carry all forms of municipal-distribution (except for dangerous goods, very long or very heavy goods, trips for merchandise- or service activities and trips which will be shorter than 60 minutes);
9	Underlying problem or objective	congestion in ground-based transport
10	Place in transport system	substitution of ground-based distribution of freight
11	Advantages for accessibility	in case of a direct linkage to the network the accessibility will increase, otherwise accessibility may decrease
12	Advantages for transport service	direct linkage to network may decrease delivery times; the reliability improves as a result of the absence of congestion; transport costs and labour costs (because of driverless trains) are lower
13	Environmental advantages	expectations are a 20 percent decrease of ground-based transport kilometres in favour of underground transport, which decreases noise, emissions and visual pollution
14	Expected transport volume	
15	Comparable projects or developments	IPOT
16	Contact	
17	Partners in project	
18	Planning of project or development	there have been test models on scale

19	Financial information	investments are estimated at 48 billion US dollar of which 26 billion will be paid by the Japanese Government; time benefits due to the system are estimated at 92 billion US dollar within 20 years
20	Donors	
21	Additional information	

A2.3.6 Tokyo Linear-Motor-Network

1	Project, development, concept	**Tokyo L-Net (Linear-Motor-Network)**
2	Type of transport	freight (mail)
3	Transport or logistic concept	underground rail
4	Type of vehicle concept	automated super light-weight trains
5	Type of propulsion and fuel	linear engines
6	Geographical scale	urban, between the major post-offices in Tokyo
7	Technical or organisational innovations	technical: automated trains with linear engines and Continue Vertical Conveyer System for vertical transport of mail from underground stations to the post-offices
8	Short description	super light-weight post trains with linear engines will transport mail between the major post-offices in Tokyo; the tunnels of the network will be located approximately 50 to 70 meters underneath the ground surface; transportation from the underground stations to the post-offices will be done by a Continue Vertical Conveyer System; the trains will run fully automatically with a maximum speed of 70 km/h; the wagons can follow each other at intervals of 150 seconds
9	Underlying problem or objective	congested and unreliable road-based transport
10	Place in transport system	substitution of ground-based mail transport
11	Advantages for accessibility	direct connection between post-offices
12	Advantages for transport service	individual trains can be guided automatically in a dedicated system: the system is therefore demand responsive and reliable
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	IPOT
16	Contact	
17	Partners in project	
18	Planning of project or development	realisation will not be very soon
19	Financial information	
20	Donors	
21	Additional information	

A2.3.7 Transport System for the Future (TSF)

1	Project, development, concept	**Transport System for the Future (TSF)**
2	Type of transport	freight and passengers
3	Transport or logistic concept	underground rail
4	Type of vehicle concept	train
5	Type of propulsion and fuel	electric-motors and a diesel engine to assist in terminals
6	Geographical scale	long distance
7	Technical or organisational innovations	technical: tunnel where air-resistance has been eliminated and derailing has been made impossible
8	Short description	electrically driven train that can move at very high speeds (maximums of 500 km/h can be reached); the TSF-train will run in a tunnel in which air-resistance has been eliminated and derailing made impossible; distance between tunnel and train has been reduced to minimum; a TSF-train will consist of two locomotives and ten Ro-Ro-waggons with supporting wheel on top, which are used to take the corners; the trains are fully automated but can also be steered by hand
9	Underlying problem or objective	
10	Place in transport system	substitution of intra-European air-traffic and complementary within intermodal cargo freight systems
11	Advantages for accessibility	the TSF-trains can carry trucks and private-cars and are therefore be very accessible
12	Advantages for transport service	fast and reliable freight transport service, with good connections to other transport services
13	Environmental advantages	highly efficient underground system that will produce less emissions, noise and visual pollution
14	Expected transport volume	large transport capacity of about 60 trucks and 100 private cars; the system can be compared with a highway with double lanes
15	Comparable projects or developments	
16	Contact	
17	Partners in project	
18	Planning of project or development	tests to scale have been undertaken between 1990 and 1994; a track could be build between Antwerp and Rotterdam, but this will not be in the near future
19	Financial information	investments are estimated at 25 to 50 million NLG/km (about 12 to 23 million EUR/km); this will be financed in a public-private-partnership; a break-even exploitation is possible
20	Donors	

21	Additional informa-tion	the system consists of two tunnels, one for each direction, with a diameter of 9 meters; they will lie approximately 4 meters from each other; every 100 to 150 meters an air-lock relieves air-pressure; terminals are located at surface-level

A2.4 Microtunnels

A2.4.1 Ondergronds Logistiek Systeem

1	Project, development, concept	**Ondergronds Logistiek Systeem Unit Transport by Pipe (UTP)**
2	Type of transport	freight
3	Transport or logistic concept	underground
4	Type of vehicle concept	train
5	Type of propulsion and fuel	linear induction motor
6	Geographical scale	both short distances (plant sites) and long distances (Rotterdam-Antwerp) are considered
7	Technical or organisational innovations	none
8	Short description	based on the existing sizes of load units, units of 1.25 m^2 are transported on a plateau in a pipeline
9	Underlying problem or objective	congestion: transport by pipe is an alternative transport mode that may complement existing but congested means of transport
10	Place in transport system	complement existing means of transport and substitution for freight transport by rail or road
11	Advantages for accessibility	pipelines can be constructed between production and distribution sites to offer more direct transport
12	Advantages for transport service	high reliability and punctuality
13	Environmental advantages	reduced local emission and noise, no visual pollution
14	Expected transport volume	
15	Comparable projects or developments	UTTS
16	Contact	Raadgevend Ingenieursbureau Lievense BV
17	Partners in project	Holec Machines & Apparaten BV
18	Planning of project or development	feasibility study carried out in 1995
19	Financial information	
20	Donors	Dutch Ministry of Transport
21	Additional information	OLS is an underground system of pipelines for transport of time dependable goods like flowers, airfreight, etc. In pipelines with a diameter of 2 to 5 meters, a rotary current automatically drives vehicles. The vehicles will move on rubber wheels and their maximum speed will be 20 to 40 km/h. The OLS will connect the Amsterdam Airport Shiphol with the Aalsmeer Flower Auction over a distance of 24 km. Investment costs will be 440 million NLG/24 km. (18 million NLG/km)

A2.4.2 Mail Tube System

1	Project, development, concept	**Mail Tube System**
2	Type of transport	freight (mail)
3	Transport or logistic concept	capsules in an underground tube, without track
4	Type of vehicle concept	capsules, space for loads: 0.38 m x 0.38 m x 1.00 m
5	Type of propulsion system and fuel	pneumatic
6	Geographical scale	short distance, urban
7	Technical or organisational innovations	
8	Short description	Plant in Hamburg 2 x 1.8 km connecting several post offices; tube diameter 0.45 m; capsule speed 36 km/h; self weight 100 kg, payload 30 kg
9	Underlying problem or objective	transport of mail (letters) between post offices without interference with surface traffic
10	Place in transport system	complementary
11	Advantages for accessibility	direct transport from source to destination
12	Advantages for transport service	high reliability
13	Environmental advantages	no local emission, no noise or vibration
14	Expected transport volume	transport volume 960 capsules/day; max. capacity 5 capsules/min.
15	Comparable projects or developments	UTP; similar plants in other German cities and abroad
16	Contact	Information from literature
17	Partners in project	Deutsche Bundespost, City of Hamburg
18	Planning of project or development	In operation 1962-1973; disassembled due to high cost for energy; fully automatic operation was not possible; parcels had parallel to be transported by lorry
19	Financial information	
20	Donors	
21	Additional information	

A2.4.3 Sumitomo Cement Capsule Liner

1	Project, development, concept	**Sumitomo Cement Capsule Liner**
2	Type of transport	freight (limestone)
3	Transport or logistic concept	train of three capsules in a tube, without track
4	Type of vehicle concept	capsules, length of load space 3 m
5	Type of propulsion system and fuel	pneumatic
6	Geographical scale	short distance, local
7	Technical or organisational innovations	
8	Short description	Connection of a quarry and cement plant, 2 x 3.2 km; steel tubes mainly elevated; tube diameter 1.0 m; train speed 32 km/h; support and guidance with five rubber wheels at each end of a capsule; each capsule has a payload of 1.5 tons; automatically loading and unloading
9	Underlying problem or objective	
10	Place in transport system	
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	
14	Expected transport volume	6,000 h operation per year; 2.5 million tons per year
15	Comparable projects or developments	proposals / operating systems with a similar technology (capsules pumped by air-pressure through a pipeline) are known under the names Airapid (Japan), BHRA (UK), Transprogress (GOS), TUBEXPRESS (USA), Subtrans (USA)
16	Contact	Information from literature
17	Partners in project	Kajima Work Tokyo
18	Planning of project or development	Installation 1973; in 1992 still in operation
19	Financial information	
20	Donors	

A2.4.4 Slurry Pipeline

1	Project, development, concept	**Slurry pipeline**
2	Type of transport	freight (coal, ore in a slurry)
3	Transport or logistic concept	pipeline, above ground or underground
4	Type of vehicle concept	no vehicle
5	Type of propulsion system and fuel	high pressure in a liquid
6	Geographical scale	short distance – long distance
7	Technical or organisational innovations	
8	Short description	Transport of fine-grained coal or ore in a liquid under high pressure (up to 350 bar) in a pipeline (diameter up to 500 mm)
9	Underlying problem or objective	High cost of lorry or rail transport; bad or missing roads or tracks
10	Place in transport system	complementary
11	Advantages for accessibility	
12	Advantages for transport service	continuos flow of goods; no interference with other traffic
13	Environmental advantages	no local emissions
14	Expected transport volume	
15	Comparable projects or developments	Several plants around the world, distance of up to 440 km (Arizona, USA, in operation since 1970)
16	Contact	Information from literature
17	Partners in project	
18	Planning of project or development	
19	Financial information	
20	Donors	
21	Additional information	

A3 Airships and hypersonic transport

A3.1 Airships

Note For those concepts incorporating several similar vehicles (product family) the following tables depict specifications for one model, considered most interesting within this study. For additional comparison on airship sub-classes please consult supplements A and B.
Not covered in this survey are all sorts of very small airships, i.e. with a maximum take-off weight below one ton or a payload less than 500 kilogram, remotely controlled vehicles, in-door airships, demonstrators and so on.

