EUROPEAN PARLIAMENT

DIRECTORATE GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT B: STRUCTURAL AND COHESION POLICIES

TRANSPORT AND TOURISM

WORKSHOP
'THE FUTURE OF TRANSPORT'

THE FUTURE OF TRANSPORT IN URBAN AREAS

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Abstract

Urban mobility is analysed with a systems approach and from the point of view of functionality and service. The concepts and modes that are likely to predominate in 2050 are presented. Most of the innovation in urban mobility will come from the re-engineering of old concepts with the help of ICT: success or failure of implementation will depend on a package of 'soft' management measures that involve understanding stakeholder behaviour and managing the system in an integrated, efficient and dynamic (real-time) way, rather than on 'hard' physical infrastructure or new vehicles. New energy sources for vehicles are tactical changes; however, the physical or functional aspects of overcoming a certain distance at a certain speed will remain.

The issues covered by this note were presented and discussed at the workshop on 'The Future of Transport' held at the European Parliament on 2 December 2009.

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LIST OF ABBREVIATIONS

AGT Automated Guideway Transit

AMW Accelerating Moving Walkways

<B> High performance bus service such as netbus

(B) Conventional bus service

(b) Proximity bus or quarter bus

BiCiNg Brand for the public shared bicycles in Barcelona. The word does not have any meaning in English but 'bici' means 'bike' in Spanish and Catalan, and BCN is the acronym for Barcelona airport.

BLIP Bus Lane with Intermittent Priority (concept developed by C. F. Daganzo, UC Berkeley). Equivalent to IBL.

BRT Bus Rapid Transit System

Car pool Increase in the number of occupants in a car by having several passengers for the same trip. The passengers can meet somewhere, such as a park-and-pool facility.

Car sharing Temporary rental of a car by the hour, day, etc. with an automated system for pick-up and delivery of the car from a parking facility. Reservations are made by phone or Internet and the car key is a smart card. The usual (large) fixed and variable costs of owning a car that is not being used most of the time, become higher variable costs only when we need it (provided that the operator guarantees car availability). Car sharing may be advantageous for users travelling less than 5,000 km/year by car.

CBA Cost Benefit Analysis

CBD Central Business District of a city

Collective or shared taxis Taxis with a driver who picks up and delivers several independent customers (maximum of four for a regular car, up to nine for a van, and even more for micro- or minibuses), as they operate in both developing and developed countries.

DART Dial-a-Ride Transit

DRT Demand Responsive Transit

EC European Commission

EIB European Investment Bank

GPS Global Positioning System (Galileo in the future, in Europe)

HOV High Occupancy Vehicles

HT Human Transporter, for Segway electric scooters

IBL Intermittent Bus Lanes (concept developed by J. M. Viegas, Lisbon). Equivalent to BLIP.

ICT Information and Communication Technologies

ICE Internal Combustion Engine

ITS Intelligent Transport Systems

'ITS' Information in Transport Systems, a particular case of ITS where 'intelligence' still needs to be proven.

IVI Infrastructure to vehicle interaction

LRT Light Rail Transit System

<M> Metro or subway (tube in London)

MFD Macroscopic Fundamental Diagram (of traffic in cities)

Netbus Network of BRTs (operating in network) in a European city

OECD Organisation for Economic Co-operation and Development

PPP Public Private Partnership

PRT Personal Rapid Transit system

<R> Rail commuter service

R+D+i+d Research, Development, innovation and deployment

R&D Research & Development

RMP Reduced Mobility Person

<T> Tram (streetcar in the United States)

TDM Transport Demand Management

UITP International Association of Public Transport

UM Urban Mobility

VVI Vehicle to vehicle interaction

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'Big whirls have little whirls,
That feed on their velocity,
And little whirls have lesser whirls,
And so on to viscosity.'
— Lewis Fry Richardson

1. TRANSPORT IN URBAN AREAS

KEY FINDINGS

- Urban mobility (UM) is undergoing a **change of concept (mutation)** and needs a **re-engineering and systems approach** to interact with city planning and ICT.
- **Revaluation of the street** as a scarce public good in European cities should be considered.
- **Emphasis should be placed on the role of human cities as leading a social project of integration** in Europe.
- **Social considerations** lead to some **new concepts regarding UM**.
- **Sustainable urban mobility** must incorporate the **'business' perspective of the *operators*** (public transport, loading and unloading of goods) and the perspective of ***stakeholder* behaviour** (users, operators and administration), including the ***users' perception*** of the service.
- **Public transport** should be designed to be **competitive with private vehicles in door-to-door time and quality** (reliability, comfort, etc.).
- **Congestion pricing converts the time spent by people waiting into money** that can be used for promoting sustainable mobility. **The optimal policy consists of a *combination* of charging and restrictions.**
- **Parking pricing is an incomplete substitute for congestion pricing**. Large parking facilities should evolve from static, passive, gloomy 'warehouses' of cars to **proactive mobility terminals** that bring added value to their users (shopping, boxes for e-commerce, car washing and repair shops, etc.) besides connecting cars with walking.
- A **generic macroscopic fundamental diagram (MFD) for traffic in cities** will make it possible to regulate traffic congestion in European cities and change the current logic of traffic signals and simulation models.
- **High performance buses integrated in human cities (netbus) will operate in networks** providing a level of service supply competitive with tramways.
- ICT does not develop **Intelligent Transportation Systems (ITS)** automatically. 'Intelligence' should be developed on the basis of **scientifically sound research and innovation**.

1.1. Mutation in urban mobility

This 21st century is going to be the first urban century in history and this change, together with the possibilities presented by ICT and social, environmental, energy and safety challenges, gives rise to the need for a **change of concept**. City planners, transport engineers, politicians and users need to **rethink urban mobility** from a **re-engineering and systems approach**.

Mobility flows (people, goods, information and services) operate in economic spaces. As such, city planning should consider **networks of flows and services** as the skeleton of a

social project. In discussing network-oriented thinking in urban and regional planning, Gabriel Dupuy (2008) has rediscovered the contribution of Ildefons Cerdà, the Spanish civil engineer who designed the expansion of Barcelona in 1859 and introduced the 'social science' of urban planning back in 1867. Dupuy questions the **static vision of urban general plans**. The interzonal **mobility models** developed in the late 1950s also **need to be thoroughly reformulated.** While fast computing and real-time data provided by ICT can provide 'real-time microsimulation', this is often used only to reproduce the same outdated philosophy more quickly.

Cities have grown (urban sprawl) thanks to **economies of agglomeration and proximity** (Thisse, 2009), which are related to mobility speed. Cities have incorporated **fast modes** which have, in turn, almost defeated them in a confusion of goals and means. Long-distance modes have also penetrated the cities, becoming a factor in door-to-door trips and requiring **integration**. Consolidated European cities are not designed to accommodate a massive number of cars and trucks (and their parking needs and rush hour behaviour), but they did develop them.

It seems clear that several trends will shape the future of European urban mobility. These trends are 'obvious' because they cannot be politically ignored:

- Citizens want to **recover the streets** as public space forming part of the natural habitat of the urban ecosystem.
- A **spread of mode users** will mean that certain inefficient modes (in terms of space, environmental costs or safety) are retained in European cities.
- **A democratisation of priorities regarding passenger flows** will or could change an implicit hierarchy that favours cars and has given them time and space advantages in comparison to other modes (per unit passenger-km).
- There is a need for **promotion of an efficient public transport system** that is sufficiently competitive in time, cost and quality with the car system so as to achieve natural domination.
- Respect for and enrichment with **diversity and minorities** is indispensable**.**
- Cities should be regarded as a **social project of integration**.

Sustainable mobility should follow several general principles that are simply the extrapolation of the values of a 'civilised' society regarding:

- **diversity**,
- **tolerance**,
- **coexistence**,
- **removal of barriers**,
- **respect and affirmative action** (positive discrimination) for social minorities,
- **welfare**,
- **information society,**
- **right to accessibility**,
- **social equity and cohesion**, etc.

In a word, it is the **society of the people**. A void in analysis and understanding of the needs of a city is magnified by constraints in existing legislation and the lack of 'real' planning[1]. However, Table 1 shows the **mutation** that is taking place with **regard to urban mobility**.

