Intermediate public transport networks: technological innovation or new organizational concept?

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Urban public transport in France has developed considerably since the 1970s, principally as a result of the introduction of the Versement Transport [1] which made resources available for investment in more effective systems. In major conurbations exclusive right of way public transport systems like the metro (Lyon and Marseille), the VAL (Lille and Toulouse) or the tram (Nantes, Grenoble, Seine Saint-Denis, Strasbourg) have been built and have enabled public transport to increase its share in the urban transport market. In many other cities (Rennes, Rouen, Montpellier, etc.), the Transport Authorities are considering implementing such systems in order to provide a lasting solution to congestion problems in central areas. Although these systems provide service of an excellent quality in terms of speed and regularity, they have the disadvantage that they are relatively expensive, and, in particular, only profitable in very densely populated areas. It therefore seems hardly possible to install such systems outside the central areas of the largest cities: apart from the excess capacity which would be created, the financial burden is in danger of disturbing the operating balance at a time when local authorities possess increasingly scarce resources.

However, conventional buses, either with and without exclusive bus lanes, hardly seem able to sustain competition from the motor car, especially in two respects:

- the motor car has two main advantages, flexibility of use and speed,
- although its further increase is limited by the current economic situation, traffic congestion is very detrimental to the bus, which is in danger of losing its passengers to a more effective mode except on a few direct or short feeder routes.

In the absence of severe measures to restrict car use (limiting parking capacity, traffic management measures to restrict access to central areas, pricing measures like urban tolling), a situation could develop where there are two systems of transport supply. The centre and inner suburbs would be mainly served by an exclusive right of way transport system where public transport could possess a large (even a majority) share of the market, whereas the other parts of the city (with only buses) would be offered only minimum services, perhaps of a social nature, intended for those without access to a car.

With such a duality, which exists in both spacio-temporal terms and quality, it is not possible, in the longer term, to envisage an increase in public transport use. However, in recent years, concerns about improving the quality of urban life have been encouraging moves to moderate the presence of the motor car in cities. Improving the environment, whether as regards noise, pollution or the consumption of space by private transport, without reducing the mobility of citizens depends on the use of more effective mass transport. However, in order to be realistic, such a supply must meet a number of conditions. The quality of service must be good (users are particularly concerned about door-to-door travel times, hence about speed and frequency, but also about the period of time during the day for which the service operates and its reliability). The entire conurbation must be served (in order to take into account the diversity of origins and destinations which are no longer as concentrated as they were towards central areas). They must not be too expensive, either

[1] The *Versement Transport* is a tax paid by firms to the local Transport Authority in order to finance public transport. Each firm pays an amount which is proportional to its total wages bill.

in capital terms (infrastructure and vehicles), or as regards operation (external productivity, salaries, flexibility and adaptability of supply). Furthermore, it must have a good image, particularly for potential or occasional users.

To provide these characteristics, the tendency is usually to look for technological innovations. Designing a new system on the basis of such a specification is a logical first path, as existing systems would be unable to meet the requirements (see Figure 1). Without describing all the experiments involving new modes which have been initiated in the last twenty years (of which the ARAMIS project will remain a reference), efforts have been made to improve the vehicles (capacity), reduce operating costs (automatic operation) and even to propose specific products for precisely defined market segments (for example SK). However, these new technologies can hardly meet the requirements of overall coherent operation of an entire urban transport system. While a technological element is indispensable (for example encouraging the use of electric traction which causes less pollution in urban areas), on its own it cannot noticeably change the conditions of competition with the private car, which remains a priority objective for the local authority and which can only be achieved if citizens perceive a marked change in public transport supply.

The findings of the most recent household survey in Grenoble seem to indicate that there is an effect which is generated by exclusive right of way transport systems (the tram appears to have enabled public transport to gain two market share points over the entire conurbation [2]). However, such a change is mostly noticeable on origin-destination pairs which are directly served by the exclusive right of way system, even if the reorganization of bus supply (particularly for feeder purposes) enables more users to benefit from an improved quality of service. However, the mere presence of a metro or tram may also lead to some desertion of the bus, which is perceived as being too ordinary...

On the instructions of the Grouping of Transport Authorities (GART) a working party has recently been set up which links together a number of organizing authorities. The aim of this working party is to consider the functions of a new system which is known as an intermediate transport system. On the basis of the needs which existing systems (articulated buses, trolleybuses, trams) fail to meet, this group aims to specify a core of characteristics which will be shared by several networks in order to encourage manufacturers to offer new types of vehicle. The objective is thus for a system to emerge which is intermediate between a high capacity bus and a tram (for example, an articulated vehicle with two or three coaches, with perhaps a guideway system such as a rail which is set into the pavement).

The authors feel, however, that this initial conception of intermediate transport seems still quite far removed from the concept of an intermediate network as envisaged in the Lyon conurbation. Working from the origins of this concept, this paper will attempt to show in what way it provides a new approach to public transport systems: the intermediate network is more the result of a different type of organization and management of supply over the entire conurbation than the technical decision to use a certain type of vehicle.

