VARIABLE LANE ASSIGNMENT: TWO FRENCH PROJECTS FOR MINIMIZING CONGESTION ON URBAN MOTORWAYS

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ABSTRACT

Variable lane assignment provides a way of optimizing the capacity of existing roads by using dynamic devices that affect vehicle flow by selecting the number of lanes that are open or the types of vehicles which are authorized. French experience began in the 1960s. Today, two important trials are currently under way in the Paris region and the Grenoble conurbation. The principle is straightforward and promising, using the space reserved for the emergency hard shoulder for vehicles other than emergency and maintenance vehicles.

In the Paris region, the trial consists in opening the hard shoulder to traffic using automatic moveable barriers during peak periods. Opening an additional lane has a direct impact on the upstream and downstream sections. The aim of the trial is therefore to check that the gains are not local but overall (the common section and the area influenced by it) in terms of both time and safety.

In the Grenoble conurbation, recurring peak period congestion on the A48 delays the coaches that operate on a regional high level of service route that ends in the city centre. The trial developed with the Council of Isère District consists in allowing the public transport vehicles to use an emergency lane when this is justified by operating conditions (traffic levels and traffic conditions).

1. VARIABLE LANE ASSIGNMENT IN FRANCE

1.1. Objectives

As a result of the pressure of traffic and difficulties in creating new infrastructure which is often costly, new techniques allow maximum use to be made of all the available road space, in some cases by abandoning their initially intended uses. It is, for example, possible to increase the capacity of an existing road dynamically according to needs by using the entire cross section, including the emergency hard shoulder.

However, as its name indicates, the emergency hard shoulder is above all necessary for vehicles to stop or park in cases of absolute necessity, but it can also be transformed into a traffic lane during peak periods in order to absorb the maximum amount of traffic and therefore reduce the amount of time that users spend in queues.

1.2. The historical background in France

France has a long tradition of variable lane assignment, even if honesty obliges one to admit that the techniques in question have long remained unpublicised. The brief summary below outlines the major stages in dynamic lane management in France.

1.2.1. Reversible lanes

The first example of dynamic lane management probably dates from the early 1960s (Paris), with the use of very rudimentary folding signs.

Photo 1 – Variable traffic signs (Source Matthieu Flonneau: l'automobile à la conquête de Paris)

"Red crosses/green arrows" appeared next, towards the end of the 1960s, in particular in the Saint-Cloud tunnel in Paris.

The provinces were not outdone in this area, for example with the access to the Grenoble Olympic Games in 1968. However, in this case, the facility operated only very little as real traffic was considerably below the forecast levels.

Many other examples can be given:

- The Vienne flyover and the "old bridge" in Givors (introduced when setting up the "Lyon-Vienne" alternative route in 1972 because the A7 motorway around Vienne was not completed which led to a large amount of congestion). This operation was interesting as it not only made use of "red crosses/green arrows" but also variable no way signs (very exceptional!) as well as a large number of other variable message signs.

Photo 2, 3 and 4 – Variable no way signs near Givors

- The Bordeaux bridge, with a five-lane cross-section and a median lane, which could be used in either one direction or the other. Unfortunately, the longitudinal profile of the bridge was such that a large number of head-on collisions occurred causing this mode of operation to be discontinued. It was then decided to create a central carriageway separator with two lanes in each direction. With worsening traffic problems, three narrow lanes (with no hard shoulder) were then introduced in each direction. This last mode of operation is now accompanied by a 70 km/h speed limit with automatic fines and an overtaking ban for HGVs.

- Gennevilliers (with an “American-style” mobile barrier - see photo 6 of a moveable barrier of this type operating in California). A system of this type has also been used on Réunion Island, but for a much longer length of road.

Photo 5 – Pont d'Aquitaine; photo 6 – moveable barrier in California

- The Tunnel de l'Epine, on the A43 motorway. When this motorway was opened in 1974, there was only a two-way tunnel, with two normal lanes 3.50 metres wide and a central shoulder 2 metres wide. The tunnel was therefore operated with a single lane in each direction, with the central lane closed to traffic. However, during outward and return journeys from skiing holidays, traffic demand greatly exceeded the capacity of a single lane. The idea was to use the central lane with a system of “red crosses/green arrows” but with a striking feature: the motorway operators waited until a queue was formed before opening the central lane, and a strict speed limit was applied throughout the tunnel. As soon as possible, operation was returned to the original situation.

- The bus lane on the Montée des Soldats, in Lyon. This was a 2 x 2 lane urban road, which was quite dangerous because of head-on collisions. It was therefore decided to retain a single lane in each direction and turn the central space into a reversible exclusive bus lane (in the morning, the buses travel down the hill on the exclusive lane and use the ordinary traffic lane to climb the hill: the opposite applies in the evening). This solution solved the safety problem and at the same time gave a significant advantage to public transport.