Table 1: *New concepts in urban mobility*

Old concepts	New concepts
Functionalism	Sustainability
Diffuse city (urban sprawl)	Compact city
Specialised land uses	Multifunctional city
Direct costs of operation	Ecological accounting
Commuting	Cloud-shaped mobility
Required (household-based) mobility	Daily mobility
Transport policy	Mobility policy and right to accessibility
Long distance	Proximity
Longitudinal use of streets	Cross-street use

Source: Noy, 2001

Some key principles of sustainable urban development, such as **land use integration** and **minimum density of building**, ensure a critical mass of mobility demand (in turn facilitating a good supply of urban public transport) while also promoting self-restraint in a local environment that may be achievable with **ecomobility** and **traffic pacifying measures.**

Each relevant urban activity should have an associated **sustainable mobility plan**. It is difficult to understand enabling activities that generate high mobility without an **associated Transportation Demand Management (TDM) policy**. The Mobility Act (2003) and the Generated Mobility Decree (2006) of the Catalan government in Spain are examples of legislation that enforces good practice in planning, designing and implementing better mobility in cities and as such, examples of an effort to address the **'missing link' between mobility and urbanism**.

To be practicable and to ensure successful implementation**, sustainable urban mobility** must incorporate the **'business' perspective of the *operators*** (public transport, loading and unloading of goods) and the perspective of ***stakeholder* behaviour** (users, operators, and administration), including ***users'* perception** of the service.

In order to stop being an 'inferior good'[2], **public transport should be able to compete** with transport by private car **in door-to-door time and quality** (reliability, comfort, etc.). In fact, the quality factor may be critical to the survival of urban public transport in Europe: some investments in urban rail systems (tramways, subways, commuter rails) are justified for strategic reasons or quality of life values alone, rather than for their transport function, which is subject to cost-benefit analysis.

However, although we are aware of the need for a systematic and comprehensive approach, **we are still planning sector by sector**: public transport on the one hand, traffic on the other hand and the 'leftovers' for other modes of transport considered

[1] Planning is a **rational** decision making **process** that starts analyzing the system (and understanding its behaviour), and **efficiently assigning some resources** according to some objectives in a future scenario. Good planning is based on **systematic processes** of generation and appraisal of alternatives to meet the objectives.

[2] An inferior good is a good whose consumption decreases with income. Economics textbooks give examples of inferior goods: potato consumption in the daily diet, consumption of second-hand clothes, and public transport patronage. **Inferior transport modes are usually more sustainable**.

conceptually marginal, despite the fact that approximately one third of trips of more than five minutes are made on foot in many European cities).

Contemplating the street as a scarce public good involves its **democratisation.** With massive flows of cars, **the 'right' to leave cars** on the street or temporarily 'rent' space as on-street parking **becomes questionable**. We wonder why public streets have been 'rented' or made available at no cost to large private objects such as vehicles, while common sense forbids their use for other large private objects (such as furniture, tents, etc.). We even may ask if anyone (resident) should have the 'right' to purchase a private vehicle in a city without having resolved where to park it (in the CBDs of some European cities, it is forbidden to build new apartments with parking lots in order to force their residents to use public transport or pay very high parking fees).

Citizens have the **right to access to services** (food, health, education, leisure, etc.) and job markets. Rational welfare ensures a minimum quality of mobility for everyone as a matter of fairness, but it is not realistic to treat very high quality services as free, nor is it affordable to maintain them with high subsidies.

There is a **microeconomic justification for urban public transport subsidies**: the marginal cost (the cost or moving one more passenger by bus, tramway or metro) is lower than the average costs; the system optimum is an equilibrium point of high demand charged at marginal costs: the total revenues do not cover the operating costs (represented by the average costs). Thus social optimum implies operating with high demand but below the average costs and requires a subsidy equal to the demand times to be subsidised by the difference between the average cost and the marginal cost.

The reverse is true for traffic systems: average costs are lower than marginal (social) costs (both increase parabolically with the demand), which tends to allocate more users in the street than the social optimum. **The externalities generated by car traffic** (pollution and climate change, noise created, energy used, urban space occupied, accidents caused, etc.) **have to be internalised** to operate at the optimum point (where the marginal benefits are equal to the marginal costs).

In 1912, as a means to achieve the social optimum, economist **Arthur C. Pigou** proposed the concept whereby an economic tax on the average (user perceived) costs would match the higher marginal (social) costs. By paying the **Pigouvian tax**, all the costs are perceived and users' decisions correct the market outcome back to efficiency for society. The (fixed) congestion charge scheme in London is a simplified version of the Pigouvian tax and has made general mobility in the centre of London efficient, despite the high cost of the technology required to operate the system (license plate reading by cameras).

Congestion is an externality of our decisions to travel by car, since when we make a trip we impose delays on others. These delays are manifest as congestion. Of course, these third-party effects depend on traffic flow and range from zero values outside rush hours to very high values during rush hours. **William S. Vickrey** received the Nobel Prize in Economics in 1996 for showing that congestion charging *(**congestion pricing** or **value pricing**)* benefits society. The maximum benefit is that **congestion pricing transforms the time spent by people waiting into money paid** (Vickrey, 1969): time wasted in congestion is a social loss; money retrieved from congestion participants can be reinvested in mobility with social or ecological objectives (or in maintenance of the existing mobility services).

Pricing is not the only way to regulate demand. In some countries, including Colombia, restrictions are placed on the use of certain streets according to the day of the week and the registration plate *(pico y placa,* a direct translation of 'rush hour and registration plate'). It can be shown (Daganzo, 1995) that **the optimal policy consists of a *combination* of charging and restrictions**.

Pricing may create social inequality for the captive demand (due to lack of alternatives to the urban area or lack of affordable public transport) or for residents who have less purchasing power. The local authority should ensure the mobility rights of these people via public transport, alternative routes offered at lower prices (and perhaps longer travel time) or with a 'discount policy'. However, let us remember that possession and use of a private car are associated with a certain level of income, so that **congestion pricing does not usually create any further hardship for the most socially disadvantaged**[3], and if the revenues are devoted to improving mobility, disadvantaged people will also benefit from the **value pricing**.

Since cars take up a lot of street space while carrying a small occupant load (1.1 passengers per car during the rush hour and 1.3 passengers per car on average) and are in widespread use, they generate a high demand for parking space (at the origin and at the destination) as well as causing congestion. **Partial management of car mobility can be achieved through parking management**: underground parking or parking in a building, parking turnover, parking pricing for all street surfaces in a city, parking pricing and turnover policy in central parts of the city, parking 'value pricing', etc.

Large parking facilities should evolve from the current static, passive, gloomy 'warehouses' of cars to **proactive mobility terminals** that bring added value to their users (shopping, boxes for e-commerce, car washing and repair shops, etc.) as well as connecting cars with walking.

Parking pricing is an incomplete substitute for congestion pricing. It usually takes a whole generation to assimilate the 'culture of payment' in private mobility[4]. Any new and recent implementation (parking meters) has to be discussed, understood, planned and agreed upon properly.

The 'tyranny' of cars will be restricted in most European cities, but it would be naive (an 'ostrich policy') not to recognise and understand their 'hidden values' (freedom, personality, status, etc.) and positive role in low density demand zones (enhanced by shared vehicles and electric or sustainable energy vehicles). In fact, **actions to promote the 'lower modes'** (walking, cycling, public transport) **are incomplete without restricting car use**.

Non-linear average and marginal costs for car demand mean that 'expanding a road system as a remedy to congestion is not only ineffective, but often counterproductive' (**Mogdridge paradox).** When applied to city mode equilibrium, this shows that improving the traffic system makes everyone in the city worse off, including the car users for whom the investment was made.

[3] In a city with good public transport supply. It might not be the case in rural or low density zones, but it is difficult to find congestion there, because of the low density demand.

[4] For example, Madrid implemented parking fees on a large scale in 2008 with great rejection from residents who have not yet developed the culture of 'paying for parking'; the Barcelona experience is that such a 'social culture' takes a generation (two to three decades) to develop.