A3.1.1 CargoLifter

1	Project, development, concept	**CargoLifter AG** **'CL 160' (P1)**
2	Type of transport	Freight
3	Transport or logistic concept	Airship for point-to-point delivery of heavy and bulky loads; 'air crane' concept
4	Type of vehicle concept	Semi-rigid airship
5	Type of propulsion system and fuel	Six diesel engines for cruising, two additional gas turbines (vector thrust) for manoeuvring during loading/unloading
6	Geographical scale	Medium to long distance (10,000 km at maximum payload)
7	Technical or organisational innovations	Modern lightweight and extremely strong materials allow for semi-rigid design; the concept of an 'air crane' introduces a container system (multibox) for point-to-point delivery
8	Short description	Very large size airship: 260 m long, max. diameter 65 m, max. height 82 m, volume 550,000 m³, payload capacity 160 tons; cruise speed 80-100 km/h, max. speed 135 km/h; 9.33 MW installed power; range at least 10,000 km
9	Underlying problem or objective	Time-consuming shipment of bulky and heavy cargo to regions without sufficient existing infrastructure
10	Place in transport system	Substituting for bulky freight or complementary for general heavy load transport
11	Advantages for accessibility	Remote areas with underdeveloped infrastructure are easily accessible; in regions with extensive infrastructure it could as well be an option for transport of bulky freight which would otherwise require bridges to be temporarily removed or loads to be disassembled and reassembled
12	Advantages for transport service	With a strategic network of airship home bases deliverable, the speed of point-to-point delivery of heavy freight in the long range sector could possibly increase by a factor of 10; planning for such shipments should become much less complex
13	Environmental advantages	Transport by airship is expected to be highly environmental friendly, esp. if fuel consumption and noise level are considered

14	Expected transport volume	VDMA (German Machine and Plant Manufacturers Association) market analysis (1994) and study (1995). Based on 1996 worldwide transport figures a target market for the CargoLifter of 50 million tons was identified, with just a 1 % share covered by a fleet of 46 operating airships.
15	Comparable projects or developments	Other rigid and semi-rigid airship concepts, though most other concepts include much smaller vehicles (RAD, Aeros D-4/D-8)
16	Contact	CargoLifter AG, Kreuzberger Ring 21, D-65205 Wiesbaden, Germany; Tel: +49/611/9748-188, Fax: +49/611/9748-100, E-mail: info@cargolifter.com, Internet: www.cargolifter.com
17	Partners in project	Technical systems: Conti-Tech, Steinbeis/Dornier, Liebherr, Technoflug, AIDA, Praxair, Linde; Finance: ABB PTF, Commerzbank AG, Deutsche Bank AG, Hauck&Aufhauser; Logistics: several cargo services
18	Planning of project or development	Initial project start in 1994; scaled prototype (1/8) 'Joey' flying; conceptual design freeze in late 1998; first full scale prototype to fly in summer 2001; a preliminary certification program with German Aviation Authority (LBA) is under way; a design center is opened and the construction site to be established at the former military airfield of Brand, some 60 km south of Berlin (Ger)
19	Financial information	Development costs incl. first prototype are estimated to be 123 million EUR (240 million DEM); production cost per airship is rated at 51 million EUR (100 million DEM); ship-yard infrastructure at Brand airfield will cost up to 80 million EUR (155 million DEM); overall costs are figured as 210 million EUR (412 million DEM)
20	Donors	CargoLifter AG has originally been a privately financed company with risk sharing partners from industry and transport business, however in the meantime it's offering shares to the public as well; additional federal surety of 53 million EUR (104 million DEM) is secured
21	Additional information	Larger versions are envisaged

CargoLifter AG was founded in September 1996 in order to manage the development and promotion of a large freight airship that is meant to fill an existing gap in the transport chain between slowly moving ships and fast moving cargo aircraft, thereby allowing for shipment of bulky and heavy loads to remote areas at reasonable expenditure.
Extensive shipment costs and average delivery times for oversize and heavy freight have been the impetus to the idea of especially avoiding further costly infrastructure for each single shipment. The whole logistic concept is – among comparable projects – by far the most thoroughly investigated, ensuring a viable niche market for such a new means of transport. From the very start, potential customers have been involved in defining base characteristics of the vehicle and the operational concept, thus securing the development of a product fit to actual and future market demands.
The vehicle itself, introducing the ‘air crane’ feature for handling the loading/unloading process, has been tested to date by using a scale model, verifying the feasibility and usefulness of the full size airship. The CargoLifter will in fact be more than two and a half times larger than the 'Hindenburg' zeppelin (and its sister ship ‘Graf Zeppelin II’), the biggest flying craft to date.

A3.1.2 Hamilton Airship

1	Project, development, concept	**The Hamilton Airship Company (THAC) 'HA 160-TA'**
2	Type of transport	Passengers, freight
3	Transport or logistic concept	Passenger transport for leisure purposes; transport of bulky freight
4	Type of vehicle concept	Rigid airship
5	Type of propulsion system and fuel	One diesel and two turboprop engines for cruising and manoeuvring
6	Geographical scale	Medium and long distance (designated range is 10,000 km)
7	Technical or organisational innovations	Modern lightweight, extremely strong materials such as carbon fibres and kevlar allow for a strong and flexible (!) construction of a rigid airship; the design is modular and scalable to adopt to customers' needs, supplying an internal hydraulically deployable mooring mast for landing
8	Short description	Medium size airship: 160 m long, max. width 24 m, volume 55,000 m^3, payload capacity 20 tons; cruise speed 90 km/h, max. speed 145 km/h; 2.45 MW installed power; range 10,000 km
9	Underlying problem or objective	
10	Place in transport system	Complementary
11	Advantages for accessibility	Point-to-point delivery of bulky freight; high comfort level for passenger leisure travel
12	Advantages for transport service	
13	Environmental advantages	Low operating costs, estimated at one fourth of modern narrow body jets (low fuel consumption and noise level)
14	Expected transport volume	
15	Comparable projects or developments	Other airship concepts, even non-rigids (RAD, RosAeroSystems DPD-5000, Aeros D-1; large blimps)
16	Contact	The Hamilton Airship Company, P.O. Box 67492, Bryanston 2021, South Africa; Tel: +27/11/884-4352, Fax: +27/11/884-3277, E-mail: jhamilton@hamilton.co.za, Internet: www.hamilton.co.za
17	Partners in project	Design team: Denel Aviation
18	Planning of project or development	Project start in 1996; test flights and a certification program are scheduled for 1999
19	Financial information	Production cost per airship is quoted as below 20 million EUR (85 million Rand); no figures for development or overall costs are given
20	Donors	Local banks and private investors are said to back the project
21	Additional information	Whether project continues seems unclear as by spring 1999

A3.1.3 Rigid Airship Design

1	Project, development, concept	**Rigid Airship Design N.V. (RAD)** **'NL-1' (Holland Navigator)**
2	Type of transport	Passengers, freight
3	Transport or logistic concept	Passenger transport for leisure purposes; transport of bulky freight
4	Type of vehicle concept	Rigid airship
5	Type of propulsion system and fuel	Six engines of a not specified type
6	Geographical scale	Medium and long distance for passenger transport or long distance for freight missions
7	Technical or organisational innovations	Rigid airship concept shall allow for 'internal' transport of passengers or freight, without the need for an exterior cabin or gondola
8	Short description	Medium size airship: 180 m long, max. diameter 30 m, volume 83,100 m³, payload capacity 35 tons; max. speed 148 km/h; 2.65 MW installed power; range 20,000 km
9	Underlying problem or objective	
10	Place in transport system	Complementary
11	Advantages for accessibility	Point-to-point delivery of freight; high comfort level for passenger leisure travel
12	Advantages for transport service	
13	Environmental advantages	Extremely low operating costs for luxury leisure travel are expected due to the simplicity of the technology (low fuel consumption and noise level)
14	Expected transport volume	
15	Comparable projects or developments	Other rigid and semi-rigid airship concepts (CargoLifter, THAC, Aeros D-1/D-4)
16	Contact	Rigid Airship Design N.V., Franse Kampweg 7, NL-1243 JC 's-Graveland, NH, The Netherlands; Tel: +31/35/656-4877 Fax: +31/35/656-3007, E-mail: rigidair@worldonline.nl, Internet: www.rigidair.com
17	Partners in project	Design team: Nevesbu, Fokker Aviation, RDM Technologies, Stork; TU Delft
18	Planning of project or development	Formal project start in 1996; construction and assembly of a first prototype is planned to start in 2000, with certification by the Dutch Flight Certification Authority (RLD) accomplished in the following year; the assembly site will be located at Lelystad (NL)
19	Financial information	
20	Donors	The project is said to benefit from governmental support
21	Additional information	

The medium size rigid airship can be dubbed a true relative to pre-war zeppelins, however increasing the range of possible applications due to technological innovations and new operational ideas. The 'Holland Navigator' claims to follow proven operational concepts and available state of the art design principles, when it comes to using light weight materials, modern flight avionics and safety features.

At an early stage RAD has apparently been seeking co-operation with the Dutch flight certification authority to prevent project delay by underestimating the implementation phase. The basic design of the airship is meant to establish a versatile vehicle that could cover applications from regular short distance to long range passenger leisure travel as well as freight shipments, promotional or surveillance tasks. The development of a modern type rigid airship might as well be seen in the context of several proposals by Dutch institutions to target congestion on inter urban connections within densely populated areas by introducing airships and new infrastructure means.

A3.1.4 RosAeroSystems

1	Project, development, concept	**Russian Aeronautical Systems Ltd. (RosAeroSystems) 'DPD-5000' (PD-160, MD-900)**
2	Type of transport	Passengers, freight
3	Transport or logistic concept	Passenger transport; transport of oversized loads
4	Type of vehicle concept	Semi-rigid airship
5	Type of propulsion system and fuel	Two engines for cruising and one additional for increased manoeuvrability (turbo-diesel engines)
6	Geographical scale	Medium to long distance
7	Technical or organisational innovations	Modern construction with three detachable sections and independent ballonets; the longitudinal solid keel holds gondola, engines and aft steering unit; a fly-by-wire system and modern avionics are to be installed to deliver all weather capability
8	Short description	Medium size airship (DPD-5000): 126.8 m long, max. diameter 28.2 m, volume 50,150 m³, payload capacity 15.2 tons; cruise speed 110 km/h, max. speed 150 km/h; 3.13 MW installed power; range 8,700 km
9	Underlying problem or objective	
10	Place in transport system	Complementary
11	Advantages for accessibility	Delivery of bulky freight; high comfort level for passenger leisure travel; surveillance missions
12	Advantages for transport service	
13	Environmental advantages	Low operating costs and low emissions (fuel consumption and noise level)
14	Expected transport volume	
15	Comparable projects or developments	Other airship concepts, even non-rigids (THAC, Aeros D-1, Zeppelin NT; large blimps)
16	Contact	Russian Aeronautical Systems Ltd., Ulitsa Stepana Shutova 4, 109380 Moscow, Russia; Tel: +7/095/359-1001, Fax: +7/095/359-1065, Internet: www.augur.com2com.ru
17	Partners in project	
18	Planning of project or development	Project is in design phase
19	Financial information	Production cost for the larger DPD-5000 is expected to be 50 million EUR
20	Donors	
21	Additional information	A family of small (PD-160, MD-900) to medium size (DPD-5000) semi-rigid airships is proposed; for a comparison see *Supplement A 'Rigid and semi-rigid airships'*

A3.1.5 Aeros

1	Project, development, concept	**Worldwide Aeros Corporation 'Aeros D-Series' (D-1, D-4, D-8)**
2	Type of transport	Passengers, freight
3	Transport or logistic concept	Large scale transport of passengers or very heavy and bulky freight
4	Type of vehicle concept	Rigid airship
5	Type of propulsion system and fuel	
6	Geographical scale	Presumably long distance
7	Technical or organisational innovations	Modern lightweight construction with an additional rigid envelope designed as a semi-monocoque structure; inside passenger/freight compartment; avionics and steering systems are similar to those used in typical modern fixed wing aircraft
8	Short description	Large size airship (Aeros D-4): 168 m long, volume 222,000 m³, payload capacity 127 tons; max. speed 280 km/h; long range
9	Underlying problem or objective	
10	Place in transport system	Complementary and/or substituting
11	Advantages for accessibility	Delivery of bulky freight; high comfort level for passenger leisure travel; surveillance missions
12	Advantages for transport service	
13	Environmental advantages	Low operating costs and low emissions (fuel consumption and noise level); high safety standard
14	Expected transport volume	
15	Comparable projects or developments	Other rigid and semi-rigid airship concepts (CargoLifter, RAD, THAC)
16	Contact	Worldwide Aeros Corporation, 9617 Canoga Avenue, Chatsworth, CA 91311, USA; Tel: +1/818/993-5533, Fax: +1/818/993-9435, E-mail: aeros-us@worldnet.att.net, Internet: www.aeros-airships.com
17	Partners in project	
18	Planning of project or development	Project is in design phase
19	Financial information	
20	Donors	
21	Additional information	A family of small (D-1), large (D-4) and very large size (D-8) rigid airships is proposed; figures available are considered highly promotional, e.g. for quoted payloads and cruising speeds; for a comparison see *Supplement A 'Rigid and semi-rigid airships'*