1.2.2. Changing the number of lanes without changing their direction

- Urban expressway at Chambéry: on the return journeys from skiing holidays, on Sunday evenings, a two-lane exit is required leading from the Chambéry expressway onto the A43 and A41 motorways. The rest of the time, a single lane is sufficient. The central part of the gantry-mounted directional signing therefore contains prisms with a green or blue background so that the motorway can be supplied with traffic either by a single lane or by both lanes (see photographs below). The only real defect of the system is that the horizontal signing is not always consistent with the vertical signing.

Photo 7 and 8 – Variable message signs

- The operation on the A3-A86 motorway concurrent section to the East of Paris: completion of the A86 motorway in the Seine-Saint-Denis Département to the North of Paris led to a marked increase in traffic on the section which is concurrent with the A3 motorway, which was already saturated. In view of the geometric configuration of this concurrent section – it passes over a curved viaduct and it must allow weaving between the routes on the A3 and the A86 – widening was not possible at a reasonable cost. For this reason, a lane management solution was selected. This operation, the first of the type, conducted in 2000, deserves to be highlighted. By reducing lane width and at the same time using the hard shoulder, the 650 m weaving section located on the A3-A86 concurrent section was augmented from 2 x 4 lanes with a hard shoulder to 2 x 5 lanes without a hard shoulder. Specific operating measures were introduced to avoid any reduction in safety as a result of the removal of the hard shoulder. Safety functions have been enhanced by means of dynamic equipment such as the emergency calls network, variable message signs (VMS) located on each lane upstream of the section and above all remote monitoring and automatic incident detection (AID) cameras. The change has considerably increased capacity. On the Paris-bound carriageway, the increase is 600 vehicles/hour as flow is limited by the saturation downstream of the facility. The impact is substantial on the carriageway leading away from Paris: between 1200 and 1500 vehicles/hour, i.e. a significant part of the nominal capacity of an additional lane. In terms of congestion, the impact can be evaluated on the influenced network. This network is defined as all the roads, which are directly affected by any marked change in the traffic conditions on the facility. An assessment can be made on the basis of before/after changes in travel time [3]. Traffic counts have shown daily time savings of 1204 hours, i.e. more than 300,000 hours of congestion avoided in one year. A comparison on the basis of the Police and the Gendarmerie Accident Analysis Reports (BAAC) highlights the principal accident-related changes. The accident rate increased considerably after the 2 x 5 lane road was opened - by a factor of five. Nevertheless, it should be noted there have been no fatalities on this part of the motorways since 1999 and that accident severity has also been reduced, on average, by a factor of 5. The consequences in terms of greenhouse gas emissions and local pollution remain favourable [4], albeit limited. The installation of noise screens, with a high overall cost (more than 60% of the entire cost of the operation), was nevertheless cost-effective. On the basis of a conventional public economic calculation, the total investment of €20.3 million - of which noise screens account for €12.7 million - must be compared with the various benefits, which fall within a range of €2 to 4 million annually. The investment is therefore cost-effective, but only within a medium term perspective. In spite of some areas of uncertainty, the first lessons gave valuable insights to economic decision-makers whose opinions concerning the value of new motorway design and operation practices of this type are increasingly sought.

The rest of this article will describe two particularly interesting examples: the A4-A86 concurrent section, and the creation of an exclusive bus lane in Grenoble (A48).

2. THE OPENING OF AN AUXILIARY LANE ON THE A4 AND THE A86

This project, which has been operating on an experimental basis since September 2005, aims to implement a solution that optimises the capacity of the existing infrastructure on the common trunk section of the A4 and A86 motorways. The technical design for the project was made in collaboration with the technical structures of the French Ministry of transport and particularly with the SETRA.

2.1. Context

In the Département of Val-de-Marne the concurrent section of the A4 and A86 motorways the road passes through Joinville-le-Pont on a viaduct and runs parallel to the river Marne for almost 2200 m. Until the summer of 2005, the 280,000 vehicles that used this section of road every day were responsible for some of the largest traffic jams in France: more than 10 hours of congestion per day with tailbacks regularly exceeding 10 km. The reason for this is that the two-lane sections of the A86 and the three-lane sections of the A4 join together on this concurrent section, which only has four lanes. As a result, the capacity is inadequate leading to recurrent congestion.