[2] It should, however, be emphasized that this gain took place in the context of an economic crisis. However, according to projections using the QuinQuin model developed by the Laboratoire d'Économie des Transports, such economic conditions tend to limit the increase of car use. This is a factor which favours public transport.

SOME DEFINITIONS

Exclusive right of way public transport system : any public transport system running on an infrastructure (underground, elevated or surface) which is exclusively reserved for its use.

IN : intermediate network. This designates a new organizational concept which is being applied on the Lyon network. It has three elements; a new type of vehicle which is intermediate between a conventional exclusive right of way system and the bus, the creation of a grid network with nodes for multimodal interchange, and the quality of service which results from the use of exclusive ways on the road system.

PT : public transport. This may refer to either the mode of transport or the network of public transport.

SEMALY : Société d'économie mixte du métropolitain de l'agglomération lyonnaise — the company responsible for the design and construction of the Lyon metro.

SLTC : Société lyonnaise de transports en commun — the company which operates the TCL network, a subsidiary of VIA-TRANSPORT.

SYTRAL : Syndicat des transports du Rhône et de l'agglomération lyonnaise. This is a transport authority, half of which represents the Rhône Département and the other half the Lyon conurbation.

TA : transport authority. This is a structure involving several communes which is responsible for setting up and organizing public transport networks.

TCL : Transports en commun lyonnais. This is the public transport network run by the SYTRAL

UPT : urban public transport. This refers to all the systems of public transport which are on the responsibility of an transport authority.

Between a metro and a bus...

Apart from the specific issue of the need ultimately to replace the trolleybus fleet, which is approaching obsolescence through age, a wider ranging consideration of the general operation of the Lyon network has been undertaken in recent years. This took place within the framework of a strategic plan which aims to define the future role and forms of public transport in the conurbation. The Lyon public transport system has been profoundly changed in the last fifteen years with the gradual creation of a metro system. As in most cities, the Lyon public transport network has to face a dual crisis, which typifies the position of public transport in the 1990s: a crisis of congestion, which severely reduces the quality of service provided by surface transport (slow and irregular services), and a crisis of finance, which is linked to the first (loss of external productivity, no increase, or even a reduction in the number of passengers). This dual crisis considerably reduces the possibilities of investment. Although the opening of the line D means that the Lyon conurbation now possesses a genuine metro system, any increase in the size of this underground network is likely to be restricted to a few extensions of the lines to areas on the outskirts of the city centre. The first reason for this is financial, as it will be impossible to maintain the effort which has been made in recent years in the future without endangering the financial stability of the system. The second reason is more strategic in nature, and aims to take more account of the change in travel demand by providing spatial cover and good quality of service over a larger geographical area.

Although the Lyon public transport network is one of the few which continues to experience an increase in traffic — of the order of 3% in 1993 — it would seem difficult for it to increase market share, and the possibility of a future levelling off of passenger numbers is causing concern. As regards market share, it is apparent that there are major differences depending on the nature of the link (see Table 1), which indicates that in some market segments where urban public transport (UPT) is in a good position it is hardly realistic to expect a major increase, whereas in others there is scope for it to attract new passengers.

Market share obviously depends on the level of supply for each link (in terms of origin-destination pairs) but also the quality of this supply in terms of speed (user journey times) and comfort (direct link or with transfers). In this way the conditions of competition with the private car can be observed, but it should be noted that even when transfers are involved public transport can be effective on some links and attract a substantial number of passengers. Such links are links towards the centre, and the high market share is not only due to the quality of supply but no doubt also to the fact that traffic conditions and car parking are poor in the central area, which alters the conditions of competition to the advantage of public transport.

The difference in performance between the metro and the bus is caused by many factors, and these mean that these two modes are completely different types of transport system. An analysis of the features of the systems allows us to understand these differences better, on condition that they are considered not solely from the technical point of view but also as transport systems which operate as networks.

TABLE 1
Approximate percentages of market share towards the city centre (Presqu'île) for different types of link (the average market share is 39%).

Source: SLTC Marketing Department (from the 1986 household survey)

	Type of supply			
	Metro	Bus journey		
		less than 5 km	5 - 10 km	more than 10 km
Direct journey	55% (direct metro)	45% (direct bus)	40% (direct bus)	30% (direct bus)
One connection (journey which includes metro)	45% (métro + métro)	45% (bus + métro)	40% (bus + métro)	30% (bus + métro)
One connection (bus + bus)		35%	30%	20%
Two connections (bus + metro + metro)		35%	30%	20%

Mass transport or distribution?

Because the metro is a high capacity transport system it can only be profitable on routes with high traffic, therefore which serve the city centre and the most densely populated zones in the conurbation. The operating approach is therefore to attempt to group together flows, which generally means that the metro lines provide a structure around which the rest of the public transport network is organized. Thus the metro takes the place of the bus routes with the highest loads and gains further passengers as a result of shuttle feeder services.