A3.1.6 Zeppelin NT

1	Project, development, concept	**Zeppelin Luftschifftechnik GmbH ‘Zeppelin NT’ (LZ N07, LZ N17, LZ N30)**
2	Type of transport	Passengers
3	Transport or logistic concept	Passenger transport for leisure purposes
4	Type of vehicle concept	(Semi-)rigid airship
5	Type of propulsion system and fuel	Three piston engines for cruising and manoeuvring that can be pivoted for VTOL; additional aft port side propeller for lateral control
6	Geographical scale	Short distance
7	Technical or organisational innovations	Modern lightweight construction with very good manoeuvrability due to adjustable engines which allow for a landing crew of just 3 members; avionics and fly-by-wire system are similar to those used in typical modern jet or turboprop airplanes
8	Short description	Small size airship (LZ N07): 75 m long, max. diameter 14.2 m, total volume 8,225 m³, ballonet volume 1,805 m³, payload capacity 1.85 tons; cruise speed 84-115 km/h, max. speed 130 km/h; 0.44 MW installed power; range 900 km; excellent manoeuvrability
9	Underlying problem or objective	Improving manoeuvrability and reducing ground crew; versatile airborne platform
10	Place in transport system	Complementary
11	Advantages for accessibility	New level of comfort for passenger leisure travel; airborne platform for environmental protection, atmospheric research, remote sensing, observation etc.
12	Advantages for transport service	
13	Environmental advantages	Extremely low operating costs for leisure travel and minimum infrastructure costs are expected, as well as low fuel consumption and noise level
14	Expected transport volume	
15	Comparable projects or developments	Other rigid, semi-rigid and non-rigid airship concepts (RosAeroSystems MD-900, Aeros D-1; blimps)
16	Contact	Dietmar Blasius, Zeppelin Luftschifftechnik GmbH, Zeppelin Werftgelände 31, D-88045 Friedrichshafen, Germany; Tel: +49/7541/202-588, Fax: +49/7541/202-499, Internet: www.zeppelin-nt.com
17	Partners in project	ZF Friedrichshafen, Lycoming, Linde
18	Planning of project or development	Program start dates back to 1993; maiden flight of full scale prototype LZ N07 occurred on 18th September 1997; at the moment flight certification program with German Aviation Authority (LBA) is well under way and should be finished by end of 2000; construction site (hangar and headquarter) is located at the Friedrichshafen airport

19	Financial information	System costs for LZ N07, including a moveable mooring mast and a special pressure refuelling unit, will be some 6.9 million EUR (13.5 million DEM)
20	Donors	ZF Friedrichshafen, Lemförder Metallwaren AG, Mrs. E. Veil (granddaughter of Count Ferdinand von Zeppelin); CSC Microcadam, Stuttgarter Hofbräu, Linde
21	Additional information	Concept could be adopted for much larger (semi-)rigid airships; see *Supplement A 'Rigid and semi-rigid airships'*

The Zeppelin NT – NT stands for new technology – is the first tangible sign of the revival of classic airships. Though the approach of introducing a small size (semi-)rigid airship competing against well established blimps, who never vanished from the skies, might seem questionable, the whole concept incorporates a couple of high-tech design features that should prove essential for all larger airships to be designed.

Two major objectives in the design of LZ N07 have been reducing the overall structural weight of the vehicle and enhancing its manoeuvrability, thus reducing ground crew requirements and consequently lowering operating costs. The new Zeppelin combines a rigid structure composed of longitudinal girders and triangular frames, with ballonets inside the envelope, typical for semi-rigid airships, to ensure the hull's outer shape through regulating valves and electric fans. Tilting engines, a state of the art fly-by-wire system and standardized avionics derived from operational fixed wing aircraft are among the aspects considered for improving manoeuvrability.

Alas, problems accompanying the certification process – due to a gap in current flight regulations – prove a significant obstacle to the implementation of the new product. It has to be stated, that these problems hint at further needs to adapt certification and flight operations regulations – preferably on an European level.

LZ N07 can be in principle considered the first prototype of a new generation of (semi-) rigid airships with the potential – owed to a scalable design scheme – to evolve into a real new means of transport.

A3.1.7 Airship Technologies

1	Project, development, concept	**Airship Technologies Ltd.** **'AT-04'**
2	Type of transport	Passenger
3	Transport or logistic concept	Leisure travel
4	Type of vehicle concept	Non-rigid airship
5	Type of propulsion system and fuel	Three diesel engines with vectoring ducted propulsors
6	Geographical scale	Short range
7	Technical or organisational innovations	Enhanced manoeuvrability by using electro-pneumatic vector thrusters
8	Short description	Small airship: 82.1 m long, max. diameter 17.9 m, volume 14,200 m^3, payload capacity 1.5 tons; cruise speed 115 km/h, max. speed 155 km/h; 0.99 MW installed power; short range
9	Underlying problem or objective	
10	Place in transport system	Complementary
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	Small rigid and non-rigid airships (LZ N07, Sentinel 1000)
16	Contact	Airship Technologies, 6th floor, Town hall, St Pauls Square, Bedford, MK40 1SJ, UK; Tel: +44/1234/22-1808, Fax: +44/1234/22-1801; Internet: http://dspace.dial.pipex.com/town/parade/aag67/
17	Partners in project	
18	Planning of project or development	
19	Financial information	
20	Donors	
21	Additional information	For a comparison see *Supplement B 'Non-rigid airships'*

A3.1.8 American Blimp

1	Project, development, concept	**American Blimp Corporation (ABC) 'Lightships' (A-60+, A-100, A-130, A-150, A-170)**
2	Type of transport	Passengers, equipment
3	Transport or logistic concept	Airborne surveillance and promotion
4	Type of vehicle concept	Non-rigid airship
5	Type of propulsion system and fuel	Two diesel or piston engines
6	Geographical scale	Short distance
7	Technical or organisational innovations	
8	Short description	Small airship (A-150): 50.3 m long, max. diameter 13.1 m, volume 4,248 m^3, payload capacity 1.63 tons; cruise speed 74 km/h, max. speed 105 km/h; 0.26 MW installed power; range 990 km
9	Underlying problem or objective	Airborne surveillance (Spector: military, police, civil aid), advertising and sales promotion (Lightships)
10	Place in transport system	Complementary
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	Other small non-rigid airships (GZ-20, Aeros-40B)
16	Contact	American Blimp Corporation, 1900 NE 25th Av. Suite 5, Hillsboro, OR 97124-5983, USA; Internet: www.americanblimp.com - c/o The Lightship Group, 5728 Major Boulevard, Suite 314, Orlando, FL 32819, USA; Tel: +1/407/363-7777, Fax: +1/407/363-0962, E-mail: marketing@lightships.com, Internet: www.lightships.com
17	Partners in project	The Lightship Group, Virgin Lightships
18	Planning of project or development	First blimp model dates back to 1987 (A-50); since 1995 the Spector/Lightship family is growing, the A-100 (S 31) being the latest member to fly in mid 1999
19	Financial information	
20	Donors	
21	Additional information	The Lightship product line (Spector is the military designation) includes 5 models of blimps, of which the smallest A-60+ is dubbed the most popular airship of the world; for a comparison see *Supplement B 'Non-rigid airships'*

A3.1.9 Global Skyship

1	Project, development, concept	**Global Skyship Industries Inc. 'Skyships' (Skyship 500HL/600B, Sentinel 1000)**
2	Type of transport	Passenger
3	Transport or logistic concept	Airborne surveillance and promotion
4	Type of vehicle concept	Non-rigid airship
5	Type of propulsion system and fuel	Two turbo-charged piston engines
6	Geographical scale	Short distance
7	Technical or organisational innovations	
8	Short description	Small airship (Sentinel 1000): 68 m long, max. width 16.7m, volume 10,000 m³, payload capacity 2.7 tons; cruise speed 100 km/h, max. speed 111 km/h; 0.44 MW installed power; short range
9	Underlying problem or objective	
10	Place in transport system	
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	Other small rigid and non-rigid airships (LZ N07, GZ-20/22, WDL 1a/b)
16	Contact	Global Skyship Industries Inc., 1001 Armstrong Blvd., Unit A, Kissimmee, FL 34741, USA; Tel: +1/407/932-3779, Fax: +1/407/932-2916; E-mail: AirOpslnc@aol.com, Internet: www.globalskyships.com
17	Partners in project	Aviation Support Group Ltd. is parent company
18	Planning of project or development	
19	Financial information	
20	Donors	
21	Additional information	Formerly Westinghouse Airship Inc. (WAI); for a comparison see *Supplement B 'Non-rigid airships'*

A3.1.10 Goodyear

1	Project, development, concept	**Goodyear 'GZ-20/22'**
2	Type of transport	Passengers
3	Transport or logistic concept	Passenger leisure travel and promotion
4	Type of vehicle concept	Non-rigid airship
5	Type of propulsion system and fuel	Two turboprop engines
6	Geographical scale	Short distance
7	Technical or organisational innovations	
8	Short description	Small airship (GZ-22): 62.6 m long, max. width 14.3 m, volume 7,017 m³, cruise speed 64 km/h, max. speed 105 km/h; 0.62 MW installed power; short range
9	Underlying problem or objective	
10	Place in transport system	
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	Other non-rigid airships (Lightships, Skyships, WDL 1a/b)
16	Contact	The Goodyear Tire & Rubber Company, Airship Operations, 1144 E. Market Street, Akron, Ohio, USA; E-mail: blimp@goodyear.com, Internet: www.goodyear.com/about/blimp
17	Partners in project	
18	Planning of project or development	Production ended; Lockheed-Martin holds type certificates for GZ blimps
19	Financial information	
20	Donors	
21	Additional information	Goodyear has a perfect record of operating blimps for more than 80 years without a fatal accident; for a comparison see *Supplement B 'Non-rigid airships'*

A3.1.11 WDL

1	Project, development, concept	**Westdeutsche Luftwerbung GmbH (WDL) ‘WDL 1a/1b’**
2	Type of transport	Passenger
3	Transport or logistic concept	Airborne promotion
4	Type of vehicle concept	Non-rigid airship
5	Type of propulsion system and fuel	Two piston engines
6	Geographical scale	Short distance
7	Technical or organisational innovations	
8	Short description	Small airship (WDL 1b): 59.9 m long, max. width 16.4 m, volume 7,200 m^3, cruise speed 50 km/h, max. speed 105 km/h; 0.31 MW installed power; short range
9	Underlying problem or objective	
10	Place in transport system	Complementary
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	Other small non-rigid airships (Skyship 500 HL/600 B, GZ-20/22)
16	Contact	Westdeutsche Luftwerbung GmbH, Flughafen, 45470 Mühlheim/Ruhr, Germany; Tel: +49/208/378080
17	Partners in project	WDL Florida, USA
18	Planning of project or development	
19	Financial information	
20	Donors	
21	Additional information	For a comparison see *Supplement B ‘Non-rigid airships’*

A3.1.12 Coopership

1	Project, development, concept	**Coopership Industries 'Coopership'**
2	Type of transport	Passengers or freight
3	Transport or logistic concept	Long range transport at up to half the cruise speed of subsonic aircraft
4	Type of vehicle concept	Rigid deltoid lifting body
5	Type of propulsion system and fuel	Gas turbine engines using natural gas
6	Geographical scale	Very long distances
7	Technical or organisational innovations	Fast lighter-than-air craft for long distance/around the world travel; unique design idea
8	Short description	Very large rigid airship shaped like a thick delta: each side about 245 m long, composed of 15 spheres with a diameter of approx. 45 m each, total volume about 1,170,000 m³, gas cell volume about 720,000 m³, payload capacity 1,000 tons or 2,000 passengers & 1,000 crew; cruise speed 275 km/h, max. speed 460 km/h; range more than 19,300 km (@1,000 tons cargo)
9	Underlying problem or objective	Long range transport at low operating costs compared to aircraft or ships
10	Place in transport system	
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	Low emissions related to natural gas as proposed fuel
14	Expected transport volume	
15	Comparable projects or developments	None
16	Contact	Coopership Industries, E-mail: dale@coopership.com, Internet: www.coopership.com
17	Partners in project	
18	Planning of project or development	Conceptional idea
19	Financial information	
20	Donors	
21	Additional information	Web information regarding technical specifications is not consistent