Traffic performance in congested urban or metropolitan networks is far from scientifically known. The '**Braess' paradox**' ('adding extra capacity to a network, when the cars selfishly choose their route, can in some cases reduce overall performance') and the latest findings by Daganzo and Geroliminis (2008) point out the difficulties of dealing with queuing networks. Figure 1 shows a paramount result: the **existence of a generic macroscopic fundamental diagram (MFD) for traffic in cities** that will make it possible to conceptually switch from 'congestion is needed to regulate traffic demand' to 'there is no excuse to maintain a city under congestion'. This result **will completely change the logic of traffic signals and all traffic microsimulation models in the next 20 years**[5].

Figure 1: ***Macroscopic fundamental diagram for traffic in cities that relates the vehicle-km travelled per unit of time (vertical axis) to the accumulation of cars in the street network (horizontal axis).***

Source: Daganzo and Geroliminis (2008).

ICT will provide **a huge amount of real-time information from low-cost, reliable sensors** (cameras, parking spot detector, traffic loop detector, GPS and Galileo, Bluetooth in cellular phones, etc.) but 'intelligence' (**scientifically sound research and innovation**) should still be developed in order to obtain **intelligent transport systems** (ITS).

In addition to **research and innovation**, we should mention **training needs in urban mobility at all professional levels** (companies and local authorities) and **education** for social awareness (including media and politicians). Regardless of the investment efforts made in the various EU research framework programmes, the results are not cost-effective. **We still need much basic and applied research**[6] (rather than descriptive compilation of existing practices and widespread knowledge) and collaboration between local authorities, companies and universities[7]. **Urban mobility can be the Gordian knot of sustainable**

[5] Traffic signal coordination is currently based on continuity of car link flow (which should be balanced with pedestrian flow and public transport passenger flow); in the future it will also consider the accumulation of vehicles in a zone. Simulation models still follow a hydraulics analogy of maintaining trajectories, while in the cities they should evolve to 'cell transmission' models that maintain queues.

[6] Many EU 'research' projects are just compilations of a subject or case studies presented as work packages that are developed as consultancy. EU research projects in transport carry out very little basic research and what is carried out is unlikely to be published in peer reviewed journals. Some 'product-oriented' developments may be more successful or simply become impractical (such as several modelling efforts, some of which are ongoing).

[7] Research and innovation in transport should emanate from universities to companies and public administrations with feedback in response: major companies and institutions should have an R+D department that employs PhD students and interact continuously with universities. In a medium run scenario, research and innovation in

development and growth in Europe in the future, but urban mobility can also be the common ground for cross-fertilisation via **interdisciplinary research.**

1.2. Costs and efficiency

Urban mobility can be treated from many points of view, but we will consider the **functional point of view** which should be **the main one when dealing with overcoming time and distance**.

From this functional viewpoint, **many policies are explained by thresholds in basic performance variables** such as flows, acceleration and deceleration rates, manoeuvrability, occupation, street space use, speed, energy (which depends on transported mass and speed), and so on. For example, only low flows of different speeds (gradients of at least 10 km/h) can interact in the same space without high **safety risks**. Motorcyclists benefit from a 'de facto' privilege due to their manoeuvrability, speed and smaller space requirements; they may pass cars during congestion by carefully riding between lanes, and they can use the bus lane without interfering with the purpose of these; in some cities this use is explicitly allowed, while in others it is allowed de facto[8]. Taxis are usually allowed to use the bus lane but increasing flows of taxis block bus lanes and render them useless.

Less relevant from the functional point of view, but necessary to consider, **is the source of energy.** We must address social efficiency, taking into account how the energy each transport mode uses has been generated, the externalities it causes, etc. **Walking is the mode of transport with the greatest evacuation power** (in persons per minute) for short distances (it does not have a fixed time lost in 'waiting' and 'loading'), but it is slow: its unit social cost is high (in euros/passenger-km) due to the time used to overcome distance (not considering here the gains in health by exercise, etc.).

The most efficient urban mode with respect to energy (in terms of unit cost of euros/passenger-km) **is the bicycle**. **For medium distance door-to-door trips in a city, motorcycles usually win, while bicycles take the lead for smaller distances.** Many cities maintain **social accounts of urban mobility** and keep track of them (see, for example, Robusté et al. 2000 for Barcelona).

About **one third of the urban travel in human scale European cities is walking** (trips longer than five minutes), but the footpaths include various uses (urban furniture, signalling, vegetation, lighting, motorcycle parking, kiosk, bar terraces, etc.) that add to the 'wall effect' (a safe distance from the building façade), making '**effective footpath' widths insufficient to ensure a good level of service flows for pedestrians**.

mobility will be performed by universities and research centres, companies (operators and providers), institutions and even the users (individually or perhaps organised in a consumers' NGO).

[8] The generic rule from a systems point of view can be stated as '**a generic class of vehicles may use the bus lane when all the vehicles of that class that want to use it can do so safely without interfering with the bus speed**'. Applying this rule, regular motorcycles may use the bus lane if they are careful entering and exiting such a lane. If the arriving bus reaches any vehicle on its bus lane, the vehicle should be fined with a camera activated by the bus driver.

Figure 2: A functional classification of urban transport modes

Figure 2 summarises most of the modes of transport currently found in European cities by incorporating **functional variables** such as the width of the vehicle and whether the vehicle uses segregated space or shares the street with other vehicles or users.

- Non-motorised (energy is the human body; low speeds <10km/h)
  - Walking
  - Wheeled
    - Scooter and kickbikes
    - Roller skates
    - Skateboards
    - Bicycle
      - Private
      - Shared
- Motorised (an engine moves wheels with some energy)
  - Individual
    - Narrow (half lane width)
      - Electric bicycle
      - Motor scooter (Segway)
      - Motorcycle
    - Wide (occupy a lane)
      - Adult tricycle, motorcycle with sidecar, moto-van
      - Car
        - Private
        - Shared
          - Taxi
          - Car sharing
          - Carpooling
  - Collective
    - Shared lane
      - Shared taxi
      - Bus
        - <B> Netbus (needs always bus lane)
        - (B) Conventional bus (may have bus lane)
        - (b) proximity bus
        - Bus discretionary, tourism, etc.
    - Segregated lane
      - Bus Rapid Transit System (BRT)
      - Railway
        - Tram <T> Light Rail Transit System (LRT)
        - Train-Tram
        - Metro <M>
        - Commuter rail <R>

Source: Author

Cities are rediscovering walking as a transport mode (with functionality 'rights' like other motorised modes). Pedestrian routes should be nicer, cleaner, safer, faster (traffic light coordination) and more direct. Some areas for improvement could include: routes in squares that 'punish' pedestrians with curve itineraries, which are probably appropriate from the aesthetic point of view or for walking the dog, but are not direct; unpleasant underpasses of pedestrian walkways to the train or a main boulevard (dark, small, smelly, graffiti); long bridges to cross a urban motorway without bothering the cars; traffic signals that do not respect some minimum times to allow for crossing the street, etc. Walking is the ideal transport mode as a source of health and social interaction. Its only drawback is that it is somewhat slow: it is no surprise that its unit transport costs are higher than those of the mechanised modes (Table 2).

Table 2: ***Unit social costs (in euro cents/passenger-km) of metropolitan transport in Barcelona (taxes excluded)***

	WALKING	PUBLIC TRANSPORT	PRIVATE VEHICLE
Direct operation	N/A	6.36	4.56
Indirect operation	N/A	6.66	36.78
Time	148.8	36.48	26.34
Externalities	N/A	0.66	8.82
TOTAL	**148.8**	**50.70**	**76.49**

Source: Robusté et al., 2000

The unit social cost (without taxes) for covering a passenger-km in public urban transport (if such is correctly dimensioned), **is less than the unit cost for the private vehicle** (Table 2): this is the power of occupancy. The contrary results are also possible with very low demands or very high supply (public transport in low-density urbanisation, public transport at night, etc.). In those situations, **it is usually more cost-effective to run shared taxis**[9] (an efficient form of demand responsive transport, DRT) **than a network of buses, tramways or metros**. In the future and thanks to ICT we will see more 'on demand' transport with any size vehicle (taxi, microbuses, minibuses, regular buses) according to critical mass of patronage (buses are for groups); cars or vans can be owned or shared (carpooling, carsharing) and can be driven by a traveller or a professional driver, while larger vehicles like buses always need a **professional driver**.