However, the disadvantage of this grouping together of flows is that the metro tends to offer relatively limited spatial cover. Even if a line is more attractive than a bus route (the user accepting to walk a greater distance to reach a mode which performs better), it is clear that if there is no increase in the number of lines, the metro cannot provide a dense service in all districts of a city. Similarly, because it can only be profitable with high passenger levels this mode cannot penetrate far into the outskirts: in the Lyon conurbation population and employment densities fall rapidly outside the central zone (Lyon and Villeurbanne), and it does not seem possible to envisage major extensions unless long term developments are anticipated (which would involve taking on the financial burden of excess capacity for many years).

The bus is more flexible in two ways. It is able to enter different districts (few vehicle clearance constraints) in order to provide very dense cover and pass very close to the homes of users. The fact that the bus travels on roads also gives it a degree of flexibility, in that routes are able to adapt rapidly to changes in the urban tissue [3]. The dominant logic here is to distribute supply in order to achieve better cover as near as possible to passengers.

The consequences of this flexibility, however, is a poor level of service. Dense cover (low distance between stops and a large number of routes) necessarily encounters two disadvantages. The first of these is the low speeds which result from the short distances between stops and the second is the distribution of the bus fleet over a large number of links (low frequencies, due both to the dispersion of available vehicles and the small number of passengers obtained in sparsely populated districts). Of course, commercial speeds for users are on average higher in the outskirts than in the centre (see Table 2) (even if there is greater dispersion of observed values), but the increase in the length of routes means that users at the end of the routes experience journey times which they consider excessive.

[3] It should be remembered that many years ago this flexibility was used as an argument against on rail systems with exclusive right of way such as the train or tram...

TABLE 2
Description of the bus and trolleybus routes in the tcl network (average values)

Type of link	Length of route (metres)	Commercial speed at peak periods (km/h)	Distance between stops (metres)	Number of traffic signals per km of route	Peak hour frequency (min)	Revenue/expenditure ratio	Passengers per commercial kilometre
Centre → centre (trolleybus)	6.494	12.04	338	2.10	6.50	0.50	6.60
Centre → centre (bus)	8.672	14.39	388	1.50	9.00	0.53	6.10
Centre → outskirts <10 km	8.900	16.95	459	1.04	8.55	0.38	4.42
Centre → outskirts >10 km	13.121	17.97	470	0.94	11.6	0.34	3.38
Centre → outskirts > 10 km with partial terminus	16.317	19.65	470	0.78	9.36	0.33	3.15
Outskirts → outskirts and others	13.135	21.65	524	0.78	22.3	0.20	1.94

What quality of service ?

The contrast between the two approaches of mass transport and distribution is not the only important difference between these two types of public transport. Neither are spatial cover and the hierarchical organization around a main structure the only factors which influence users in their choice. Because it occupies its own underground space the metro can provide both high speeds and good frequencies of service, and is therefore better able to withstand comparisons with the motor car (it can even provide better performance within inner city areas). Because it aims to meet large-scale demand its services are more frequent (every few minutes at peak periods) and run for a greater period of time each day — passengers are particularly sensitive to these two factors. Because the metro is guided and has a high capacity it is also more comfortable for users.

The bus suffers from sharing space with other vehicles. Apart from delays caused by traffic congestion and irregularities caused at intersections, the closeness of stops means that its performance in terms of journey time will always be inferior to that of the car, if the use of cars is not better controlled. The difference in quality of service between the metro and the bus is so great that users consider them as being two completely different modes of transport.

Furthermore, the bus is in direct conflict with the car as regards utilization of road space, whereas the metro is elsewhere and does not interfere with cars... It is even paradoxical to note that in the appraisal of projects for metro lines the benefits to motorists (the sum of time savings which result from the improvement of traffic conditions on roads because of the removal of bus routes and the transfer of a small number of motorists to the metro) are greater than the benefits to future users of the future metro (time savings from changing from the bus to the metro) [4] ! Thus, constructing a metro leads to an increase in overall transport supply rather than a reorganization of the urban transport system requiring a new balance between public transport and the passenger car as would be required by the installation of a high performance surface system. A new division of the road space by organizing separated infrastructure (such as tramways) expresses a policy decision to organize trip-making which is much more difficult to implement, but which is necessary in order to provide good quality of service.

From the *intermediate product* to the *intermediate system*

Is it possible for there to be a public transport system which provides a reasonable compromise between the advantages and disadvantages of each of these two systems of transport? This was the question which gave rise to the idea of an intermediate transport system. Is it possible to design a system which provides a quality of service which is comparable to the metro while at the same time, and at the least possible cost, allowing better spatial cover and a greater flexibility and adaptivity of supply to demand — demand which although more geographically spread over the conurbation nevertheless represents a sizeable market, although one which is insufficient to justify the construction of a high capacity system such as the metro.

