



THE AUSTRIAN HOV-LANE - EXPERIENCES IN IMPLEMENTATION AND OPERATION

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Abstract. The ever increasing use of private vehicles for daily commuting trips contributes to a rising level of congestion in metropolitan areas. The trip times for each driver grow constantly. Just this situation is approaching Linz (ca 200 000 inhabitants), which is the capital of Upper Austria and also the political and economical centre of the region. At one every workday morning heavily congested arterial road towards the city, since 1998 high occupancy vehicles (HOV) with 3 or more occupants (3+) have been permitted to use the existing bus lane too. The opportunity to save time should encourage commuters to share their cars and should result in a more efficient car use.

Based on a study, by which the efficiency of that first HOV-lane in Austria was investigated, the effects and the influences on the trip duration, commuting behaviour, drivers attitudes towards the measure, bus drivers' and policemen's experiences as well as the environmental and public costs are described. Additionally, some imperfections are revealed concerning, for instance, the used traffic signs.

As the main outcome the implementation of this HOV-lane proves to be a practical approach for improving the bad commuting traffic situation on a local level. However, it must be seen only as one of many measures that would be necessary to create a real sustainable solution for the whole metropolitan area.

Keywords: high occupancy vehicle, HOV-lane, bus lane, arterial roads, congestion, public costs, Austria.

1. Introduction

In and near metropolitan areas the risk of traffic congestion especially during the peak hours is high, mainly caused by the steady increasing use of private vehicles for daily commuting trips. The trip times for each driver often are varying enormously on their regular journeys, and on average they are constantly growing. Therefore it appears necessary to find sustainable solutions to keep the density of cars on the road at the same level or even to reduce it.

A possible measure to improve the situation on arterial roads in particular is the implementation of the so-called HOV-lanes. These are lanes kept for high occupancy vehicles and, respectively, forbidden for vehicles with less than a prescribed number of passengers on board. The opportunity to save time on daily trips to work should encourage commuters to share their cars and should result in a more efficient car use: the same number of commuters are travelling in less cars. Roads with HOV-lanes are quite usual in the USA. In Europe, such facilities are, for instance, in Madrid since 1995 and in Leeds since 1998 [1], and in Trondheim since May 2001 [2] successfully in operation. In October 1998 the first Austrian HOV-lane was put into operation. In the fol-

lowing the results of a study for the government of Upper Austria [3] are described. The objective was to investigate the efficiency of this new measure.

2. Situation

According to the law in Austria, a designated bus-lane is usually opened for buses, emergency vehicles on duty and taxis. By decree of the government of Upper Austria with effect from October 1st 1998, the existing bus-lane on federal road B127 from the small town Puchenu entering the conurbation of Linz was also opened for vehicles with at least three occupants (3+).

The thereby created HOV-lane is km 2.85 long (cp. Fig 1). It starts exactly at the border of the village of Puchenu (km 6.53). At this point, the up to now two-lane B127 is widened to 5 lanes: 3 lanes heading towards Linz (2 regular ones plus the HOV-lane on the very right), and 2 lanes heading the opposite direction.

About 400 m before the end of the HOV-lane, the two regular lanes heading towards Linz are reduced to one (km 4.14). At the end of the HOV-lane (km 3.7) the B127 is a two-lane road.

For about 800 m from the beginning of the HOV-lane the speed limit is 70 km/h, afterwards 100 km/h