Cycling is the most energy-efficient mode of transport (calories/gram-km) and is very competitive in terms of door-to-door speed. In fact, cycling wins many competitions between random itineraries (London 1988, Berlin 1990, Barcelona 1991, rush hour in Madrid 1993, etc.). On one hand, it promotes physical exercise and a positive spirit to enjoy the city and life; on the other hand, due to the existing speed gradients and flow interaction with traffic (on the street) and pedestrians (on the walkway), it presents a high risk of accidents.

Although known for their good weather, **Mediterranean cities are only now 'rediscovering' and promoting cycling,** some time after many other European cities that have more extreme climates, including Stockholm, Copenhagen, Amsterdam and London. Some factors that might explain this delay include (Thorson and Robusté, 1998):

- dispersed urban planning,
- poor quality urban environment,
- parking safety and availability at origin and destination,
- bicycle theft and vandalism,
- safety concerns,
- non-flat cities with grades that demand physical effort and being in shape,
- clothing and cultural image,
- sweating (no showers at the office),
- little integration with public transport.

[9] **Collective or shared taxis** – Taxis with a professional driver who picks up and delivers several independent customers (maximum of four), as they operate in some countries (both developing countries including Latin America and Asia and developed countries, including the scheme in Washington DC, United States).

An example paradigm of **how the situation can change with critical mass and catalysts** (in this case, involvement of the local authority) is the case of the public bicycle rental scheme in Barcelona ('BiCiNg'[10]). When Copenhagen introduced its Bycyklen in 1995, 'Barcelona was not designed for bicycles'. It was not until more than a decade later that Barcelona opened a shared public bike service in March 2007. Since then, the 'BiCiNg' (together with the tourist bus a decade ago) has become a symbol of Barcelona: 400 bicycle stops distributed throughout the city, a total of 6,000 bikes and more than 182,000 subscribers who make 35,000 to 58,000 daily trips at a public cost of more than EUR 20 million per annum. Perhaps such a high cost can be interpreted as an 'act of contrition', an institutional 'mea culpa' for so many years of forgetting bicycles and pacified traffic.

Most of the urban modes are known and will not change much in essence (energy source is a tactical rather than a strategic change, and ICT has only recently become operational in mobility) but they **will have to be re-engineered**. One of the concepts with a long history and great untapped potential in European cities is buses. We will see **high performance buses (netbus)** or integrated[11] bus rapid transit systems (BRT) **operating in networks with service supply competitive with trams**.

ICT and social consciousness **will increase the occupation of vehicles** accessing the main cities if **bus and high occupancy vehicle (HOV) lanes** (and facilities like **park-and-pool and park-and-ride)** are provided connecting metropolitan corridors with the city.

When high flows of buses access a large city with high frequency, they need segregated lanes to provide speed and reliability; this arrival rate and concentration of buses need to bring their customers to central[12] mobility poles of the city with **public transport interchanges**. Madrid is a good example of implementation in Europe with several generations of improved public transport interchanges: while the first ones where the usual simple and functional bus station, the later ones are designed with the same quality and philosophy as small airport buildings; the simpler public transport interchanges are self-supported economically by the bus operators, while the better quality ones need a high subsidy. This concept of public transport interchange is correct from a logistics point of view (**the interchanges are hub terminals**) but needs a lot of surface space that does not always exist in dense and human European cities or requires a lot of infrastructure and investment[13] (large underground terminal and underground bus lane access). While the

[10] **BiCiNg** – Brand for the public shared bicycles in Barcelona. The word does not have any meaning in English, but 'bici' means 'bike' in Spanish and Catalan, and BCN is the acronym for Barcelona airport.

[11] Segregated and 'hard' BRTs that emulate heavy rail systems (commuter rails or metro lines) have been operating or under construction for several decades in many developing countries (Curitiba's BRT commenced in 1972) and even in some European countries in the 1990s. They trade running speed (high) for local accessibility (poor and usually creating a border effect). In the coming decades, these 'hard' segregated services will probably follow the same process of integration that surface railways followed a century ago: they will have to use underground lines so that the surface space can be returned to residents. We propose the alternative of 'soft' and integrated BRT lines that offer a good balance between speed and cross-accessibility: **netbus**.

[12] During decades (and even in current implementations such as the Transmetro, the BRT in Guatemala City) incoming buses where left in the outskirts of the city because of 'territory' business split between the interurban bus operator and the urban bus operator. Metropolitan sprawl has made fuzzier the boundaries of their business and public sector has imposed a better 'service' to the customers avoiding the penalty of transfers (in time and in fare in no **integrated fare system** exists) and letting the exterior buses stop in neural points of the city.

[13] Unit cost of EUR 120 million for last-generation public transport interchanges in Madrid, which is financed by the metropolitan bus operators and receives a large subsidy from Madrid public transport authority (Consorcio Regional de Transportes de Madrid).

concept is adequate for freight or in a regional scale even for passengers, it is improbable that many European cities follow the **leadership of Madrid**[14] for lack of surface space, willingness of integration (as opposed to segregation) or lack of financing.

Rental cars **(car sharing**), **collective taxis** and even **on-demand collective buses** (for groups) can improve energy efficiency and occupation of space, and will also become common in European cities.

[14] OECD and UITP have awarded Madrid (Consorcio Regional de Transportes de Madrid, Madrid Public Transport Authority) the **Prize to innovation in public transport** in the International Transport Forum of Leipzig (May 26-28, 2010).

2. AN EFFICIENT URBAN MOBILITY DECALOGUE

The following 10 points are a guideline for some **ethical cross-disciplinary principles** (deontology) for **efficient urban mobility**:

1. look at mobility from a **systemic** point of view and from the perspective of **service to the user**, integrated into the **urban** planning;
2. **causal** (as opposed to 'casual') alternatives generation according to defined objectives, enhancing the **prospects for management** via ICT and sustainability;
3. **scientific, transparent assessment** to prioritise alternatives, in response to social cost effectiveness and check that objectives are met;
4. **causal 'closing of the loop'**:
   - incorporating capital gains of the land in financing,
   - internalising externalities,
   - activity regulation regarding generation/attraction of mobility,
   - 'pooling' in the city between modes, services areas, time, etc.,
   - streets referred to as scarce public good,
   - understanding behaviour patterns, operators 'business' and 'hidden attributes' of cars;
5. promote advanced **training** and require **explicit accreditation** or professional qualification in mobility;
6. require and reward **good planning** (with time, money and human resources, and unhurried, consensual[15] planning) and **R + D + i** (research, development and innovation) in universities, companies and the local authority;
7. **think globally – act locally** with shared institutional commitment and participation of operators, users and affected citizens[16];
8. encourage **education** of politicians, media, professionals, and the public, to defend the functional and economic 'logic';
9. develop the **legal infrastructure** to support the implementation of solutions to the demands of mobility: we need '**functional legislation**'[17] to regulate urban mobility;
10. **resources** (money, time and knowledge, 'knowledge' as a bottleneck)[18].

[15] **Participative planning** interacting with users and local stakeholders; **conjoint planning**.

[16] An ideal situation envisages institutions working towards a shared 'global' goal that has been agreed upon and whose implementation will be carefully incorporated in 'local' constraints. Operators and users/citizens can be **proactive in the planning stages** too, with a **bottom-up approach** (not just leaving the implementation of the 'local constraints' to top-down solutions).

[17] For example: building new houses with two parking spaces may seem a good practice for a large city, but **the law is not linked functionally**: the **apartments and parking facilities are built, but they are sold independently**; their users can purchase the apartment and the two parking positions, or just one, or even none (because they do not need them or because they cannot afford the parking spots at the beginning, with the furniture, mortgage and taxes expenses); this happened in the new quarter 'Olympic Village' in Barcelona: after the Summer Olympic Games of 1992, the 'Olympic Village' was occupied by residents who could not afford the parking spaces (they did not need them either because at the beginning it was easy to park on the street). In 1994-1996 that part of the city had one of the most serious problems of parking on the street, similar to very old and consolidated quarters: the streets were full of cars but the parking facilities were empty. As already stated, new **sustainable policies forbid the building of new apartments with parking spaces in CBDs**, thus forcing their future occupants to use public transport or to pay high parking fees elsewhere (the fees plus the distance are a deterrent to car use). **Functional legislation** needs to handle continuous variables as opposed to 0-1 variables and would get rid of 'zonal' concessions, promote cause-and-effect links and economic logic, or forbid impractical procedures that slow down or reduce the throughput of the mobility system.