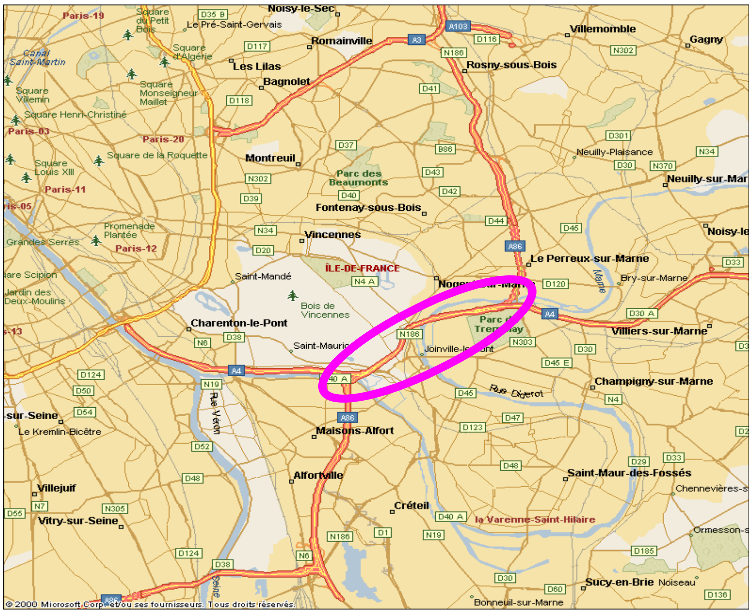

Figure 1 – The A4-A86 concurrent motorway section and its zone of influence
(Source Microsoft AutoRoute 2001)

2.2. The auxiliary lane

Awaiting a possible dualling of the A86 under the Marne at a date which is still unknown at present, an alternative solution consisted of testing dynamic operating measures that could improve peak period traffic flow in the zone.

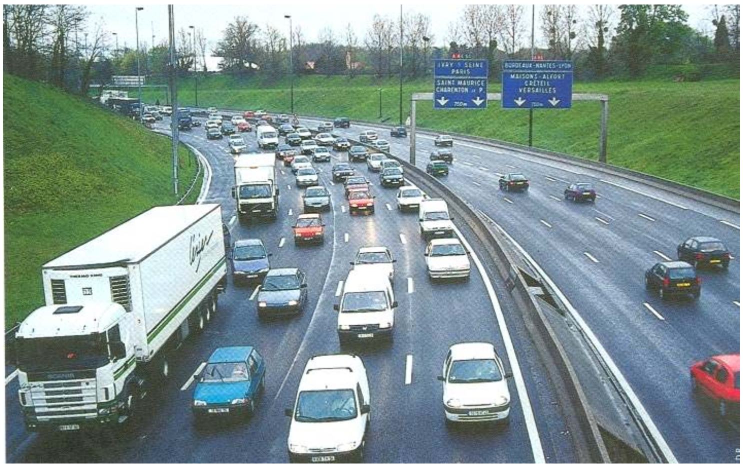

Photo 9 –The A4-A86 concurrent section prior to the modifications

The solution that has been implemented since the summer of 2005 consists of allowing traffic to use an auxiliary lane to the right of the carriageway during periods of high demand. This lane uses the hard shoulder and therefore remains closed to traffic outside peak periods. On the Paris-bound carriageway, this arrangement has also been implemented on the Nogent-Créteil viaduct which links the concurrent section to the inner A86 at Maisons-Alfort which operates with three lanes during the morning peak period. After several months of works in 2004 and 2005, the widths of the trafficked lanes were modified without altering the total width of the motorway and without any major structural works. The width of the lanes was reduced from the standard 3.5 m to 3 m or 3.20 m.

Photo 10 – General view of the concurrent section with the auxiliary lane

2.3. Equipment installed

2.3.1. Signing

Drivers are informed of the opening or closure of the lane by dynamic vertical signing which modifies the directional signing in accordance with the variable layout. In addition, to emphasize the difference in use between the auxiliary lane and a traffic lane or a hard shoulder, and to show drivers the specific nature of the zone, the auxiliary lane has specific road markings and a light-coloured surfacing. Moreover, the entire pavement has been resurfaced with low noise asphalt in order to reduce rolling noise.

2.3.2. Safety

The moveable safety barriers are installed on the right side of the auxiliary lane. When this lane is closed, the device pivots around its upstream end until it forms a lane reduction taper which takes up almost the entirety of the auxiliary lane. These closure devices are installed at several key locations on the section so that drivers can see them from any point on the route and are dissuaded from using the lane. In each traffic direction, the first device encountered by drivers is 69 m long and the next ones are 25 m long. The barriers were tested between June and October 2004 on an un-trafficked experimental site at Champing. The durability of the devices was guaranteed by continuous operation of one cycle every six minutes, which was equivalent to approximately 20 years of intensive use under real conditions.

Photo 11 – Moveable barrier

2.3.3. Accompanying measures

Accompanying measures were implemented to modify the cross-sections of the existing entries in order to improve traffic flow in the link sections. They involve the creation of two entry slip roads:

- on the outer A86, for traffic coming from the Maisons-Alfort bridge (N19)
- and for traffic coming from “les Boullereaux” district of Champigny-sur-Marne towards the A4 in the direction of Paris with the creation of a fifth collector lane in the direction towards the outer A86.

Safety has been enhanced by the installation of automatic incident detection cameras. In the event of an incident or accident when the lane is open, stationary vehicles on the auxiliary lane can therefore be detected, leading to the closure of the lane. Additional safety is provided by speed control radars on the A4 motorway in both traffic directions.