A3.1.13 Aérospatiale

1	Project, development, concept	**Aérospatiale ‘Ballon-Ludion Cargo’**
2	Type of transport	Freight
3	Transport or logistic concept	Supposedly point-to-point delivery of heavy and bulky freight
4	Type of vehicle concept	Semi-rigid airship
5	Type of propulsion system and fuel	
6	Geographical scale	
7	Technical or organisational innovations	Several cylindrical gas cells are clustered to form a grape; according to payload requirements, the number of gas cylinders can be adapted to avoid extensive ballast exchange at loading/unloading; double envelope system works with an outer ballonet casing the inner helium gas cylinder, thus compensating changes in air pressure
8	Short description	Large airship shaped like a cylindrical teardrop: about 150 m long, 100 m wide and 100 m high, payload capacity 250 tons; container transport
9	Underlying problem or objective	Shipment of bulky and heavy cargo
10	Place in transport system	Substituting for bulky freight or complementary for general heavy load transport
11	Advantages for accessibility	
12	Advantages for transport service	
13	Environmental advantages	
14	Expected transport volume	
15	Comparable projects or developments	Targets the same market segment as the CargoLifter
16	Contact	Nathalie Delattre, Aérospatiale SA, 37, Boulevard de Montmorency, 75781 Paris Cedex 16, France; Internet: www.aerospatiale.fr
17	Partners in project	
18	Planning of project or development	Early conceptual design phase
19	Financial information	
20	Donors	
21	Additional information	Little information available

A3.2 Supersonic/hypersonic transport

Note This survey only covers selected projects aiming at developing full scale operational systems. All countries involved in basic research on future supersonic and hypersonic transport means, are using a couple of demonstrators and small models to apply to a step by step approach. Due to a number of uncertainties related to new technologies and their impacts, huge research expenditures have thus been addressed.

A3.2.1 HSCT

1	Project, development, concept	**Boeing Company 'High-Speed Civilian Transport' (HSCT)**
2	Type of transport	Passengers
3	Transport or logistic concept	Supersonic transport from and to existing intercontinental airports (hubs)
4	Type of vehicle concept	Advanced supersonic passenger aircraft
5	Type of propulsion system and fuel	Four mixed-flow, low-bypass turbofan jet engines (proposed)
6	Geographical scale	Intercontinental/long distance
7	Technical or organisational innovations	Environment friendly design approach (noise, sonic boom, emissions, etc.)
8	Short description	Large aircraft (Model 2.4-7A): 101.80 m long, wing span 39.01 m, height 17.07 m, maximum take-off weight 341.6 tons, seating capacity 300 passengers; cruise speed Mach 2.4; target range more than 9,000 km
9	Underlying problem or objective	Reducing the overall noise level, complying to future standards (8-10 dB below FAA Stage 3 noise requirements) and significantly limiting all other critical emissions
10	Place in transport system	Complementary or substituting for intercontinental passenger travel
11	Advantages for accessibility	Presumably, a network including international airports would help reach metropoles worldwide
12	Advantages for transport service	Reducing travel time in intercontinental passenger service
13	Environmental advantages	Compared to existing supersonic transports, noise and emissions (esp. NO_X) should be down to standards of subsonic commercial aircraft
14	Expected transport volume	Market projections from 1995 to 2015 indicate a potential share for about 1,000 supersonic aircraft
15	Comparable projects or developments	Supersonic business jets investigated by Dassault (Falcon SS-BJ) and Gulfstream; evaluated Concorde successor
16	Contact	The Boeing Company, Douglas Aircraft Division, 3855 Lakewood Boulevard, Long Beach, CA 90846, USA; Tel: +1/562/593-4089, Fax: +1/562/982-6713; Internet: www.boeing.com

17	Partners in project	General Electric, Pratt&Whitney, Honeywell; 70 major sub-contractors
18	Planning of project or development	The NASA HSR programme started in 1990 with the target of achieving technology readiness in 2002; due to budget shifts at NASA, an operational aircraft will not be available before the year 2020; programme delay is mostly related to the unreachable noise target
19	Financial information	The HSR programme was estimated to cost more than 1.5 billion EUR (1.68 billion US$)
20	Donors	NASA Langley Research Centre (HSR=High Speed Research Programme), Jet Propulsion Laboratory
21	Additional information	

A3.2.2 HyperSoar

1	Project, development, concept	**Lawrence Livermore National Laboratory 'HyperSoar'**
2	Type of transport	Passenger or freight; other applications may include space launch platform, reconnaissance craft or strategic bomber
3	Transport or logistic concept	Horizontal take-off and landing vehicle
4	Type of vehicle concept	Hypersonic aircraft (one-stage system); may serve as launch platform
5	Type of propulsion system and fuel	Rocket-based combined cycle engine (=rocket&scramjet); liquid hydrogen fuel
6	Geographical scale	Long distance passenger or freight transport
7	Technical or organisational innovations	The unique skipping trajectory of the aircraft (see below) promises less structural heat-up compared to other hypersonic designs
8	Short description	Large aircraft: 65 m long, wing span 24 m, height 13.5 m, maximum take-off weight 225 tons, payload capacity 45 tons; cruise speed Mach 10; target range 10,000 km
9	Underlying problem or objective	Cost efficient and environmentally friendly long range transport
10	Place in transport system	Complementary or substituting according to task
11	Advantages for accessibility	Possibility of efficient round the world travel from international airports
12	Advantages for transport service	Extremely fast transport with operating costs about twice as high as for subsonic aircraft, but possibly generating up to 10 times the revenue
13	Environmental advantages	Emissions should be down to the level of today's subsonic commercial aircraft
14	Expected transport volume	
15	Comparable projects or developments	Several projects in concept phase (USA: Hyper-X; Russia: Raduga, Arkc; Japan: Hope-X, Hyflex; Germany: Sänger)
16	Contact	Lawrence Livermore National Laboratory, University of California, 7000 East Avenue, L-043 Livermore, CA, USA; Tel: +1/925/423-3117, E-mail: yano1@llnl.gov, Internet: www.llnl.gov
17	Partners in project	University of Maryland, Dep. of Aerospace Engineering
18	Planning of project or development	Program start in 1998 (concept phase); a 16 m long unmanned demonstrator could be developed until 2001
19	Financial information	Development costs including the scaled prototype are estimated to be about 460 million EUR (500 million US$); a full-scale aircraft would cost presumably the same as a modern wide body aircraft (like Boeing's 777) to develop
20	Donors	US Department of Energy
21	Additional information	

Key to the 'HyperSoar' concept is the idea of an aircraft horizontally taking off from a normal 3,000 m runway, accelerating – by using air-breathing engines – to Mach 10 while climbing to about 40 km altitude and there shutting down its rocket-based combined cycle engines. A skipping motion would then begin in the form of a sine-wave trajectory with peaks at 60 km and troughs at about 35 km. The rocket engines would reignite briefly at those turning points to ensure acceleration for the next skipping cycle. This wave-riding trajectory would mean that the aircraft spends much of the flight out of the Earth's atmosphere, thus avoiding critical heating of the structure. Depending on a flight's range, 'HyperSoar' would have to repeat skipping cycles, which will be about 400 km long each, thereby subjecting passengers to a moderate 1.5 times the Earth's gravity at the bottom of each skip.

The idea of periodic hypersonic cruise has been around for some 20 years, with the new 'HyperSoar' concept introducing a different approach to a couple of identified technical and conceptual problems that terminated most earlier hypersonic projects.

Though the new design seems highly credible, a lot of aspects have to be addressed before introducing a truly operational aircraft.

A3.2.3 Sänger

1	Project, development, concept	**DaimlerChrysler Aerospace 'Sänger'**
2	Type of transport	Passenger
3	Transport or logistic concept	Airport to airport service worldwide
4	Type of vehicle concept	Horizontal take-off and landing; aircraft like operation (derivative of the Mach 7 lower stage 'Sänger')
5	Type of propulsion system and fuel	Turbo jet/ramjet engines; liquid hydrogen fuel
6	Geographical scale	Global connections
7	Technical or organisational innovations	Ultra high speed at extreme altitudes
8	Short description	Large aircraft (Sänger, config. 12/92): 86.43 m long, wing span ~42 m, wing area 1,450 m², maximum take-off weight 435 tons, payload capacity 115 tons; cruise speed Mach 7; global range
9	Underlying problem or objective	Fast intercontinental or even global transport
10	Place in transport system	Complementary for long distance transport
11	Advantages for accessibility	
12	Advantages for transport service	Extremely fast transport in non-stop mode
13	Environmental advantages	Hydrogen combustion promises to be emission friendly
14	Expected transport volume	Low (niche market)
15	Comparable projects or developments	Several projects in concept phase (USA: Hyper-X, Hyper-Soar; Russia: Raduga, Arkc; Japan: Hope-X, Hyflex)
16	Contact	Dr. Heribert Kuczera c/o DaimlerChrysler Aerospace AG, PO Box 801109, 81663 Munich, Germany; Tel: +49/89/607-0, Fax: +49/89/607-26481; Internet: www.dasa.com
17	Partners in project	German aerospace industry (MBB, MTU, Dornier), DLR, several universities (DFG)
18	Planning of project or development	Technology programme start dates back to 1987; component hardware tests, in depth design studies; concept phase terminated in 1995, further research or development halted
19	Financial information	Development costs spent approx. 250 million EUR
20	Donors	BMBF (German Ministry of Education and Research)
21	Additional information	'Sänger' has been the reference concept of the so-called Hypersonic Technology Programme aiming at a reusable space transportation system; the 'Sänger' vehicle itself is the lower stage of a two stage concept, the upper stage 'Horus' being a compact space orbiter; the project was meant to continue in a wider European context

ANNEX B NEW INFRASTRUCTURE SURVEY

B1 Ground level infrastructure

B1.1 Introduction

The target of the annex ground level infrastructure is to give a short overview of existing and planned infrastructure for new means of transportation. The problem which had to be overcome in the process of collecting relevant data is, that there is mainly a very strong relationship between infrastructure and vehicle technology and therefore the infrastructure is tailor-made for existing vehicle technology. Only common transportation infrastructure like the road or, to a lower extent due to standardisation reasons, the rail network are suitable for more types of vehicles.
The special conception of the infrastructure is also strongly related to the area of application and the local circumstances. For example for application in inner city areas all types of infrastructure have in common that a main focus is laid on noise emission protection, to limit the impairments for the persons living there. Elevated structures are also simply a result of limited space availability and already existing congestion on the normal road network. If there is insufficient capacity another level has to be made available for transportation, to allow crossing free mobility for additional modes.
In the following the infrastructure is categorised and the main components are listed in a general overview. The categories are the track, which means the general feature of the infrastructure, the guidance, which keeps the vehicles on course, the propulsion, in case it is not a matter of the vehicle and the energy supply. To make this more clear a normal electrified railroad has commonly a track on the normal surface, the guidance is mechanical with dual rails, the propulsion is within the vehicle and the energy is supplied by an overhead cable.
Systems, which only consist of infrastructure like moving walkways, escalators or elevators are not dealt with in this section.