[18] Even when money is available, it is not evident that it is allocated efficiently. Time constraints are always present in political decisions that act with short horizons of two to three years. Even with money and time, it may take five to ten years to achieve a good level of training of those involved (provided that good trainers are available); a similar time span applies for producing basic research such as a collection of PhD theses.

In 1998, Barcelona developed an **URBAN MOBILITY AGREEMENT** that presents 10 modal goals and makes it possible to **referee conflicts of interest among the urban mobility stakeholders**:

1. achieve high-quality, integrated **public transport**;
2. maintain **traffic speeds** and improve the **speed** of surface public transport;
3. increase the surface area and quality of zones devoted to **pedestrian** use;
4. increase the number of **parking spaces** and improve their quality[19];
5. improve citizens' **information,** awareness and skills, and improve road **signals and signs**;
6. achieve a set of **legal regulations** suitable for managing mobility in Barcelona;
7. improve **street safety** and respect among users of the different modes of transport;
8. promote the use of **less polluting** fuels and control air and noise pollution caused by traffic;
9. promote the use of **bicycles** as a regular means of transport;
10. achieve swift, orderly **distribution of goods** and products throughout the city.

[19] The city council or the parking facilities association can draw up '**layout standards**' for designing and operating new parking facilities in the city, promoting a '**quality label**' and, accordingly, a 'quality fare', similar to the hotel 'stars' system. A good parking facility should be accessible for vehicles and pedestrians (ramp with walkway), have large parking positions, be clean, well-lit and easy to identify (different colour for each floor, animals or objects for each zone), with information about parking availability inside and outside (on the street), internal walkways for pedestrians, cameras for security, traffic signalling (give way, stop, etc.), etc. See Caicedo (1995). The European Parking Association and DG TREN are working together on projects to give a quality label for truck parking facilities (LABEL, www.truckparkinglabel.eu).

3. COMMENTS ON EC DOCUMENTS

KEY FINDINGS

- Most of the goals and objectives are **correct in terms of policy but too vague or philosophical.**
- ICT technology has a key operational role, but a **distinction should be made between ICT and ITS**, since not all ICT urban mobility applications are 'intelligent' or even socially feasible (in terms of cost-effectiveness). **Intelligence will come from scientifically proven R+D+i** and there is a long way to go in urban mobility research.
- **PRT do not have a generic role in European** liveable and human scale **cities** (in the same way that 'hard' segregated BRTs are difficult to integrate in consolidated European CBDs). Their functional contributions can be supplied in a cost-effective way by **shared taxis** driving on the streets.
- ITS is too ICT-oriented when applied to 'urban mobility optimisation' and **does not address the real problems**, which involve **people, stakeholder behaviour** (internal and external administrations, operators, users and citizens), and **complex conceptual design problems** (queuing networks, multicommodity flows, etc.) still under research.

3.1. A sustainable future for transport – COM(2009) 279 final

The EC published this document in June 2009, in an attempt to set European policies for sustainable transport. These policies are related to infrastructures, funding, technology, legislation, interaction between governments and the need to speak with one voice.

The **title '**Towards an integrated, technology-led and user friendly system' is either **too philosophical** (integrated) or **too cold** (technology-led and user friendly). The Personal Rapid Transit[20] system (PRT) chosen for the cover picture and the comment 'Monorail pod cars are an innovative way of integrating any two transport modes; in the future, they could also offer a sustainable solution in urban areas' indicates a completely different understanding of what urban transport is about. The image looks futuristic, **but PRT does not have any role in European cities** except for connecting a transport terminal on the outskirts (such as an airport, a high-speed rail station or a public transport interchange) with a more accessible point. Dense cities for people should not become automatic warehouses, full of guide elevated infrastructure and elevated stations. As stated, **shared taxis are the most cost efficient PRT** (the elevated infrastructure is changed by the streets; taxis will be **electrical in just a decade**: **we can even eliminate the need for a professional driver by integrating car sharing and car pooling**). A suggestion for the cover image is to include happy citizens walking in a liveable, human scale, city, or modern buses in a

[20] **PRT**, a concept that was developed in the 70's by the railway industry and has been recovered by the aircraft industry in the last decade. Surprisingly, it is the airline industry that first implemented it for the automated baggage handling system in airports ('**telecars**', trays provided with an electric vehicles running on rails) in the 70's and all the airlines have rejected the 'rail concept' (the last telecar bag handling system under operation was the SFO United Airlines systems until the 90's; the drawbacks of the system were analysed by Robusté, 1988).

boulevard (full of walking pedestrians and bicycles); they may not be particularly 'technology driven' but they are what urban mobility is about.

The document analyses several trends in Europe, such as ageing citizens, migration and internal mobility, environmental challenges, fossil fuel scarcity and price increases, increased urbanisation and global trends. Some **emphasis is given to security** that could be avoided (security is part of our lives nowadays, but its continuous and explicit presence can turn this environmental issue into an obsessive constraint). All the PRT, the 'technology-led' goal (which is not a goal by itself in urban mobility; it has not been for thousands of years and most of the problems and solutions are similar to those faced by Ancient Rome) and the security obsession may be interpreted as **'technology provider's' interests** in increasing their business.

We should distinguish ICT from ITS: some ITS measures do not involve chips or satellites (e.g.: smart freight parking regulation in Barcelona is achieved with a circle of paper: small trucks and vans have 30 minutes for loading/unloading) and **some ICT measures have led to wrong implementation because** ICT might be a necessary condition for ITS but **it does not guarantee 'intelligence'** unless it is developed and scientifically proven. Many algorithms used for urban mobility management and even many simulation models in urban mobility are not based on sound scientific principles[21].

Most of the objectives are politically correct: achieving quality transport that is also safe (and secure) will enable the increasingly heterogeneous society of the future to reduce accidents and protect passengers' rights. A second objective – a well-maintained and fully integrated network – will reduce congestion, emissions, pollution and accidents. A third goal is more environmentally sustainable transport. The EU is a leader in transport infrastructure, transport services and logistics: maintaining this leadership will entail enhancing the EU's productivity by '**maintaining an efficient transport system and investing more in R&D**'; protecting and developing human capital is a prerequisite. Better price schemes will include price differentiation depending on the time of day, economic incentives to use environmentally friendly vehicles, etc. Finally, planning public services with a view to increase efficiency in terms of transport is another important objective for the EU.

The EU proposes the policies to follow to reach all these goals and respond to sustainability: maintenance, development and integration of modal networks, how to find the resources for sustainable transport, how to accelerate the transition to a low-carbon society, opening and fostering competition, how to educate, inform and involve, how to make coordinated actions and the need for Europe to speak with one voice.

3.2. Action plan on Urban Mobility – COM(2009) 490 final

In September 2009, the EU published this communication to help actors in the EU and its industrial sector to develop efficient transport systems in urban areas, where most of the European population lives. Six actions were defined and all of them are correct in terms of policy:

[21] None of the commercial packages to date have addressed the problems posed by Daganzo (1995) in *Requiem for second-order fluid approximations of traffic flow.*

1. Promoting **integrated policies**, which involves three actions: accelerating the take-up of sustainable urban mobility plans, regional policy and transport for healthy urban environments, and sustainable urban mobility.

2. Focusing on **citizens**, it involves six more actions: a platform on passenger rights in urban public transport, improving accessibility for persons with reduced mobility, improving travel information, access to green zones, campaigns on sustainable mobility behaviour, and energy-efficient driving as a part of driver education.

3. **Greening urban transport**: Research and demonstration projects for lower and zero emission vehicles, Internet guide on clean, energy-efficient vehicles, study on urban aspects of the internalisation of external costs, and information exchange on urban pricing schemes.

4. **Strengthening funding**, which comprises optimising existing funding sources and analysing future funding needs.

5. **Sharing experience and knowledge**: Upgrading data and statistics, setting up an urban mobility observatory and contributing to international dialogue and information exchange.

6. **Optimising urban mobility**, involving urban freight transport and ITS for urban mobility. ITS is too ICT-oriented and is not addressing the real problems to be improved, which involve people, stakeholder behaviour (internal and external administrations, operators, users and citizens; see, for example, Vanderbilt 2008 regarding traffic) and **complex conceptual design problems** (queuing networks, multicommodity flows, etc.) still under research.