2.4. Operating strategy

The benefit of the auxiliary lane is that it deals both with the recurrent congestion that results from excessive demand and accidental congestion created by incidents, accidents and other disruptions. Dynamic vertical signing, consisting of Variable Message Signs (VMS) and Lane Assignment Signals (LAS) placed one above the other, warns users of the opening or closure of the auxiliary lane. The lane is open or closed not on the basis of a fixed time slot, but on the basis of the speeds and occupancy rates measured in the common trunk section.

In normal mode, the auxiliary lane is opened before the appearance of recurrent congestion and prevents the formation of congestion upstream of the common trunk section. The opening and closure of the auxiliary lanes are activated from the Champigny traffic control centre on the basis of the following criteria:

- a “traffic” criterion relating to the occupancy rates (OR) measured upstream of the common trunk section (opening OR = 20%; closure OR = 15%);
- a “safety” criterion which relates to the speed of traffic in the Nogent subfluvial tunnel (saturation speed = 15 km/h).

In degraded mode, the auxiliary lane is opened exceptionally in order to cope with the consequences of a particularly disruptive traffic event (the closure of at least one traffic lane as a result of an incident) that has occurred on the common trunk or downstream of it. The objective is to speed up the return to normal traffic conditions. This opening must remain compatible with the need of emergency services to be able to reach road users, and with the main occupancy configuration adjacent to the incident. The auxiliary lane is also opened to improve traffic flow in the event of disruptive works (closure of left-hand lanes). An occupancy rate that remains below 15% for some time on the two upstream branches of the common trunk section causes the closure of the auxiliary lane. This closure criterion is still empirical. The operator must ascertain that there is no congestion on the common trunk section and the two upstream branches.

2.5. Impact analyses [2]

2.5.1. As regards capacity

The traffic lanes are equipped with sensors which output the fundamental traffic parameters: flow, speed and occupancy rate. These basic data can be used to determine the capacity of the facility, that is to say the maximum allowable flow. The figure below illustrates the variations in the flow and speed measurements made on the common trunk section in the direction away from Paris. With the auxiliary lane open there is a very marked increase in flows, particularly at capacity.

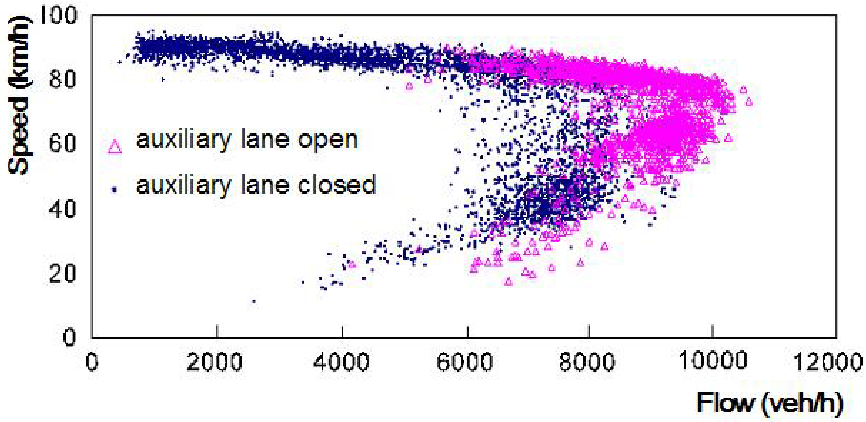

Figure 2 – Speed/flow measurements, auxiliary lane open or closed in the direction away from Paris

The capacity in the different configurations has been estimated by applying appropriate statistical calibration of the speed/flow plot. The results are set out in Table 1:

Table 1 - capacity of the A4-A86 concurrent section before and after the creation of the facility

Capacity (veh/h)	**2003** *4 lanes + hard shoulder*	**2006** *4 lanes + auxiliary lane closed*	**2006** *4 lanes + auxiliary lane open*	Difference (véh/h)
A4 W 7.05	8670	7610	9310	640
A4 Y 6.14	8820	8185	9725	905

The effects of use of the auxiliary lane are apparent in both traffic directions, although they differ in degree.

In the Paris bound direction (A4 W), the gain in capacity observed on the common trunk section is approximately 7.5 %, i.e. 650 veh/h. In 2003, the 4 lane section with a hard shoulder had a capacity of approximately 8700 veh/h. In 2006, the capacity obtained with the auxiliary lane opened exceeded 9300 vehicles/hour. When the auxiliary lane is closed, the maximum flow was only 7600 vehicles/h. In this case, what is involved is not so much a capacity but a threshold for opening the auxiliary lane.

In the direction away from Paris (A4 Y), the gain is even greater. The increase in capacity is of the order of 10%, i.e. 900 vehicles/h. In 2003, the section with 4 lanes and a hard shoulder had a capacity in excess of 8800 vehicles/h. In 2006, the capacity with the auxiliary lane open was of the order of 9700 vehicles/h. With the auxiliary lane closed, the maximum flow was approximately 8200 vehicles/h.