The search for a less expensive system leads to consideration of surface vehicles (low infrastructure costs) whose gauge allows it to enter old districts where road geometry (for example the radius of curves) is restricted, while at the same time providing high capacity (an articulated vehicle with three or four coaches). However, to achieve good quality of service, this type of vehicle must run almost entirely on exclusive ways. Roads must be re-designed for this, particularly to allow the new vehicles to negotiate intersections.

The guideway solution is interesting from several points of view. More than in increasing speed (which is only significant on routes with large distances between stops like in the Australian city of Adelaide) the main advantage of track guidance lies in its ability to provide perfect docking at stations. This improves access, in particular for persons of reduced mobility. The second advantage stems from a reduced space requirement in the case of installation in difficult sites, as two vehicles travelling in opposite directions can cross without problems. Finally, and this may be important in some areas of a city, the presence of guidance tracks in the pavement is a visible sign of the existence of an exclusive right of way transport system (as it is with a tramway). This gives the transport system a more powerful image than conventional buses and also provides people with a means of locating their position in the town. The desire for a flexible system means that the road mode must be selected (the rail mode, for example the tram, is unable to leave its rails), with a type of motorization which allows it a degree of independence while still respecting the quality of the environment (electrical or hybrid traction).

Finally, the vehicle's design should identify it as a new and specific product, i.e. one that is very different from the familiar bus. The external and internal appearance, the comfort and the type of traction should make it plain to the user that this new type of vehicle is not simply a very high capacity bus and that it is to play a major role in the operation of the network as a whole, like the tram, which has a very positive image. It is for this reason that the new vehicles are sometimes referred to as a tyred tram...

[4] This result is due to the fact that many motorists save a few minutes whereas a much number — sometimes one tenth as many — of public transport users can save several tens of minutes.

Operation in a hierarchical network

However, specifying a new technology for vehicles cannot in itself lead to a profound change in user perceptions and the effectiveness of the public transport system. By analyzing the market shares which are gained on the basis of types of links and origin-destination pairs it is possible to identify areas where public transport is currently not very attractive but where a certain potential level of demand does exist (on condition that there is a profound change in the conditions of competition with the car).

It is these origin-destination pairs which should be the first to benefit from a quality supply, i.e. a high speed link with few transfers. The current structure of the metro network has left some areas poorly served and obliges users to make connections which are unpleasant because of differences in frequencies of service and the irregularity of buses.

Irrespective of the type of vehicle (which should nevertheless be modern, with good capacity and satisfy passenger comfort requirements), an intermediate system of transport can only be introduced within a hierarchical public transport system. This already exists, in that the theoretical duality of supply has given way to a segmentation, with, in particular, the introduction of express services (articulated vehicles, high frequencies, high proportion of distance covered on exclusive infrastructure). However, this supply is still very much governed by the dominance of main axes and not by the idea of access to a grid system which provides a large number of possible destinations.

Table 2 shows some important differences in the characteristics and quality of service for several types of links in the Lyon conurbation.

Spatial cover with a grid network

There is, of course, nothing new about the idea of a grid network, but it should be noted that with an equivalent level of finance a larger number of routes is possible with an intermediate surface system, and these routes can extend into suburban areas with moderate population densities. Furthermore, the grid network ensures that districts receive good coverage and are better connected to the metro system. The grid network is also a means of modifying the traditional radial and concentric structure of the network to changes in demand, by instituting orbital routes which are connected to radial roads. Figures 2 and 3 make a rudimentary attempt to illustrate the benefits of hierarchical grid network operation as opposed to a more traditional radial and concentric structure (in Figure 2). The first type system has been transformed into the second by adding four intermediate routes, *some of which have replaced existing bus routes. This assists interconnections between major routes offering high quality of service and greatly increases the number of links which are possible with a small number of connections.*

The hierarchical grid network does, however, raise one fundamental problem, for which satisfactory solutions are still frequently not found. Increasing the number of destinations inevitably means that users have to change from one route in the network to another. These transfers are always perceived very negatively and it is essential to consider specific measures at the nodes in the system. The case of the Paris metro shows us, of course, that connections can be accepted, as long as too much walking is not involved and, in particular, waiting times are short. Although the intermediate network provides high frequency regular services (because it does not share space with other traffic and also due to a vehicle control system), design must provide easy pedestrian access at a node and users should also be well informed about routes. The quality of transfers is doubtless one of the main necessary conditions for the success of grid network operation.

Thus, one of the best features of the intermediate network is that, due to its relatively dense coverage, it allows a large number of connections between different routes (metro, bus) so that any user entering the public transport system is presented with a wide range of possible destinations which can be reached with a limited number of transfers (see Figure 4). This requires particularly good design of transfer points. Major nodes should have several specific features. As regards quality of service, the high frequencies and the considerable length of time for which they run during the day which are envisaged are an initial way of limiting the travel time losses caused by a transfer. However, the connection points themselves (metro/IN, IN/IN, IN/bus) must include physical design of the transfer space. The traditional type of connection between several bus stops at an intersection where pedestrians sometimes have difficulty negotiating motor car traffic and traffic signals does not meet the quality requirements which passengers have a right to expect. What should be aimed at is more the concept of an interchange station, perhaps ultimately with connections on the same platform, which would mean that roads might need to be re-designed. Finally, these nodes must be considered from a multimodal perspective, as they may provide improved access to the urban public transport system. In addition to connection with intercity services (rail, coaches), the creation of car parks should encourage use of the car for feeder purposes, in particular in zones which are just outside the centre.