4. TRANSPORT IN EU URBAN AREAS 2050

KEY FINDINGS

- **No 'epic' or 'bold' changes** in urban mobility **are envisioned.** Many improvements and innovations will use well-known concepts boosted by **ICT** and a **re-engineering process**.
- **Demand for speed is far from saturation**, but speed has a **social price** and **needs space**. This immature behaviour will collide with or at least will be smoothed out by eco-mobility and relaxed attitudes, leading to new urban planning mix.
- **The current apparent technological promiscuity will converge to just a few concepts** with many variations.
- **The best PRT in urban areas is a shared taxi or a shared car.** In the future, these cars will be electric and run on existing infrastructure, the streets. Depending on critical mass of demand, dial-a-ride and shared services can be also applied to buses.
- **Sustainable urban mobility** must incorporate the **'business' perspective of the *operators*** (public transport, loading and unloading of goods) and the perspective of ***stakeholder* behaviour** (users, operators, and administration).
- **Promote urban safety from an integrated and multimodal point of view.**

4.1. Future trends in urban mobility

We are concerned that urban mobility in the future will continue to see **slow technological innovation in global concepts and feasible modes** due to the ballast of **stakeholder behaviour** (citizens, users, operators and administration) and the **limited** attention devoted to urban mobility in **basic research**. We expect to see **many applications of ICT** that may improve **sensors and real-time data** collection, tracking of vehicles and people, urban safety, information, etc. Improvement of operations and sustainability, while keeping cities competitive and addressing citizens' needs regarding mobility, will **require developing intelligence in the form of re-engineering processes and** research, development, innovation and deployment.

No 'epic' or 'bold' changes in UM are envisioned in the short or medium term: we do not anticipate that we will travel in personal helicopters, nor in helium balloons or flying chairs, and not even in PRT systems or moving sidewalks in Mediterranean cities; and even if that was feasible, it would not be too innovative. Teleportation is not possible: it can be done with photons and electrons but atoms are the material that concerns us (in fact, **we move atoms with the help of energy, photons and electrons**). It is good to keep imagination and innovation running, thinking outside the box, but with feet on the ground, especially in mobility.

Many improvements and innovations will use well-known concepts (rentals, dial-a-ride, car pool, car sharing, park-and-ride, buses, pedestrians, bicycles, etc.) **boosted by ICT** (use of real-time information) **and a re-engineering process**.

Speed in cities enabled them to develop. **Demand for speed** is directly linked to GDP and individual welfare and **is far from saturation** (Thisse, 2009). Most people 'want to get there as fast as possible', regardless of the destination. This is due to increasing value of time: we want to do more things (especially with our free time) in a day that still has 24 hours. This behaviour is empirically shown regardless of knowing that **speed has a price**: economic (e.g. Concorde and high-speed rail; non-linear effects beyond certain feasible speeds), social (e.g. accidents, scarce urban space and lack of cohesion) and environmental (e.g.: emissions and climate change).

Increasing mobility creates a demand for travel 'further away, faster and more frequent trips for a shorter stay' (Crozet, 2009). This **immature behaviour** will collide with the current trends that praise slowness (Honoré, 2006), and will eventually mature into **ecomobility and relaxed attitudes**. This will mean changes in urban planning too.

The current apparent technological promiscuity (customer personification has made the leap from the car model, motorisation, add-ins and colour customisation to a wider range of differentiating issues that include even the vehicle type and concept) in **the end will converge into just a few concepts, none of them very innovative**, except that they will use electricity as energy (or solar plus electrical or hydrogen cells or other hybrid source in the next two decades): **small electric cars** (microcars) following the Smart concept or **urban microcars** and leaving other older concepts like the 'lean machines' of the 1980s (mono or tandem cars tilting in curves to go faster but in European human cities cars do not need to go fast; in fact, they will not be allowed to go fast); **electric motorcycles and electric bikes** (they may converge according to weight, but they will probably still be separate concepts, since they respond to different idiosyncrasies of their users); **electric buses and also electric fleets for urban freight distribution**; the current **rail systems** (tramways, metros and commuter rails); and **taxis** with improved efficiency and used as dial-a-ride public transport when appropriated.

New electric vehicle types may mean a reduction in emissions (assuming that the electrical energy is produced cleanly), but **we will still face the challenges of the physical management of mobility and road safety**, which depend on interacting flows, gradients of speed between different modes, mass, speed, dispersion of speeds, etc. There is a need to **promote urban safety from an integrated and multimodal point of view**.

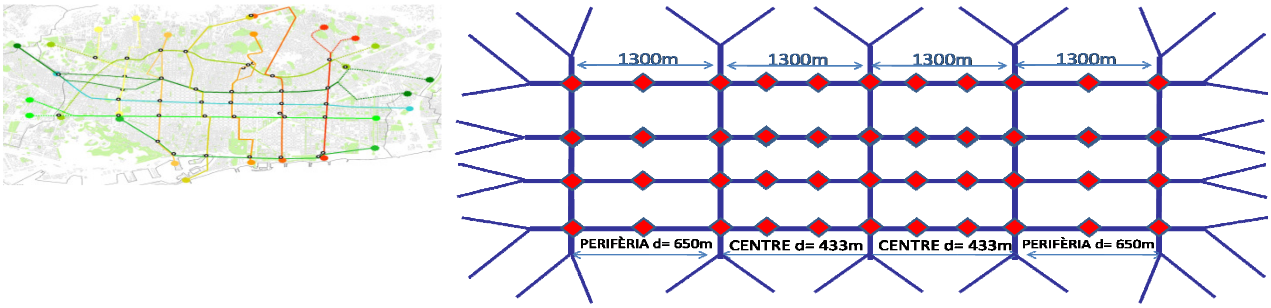
The electric scooter, **Segway HT***,* is difficult to insert in European cities and it is an example of poorly oriented ICT innovation: while keeping the equilibrium with two parallel wheels may be 'cool', a fast vulnerable vehicle with very little manoeuvrability does not have a place in a liveable city. The concept will probably evolve towards electric microcars (with two wheels) or electric motorcycles (with two wheels in parallel) to be integrated into Mediterranean cities. Otherwise, their use will continue to be marginal, limited to areas of very low flow of vehicles and in low-density areas or estates: messengers, industrial warehouses, airports and large terminals, university campuses and theme parks, security patrols and post distribution in low dense zones, etc.

We will see more high performance buses or bus rapid transit systems (BRT) that will operate in a network (Figure 3), the '**netbus' concept**[22] (not just the metropolitan access

[22] BRT integrated in a city (without physical segregation) and operating in a mixed network: grid network in the CBD and 'hub&spoke' network in the suburbs. This concept is being developed by CENIT (Centre for Innovation in Transport, Barcelona) and the University of California at Berkeley for Barcelona (city council and bus operator TMB); see Daganzo (2010) and Estrada et al. (2010). Such a system, named '**RetBus**' (netbus), is being developed in Barcelona and is expected to be implemented by phases in 2011; in Figure 3, each vertical and

to the city): such a network can give service similar to that of a network of trams, but with a much more efficient social cost.

Figure 3: The 'netbus' concept and its implementation in Barcelona



Source: (Robusté 2009; Daganzo, 2010; Estrada et al., 2010)

The **energy source** is not a strategic issue in the short and medium term, but a tactical one. Restrictions and pricing schemes will penalise unsustainable energy vehicles. **ICT will place sensors throughout the city** and provide information in real time to improve mobility management and increase street safety.

We will see **increased use of shared vehicles** (public rental electric bicycles, urban car sharing with electrical microcars, even shared microbuses, minibuses and buses for groups, etc.) **and increased occupation** (car pooling). There are already **electric rental vehicles** in Paris. This sharing of vehicles is not strategic, but operational.

The true revolution ahead of us is re-engineering of a sustainable, safe and intelligent urban mobility.

Some planners have recently discovered **'personal rapid transit' (PRT),** (a concept from the 1970s, promoted by the railway sector and recently by the aeronautical sector; even the cover of the EC document COM(2009) 279 *A sustainable future for transport* shows such a system as an example of 'integrated, technology-led and user friendly system'), cabins for four to six passengers, usually moved along elevated rails. **The best PRT in urban areas is shared or collective taxis or cars** (without the professional driver): in the future cars and taxis will be electric; the infrastructure – streets – already exists.