2.5.2. As regards the level of service provided to traffic

The concept of level of service refers to the traffic conditions that are observed locally on the common trunk section. Research on this area in France has led to the adoption of the following classification with 4 levels (instead of the 6 in the American Highway Capacity Manual [6]): free flow, free flow to dense traffic, capacity flow, saturation.

The use of the auxiliary lane on the common trunk section leads to a marked improvement in the level of service on weekdays, as shown in the charts below. Today, in comparison with the previous situation in 2003, the progress has resulted in an increase in operating time in free flow and fluid to dense traffic conditions and a correlative reduction in congested operating time.

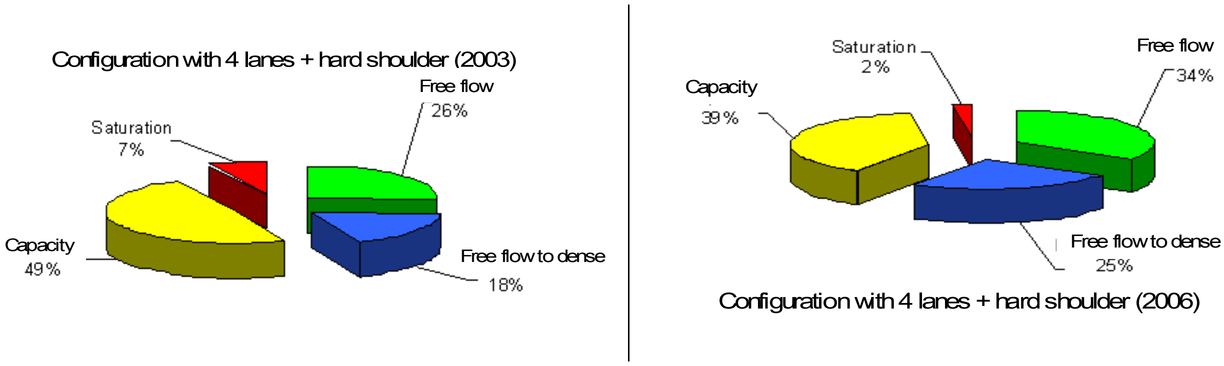

Figure 3 – Temporal distribution of the levels of service on weekdays, in the direction into Paris, before 2003 and after the opening of the facility (2006)

This result was obtained with an average utilization of the auxiliary lane of approximately 5 hours a day in the direction towards Paris and 4 hours a day in the opposite direction.

2.5.3. In terms of average travel speeds

This indicator is measured on the network that is influenced by the A4-A86 common trunk section, which is defined as all the roads which are directly affected by any major change in the traffic conditions on the defined section. This network includes, on the A4 motorway, the route between Noisy-le-Grand and Bercy, and, on the A86 motorway, the route between Rosny and the Pompadour intersection.

The effects on average travel speeds on the roads influenced by the project are generally positive, as shown in the figure: there has been an improvement, in some cases spectacular, on 4 of the 6 routes analysed and limited deterioration on the two others.
Last, a major decrease – of as much as 15% on workdays - in the *volume of congestion* (expressed in hours x km of queues, i.e. traffic moving at less than 30 km/h).

This evaluation, performed by INRETS, will at a later date be supplemented by three other appraisals dealing respectively with the environmental impact (fuel consumption, pollution, noise), the road safety impact and last the socio-economic profitability of the operation.

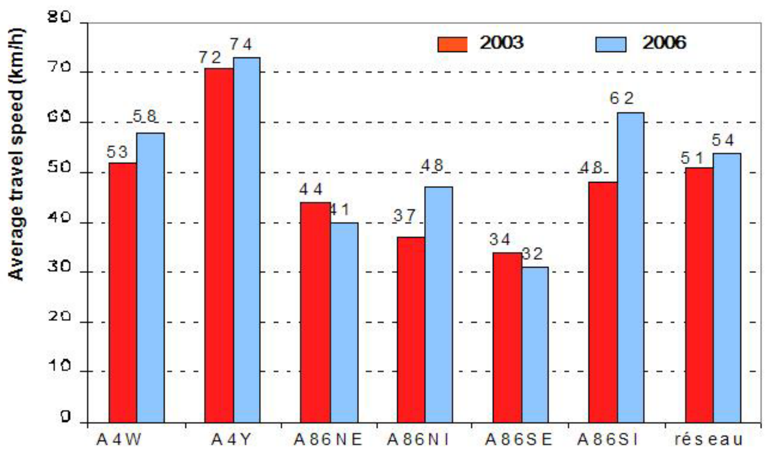

Figure 4 – Changes in travel speeds before/after the operation

2.6. Safety

The before and after changes on the A4-A86 common trunk section raise questions about the impact on user safety. In order to evaluate this impact a statistical analysis must be conducted on samples of a significant size, for which accident data for several consecutive years are required. It is still too soon to conduct an evaluation of this type on the basis of the police accident reports (BAAC files).