B1.2 Track

The track in this context means the substructure or base on which the specific infrastructure used for transportation is "mounted". The ground level infrastructure consists in the scope of RECONNECT of tracks on ground level and of tracks on elevated structures.
On ground level
This is the most common infrastructure. The track is installed mainly on even ground. The construction efforts and costs are low compared to the other possibilities. Examples for this group are the extensive road and rail network. These tracks can be shared with other modes (like the normal road network, or the trams) or they can be crossing free or have the right of way (like for example the heavy rail network).

Elevated (suspended or supported)
The reason for elevated structures are mainly shortages of space available on the ground level. In densely built up inner-city areas it is not possible (and also not desired) to widen streets to such extents to avoid congestion. But to give other modes the possi-

bility to pass by the congestion on roads the elevated level is used for the new infrastructure.
The vehicles can drive on top of the track (supported) or can be operated suspended hanging from the track. These tracks are crossing free and not impeded by other modes.
The track construction consists of the carriageway underbelly on which the running surface is mounted, the guideway - column juncture, the support column and the column footing.
The running surface can be constructed open or solid, the solid version is only needed for air cushion systems.
The underbelly can be constructed open or closed. The advantage of the open structure is, that natural elements like sunlight and rain may penetrate and that the weight and therefore cost of the whole construction is reduced. But on the other hand the noise generated by the vehicle is increased and hazards of falling objects occur. The underbelly also has to accommodate the electric- and communication-wiring and fulfils the requirements for utility easement, access for rescue and maintenance staff and equipment and water or snow draining systems.
For elevated structures, facilities like escalators and elevators improve the accessibility to the stations. Several systems in the United States have solved this problem by integrating the stations directly in buildings.
Another problem - not from the technical but from the traffic planner's point of view - is the fact that elevated tracks further devalue the quality of living in the lower floors by adding visual intrusion to the noise already generated by the traffic below.

B1.3 Guidance

Guidance facilities control the direction of the vehicle.
None guidance facilities
The control-facilities are exclusively within the vehicle. The best example for this is the car in combination with the normal road infrastructure. The driving and steering is only vehicle related, the vehicles must have a driver.
Electronic guidance
This sort of guidance is used in automatically operated vehicles. The position readings are originally calculated internally with distance and turn measuring systems in combination with an electronic area map. Transponders, which are passive radio frequency tags embedded in regular intervals in the surface or mounted on poles beside the track, are used by the vehicle to calibrate the position readings. These transponders are mainly used in combination with a global positioning system that uses satellites for the position determination. These systems are capable of a very accurate positioning, but the accuracy for normal application is reduced to several metres due to military reasons.
Mainly the automatic guidance is a combination of all three systems mentioned above.
Another possibility for electronic guidance is the usage of inductive facilities embedded in the ground, or - to be more flexible - laid on the ground (like the guidance-facilities used for the Serpentine system).
Mechanical guidance
Mechanical guidance consists of all sorts of "rails". "Rail" in this context is not limited to metal rails, which are used for normal railways, but also means facilities on which rubber wheeled vehicles with additional guidewheels can run. Usually the vehicles are riding on top of the rails, but monorails are also built for suspended vehicles.

Twin rails:
An example for this is the ordinary railway. Although the shapes and width of the rails are mainly standardised, in fact there is a lot of variation in dimensions and shapes between different countries and applications (heavy rail normal track with different dimensions in different countries, narrow gauge railway, tram). There are no separated load and guide wheels. Rails and wheels consist of metal.
Monorails:
The goal of inventing monorails was to cut infrastructure costs due to less expensive constructions. Monorails are not standardised and therefore built in different shapes.
Most common is a guideway beam with rectangular shape and the running surface on top on which the vehicle load tires run. The guide wheels run on the side of the guideway beam. Other systems implement to use a triangular shaped guideway beam (like the RUF-system) and special designed vehicles with a fitting shape. This has the advantage that the guide wheels also function as load wheels. Mainly vehicles with rubber wheels are used. Monorails are also suitable for applications of the magnetic levitation technology for suspension.
Other rails:
Most peoplemover systems in the United States are within this category. They use rubber wheels on mainly elevated tracks made of concrete or metal. These tracks are not standardised and have closed or open driveway surface. Mainly they have two tracks for the rubber wheels and guidewheels on both sides for side clearance or on a central guide-rail below the vehicle. If air cushioned vehicles are used, the track must have a closed surface. Air cushion systems also use guidewheels.
All rail based systems have switches for line change. Usually they have switches like normal rail. Some systems have rotary switches with less moving parts. The RUF system has no switches, but it is planned to have automatic vehicle guidance on normal road surface for the change procedure.
Cable:
The vehicles are suspended from a cable, which also can function as propulsion system. The drawback of these systems is the difficult implementation of switches.

B1.4 Propulsion

Most of the systems relate to self propelled vehicles which have their own engines on board.
Mechanical
The vehicles are cable propelled. The cables are either in permanent movement and the vehicles have to be capable of coupling and de-coupling with the cable at the stops, or the vehicles are fixed to the cable. The second version has the drawbacks that it is rather inflexible and is limited to the same distances between stops since all vehicles are moving at the same time.
Magnetic
The principal of magnetic propulsion with linear syncronous motors uses moving magnetic fields on the infrastructure and superconducting magnets on board of the vehicles.
The magnetic propulsion is very expensive and technologically sophisticated and the real advantages are to be seen in high speed operation, where ordinary propulsion has problems with the power transmission from wheel to rail.

B1.5 Energy Supply

Energy supply by the infrastructure is only possible for vehicles with electric propulsion systems.
Combustion engines of all kinds can hardly be refilled on line. Mostly the energy supply facilities are off line, like normal petrol stations or filling stations for gas. The vehicles have to have storage facilities on board.

Overhead cable / conductor rail
This is the most common form of energy supply used in all electric-railways. The vehicles pick up the electricity from the overhead cable or conductor rail with a current collector.
Inductive
Inductive energy supply works without touching parts and therefore no mechanical wear. The current-loop in the vehicle picks up the energy from the changing electromagnetic field in the ground infrastructure.

B1.6 Bibliography

SPROULE J. W./ NEUMANN E. S. / BONDADA M., Automated People Movers IV - Enhancing values in major activity centers (1993)

MAGLEV: A Physics Viewpoint - Internet Homepage.
(URL http://bmes.ece.utexas.edu)

TRANSRAPID Information - Internet Homepage.
(URL http://transrapid.simplenet.com/)

SWISSMETRO - Internet Homepage.
(URL http://sentenext1.epfl.ch/swissmetro/)

RUF Rapid Urban Flexible - Internet Homepage and information material,
(URL http://www.ruf.dk/)

SERPENTINE product information

B2 Tunnelling technologies

B2.1 Introduction

In his keynote lecture "Tunnels and Infrastructure for Metropolises: the Habitat Agenda Perspective" given at the World Tunnel Congress '98, held in Sao Paulo, Brazil, in April 1998, Mr. Kalyan Ray, Chief of the Building Infrastructure and Technology Section, Research and Development Division, United Nations Centre for Human Settlements (Habitat) pointed out among others (Ray, 1998):

"The rapid growth of urban mobility is also a cause of major concern. It is contributing to severe congestion, air pollution and claims a large share of energy consumption in our cities. The Global Plan of Action outlines a wide range of measures to make urban transport more efficient, less polluting and affordable to all.

Mass public transportation modes provide the best option for urban mobility and can reduce the growing dependence on automobiles. However, surface transport will find increasing difficult to cope with the exponential growth of urban passenger trips in the coming decades. One major constraint will be the availability of land. Underground mass rapid transit will increasingly be considered in such situations.

The reasons why underground mass rapid transit hat not found wider use yet in our cities is, principally, one of high initial cost of putting such a system in place especially in development country cities. Current financial viability studies, however, take little account of the huge social costs and environmental externalities of surface mobility and total life-cycle costs. The result is that current investments decisions are heavily skewed towards surface transport.

International associations (such as ITA and PIARC) can play an important role in disseminating the true social and environmental benefits of underground transport modes, and in advancing the economic rationale for adopting life-cycle costing in evaluating such investments."

Generally speaking, there are no technological limitations on underground construction, but in most cases the aboveground option is the easiest way to execute a project technically, financially and administratively alike. There must, therefore, be clear motives for choosing the underground option on the basis of its specific advantages. In that respect, various actors or groupings will have various motives (table B2.1, Edelenbos, et.al., 1998).

Table B2.1 Motives for underground construction, relevance per grouping

	(Category of) motive forced	Largely relevant for (groupings)
1.	Underground construction as the only realistic alternative	Users, investors/operators, community/society
2.	Greater functionality	Users, investors/operators
3.	Shelter from 'outside'	Users, investors/operators
4.	Energy saving	Investors/operators, community/society
5.	Durability and maintenance	Investors/operators, community/society
6.	Higher building densities	Investors/operators, neighbourhood residents/workers, community/society
7.	Better accessibility/ reduced barrier effect	Users, neighbourhood residents/workers
8.	Multiple/efficient land use	Investors/operators, neighbourhood residents/workers, community/society
9.	Combinations with other facilities	Users, investors/operators

10. 'Ugly' things underground	Investors/operators, neighbourhood residents/workers
11. Reduced impact on surroundings	Investors/operators, neighbourhood residents/workers
12. Reduced environmental impact	Community/society
13. Preservation of valuable functions	Neighbourhood residents/workers, community/society
14. Increased external safety	Neighbourhood residents/workers, community/society
15. Economy and exports	Investors/operators, community/society

Working groups of International Tunnelling Association are active in defining the advantages of using underground space especially for transport systems (e.g. Godard/ Sterling, 1995):

Factors Relating to the Considered Structure

The following conditions relate to the integration of the structure into its environment:

- Natural obstacles (mountains, isolated geographical relief features, water courses and straits).
- Topography.
- Obstruction or congestion of surface space.
- Building conditions.

The following conditions relate to protection that the structure offers against hostile elements of the environment:

- Climatic conditions: temperature level and variation, and adverse weather conditions.
- Natural risks: earthquakes, landslides and floods.
- Attacks, terrorism and sabotage.
- Acts of war.

The following factors relate to the quality of services provided for users:

- The location of the structure.
- Accessibility of the structure.
- The environmental conditions within the structure, e.g. hygiene, comfort, attractiveness.
- Personal safety within the structure.

The following factors relate to construction costs:

- Land acquisition costs.
- The construction and additional works costs incurred in clearing rights of way to the structure.
- Any returns from the sale of materials or natural resources extracted from the ground in the construction phase.

The following factors relate to operating costs:

- Staff.
- Energy.
- Maintenance.
- Insurance.

Factors Related to the External Effects Generated by the Building and Operation of the Structure

The external effects generated by the structure are the overall consequences – whether favourable or unfavourable – that the building and operation of the structure inflict on the other parties in close proximity to it.
Identifying the following factors and taking them into account is of the utmost importance, because they are usually the cause of either opposition to the building of the structure; or, on the contrary, encouragement or even pressure to build it.

The following factors relate to nuisance caused by the structure:

- Noise and vibrations.
- Visual impact.
- Isolation and separation of communities.

The following factors relate to risks to the surrounding area:

- During the construction phase, risks to the stability of the neighbouring structures.
- Risks in the operational phase, due to the dangerous nature of:
- the type of activities carried out within the structure; or
- the nature of the products held within the structure (e.g., toxic waste, radioactive waste).

The following factors relate to the impact on the natural environment:

- Air pollution.
- Water pollution.
- Toxic waste pollution.
- Impact on natural landscapes.

The following factors relate to town and country planning (local, regional and national):

- Occupation of surface space.
- Dividing up of space among various uses (particularly in an urban area).

The following factors relate to the social costs of the structure:

- External economies and expenditures: financial consequences (whether positive or negative) on the other parties or economic players (whether individual or corporate).
- External costs financed by the community.

The following factor relates to the economic defense for building a structure:

- The possibility of creating various strategic energy reserves (hydrocarbons, gas), and reserves of primary resources and foodstuffs.