To **compensate for revenue losses from taxes to petrol**, if a growing percentage of vehicles are electric (or hybrid in the short term), Member States will have to obtain new income from **Eurovignette** (pay per use of heavy good vehicles on roads in a first phase that will be extended to light vehicles in a second phase) **and urban congestion pricing**. In Vallvidrera tunnel accessing Barcelona, value pricing is applied to tolls differentiating rush hour and non-rush hour. Tolls will soon incorporate discounts for low emission cars and high occupancy vehicles, and **mark-ups for** extra power of the car and other **social inefficiencies**. Congestion charge schemes will be common, in coordination with parking policy and pricing.

horizontal line represents a netbus line running at commercial speeds of 15 km/h, with bus headways of three to four minutes during the rush hours; netbus stops are 650 m apart on the average, but just 433 m in the centre of town; service frequencies in the peripheral branches are halved. Such a network can serve the current bus demand of Barcelona with one third of the buses, half the total length of bus lanes and 40% faster commercial speed.

Vehicle to vehicle interaction (VVI) and infrastructure to vehicle interaction (IVI) will have to bear most of the 'intelligent infrastructure' and the cost of VVI. We envisage **many useful applications** to help with driving and parking and avoiding accidents, **but the full interaction is far from become a reality**.

Teleworking and video conferencing has been hailed as a solution to mobility ('people want connectivity, not mobility') since the 1980s; the **Bangemann Report** (Corfu, 1994) forecast 'the end of distance' and 10 million teleworkers in Europe by 2000. This is another **forecasting mistake that did not consider human behaviour and psychology**. People still need to interact personally (face-to-face meetings and interaction foster confidence, a key point in business) and want to leave home to differentiate work from private life. For example, business people from Madrid and Barcelona meet in Zaragoza, half way between the two state capitals and only 1 hour 15 minutes away from either thanks to high-speed rail.

The role of technology in mobility has had three well-defined phases: a **strategic phase** initially (infrastructure provisioning) focused on functional and physical aspects, followed by a **tactical** phase from the industrial revolution, focusing on mechanisms, engines and energy, and the latest **operational** phase with ICT and other management tools applied to mobility. The ethics of these phases are also different: public service, productivity and market.

It is still **strategic to develop science and knowledge**. The mobility sector has little sophistication and needs advanced training. Cities should increase collaboration with universities and help strengthen research and innovation in urban mobility in organisations such as operators, institutions and users' associations. The **opportunity to completely re-engineer urban mobility** is unique and must be taken and also **defended as a strategic priority for smart, liveable and efficient cities in Europe.**

4.2. 'In' concepts in future European urban mobility

Among the likely trends for Europe 2050 we envisage:

- **Pedestrians**. With the 'rights' of a transport mode (Thorson and Robusté, 1999).
- **Bicycles**. Private or shared (Thorson and Robusté, 1999). Will probably be supplemented by electric bicycles.
- **Multipurpose lane management**. Managed lanes. This technology will allow **BLIPs bus lanes with intermittent priority** to be implemented or **IBL intermittent bus lanes** similar to the test implemented in Lisbon.
- **Shared vehicles.** Many vehicles are stationary most of the time in cities: they could be used by several users reducing the unit indirect costs. Public administrations have promoted **shared bicycles** with great success (Paris, Barcelona), as well as **car sharing** (Mobility CarSharing in **Switzerland** is a leading example of deployment in Europe).
- **Diversification in vehicles** ('promiscuity') but as taste or marketing **variations of the same concepts:** small electric cars (hybrid until 2020-2030), electric bicycles and motorcycles (the two concepts may or may not converge, since they respond to different life attitudes of their users), bus-based public transport systems *(*netbus or metrobus or BRT, conventional bus, proximity bus), rail-based public transport

systems (commuter rail, metro, tramway or LRT, train-tram) and more efficient taxis used as dial-a-ride public transport.

- **Netbus.** Bus Rapid Transit systems (BRT) have been conceived in developing countries as the 'low cost' version of commuter rail, metro (subways) or trams. Netbus consists of a **network of BRTs** which, even integrated (non segregated) in a consolidated city, presents the same supply performance characteristics as trams and even metro. Double bus stops, bus lanes, traffic signal priority for buses, reduction of stop time, high frequency (headway of three to four minutes during rush hour, etc.). Can be **guided buses** in some critical stretches narrower than 3.15 metres.
- **Integration and hierarchy of urban public transport systems**, consisting of metro <M>, tramways <T>, netbus <B>, conventional bus (B), and proximity bus in quarters (b) plus dial-a-ride taxi pool. Needs **Park-and-Ride**[23] and **Park-and-Pool** in the metropolitan area.
- **Car pooling.** Infrastructure investment by itself does not guarantee an increase of occupancy since there are behavioural issues (planning for trips, working schedules, **Park-and-Pool**[24] facilities, etc.). The bus-HOV lane in Madrid (N-VI motorway, in operation since 1993) has greatly improved the bus service but had hardly any effect on car pooling.
- **Taxis.** They will serve different **market segments**: **business people** in a rush that want to travel fast and alone, but also regular people that will use **shared services at night or as complement to direct public transport services**. Taxicab services will improve with '**smart taxi stops**' that detect demand needs and queues, **supply-demand matching**, **drivers schedule improvement**, urgent freight distribution, taxicabs as **sensors for current traffic conditions**, etc.
- **Pricing. Congestion charges** and **value pricing** will become widespread in European cities. Many cities including London, Milan, Oslo and Stockholm have already been successful here. Value pricing is being introduced but several cities have already implemented a simplified 'proxy' such as London (fixed congestion charge), Barcelona ('green area' of parking pricing) and Milan.
- **Fare integration in public transport and smart card/contactless tickets**[25]**.** Fare integration economically benefits transfer users but it costs a lot of money if a 'financial equilibrium' has to be kept for the operators. A mix of 'flat rate' zones and 'distance fares' gives 'patchwork fare' systems where users pay according to the number of zones that they cross.
- **Intelligent territory**. **Sensors** and **real time data** will be **cost-effectively** available in European cities for managing parking space availability and reservation, traffic congestion, public transport reliability (avoid bunching), etc.
- **Congestion regulation**. Macroscopic fundamental diagrams of traffic in cities will enable congestion to be regulated (Daganzo and Geroliminis, 2008).

[23] **Park-and-Rides**: Parking facilities close by a public transport station or stop. They need a cooperation between the local city where the facility is located, the public transport operator (and infrastructure administrator, if needed) and the large city that benefits from the sustainable modal shift.

[24] **Park-and-Pools**: Parking facilities close to ramps of highways or by a hypermarket or commercial mall with access by road: people with matched origin-destinations (along a stretch of their trip) and desired travel times meet with several cars on the Park-and-pool facility and enter the highway in just one car with increased occupancy; they usually benefit from advantages in tolls, HOV lanes, parking priorities, etc. Concept developed many decades ago in California; works best for commuters with regular and homogenous working schedules.

[25] **Smart cards** are ticket cards with a chip and a communication technology that allows payment without physical contact (contact-less), thus speeding up the payment process.