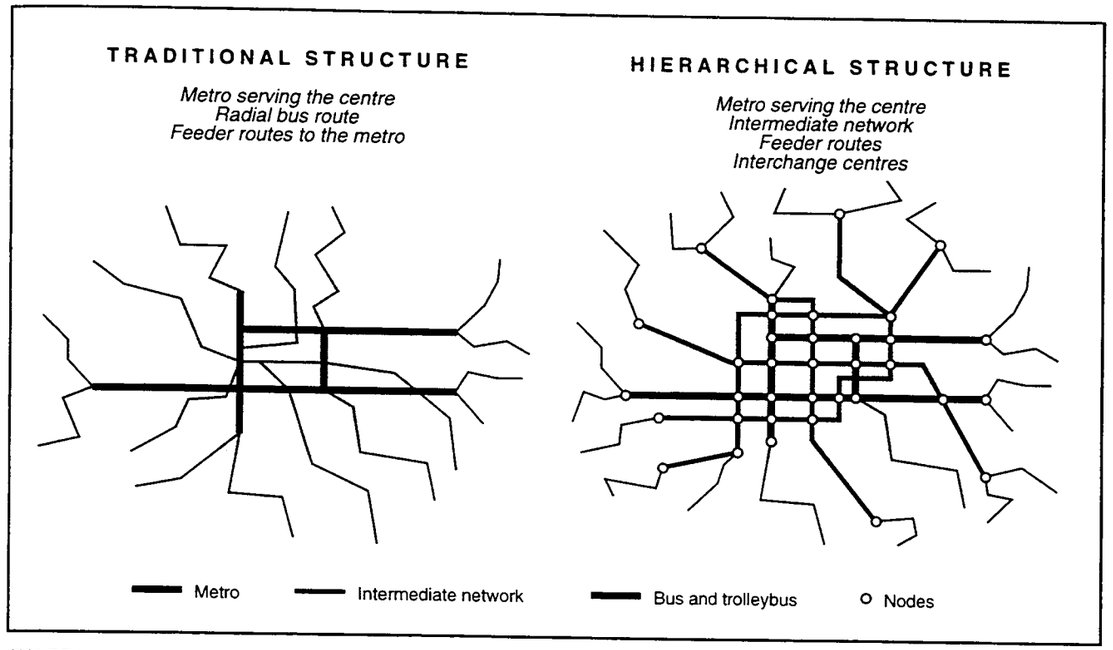
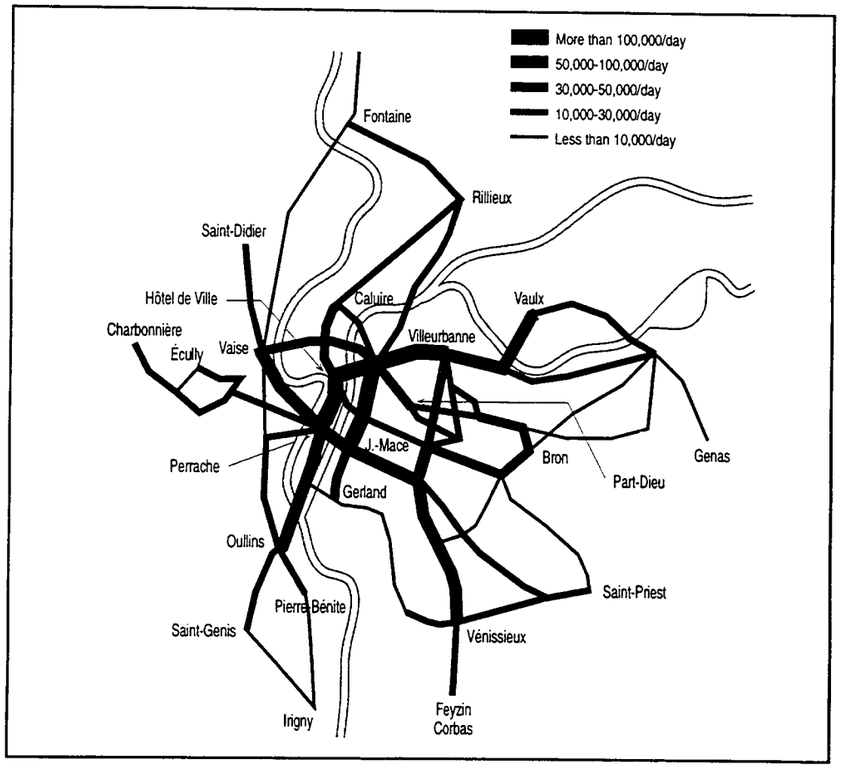


FIGURE 2
Comparison between traditional and grid/hierarchical structures.