The following factors relate to civil protection:

- Protection against natural risks: earthquakes, landslides and floods.
- Protection against major technological risks: explosions, the effects of blasts, radiation, radioactive fall out, thermal effects.
- Protection against attack, terrorism and sabotage.

When assessing these factors, different parties have to be taken into account.

- Parties who are directly involved with the considered structure, i.e.:
  - The owner;
  - The users of the facility or services provided;
  - The operating company;
  - The employees of the operating company;
  - The institutional and political bodies that have a functional and/or territorial responsibility with regard to the structure under consideration.
- Various parties involved directly or indirectly with the consequences (the "effects") of the creation of the structure, throughout its operating life (building, operation and maintenance). This category consists of the parties concerned with the neighbouring activities or structures (whether already in existence or planned for the future), and with the natural environment.
  - The owners of neighbouring structures and of planned structures and facilities;
  - The users of the neighbouring structures and the "users" of the natural environment;
  - The companies operating neighbouring structures;
  - The employees of the companies operating such structures;
  - The institutional and political organisations that have a functional and/or territorial responsibility for neighbouring structures and for the natural environment.

But it must be seen, that the use of underground space suffers from some – potential – impediments as listed in table B2.2 (Edelenbos et.al., 1998).

Table B2.2 Summary of potential impediments to underground construction

Impediments	Nuances / Possible Solutions
I. Costs	
• Underground construction is relatively expensive	• An objective cost comparison of above-ground options must include not only the "standard" construction costs but also those costs and benefits that are less easily expressed in monetary terms (e.g. multiple land use, form of nuisance, physical lifetime); these must be assessed in relation to the financial investments • In underground construction procedures, specific cost optimization is possible (e.g. with regard to tunnel diameters and multidisciplinary and integrated design)
II. Perception aspects	
• Negative associations with underground spaces in general • Realistic senses of lack of safety and orientation	• Measures relating to layout, design, safety and ventilation can exert a positive effect on perceptions. • The functionality of the underground location of a facility must be clear to the user
III. Uncertainties with regard to application of technology, safety and use aspects	
• Unfamiliarity with certain construction methods (e.g., tunnel boring) may lead to overestimation of risks and costs, or precisely the underestimation of risks. • There is uncertainty as to safety standards to be imposed for underground spaces. • An underground space is inflexible; enlargement involves engineering problems • Maintenance and management of underground facilities is more difficult.	• Hands-on experience can improve familiarity with new techniques • Development of a clear-cut safeguarding vision has been initiated with regard to safety standards • A long-term vision can increase the economic and societal value of an underground facility • Specific inspection techniques are available for underground facilities
IV. Nuisance and damage during and after construction	
• Noise and vibration are potential sources of nuisance during construction • The realization of underground construction can easily cause settlement and subsidence • Construction work can create a traffic nuisance and reduce the accessibility of buildings and areas	• Technical measures (insulation, damping etc.) can reduce vibration • Engineering measures can be taken where subsidence of the ground level is unacceptable • Application of trenchless techniques and tunnel boring methods enables substantial reduction of nuisance effects at ground level. • Damage to underground facilities caused by other excavation or construction operations can be partly prevented by means of appropriate records in the land register
V. Geo-conditions	
• The soil survey does not generally give a totally reliable picture of the physical geo-conditions.	• The soil survey should be performed in an optimized way • Good preparation enables rapid and effective action to be taken if unexpected soil conditions and objects are encountered.

B2.2 Volume of underground structures

The volume of underground structures for transport systems is – generally speaking – directly related to the capacity of the system. The dimensions of the vehicle cross-section determine the dimensions of the necessary tunnel cross-section. Further factors are for example the emergency-concept (emergency walkway along the track yes or no), the maximum speed of vehicles in the tunnel (air resistance).

Table B2.3 Dimensions of the internal cross-section of route tunnels for some existing and proposed urban and high speed transport systems

	Single track circular tunnel		Double track box shaped tunnel	
	diameter m	cross-section m²	width x height m x m	cross-section m²
URBAN				
Metro				
Hamburg	5.04	~ 20	7.30 x 4.20	30.66
Munich	5.53	~ 24	7.60 x 4.90	37.24
Paris, Meteor	7.50 [1)]	~ 44 [1)]		
VAL	4.40	~ 15	6.10 x 4.05	24.71
Dorfbahn Serfaus	3.24 x 3.52 [2)]	11.40 [2)]		
Small Metro (proposal)	3.60	~ 10		
HIGH SPEED				
German Railways				~ 100 [3)]
Swissmetro (proposal)	5.00	~ 20		
Eurotunnel (proposal)	7.40	~ 43		

1) double track tunnel
2) single track tunnel, box shaped
3) horseshoe shaped cross-section

Table B2.3 shows some typical data of the internal cross-section of route tunnels for some existing and proposed urban and high speed transport systems. Tunnelling costs for route tunnels are closely related to the m² cross section of the tunnel and it is obvious that systems with smaller vehicles – and lower capacity – produce lower cost for route tunnels due to a smaller cross section.
Regarding underground stations there are similar relationships and dependencies. Systems with a smaller capacity (small vehicles, short trains) need shorter and less wide platforms than high capacity systems. Usual platform lengths for a metro system are between 80 m and 120 m, platforms for regional railways (RER in Paris, S-Bahn in Germany) are 160 m to 200 m long. Compared to this the VAL-System in Lille has platforms with a length of 26 m which can be extended to 52 m in the future if the demand requires it. The stations have already 52 m long platforms but these are not fully equipped.
Entrances and exits to and from underground stations have to be dimensioned according to the capacity of the system and the needs to integrate the station into the traffic infrastructure at surface level.
So called micro-tunnels which are used for transport of goods (common: liquids and gas; new proposals: suspensions, transport of units) can have a diameter of 0.8 m to 3.0 m.

B2.3 Cost of tunnelling

As mentioned above, the use of underground space may be hindered due to the high cost of the construction of running tunnels, stations and the like. But if for example some of the above mentioned benefits are taken into account and monetarised, it can be shown, that the cost advantage of a surface or above ground solution is reduced (table B2.4, Edelenbos et.al., 1998).

Table B2.4 Case study of underground options for construction of an extremely busy railway track passing straight through the city of Delft

	Viaduct	Tunnel (open trench)	Tunnel (TBM method)
Construction costs	308	494	536
Land / demolition / damage	122	146	37
Sub-item 1: Direct costs	430 (100 %)	640 (148 %)	573 (133 %)
Maintenance and operation	31	64	47
Sub-item 2: Life-cycle cost	461 (100 %)	704 (152 %)	620 (134 %)
Nuisance (monetarised)	133	168	5
Sub-item 3: Total costs incl. nuisance	594 (100 %)	872 (147 %)	625 (105 %)

The cost for underground structures are influenced by various factors:

- ground and groundwater conditions (soft ground / rock, homogeneity of ground, level and aggressiveness of ground water)
- topography (mountains, rivers, straits to overcome)
- situation at the surface level (buildings, roads, green areas)
- situation underground (deep foundations of buildings, other transport systems, underground car parks, sewers, cables, pipes)
- volume of the underground facilities (diameter of running tunnels, dimensions of stations)
- requirements regarding equipment and installations in running tunnels and stations (vibration damping track bed, electric / electronic installations, safety installations, fire protection, elevators / escalators, architecture)
- planning, design, construction (political influence; size of construction lots, construction techniques)
- environmental restraints (avoidance of dust, noise, vibration during the construction phase, muck disposal, handling of ground water)

An example for the influence of the tunnel cross section on the construction cost for a bored tunnel is shown in table B2.5 (Edelenbos et.al., 1998).

Table B2.5: The influence of diameter on the cost of bored tunnels (indicative)

Diameter of tunnel cross section (m)	Percentage cost
12.0	114 %
10.0	100 %
7.5	63 %
6.0	50 %
4.5	38 %

The cost for the underground infrastructure including all side costs (land acquisition, dislocation of pipes and sewers etc) are in a range of 70 % to 80 % of the cost for a complete underground urban railway system. This leads to the conclusion that new modes of transport which are installed underground need a reduction of tunnelling cost independent of the kind of the technology of the system (propulsion, levitation, automatic operation etc), to promote the chance of an extensive application.

B2.4 Potential to cut costs of tunnel construction

A key issue of many proposals of new modes of transport is the more intensive use of the underground space. Irrespective of the kind of vehicle, its propulsion and levitation system etc, the main problems are the high cost and the long construction times of running tunnels, underground stations and other necessary underground facilities. The potential of new modes of transport could be enhanced, if underground construction could be made cheaper and/or faster without higher risk or a reduction in safety.
(Remark: The following text deals with underground methods of tunnel driving only. The construction of a tunnel from the surface with the so called cut-and-cover method (digging a trench, tunnel construction, filling the trench and covering the tunnel) and its variations are not subject of the reflections. These methods can hardly be used today in densely settled areas due to their impairment of the surroundings. It can not be used to cross mountains or rivers.
There can be given only a very rough picture of tunnelling technology within the framework of this study. Due to the diversity of the ground conditions and local needs there exists a great variety of methods and technologies.)

Ground exploration
The knowledge of the ground conditions under which a tunnel has to be driven is essential for the technical and financial success of a project. In urban areas the information about the ground is very often quite sufficient down to a certain depth from earlier activities of underground construction. But accidents like in London-Heathrow and Munich show, that there is still exists a potential of risks. Problems may occur at greater depths or when straits and rivers have to be undercrossed or mountains to be penetrated.
Ground conditions for a tunnel project are usually investigated in advance form the ground surface to decide upon the method and machines for excavation, the design of the tunnel lining, the necessary system for waterproofing etc. In any case this can only give a local and therefore limited knowledge or the geological and hydrogeological situation. Methods which additionally allow to survey a larger area like seismic exploration may overcome these disadvantages to a certain extent. That is why in some cases of difficult ground conditions a pilot tunnel is driven to get a complete picture of the geological situation.
Especially for tunnel drives with high overburdens or deep under the sea, where ground examination from the surface is difficult and costly, the pre exploration of ground conditions from the tunnel face becomes important. The aim is to get as early as possible reliable information of what has to be expected in front of the tunnelling machine. The data gained should allow a geological interpretation to draw conclusions for necessary reactions e.g. grouting in weak zones.
The use of pilot bores from the tunnel face has become quite usual. This includes e.g. boreholes of up to several hundred m length along the tunnel axis or fan-shaped borings around the tunnel face. Sometimes this pilot boring is not only used to investigate the ground conditions but also for improvement of the ground by grouting. If a complete

pilot heading is driven over the whole length of the tunnel, it is in some cases also used for the mucking procedure.
In difficult ground conditions these "conventional" methods can not always be used e.g. if the tunnel face is not accessible. New developments include the application of geophysical methods like seismic waves, sound waves, georadar, tomography panels, microgravimetry. Tests are made with seismic waves in rock tunnels like the Vereina tunnel in Switzerland. In other cases, directly behind the bore head, the rock is analysed by geomapping and deformation measurement to determine, whether additional reinforcement in form of bolting or shotcrete is required. In Japan a system has been developed recently, which uses a combination of sound waves and Rayleigh waves to detect obstacles, caves or strata boundaries. Tests with geotechnical methods of ground exploration are carried out in Germany in connection with the construction of the new 4th tube for the River Elbe Tunnel in Hamburg.