- **Megalopolis.** Europe will become a **network of metropolitan areas** or '**cities of cities**' in competition but also in cooperation with each other.
- **Parking management and pricing**. Parking facilities as active nodes of mobility that bring added value to their users (shops, boxes for e-commerce, etc.) like small public transport interchanges. Parking operators diversifying their business into integral urban mobility (e.g. car sharing, shared bicycles, car pooling).
- **Urban freight distribution**. More infrastructure (**urban logistics platforms**), **electric vehicles**, **silent distribution at night** and less in street, **regulation and pricing**, **modular and standard load devices**, etc.
- **Governance**. Mobility '**service charter**' for citizens. **Mobility agreements**. 'Interested Management' **contracts for operators** with **bonuses** and **penalties**[26].
- **Functional legislation** and **mobility laws**. **Land price integration**. Capital gains in land when accessibility is increased.
- **City planning** and mobility integration.
- **Proximity buses for elderly people and RMP[27]**: Speed is not important because their value of time is small, but they want proximity to avoid walking[28]. They may need **external elevators or escalators** on the street to overcome some heights.
- **Disabled & RMP.** No architectonic barriers, adapted taxis, low-floor buses, ramps to access all public transport vehicles, etc.
- **Energy:** is the future electric? Hydrogen cells may also have a place and in the next one or two decades, most of the new vehicles will include hybrid technologies. Decarbonisation of transport is the EU's strategic goal. Besides vehicle technology, some infrastructure and logistics is involved in the electrification of vehicles. Current **revenue from fuel taxes** will have to be compensated, probably with **congestion pricing** schemes and interurban pay-per-use schemes like **Eurovignette** (for heavy goods vehicles in a first phase and for all vehicles in a second phase). Internal combustion engines or hybrid energy sources are expected to be in place until 2030.
- **Urban safety**. Problems related to emissions and energy might be solved within two decades. But as long as we move atoms at some speed, safety issues will prevail (body/vehicle energy is still the mass times the square of the speed, regardless of the energy source). Swedish '**zero vision**' culture in road safety will migrate to urban environments.
- **Inland water transport** in cities with canals or rivers large enough to make this worthwhile, like Amsterdam.
- **Trams and metro.** These will continue playing a role according to speed (trams 20-22 km/h of commercial speed, metro 28-35 km/h) and capacity, but in the lower range of capacity and speeds (15-18 km/h) they will progressively be replaced by **netbuses** which, in the near future, will incorporate electric or hybrid buses.

[26] The local authority and the operator share the results of the service according to the terms of reference. These contracts usually include some **incentives** (bonuses) for demand increasing, quantity and quality of the supplied service, and include a **penalty** for deficient performance by the operator. They also specify 'public service obligations' required by the authority for social reasons.

[27] **Reduced Mobility Person**, RMP, is any person who is unable because of physical constraints (permanent or temporary) to move 'normally' (in speed, distance and manoeuvrability), such as elderly people, people carrying bags or loads, adults with small children, pregnant women, people with disabilities, etc.

[28] In public transport, elderly and RMP usually value their walking access time more highly than their waiting time (about two or three times the unit value of the riding time); instead, business people value their waiting time more highly because they usually have a deadline.

- **Cargo trams and metro in some cities**, but with separate vehicles from those for passengers to avoid slowing down the load/unload process; the cargo vehicles can use time slots between passenger vehicles, but their loading/unloading process should not affect the passenger vehicle speeds: this can be achieved by modular containers for quick loading/unloading and/or parallel platforms.

4.3. 'Out' concepts in European urban mobility

Some things we are not likely to see in Europe at large scale:

- Segways and two parallel wheel motorcycles[29],
- countdown time (for pedestrians) or amber transition from red to green (for car drivers to 'get ready') in traffic signals[30],
- kickbikes[31],
- tricycles,
- 'concept' motorcycles with three wheels (Piaggio M3), closed like cars (BMW C1), etc.[32],
- 'lean machine' cars[33],
- mixed freight distribution with passenger trams and subways[34],
- PRT (Personal Rapid Transit), AGT (Automated Guideway Transit) and monorails[35],
- continuous transport – high-speed or accelerating moving walkways (AMW)[36],
- trolley buses[37],
- 'paratransit' with dial-a-ride buses – shared (pooled) taxis perform better for low density demand; on demand buses (micro-, mini- or regular buses) can be effectively used for groups (e.g. sport events, shopping malls, business fares, tourist trips),
- funiculars, cable cars, air cabins – only for very specific situations.

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[29] A version of the Segway obtained by joining the two wheels and including a seat; this 'motorcycle's only advantage is that it keeps its equilibrium without touching the floor, but loses manoeuvrability (braking power, turning performance) as compared to regular motorcycles.

[30] They increase intersection capacity but reduce safety; they are contrary to the liveable cities philosophy (see Honoré, 2006).

[31] Scooter with large wheels and brakes that is propelled by kicking on the ground; they are used for tourism purposes to tour a city, since bicycles are more energy-efficient.

[32] They are only successful for very specific types of customers, and usually the 'concepts' are contrary to the motorcyclist lifestyle.

[33] Concept developed in the 1980s consisting of tilting vehicles for two passengers (usually one in front of the other) that make it possible to take turns faster.

[34] As stated above, it reduces the commercial speed for passengers, it is expensive due to manual loading/unloading and it usually does not compensate economically the distribution of surface freight by trucks and vans with the current structure of public transport networks of fixed infrastructure and the current cost structure of the urban freight distribution (including parking, loading/unloading regulations and current fees, wages and operation costs).

[35] Elevated infrastructures are not suitable for European consolidated cities, although they may work in suburban zones, public transport terminals and airports and the like.

[36] Again, continuous transport is uni-directional and creates a multitude of barriers that are not acceptable in a liveable city. However, it can be used in airports, public transport interchanges, etc. in suburban city planning.

[37] In the near future, buses will be electrical or hybrid. There is no need to cover the streets with electric wires so that citizens feel trapped in a cage set up by the public transport modes that theoretically give them freedom.

- public transport interchanges; they will work in large dynamic (still growing along corridors) cities with radial access networks and enough space and money to build and subsidize these facilities, like Madrid.

4.4. EU measures to accelerate the development of urban mobility

- **Directives for 'politically difficult' measures** such as congestion pricing. European Parliament could assist mayors to implement value pricing measures in their cities by passing directives similar to the Eurovignette Directive.
- European **standards and labels** for urban mobility. A 'catalogue' of standards and 'labels' for urban mobility concepts could be developed for all planning, construction, deployment, operation, and maintenance phases. Taxonomy of cases should consider flows, user expectations and behaviour, costs, environment, cultural issues, etc. For instance, when a city (of a certain size and with Latin-temperament residents) is considering implementing such a concept, these are the minimum standards in the planning phase: demand study, alternatives appraisal, environmental analysis, etc.
- Thorough analysis and dissemination of '**best cases**'. Many European projects have produced a database to include the cities experiences in innovative mobility (e.g.: eltis.org), but there is no audit or standardisation in the inputs and outputs and this makes extrapolation very difficult. The conclusion is that 'every city is different'. We maintain that **the city considered as a system is a generic concept** and can be analysed with a systems approach. A critical analysis of these existing databases by experts (from the point of view of scientists, consultancies, administrations and users) should be able to identify the best performing implementations in Europe (probably adapted to some specific situations), and extrapolate or forecast how successful a specific concept would be in a city.
- **Appraisal of implementations**[38]. This appraisal is linked to the previous point.
- Give a **grade**. 'Grading' UM is always difficult, but it could be helpful to evaluate the performance of some cities. The grade should include all the stakeholders' performance and perception (especially, the users' perception with '**customer satisfaction indicators**' and 'perceived quality' issues), the quantity and the quality of the transport supply, sustainability and safety, the economic and social efficiency to address some mobility needs. Once the grading system has been agreed upon, it could be used to **monitor the grade** and to link the prospects for financing to the grade[39].
- **Link financing** (EIB, EU research projects, ERDF funds, etc.) **to performance** achieving social quality and cost-benefit feasibility in urban mobility projects. Linked to the previous point of the grade and also to 'Interested Management' contracts. In the future, cities should guarantee a '**mobility services menu**' in mobility

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[38] Only recently (Carvajal, 2004), the European Investment Bank appraised all the LRT and metro projects it had financed; despite the importance to management, this appraisal was performed as part of a work experience placement with a symbolic budget (two months student grant) instead of using professional resources.

[39] For example, an innovative city focused on its residents (A) may implement a bus system that performs well such as a netbus, giving certain service at a certain cost, while city B simply keeps sinking money in a poorly performing existing bus network. City A implements a congestion pricing scheme and regulates congestion to social optimum values using the MFD of traffic in cities, while city B implements a 'blind' pricing scheme with no regulation, just to raise funds; city B benefits from its bad performance regulating congestion by making more money.

(including reliability); financing is a good tool to motivate designing and guaranteeing this menu.

- **Promote basic research and innovation in Urban Mobility**. This has been done in part with the 7th Research Framework Programmes, but specific attention is still needed. The 21st century is going to be the first urban century in the history of humanity and many concepts are still under development. We cannot afford to wait until the end of the century. **Cross-fertilisation between different sectors related to mobility and ICT possibilities** can stimulate innovative and practical ideas.

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