3. THE CREATION OF AN EMERGENCY VEHICLE AND PUBLIC TRANSPORT LANE ON THE A48

In this second project, dynamic lane assignment has been introduced to assist the movement of public transport vehicles.

3.1. Context

Since 2001, the General Council of the Département of Isère has been committed to improving suburban public transport in the Grenoble conurbation. In particular, this policy has resulted in the creation of a regional express coach network which uses a section of motorway.

The frequent peak period congestion on the A48 motorway leads to a reduction in the commercial speed of the coaches on the regional express coach network that was set up in 2002 between Voiron, Grenoble and Crolles. The topography of Grenoble makes any new infrastructure project extremely complex and costly. The President of the General Council of the Département of Isère therefore approached the Ministry of Infrastructure for permission to allow the express coaches to use the hard shoulder of the A48 motorway. This project is part of a set of measures to improve the access of public transport and emergency vehicles to the centre of Grenoble without major investment and within a relatively short time scale.

3.2. The project

The General Council of the Département of Isère decided to implement the emergency vehicle and public transport lane on the A48 in two phases. The first phase involves the trialling of an exclusive lane for regular coach services that would take over the hard shoulder. The location of the facility, whose total length is approximately 1100 metres, is the A48 motorway exit on the Pont d'Oxford sliproad which connects to the roundabout on the Avenue des Martyrs. The lane has been operating since the end of April 2004. The second phase is larger and involves 4200 m of 2x2 lane and 2x3 lane motorway located between the start of the bus lane of the first phase and the St Egrève Nord interchange, still on the A48. The "High Occupancy Vehicle" (HOV) lane will therefore join onto the existing bus lane to form a coherent exclusive bus lane system. The necessary infrastructure works began in July 2006.

Figure 5 – The current situation of the HOV lane trial (Map data provided by TeleAtlas for Google Maps)

3.3. First phase (bus lane)

The facility was completed and opened in April 2004. The initial cross-section which included a 4.25 m traffic lane and a 2.00 m right hard shoulder was modified in order to create an additional exclusive lane for authorized vehicles. The new-cross section consists of a 1.50 m right shoulder, 3.50 m exclusive coach lane, the 3.00 m lane for normal traffic and a 0.55 m left shoulder.

Photo 12 – View of the bus lane (Source: DDE 38)

The HOV lane has a coloured surfacing and specific information signing, in the absence of prescribed signs that are appropriate for this experimental situation. Upstream, the facility has been accompanied by a modification of the exit taper and also by the installation of specific horizontal and vertical signing. Downstream, for the single traffic lane, a system of three-coloured signals has been installed to give priority to the coaches. Beyond this, a system of traffic signals which are coordinated with the upstream signals helps the coaches gain access to a roundabout and then an exclusive urban bus lane.

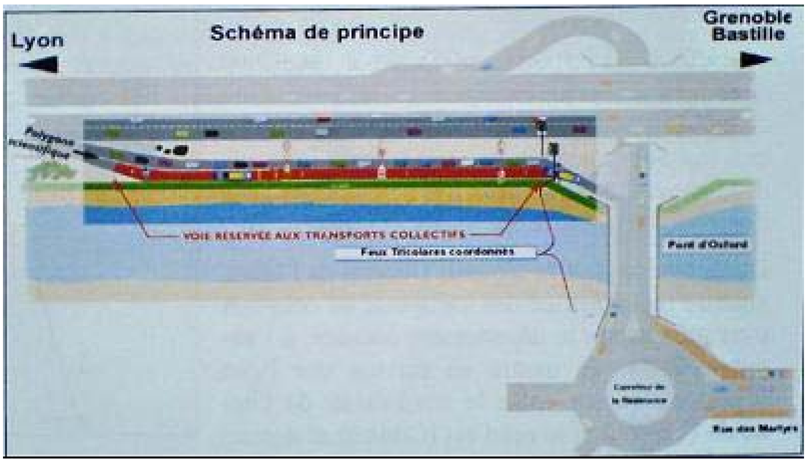

Figure 6 – The location of the bus lane

Consequently, this exit control could lead to dangerous tailbacks on the A48 upstream of the exit taper. In the event of this occurring, a loop detects the lengthening of the queue and changes the bus signal to red. The maximum length of the queue on the slip road is approximately 400 m.