Tunnel Driving
Tunnels in greater depths, under densely occupied urban areas and/or longer stretches are excavated with Tunnel-Boring-Machines (TBM) or by means of shotcrete construction methods. In both cases the knowledge of the ground and groundwater conditions is essential for the right choice of the tunnel driving method and it's success. A challenge for the future are TBM's which can cope within a certain range with changing ground conditions along a tunnel bore.
In hard rock tunnelling either TBM's are used as well or the tunnel is excavated with the bore-and-blast-method. Both methods have their range of successful application, but there exist some disadvantages (wear of tools at TBM's, dangerous fumes from blasting, slow progress in hard rock etc).This led to a boom in research and development especially in the USA in the 60ies to find new methods of rock fragmentation, with the aim of cost reduction and acceleration of tunnel excavation. A lot of methods have been studied like e.g. flame-jets, oxygen-torches, plasma-arc, laser, microwaves, chemicals and high-speed-water-jets. Test – mainly in laboratories – showed, that breakage and fragmentation of rock was possible with many methods in principle, but an application in practical tunnelling work is not known up to now. It must be open to future developments if one or several of these methods find their place in tunnel construction.
In tunnel driving usually different working steps are necessary and have to be executed simultaneously, like ground excavation, transport of the debris, installation of a tunnel lining, water-proofing, ground improvement etc. Mechanization or even automation of different work steps can help to make the difficult tasks more human and to improve the performance of tunnel construction.
In driving tunnels with a small diameter (down to 0.8 m: microtunnels in which it is not possible for men to work) some progress has already achieved: it is possible to drive the tunnel with machines which are operated by remote control from the surface.
If deep rivers, fjords or straits have to be crossed, driving a tunnel through the ground under the water becomes technically difficult and expensive. Proposals have been made and studies are on the way to use the concept of the Submerged Floating Tunnel (Ferro, 1997). It is basically a tube-like structure floating at some depth in the water, where the tube is large enough to accommodate road and/or guided traffic. As with any structure floating in water, it must be moored or fixed against excess movements by column support, tension legs or pontoons. There have been several proposals to use this concept since several years. It sounds promising, but further research is necessary (Ferro 1997).

Mucking

For long tunnel stretches with a high volume of excavated material the transport and deposit of the muck may cause severe problems. Under favourable conditions it is possible to use the debris directly for the production of the concrete for the tunnel lining. But usually the muck has to be transported over long distances to a suitable landfill. In this connection techniques and logistics should be used which minimize the negative impact on the environment.

Tunnel Lining

The tunnel lining is generally designed mainly due to geological considerations. In weak rock and soft ground the main aim is to support the ground as soon as possible to avoid ground movement and settlements to the greatest possible extent. Another aspect is e.g. the smallest number of operations to be carried for to the installation of the lining in the critical construction cycle.

For bored tunnels in weak rock or soft ground, where lining is essential, two main possibilities exist:

- a lining made of elements (precast concrete elements, cast iron elements) which are bolted together to form a continuous tube. The elements are mounted within the tail of the shield of the tunnelling machine. The annulus between the outside of the lining and the excavated profile has to be grouted. With gaskets in the joints it is possible to provide high levels of water tightness which makes a secondary inner lining unnecessary.

  This kind of lining has been used worldwide in numerous tunnel drives. New developments and improvements are on the way.
- Linings which have to be bolted and grouted may limit the performance and advance rates of modern tunnelling machines. A major step towards high speed tunnelling was the development of an expanded lining for cohesive soils in the 1950ies in Great Britain. Bolting and grouting were eliminated. This enabled the full potential of TBM's to be appreciated and allowed their further development.

  Expandable linings are formed by precast concrete elements. The final element of a ring is wedgeshaped and used to expand the ring against the excavated profile.

  Expandable linings have been used during the last 30 years in a number of contracts for water supply tunnels in London. Furthermore some 30 km of tunnels for the London Underground have been lined with this system.

  A most recent case is the Channel Tunnel between England and France, where on the English side in Chalk Marl formations, a weak rock with a very low permeability, open faced TBM's were used with expanded grouted linings without gaskets.

It is obvious, that the applicability of the different techniques is among other things due to the hydrogeological characteristics of the ground and the requirements regarding the level of water tightness aimed at. As the flexible expanded lining can not be made fully watertight, this type of lining does not need to be designed for carrying the full hydrostatic surrounding water pressure and can therefore be made thinner than a watertight lining.

New developments aim at new materials for prefabricated lining elements like steel fibre reinforced concrete instead of bar reinforcement. For tunnels under water the design of the joints and their watertightness is essential for the serviceability of the whole infrastructure.

In tunnels which are driven by other underground methods in a – at least for a certain time – stable ground, a first lining is usually sprayed with shotcrete. If necessary a waterproofing membrane is fixed and then an inner lining is poured in formwork with in situ concrete. A potential of cost reduction could be seen in new methods of waterproofing single shell tunnel linings as well as the optimization of the principle and execution of single shell in situ concrete linings.

For tunnels with a small diameter (0.8 m – 3.0 m: microtunnels) the so called pipe-jacking-method is widely used in suitable ground. The ground is dug out with an appropriate boring machine and directly behind it pipe-sections with the necessary diameter and with a length of 5 to 6 m are pressed into the ground to form the final lining of the tunnel.

Standardization of Dimensions

Up to now, metros in different cities usually have different tunnel cross-sections. This results in the fact, that e.g. Tunnel Boring Machines can not be used for construction lots in different cities.

If new modes of transport whether for passengers or for goods shall find a wide-spread application in the future it would be cost-effective, if the most important dimensions would be standardized.

B2.5 Bibliography

RAY, K.: Tunnels and Infrastructure for Metropolises: The Habitat Agenda Perspective; Tunnelling and Underground Space Technology, 13 (1998) No. 3, pp. 313-315

EDELENBOS, J. / MONNIKHOF, R. / HAASNOOT, J. / van der HOEVEN, F. / HORVAT, E. / van der KROGT, R.: Strategic Study on the Utilization of Underground Space in the Netherlands; Tunnelling and Underground Space Technology, 13 (1998) No. 2, pp. 159-165

GODARD, J.-P. / STERLING, R.L.: General Considerations in Assessing the Advantages of Using Underground Space (ITA Working Group No. 13, " Direct and Indirect Advantages of Underground Structures"); Tunnelling and Underground Space Technology 10 (1995) No. 3, pp. 287-297

MONNIKHOF, R. / EDELENBOS, J. / van der KROGT, R.: How to Determine the Necessity for Using Underground Space: an integral assessment method for strategic decision-making; Tunnelling and Underground Space Technology 13 (1998) No. 2 pp. 167-172

FERRO, G.: Analysis of the Submerged Floating Tunnel Concept; Tunnels et Ouvrages Souterrains, No 139, Jan./Fev. 1997, pp.53-63

B3 Air transport infrastructure

B3.1 Introduction

Aviation has been for a couple of years among the fastest growing transport sectors worldwide with substantial growth especially in densely populated Europe. The largest part of this development was and still is related to inner European passenger transport over relatively short distances, producing severe congestion within air space and putting strains on existing ground infrastructure.
Airports face increasing slot problems due to the use of more smaller regional and narrow body jet aircraft and the fact that terminals are not capable of handling additional passenger volume.
Looking at air transport means reported in this study, the general question has to be whether new modes would

- be able to use existing airport infrastructure, thereby not adding congestion on the airside, or
- could be independent from current aviation networks without the need for extensive infrastructure.

Considering the basically different requirements regarding take-off and landing sites for airships (vertical lift-off and landing) and hypersonic airplanes (horizontal take-off and landing), separate information will be given on each of the two classes.

B3.2 Airship infrastructure

All types of lighter-than-air craft do not require extensive runway and taxiway systems because of their vertical take-off and landing capability.
Depending on the transport mode – passenger or freight – take-off and landing sites may be located

- near to or even in cities, providing connection to other ground or underground transport infrastructure (interconnectivity), preferably to public transport,
- at tourist attractions in remote areas resp. at recreational sites, or
- at small to medium size airfields not in use by commercial or general aviation, e.g. abandoned military airfields with sound landside infrastructure and connections.

B3.2.1 Principal ground infrastructure

Typical components of airside infrastructure for airships have to include

- mooring stations, normally in the form of mooring masts, optionally with attached terminal platforms for passenger and cargo handling, refuelling, crew boarding, supply, catering etc.,
- mooring platforms, i.e. circular areas with the center mooring mast, providing sufficient clearance for departing or arriving airships (independent of the wind direction), thus slightly exceeding by radius the airship's total length,
- hangars at home base for maintenance of airship and weather protection, and
- landing systems including wind measuring equipment, radio communication systems, radar guided approach controls etc. and a ground crew supporting the landing procedure.

Assuming that every larger airship – whether semi-rigid or rigid – will require a home-base (‘airship-port’ was the consistent phrase of the zeppelin era!), used for maintenance and protection against changing weather conditions, infrastructure requirements should be specified according to the typical range of vehicles, the operational mode resp. the logistic concept.

Airships operating in short to medium range (regular) passenger service would of course require one hangar location, with all other destinations just supplied with minimum infrastructure like a mooring mast and compact terminal facilities, which should be assigned to handle passenger luggage and limited amounts of extra cargo.
All landing sites should be capable of handling refuelling, catering and small maintenance, however exceptions might be acceptable within a dense inter urban network of destinations.
For long range passenger transport by airship, it seems inevitable that complete ground infrastructure, including a hangar if appropriate according to weather conditions, has to be available at all destinations.

Shipping of heavy and especially bulky cargo will presumably require a different logistic approach. For large freight airships a viable niche market could become point-to-point delivery of bulky and heavy loads e.g. to remote regions without sufficient surface or maritime infrastructure.
To benefit from this logistic approach, minimum requirements for loading and unloading sites will be essential, presuming a cargo ship would operate within a network of home bases fit to the craft’s operational range.
One recent detailed proposal introduces the concept of a flying crane, capable of lifting up cargo containers or assembled heavy industry equipment on the site of e.g. a plant manufacturer, with the airship remaining airborne during the loading/unloading procedure. A special cargo frame will be lowered using four ropes of the crane, which has in advance anchored, putting special hooks to the ground. (The design of all necessary fixing components is derived from anchoring devices used for large cranes.) The airship is allowed for some horizontal movement during loading to compensate for gusty winds on the site. In addition ballast (water) has to be kept ready while unloading, due to the fact that the amount of lift stays constant and has to be levelled. (This is, in fact, a problem facing all airships with a large payload capacity.)

B3.2.2 Infrastructure innovations

Originally landing and take-off by rigid zeppelins back in the 1920s was performed using tall mooring masts, which allowed for an easy anchoring procedure, but left the airship in relatively unstable condition especially if exposed to strong gusty winds. The later used short mooring masts made anchoring itself more difficult and still required a large ground crew, but the airship could in addition to the mast be attached to the mooring platform, so embarking or disembarking the craft was easier and safer to handle.
A symbiosis of both systems offers to be the variable or retractable mooring mast. This configuration will initially work as a tall mast providing a save anchoring manoeuvre, then being lowered down or retracted to the mooring platform resp. the terminal. The adjustable height of a mooring mast could as well help to adopt to different sizes of airships and allow landing at relatively strong and adverse winds. Part of such a variable mast should be a (semi-)automatic clutch mechanism ensuring the airship being securely fixed to it, thus requiring a minimum ground crew or even none. With the general handling of airships improved, semi-automatic mooring manoeuvres will presumably become possible.

Mooring masts can in principle be accommodated to classic ground mooring platforms (short masts), on top of buildings like railway stations or skyscrapers (tall masts), or as integral part of floating platforms deployed at inshore waters.
Whether a mast is to be fixed to a singular position or movable (on rails or wheels) should be considered according to principle landing site requirements and the varying size of airships in service.
To summarize this aspect, an interaction of enhanced manoeuvrability of the airship itself (e.g. by introducing tilting engines) and properly designed anchoring devices could contribute to a significant cut in operating costs, mainly related to smaller ground crews.