FIGURE 3
The main travel flows in the Lyon conurbation (two way motorized traffic, without internal trips).



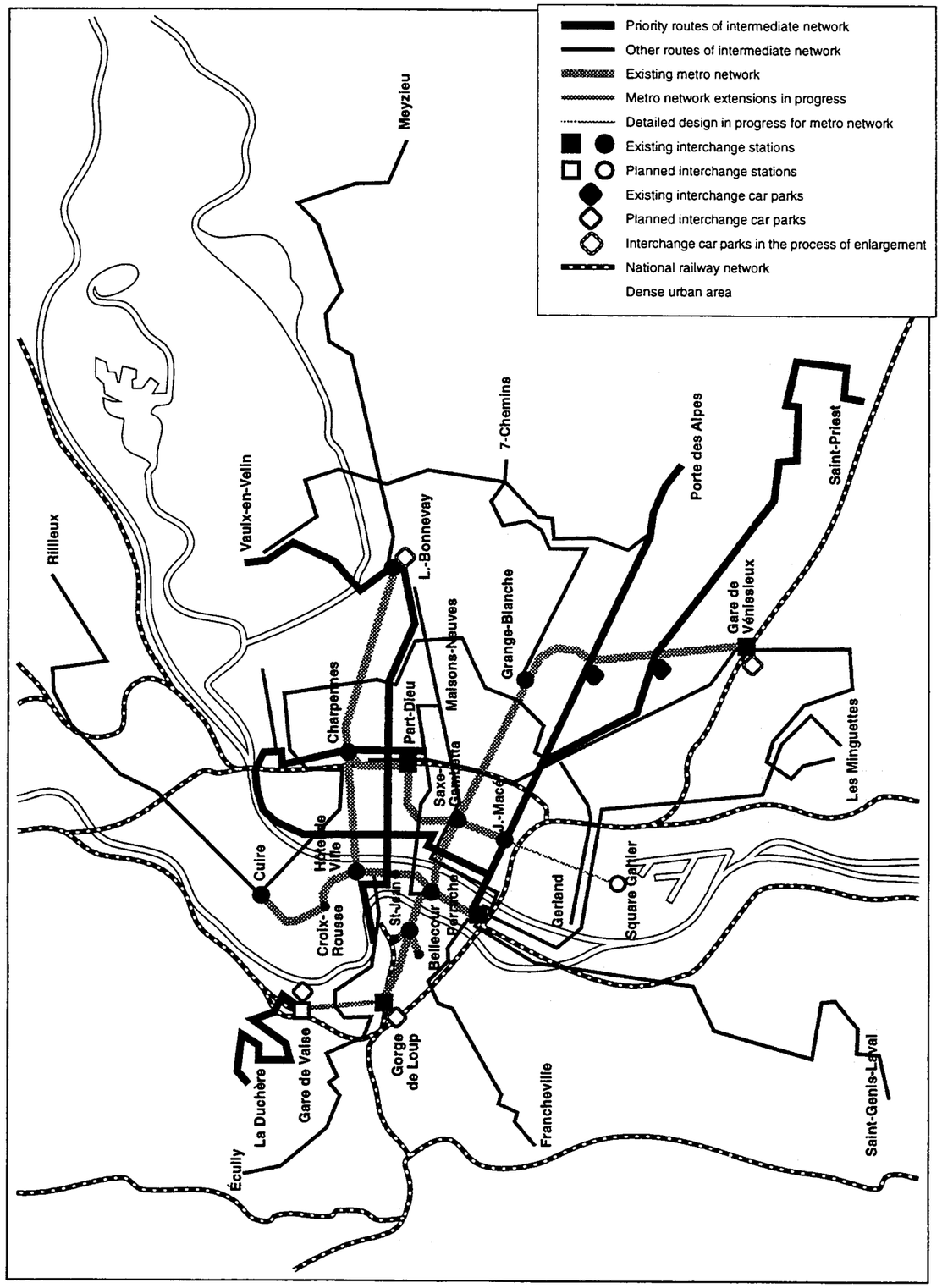
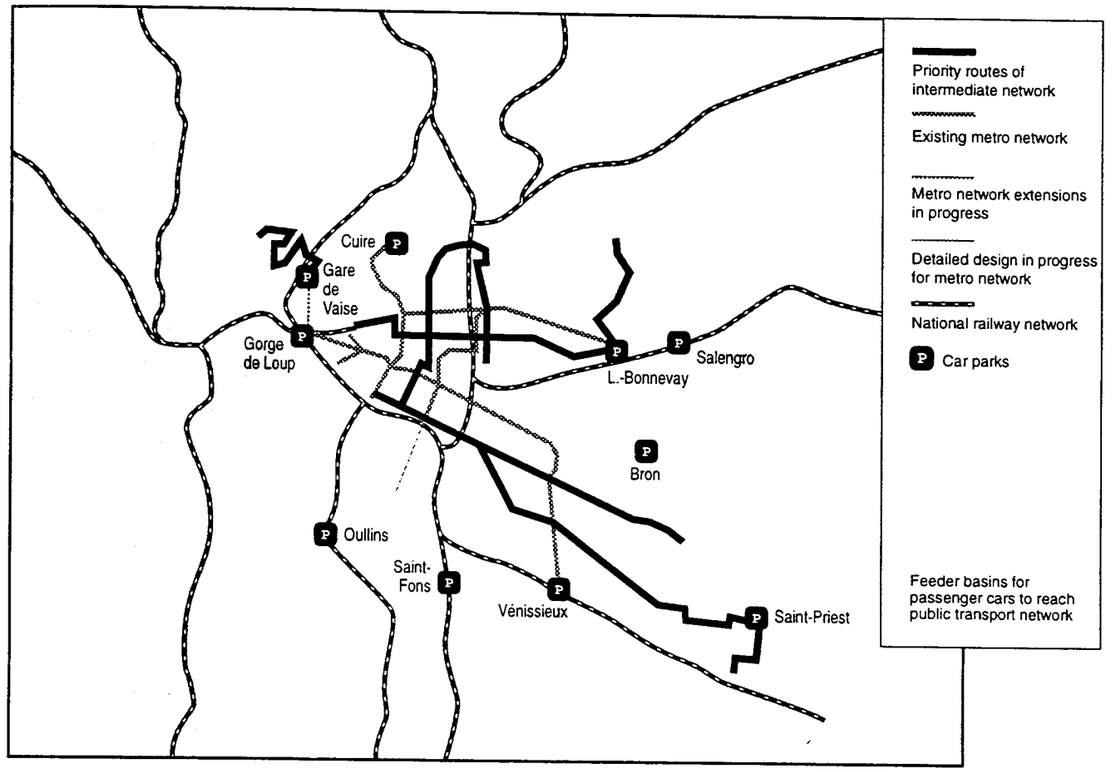