3.3.1. Evaluation measurements

The first phase was evaluated by the ZELT [1] with the principal objectives of quantifying the impacts of the system on traffic in terms of journey times, queues, and user behaviours. For this purpose, two similar measurement campaigns were necessary, one in order to characterize the so-called reference situation, in November 2003, before the implementation of the exclusive lane, and the other in early May 2004, immediately after its opening. The measurements revealed average daily bus traffic of the order of 180 vehicles on the exclusive lane, 22% of which was between 7 and 9 a.m., which is the peak period. It should be noted that the percentage of light vehicles, mostly emergency vehicles, detected on the exclusive lane varied between 3 and 10%. On the other lane, the average peak period hourly traffic was approximately 1100 vehicles/hour, with 5.2% of HGVs. The average daily flow for vehicles of all types on this lane was 6500. With regard to the operation of the bus priority signal, 84% of the bus cycles during the observation period involved no wait for the bus. The impact on traffic was not negligible as the implementation of bus priority doubled the volume of the queues on the slip road; however, the flow improved on the section between the traffic signal and the roundabout where the volume of the queues was halved.

3.3.2. Capacity and journey time reductions on the exclusive lane

Peak period capacity on the exclusive lane on the slip road is estimated at 800 passengers per hour on the basis that it carries an average of 20 buses per hour, each with an average of 40 passengers. In comparison, the capacity of the adjacent lane is 1155 passengers per hour on the basis of an average of 1.05 passengers per vehicle (from the results quoted in Household Travel Surveys for Commuting Trips) and a measured flow of 1100 vehicles/h.

With regard to bus journey times, during the morning peak period there was a significant 16% reduction for buses over the entire measured journey. The largest gain was obviously on the section of exclusive lane where the average speed of buses increased from about 30 km/h to about 50 km/h. In the case of passenger cars, overall journey times remained stable, with even a slight improvement on the Pont d'Oxford as a result of the control of the roundabout entry provided by the bus priority facility. However, if estimates of delay at the start of the exit manœuvre on the exit slip road and upstream on the A48 are added to the above measurements, we can obtain a collective evaluation of the facility in terms of journey times, on the basis of the number of passengers carried by the buses and the private cars. This comprehensive collective evaluation is positive, the time savings provided to bus passengers exceed the delays caused to private car passengers by 40%.

3.3.3. The behaviour of vehicles

The behaviour of moving vehicles on the A48 is affected by the tailback on the slip road. We have observed an increase in the percentage of vehicles travelling on the left-hand lane and, of course, an increase in the number of vehicles pulling into the right-hand lane in the zone parallel to the exit. Hazardous or illegal behaviours are rare on the exit slip road, involving only 0.2% of exiting vehicles. Illegal use of the bus lane is also rare: it is used by only 0.1% of light vehicles and HGVs.

3.4. Second phase (HOV lane)

This second phase also involved removing the hard shoulder or modifying the right shoulder when there is no hard shoulder in order to replace it by a dedicated lane known as an emergency vehicle and public transport lane. This lane is currently under construction and aims to optimise traffic flow on the improved section by replacing the existing hard shoulder over a distance of 4.2 km in the direction towards Grenoble.
Several critical points are present, in particular the bifurcation of the A48 and A480 motorways and the crossing of an entry slip road. On the modified section, the express road coach route follows a three lane section then a two lane section before joining the Pont d'Oxford slip road with the bus lane from the first phase; the lane surfacing colours are the same (ochre). This lane will be shared by authorized public transport vehicles (whose drivers will be trained in its use [8]) as well as emergency, maintenance and security vehicles. Other coaches and private cars are not authorized to use the HOV lane, so specific dynamic vertical signing has been installed. Technical design for the project was essentially performed by the Département Infrastructure Directorate (DDE) with support from the so called "Réseau Scientifique et Technique du Ministère de l'Equipement" and from CERTU and SETRA in particular. This project was validated by the Direction Générale des Routes and the Direction de la Sécurité et de la Circulation Routières in July 2006 [5].

3.4.1. Conditions of use of the emergency vehicle and public transport lane

This lane and the variable speed limits will be activated under certain conditions. For safety reasons, the variable speed limit will also be applied on the HOV lane in order to ensure that the speed differential does not exceed 20 km/h.

Table 2 – The basis for activating the HOV lane

Speed observed on A 48	Status of HOV lane	Speed limit in HOV lane	Speed limit on link section
$V_{A48} > 50$ km/h	Disactivated	–	Depending on events
30 km/h < V_{A48} < 50 km/h	Activated	50 km/h	50 km/h
V_{A48} < 30 km/h	Activated	30 km/h	30 km/h

The HOV lane will only be activated in congested situations, i.e. when the measured speeds on the link section of the motorway are below 50 km/h. When this is the case, activation of the HOV lane will be automatically proposed and to the operator for validation. However, the HOV lane will retain its function as a hard shoulder when traffic flows freely. Furthermore, ramp metering will be introduced to manage traffic at the point of conflict between the entry slip road and the motorway. Priority will be given to coaches by changing the traffic signal on the slip road to red and providing right of way on the tramway type signal when they pass over detection loops upstream of the intersection.