The most cost sensitive part of airship infrastructure will indeed remain the hangar, used at home bases for maintenance or as a combination of construction and repair shipyard. Various designs of airship hangars have proven their feasibility since the beginning of the twentieth century, so construction of such large buildings cannot be considered a completely new challenge. (Several, still existing sites e.g. in Akron, Ohio/USA or Cardington, UK display the maturity of this type of construction.)
However, remarkable improvements in construction technology will make it possible to assemble standardized hangars by using pre-fabricated components. Double or twin hangars – accommodating two large airships side by side – should be considered an option for larger home bases.
Under specific circumstances even floating hangars can be imagined, thus providing optimum adaptation to changing wind directions. (Historically, those floating hangars have proven very effective when used by early zeppelins on Lake Constanze, Ger.).

All in addition required ground infrastructure like refuelling systems, fresh water and ballast supply, catering or luggage handling units, should be derived from standardized systems of conventional airports, thereby avoiding time and budget consuming certification processes.

B3.3 Hypersonic transport infrastructure

Mandatory to all future advanced supersonic and hypersonic transport concepts will be the use of existing airports, considering that separate airport infrastructure for a single niche product cannot be a serious issue.
With respect to the envisaged range and the very speed of hypersonic vehicles, the place within existing air transport modes will be in interconnection at established international hubs.
All service in the long range subsonic transport sector requires typical airside ground infrastructure. Specifications for the design of runways, taxiways, holding and apron for hypersonic aircraft should, at least, refer to recommendations on next generation megaliners (A3XX etc.):

- a runway supplying a length of 3600 to 4000 metres (depending on the airports altitude) with a standardized width of 45 to 60 metres,
- a taxiway system accommodated to large aircraft (turn fillet requirements) and
- a ‘ground box’ of 80 x 80 metres for the apron parking position.

Due to the aerodynamic design requirements for hypersonic flight, the fuselage’s overall length might slightly exceed 80 metres.
To arrange with existing airport terminal infrastructure, e.g. passenger loading bridges, the sill height should be comparable to wide body aircraft, to allow for competitive turn-around times.

All existing principle supply systems at the apron should be suitable for hypersonic aircraft, except for the fuelling system. The most likely propulsion system will be air-breathing ramjet or scramjet engines, thus requiring liquid, cooled hydrogen as fuel. As long as specially accommodated apron sections are not available, it is assumed that refuelling takes place on dedicated areas in between apron and taxiways. (A similar procedure is still common for aircraft de-icing on most airports.) The technology for supplying liquid hydrogen can be obtained from industry standards and is not considered to be an obstacle.
When using existing airport infrastructure the compliance of a hypersonic aircraft with implemented noise and emission regulations is regarded as essential, to avoid delayed service entry as experienced with first generation supersonic passenger planes. However, structural heating during hypersonic flight might contribute to significant operational problems, if passengers wouldn't be allowed to disembark immediately after arrival. Together with the need for a complete check of the aircraft after each flight, ground handling time and routine expenditures might possibly turn out to be a huge problem.

To summarize, hypersonic transport concepts may stick to already defined airport infrastructure requirements and operational limitations resp. certifications, except for the specific fuel supply – without producing new demand.

B3.4 Bibliography

AERO INTERNATIONAL (1997-99): Several volumes.

AIR&COSMOS/Aviation Magazine International (1998-99): Several volumes.

A.N.A.E. (L'Académie Nationale de l'Air et de l'Espace, 1990): Proceedings of the European symposium on future supersonic/hypersonic transportation systems.

ARCHBOLD, Rick and MARSHALL, Ken (1994): Hindenburg. An illustrated history (German edition, 1997: Luftschiff Hindenburg und die grosse Zeit der Zeppeline)

AVIATION WEEK & Space Technology (1998-99): Several volumes.

AVIATION WEEK & Space Technology: Aerospace Source Book 1999 (Vol. 150).

CARGOLIFTER AG (1998-99): Internet homepage. (Invest, concept, technology, model, media)
(URL http://www.cargolifter.com)

DELFT University of Technology (1995): Delft Outlook 94.3 - Ancient but safe technology revives supposedly long dead competitor.
(URL http://www.bu.tudelft.nl./diec/outlook/94_3/h1.htm)

FAG (Flughafen Frankfurt/Main AG, 1995): Vision 2000 plus (Masterplan 1995). History of masterplan 1938.

FLIGHT INTERNATIONAL (1997-99): Several volumes.

FLUG REVUE (1998-99): Several volumes.
(URL http://www.flug-revue.rotor.com)

LLNL (Lawrence Livermore National Laboratory, 1998): Internet homepage.
(URL http://www.llnl.gov)

RAD N.V. (Rigid Airship Design N.V., 1999): Internet homepage. (Company profile, the business concept, benefits, markets, 1st airship, FAQs, press page, history)
(URL http://www.rigidair.com; http://www.tradezone.com/tradesites/rigid.html)

SCIENCE NEWS (Science News Online, 1998): Internet homepage.
(URL http://www.sciencenews.org/sn_arc98/9_19_98/Fob5.htm)

STORM, Martje G.A. and PEETERS, Paul M. (1996): Revival of the airship?

ZLT (Zeppelin Luftschifftechnik GmbH, 1997-99): Zeppelin NT – product information brochure; internet homepage. (FAQ, gallery, company, descriptions)
(URL http://www.zeppelin-nt.com)

Supplement A: **Rigid and semi-rigid airships**

Manufacturer, designer	Model	Type	Length [m]	Width/ diameter [m]	Height [m]	Volume [m³]	Cruise speed [km/h]	Max. speed [km/h]	max. gross weight / MTOW [kg]	max. payload [kg]	Powerplant [kW]	Range (@MTOW) [km]	Remarks
CargoLifter AG	CL 160 (P1)	s-r	260.00	∅ 65.00	82.00	550,000	80-100	135	450,000	160,000	6x1555	10,000	heavy, bulky transport
The Hamilton Airship Company	HA 160-TA	r	160.00	24.00	27.20	55,000	90	145	46,000	20,000	1x588+2x93	10,000	passenger and freight transport
Rigid Airship Design N.V.	NL-1 'Holland Navigator'	r	180.00	∅ 30.00	n/a	83,100	148	n/a	n/a	35,000	6x441	20,000	passenger and freight transport
Russian Aeronautical Systems Ltd.	PD-160	s-r	36.10	∅ 9.37	12.00	1,600	60	100	1,500	460	1x74	1,200	surveillance, patrol
	MD-900	s-r	60.00	∅ 17.10	22.00	9,050	100	130	8,630	3,170	2x275+1x37	3,000	passenger&cargo transport
	DPD-5000	s-r	126.80	∅ 28.20	32.00	50,150	110	150	43,200	15,200	2x1522+1x88	8,700	surveillance, transport
Worldwide Aeros Corporation	Aeros D-1	r	84.00	n/a	n/a	27,500	n/a	280	n/a	12,700	n/a	n/a	passenger&cargo transport
	Aeros D-4	r	168.00	n/a	n/a	222,000	n/a	280	n/a	127,000	n/a	n/a	passenger and freight transport
	Aeros D-8 *	r	297.50	n/a	n/a	1,125,000	n/a	218	n/a	750,000	n/a	n/a	heavy transport

Supplement A: **Rigid and semi-rigid airships**

Manufacturer, designer	Model	Type	Length [m]	Width/ diameter [m]	Height [m]	Volume [m³]	Cruise speed [km/h]	Max. speed [km/h]	max. gross weight / MTOW [kg]	max. payload [kg]	Powerplant [kW]	Range (@MTOW) [km]	Remarks
Zeppelin Luftschiff-technik GmbH	LZ N07	(s-)r	75.00	19.50 / ∅ 14.20	17.20	8,225	84-115	130	8,040 (VTOL) 8,340 (STOL)	1,850	3x147	900 (770)	surveillance, science, tourism, advertising
	LZ N17 *	(s-)r	91.00	∅ 18.90	n/a	17,000	115	140	17,000	5,500	3x294	n/a	surveillance, science, tourism, advertising
	LZ N30 *	(s-)r	110.00	∅ 22.50	n/a	30,000	125	140	30,000	15,000	3x515	n/a	surveillance, science, tourism, advertising

Note. * Project in early concept phase r = rigid airship, s-r = semi-rigid airship

Manufacturer, designer	Model	Type	Length [m]	Width/ diameter [m]	Height [m]	Volume [m³]	Cruise speed [km/h]	Max. speed [km/h]	max. gross weight / MTOW [kg]	max. payload [kg]	Powerplant [kW]	Range (@MTOW) [km]	Remarks
For comparison **Zeppelin-Gesellschaft**	LZ 129 'Hindenburg'	r	245.06	∅ 41.15	n/a	200,000	110	130	~210,000	~15,000	4x772	15,000	in service since 1936; largest airships ever flown (LZ 129; sister ship LZ 130 never entered regular service)

Supplement B: **Non-rigid airships (> 1 t MTOW)**

Manufacturer, designer	Model	Type	Length [m]	Width/ diameter [m]	Height [m]	Volume [m^3]	Cruise speed [km/h]	Max. speed [km/h]	Max. gross weight / MTOW [kg]	max. payload [kg]	Powerplant [kW]	Range (@MTOW) [km]	Remarks
Airship Technologies	AT-04 *	n	82.11	∅ 17.89	21.61	14,200	115	155	14,000	1,500	3x331	n/a	passenger transport, surveillance
American Blimp Corporation	A-60+ (S 19)	n	39.62	∅ 10.06	13.41	1,926	n/a	85	n/a	545	2x50	965	advertising, promotion
	A-100 (S 31) *	n	46.00	n/a	n/a	3,100	n/a	130	n/a	n/a	2x132	n/a	advertising, promotion
	A-130 (S 36)	n	48.16	∅ 12.50	n/a	3,600	n/a	105	n/a	1,180	2x132	1,045	advertising, promotion
	A-150 (S 42)	n	50.29	∅ 13.11	16.76	4,248	74	105	n/a	1,635	2x132	990	advertising, promotion
	A-170 (S 48)	n	52.43	∅ 13.72	n/a	4,800	n/a	105	n/a	2,110	2x132	935	advertising, promotion
Global Skyship Industries Inc.	Skyship 500 HL	n	59.10	19.20	20.30	6,666	56	100	n/a	n/a	2x150	645	advertising, promotion
	Skyship 600 B	n	61.00	19.20	20.30	7,188	64	105	n/a	n/a	2x188	645	advertising, promotion
	Sentinel 1000	n	68.00	16.67	20.16	10,000	100	111	n/a	2,705	2x221	n/a	(military) surveillance
Goodyear	GZ-20	n	58.52	15.24	18.14	5,740	48	80	5,825	n/a	2x155	n/a	advertising, promotion; production line closed, but airship operation continues
	GZ-22	n	62.64	14.33	18.35	7,017	64	105	6,805	n/a	2x309	n/a	
Westdeutsche Luftwerbung GmbH	WDL 1a	n	58.00	16.40	18.90	6,429	50	90	n/a	n/a	2x155	n/a	advertising, promotion
	WDL 1b	n	59.90	16.40	19.30	7,200	50	105	n/a	n/a	2x155	n/a	advertising, promotion

Supplement B: Non-rigid airships (> 1 t MTOW)

Manufacturer, designer	Model	Type	Length [m]	Width/ diameter [m]	Height [m]	Volume [m³]	Cruise speed [km/h]	Max. speed [km/h]	Max. gross weight / MTOW [kg]	max. payload [kg]	Powerplant [kW]	Range (@MTOW) [km]	Remarks
Worldwide Aeros Corporation	Aeros-40B	n	43.58	10.60	13.35	2,508	n/a	120	n/a	n/a	2x92	n/a	advertising, promotion

Note. * Project in early concept phase n = non-rigid airship

For comparison **Goodyear**	ZPG-3W	n	124.36	n/a	n/a	42,475	n/a	n/a	n/a	n/a	n/a	n/a	largest non-rigid airship built in 1958; us navy blimp used as military AEW/radar platform