FIGURE 4
The planned Lyon conurbation intermediate network with feeder basins for passenger cars to reach the TCL and national railway networks.



A different way of managing urban trips

The form which the intermediate network will take in the Lyon conurbation is now becoming clearer — that of a set of routes providing a grid which supplements the metro structure. These routes will be operated by articulated road vehicles on a surface exclusive right of way. Because this system seems generally less expensive than extending the metro system and better able to cater for increasingly widespread demand, it is very likely that it will become the major focus for activities in the Lyon conurbation in the years to come [5].

However, unlike the metro which is very much part of a Pareto process of increasing public transport supply without reducing the ability of the passenger car to use the roads, the intermediate network is based on the assumption that the characteristics of urban transport will be thoroughly reorganized. A network of this type can only be effective if it has several routes, so what is being proposed is a major programme. The successful operation of the system also depends on the creation of exclusive right of way on the existing roads. This will therefore reduce capacity for passenger cars as two-way tyred tram *traffic removes all cars from two lanes. This is only possible on major roads in the conurbation but will lead to a reduction in their capacity as regards passenger car flows (particularly in a city like Lyon where access to the hypercentre is provided by several bridges).*

A policy of this type is extremely forceful as by its nature it involves limiting car use in densely populated zones and therefore constitutes a profound change in the conditions of competition between public and private modes. It is therefore a policy which can only help to improve the financial results of the public transport network as the congestion which will necessarily result from the introduction of exclusive right of way will be a factor which greatly encourages people to transfer to public transport. This is particularly true in some areas where road space is limited. Here passenger car traffic could only be retained by banning parking at the side of the road...

[5] The SYTRAL has recently decided to construct the Lyon intermediate network, starting with five priority routes. See the extract from the register of the proceeding of the Comité Syndical No 93 707 for the meeting of 24 september 1993.

A wide-ranging examination of the way the road system is shared must be undertaken in order to install an exclusive right of way system. This involves a detailed analysis of current use of the road space - the intermediate network should not give rise to additional urban severance phenomena but on the contrary provide an opportunity for spatial re-organization by providing high quality infrastructure.

A strong argument to support the new balance of the road system in favour of public transport will no doubt be the improvement of the quality of urban life. However, for this to be achieved it is necessary to ensure that the reduction in the overall road capacity for passenger cars does not lead to traffic jams or prove counter-productive, particularly on roads which still carry conventional bus routes whose short distance and feeder function remains vital. The introduction of a genuine intermediate network therefore demands the development of a new transport policy which allows both competition with the car (on the routes which are served) and a complementary relationship with the car in less densely populated areas — achieved, in particular, by good organization around interchange centres in peripheral zones.

An intermediate solution?