3.4.2. Equipment installed

The structure of the hard shoulder had to be strengthened for it to be able to carry heavy and relatively dense traffic. Civil engineering works were also necessary to provide access for the various networks (electricity, data transmission) and the construction of 7 reserves with emergency telephones. The dynamic operation of the HOV lane will require the installation of a computer system that is connected to the signalling devices which will include:

- 3 prism lane assignment signs and 3 additional VMS;
- 4 gantries, each with 2 variable message signs for speed management purposes;
- 20 videomonitoring cameras equipped with an automatic incident detection system and 4 traffic count cameras on the A48 for activating the HOV lane;
- 19 three-coloured signals to warn coach drivers of the need to leave the HOV lane;
- 1 access control system for managing the motorway entry slip road

3.4.3. Safety and traffic management

Considerable resources have been put into ensuring road user safety, for example real-time monitoring of traffic on the HOV lane and the other traffic lanes. The entire section has video coverage from automatic incident detection cameras which are installed every 250 m which means the HOV lane closure procedure can be initiated in the event of an incident. This means the coaches must leave the HOV lane: a “bus” red warning light is positioned between each of the cameras to inform coaches to leave the HOV lane. Refuges spaced at intervals of approximately 500m allow out-of-control vehicles to stop [7]. All the equipment control devices will, initially, be centralized in the Traffic Engineering and Management Centre (CIGT), and the Direction Interdépartementale des Routes Centre-Est because the road in question (A48) is managed by central government.

3.5. The next steps and evaluation

This second phase is scheduled for opening in September 2007. Ultimately, in early 2008, the HOV lane will be managed by the future traffic control centre at Gentiane which will supervise all the traffic on the urban roads in the Grenoble conurbation. Trialling of the second phase will involve an evaluation by the "Zone Expérimentale et Laboratoire de Trafic" (ZELT).

4. CONCLUSIONS AND LESSONS

For some years, there have been increasing requests for permission to open the hard shoulders on highly trafficked sections of express roads to all types of traffic or to public transport, on either a temporary or permanent basis. These two projects give a foretaste of the measures which will have to be implemented in the very near future in major cities in which the amount of time spent in traffic jams is increasing all the time. The system implemented on the A4-A86 common trunk section is currently undergoing a thorough evaluation which seems to confirm its favourable impact in terms of safety and traffic management. The creation of the emergency vehicle and public transport lane is an appropriate solution for providing a good commercial speed for the coaches on the express road coach route that has been created in the Département of Isère. However, these innovative approaches to the use of additional lanes on existing infrastructures mean that several additional aspects need to be considered. The first of these is of a legal nature: what legal status will be given to the new traffic lane that replaces the hard shoulder? Another aspect which must not be overlooked is the cost of the variable lane management project. The overall cost of the system must be considered in relation to the expected return on investment. To give an idea, investment in the A4-A86 common trunk section operation in the Paris region is almost €20M. The cost of the entire operation on the regional express coach network in Grenoble exceeds €6M. These two operations involve the concept of sustainable road traffic. Environmental aspects and social acceptability therefore feature among their objectives. It is obvious that the next operation of this type will be directed towards the implementation of high occupancy lanes reserved mainly for carpool vehicles, taxis and public transport vehicles [9].

REFERENCES

1. BARTHE C., (2004). A48 – Echangeur du Pont Haubané à Grenoble, création d'une voie bus sur la bretelle de sortie, Rapport d'évaluation ZELT
2. COHEN S., (2005) La gestion dynamique des voies : un outil efficace d'exploitation des autoroutes ? , Revue Générale des Routes, n°842, september 2005.
3. COHEN S., (2006) A cost-benefit assessment of a managed lanes operation on an urban motorway, TRB, First International Symposium on Freeway and Tollway Operations, Athens, 4-7 june 2006.
4. COHEN S., (2005) Les voies gérées et les contraintes d'une mobilité durable, Infrastructures et Mobilité, n°44, march 2005.
5. CONSEIL GENERAL ISERE, (2005) Dossier d'Avant Projet Sommaire de création d'une VSP sur BAU de l'A48
6. Highway Capacity Manual (2000) Special Report 209, Transportation Research Board, National Research Council, Washington D.C.
7. POLLET A., BEAUBAT M., MADIER DE CHAMPVERMEIL P., (2005) Analyse des possibilités et des conditions d'utilisation des bandes d'arrêt d'urgence sur voies rapides aux fins de circulation d'autocars, Rapport CGPC n° 2003-0028-01 et 02, april 2005.
8. LHUILLIER J-P., (2007) Note sur l'usage des voies de circulation et de la bande d'arrêt d'urgence pour des véhicules spécifiques sur Voiries à Caractéristiques Autoroutières
9. PEIGNE H., (2005) Une Voirie pour tous, rapport sur la base du groupe de travail « Partage de la rue »- Conseil National des Transports.
10. NOUVIER J., CAUBET Cl., (2005) L'affectation variable des voies et de l'espace public - Communication Congrès ATEC 2005.