As we have emphasized, the intermediate public transport system stems from the desire to find an alternative which is cheaper than the metro (or the tram in some cities) and more effective than the conventional bus route. A consideration of vehicles and infrastructure also leads to a hierarchization of the transport network, based on a denser grid, the presence of major nodes, a more clearly perceptible structure of network and a complementary relationship between different systems using different technologies.

An analysis of the characteristics of current supply shows clearly that there is a market opportunity for an intermediate system, between systems requiring large resources such as the metro and traditional bus routes. Table 3 summarizes the differences between the characteristics of each of the systems. This table also includes an intermediate system which is intended to be more of an organizational innovation, based on a new attitude towards the operation of the urban transport system, than a choice of vehicles forced by increased financial constraints.

The concept of an intermediate network, *which combines the use of a new type of vehicle, the establishment of exclusive right of way on the surface and the introduction of a high quality service which supplements the existing metro network seems to be a very attractive option. It is nevertheless true that two conditions must be satisfied for such a system to be successful and operable. Firstly, a coherent transport policy must be introduced which leads to a new division of road space on the roads where exclusive right of way is to be set up. The second involves the design of the nodes where passengers enter the systems and change between different hierarchical levels of the grid network.*

Deep consideration should be given to these questions as they play a major role in determining the quality of supply (speed, transfers) and hence the emergence of a new image for public transport in built up areas. A failure to deal with these matters in a satisfactory way would be very likely to restrict the image of the intermediate system to that of a cut-price metro and ultimately to codemn the entire project to failure.

Setting up a network of this type is an ambitious project which must take a number of years. This is not incompatible with introducing the new tyred-tram vehicles on a few routes, but it is necessary to stress the importance of laying down the level and quality of service, which in our view are an integral part of the concept of intermediate system. The flexibility which results from the road-based mode (even if there is partial guidance) means that the system can be introduced on a more gradual basis, which could constitute a staged implementation of a new urban transport policy, based in particular on a different sharing of the road system which entails a reorganization of road space.

For this reason if the aim is to provide a means of transport which is attractive to passengers it would seem unwise to dissociate vehicles, infrastructure and level of service. If such a separation were to be made there would be a considerable danger of missing the opportunities offered by the concept of an intermediate system *and producing a system which is simply technologically intermediate, which would appear in a negative light either as a kind of substitute metro or tram or a far more expensive alternative to the bus.*

While this system appears to be intermediate *in an urban area which already has a metro system it is also able to provide good quality services where demand is high but less concentrated. It is thus a necessary addition in order to capture new market segments, an alternative to extensions to the metro in areas where passenger volumes are lower and finally a system which is very suitable for major conurbations which have no metro but which are interested in a transport system which is more effective than conventional buses.*

	Traditional bus route	Intermediate network	Tram	Metro
Operating principle	Distribution	Connection	Mass transportation	Mass transportation
Spatial cover	Good	Moderate (grid)	Poor	Poor
Flexibility	Very good	Good	Poor	Poor
Approach dominated by...	Accessibility, proximity	Trips (origin-destination pairs)	Flows (load on a route)	Flows (load on a route)
Main functions	Dense services, short journeys, feeder services	Access to and services from important nodes. May be complementary to metro network	Access to and services from the centre, links between two main centres	Rapid access to major nodes, serves city centre
Maximum flow (pass./h, one way)	Approx. 1,000	1,500-3,000	2,000-3,500	5,000-15,000
Commercial speed (within city centre)	12-14 km/h	16-22 km/h	18-25 km/h	30 km/h
Off peak frequency	5-10 min	3-5 min	3-5 min	1-3 min
Regularity	Poor With other traffic or bus lane	Good Exclusive right of way on road	Good Exclusive right of way on road	Very good Exclusive right of way off road
Operating between	6 am and 8 pm	5 am and 12 pm	5 pm and 12 pm	5 pm and 12 pm
Comfort	Moderate	Good	Good	Good
Distance between stops	300 m	400-500 m	500 m	700 m
Infrastructure	Roads, reserved lanes	Exclusive right of way on road	Exclusive right of way on road	Exclusive right of way off road
Infrastructure cost	Negligible	13-23 MF/km	75-150 MF/km	200-900 MF/km
Operating costs (per pass. × km)	12-23 F	27 F	30 F	30-40 F
Unit cost of vehicles	1-2.5 MF	5-9 MF	15-20MF	20-35 MF

TABLE 3
Comparison between the characteristics of the different urban transport systems (approximate values).

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ABSTRACT

There are two main types of approach which govern the supply of public transport in major built up areas. These are the mass transportation, which leads to the introduction of rail-based transport systems (underground railways or trams) and that of distribution, which aims to provide a dense network of bus routes. These two major types of transport system have very different characteristics, in terms of costs and level and quality of service. This dual nature of supply opens the way for an additional level which is concerned with ensuring that the network is connected at nodal points which operate as multimodal exchange centres. This paper discusses the characteristics of this type of intermediate network, which is based on an indissociable triple association of equipment/infrastructure/level of service, as such a network has been envisaged in the case of the Lyon conurbation.