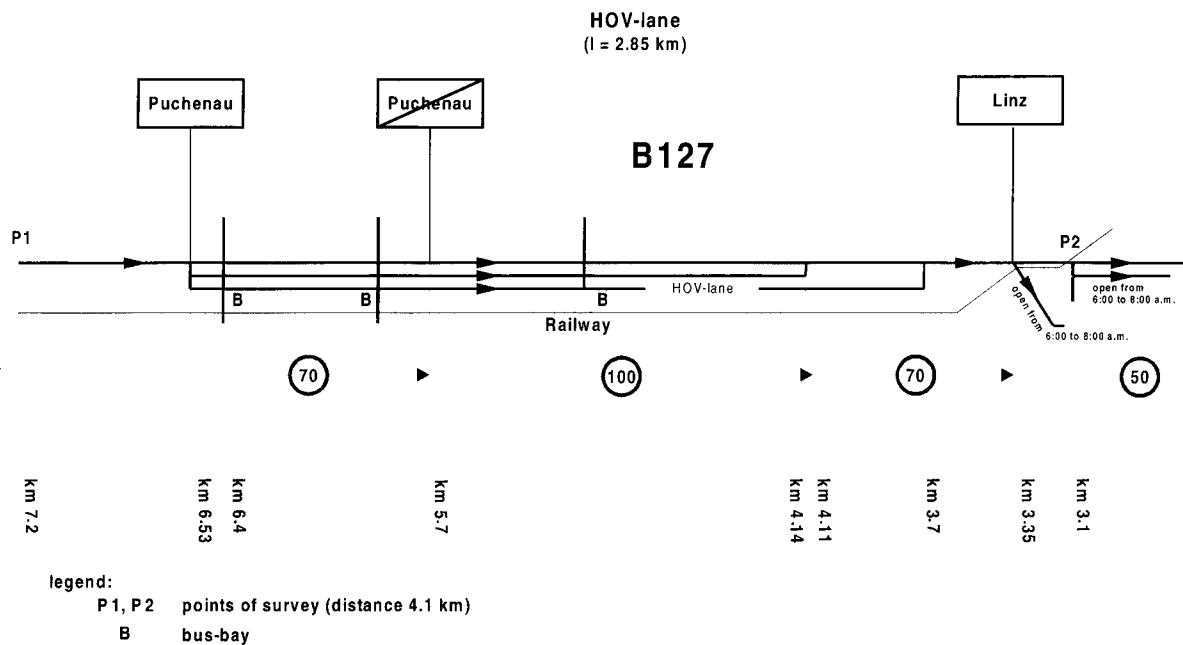


Fig 1. Schematic description of traffic organisation and distribution of lanes of the B127 in the surveyed sector with the HOV-lane (only direction towards Linz)

(open area) and from the interweaving of two regular lanes 400 m before the end of the HOV-lane – 70 km/h again.

Additionally, two special features are to be mentioned:

- 350 m after the end of the HOV-lane one can turn another road leading to Linz (km 3.35); but only between 06:00 and 08:00 am. Before and afterwards it is not possible to leave the B127 on this side street, because of a constantly closed railway-gate.

- Through a temporary no-stopping zone, the B127 is a three-lane road from 6:00 until 8:00 am, beginning at km 3.1 (two lanes heading towards Linz / centre). From 8 o'clock on parking is allowed and the street remains two-laned. In this part the B127 also gets its urban character.

The HOV-lane is continuously separated from the regular lanes by a white-line except for two intersections in Puchenau. That's why drivers of HOVs can hardly change to the HOV-lane legally, if they are not using it from the beginning. At the shoulder of the HOV-lane a continuous steel-made crash-barrier is mounted. Parallel to the whole researched strip a railway track is situated. Thus there is no possibility for police to stop cars, apart from three bus-bays along the street.

The information about the possibility of use for vehicles with minimum 3 passengers or vehicles, which transport live animals is given by altogether four traffic signs "Bus lane" with additional text along the HOV-lane (Fig 2).

The B127 is the only street worth mentioning towards the conurbation of Linz from the north-west. The

average traffic volume is about 24 000 vehicles per day, with about 5% of heavy traffic. In the direction towards Linz there is a significant morning peak: from Monday to Friday between 6:00 and 9:00 am about a third of the daily volume of traffic heading for Linz passes this cross-section. In this time about 20 regular buses and a few company owned buses for workers lead into Linz, most of them fully occupied (50 people per bus).



Fig 2. Sign posting at the HOV-lane: as there currently no specific traffic sign exists, the transfer of information can only be assured by an additional text

3. Method of investigation

The study includes the following investigations:

- Traffic observation at peak hours, using observation and video at several cross-sections: determination of the traffic volume, the number of HOV-lane users, the travel time and travel time differences, as well as the number of car occupants in order to find out the personal travel times.
- Questioning of car drivers by questionnaires, to investigate and judge the personal experiences, the level of information, as well as the individual attitude towards the new measure. This was performed by distributing questionnaires at several intersections regulated by traffic lights.
- Interviews with experts in the traffic department and the executive as well as with bus drivers of the public transport, using a questionnaire-based interview technique.

4. Results of the traffic investigation

4.1. Course of the morning traffic

The consequences of traffic on the HOV-lane can be best described, when watching a typical course of morning traffic. Fig 3 shows the accessing volume of traffic (vehicles per 15 min) before the beginning of the HOV-lane on Monday, to Linz. Between 5:45 and 9:00 am altogether 3862 vehicles (1.190 veh/h on average) passed through the investigated cross-section, including 3645 personal cars. The highest frequency is observed between 6:00 and 7:30 am with a good 370 veh/15 min, resp about 1400 veh/h. From about 8:00 on, the accessing traffic decreases to about 190 veh/15 min.

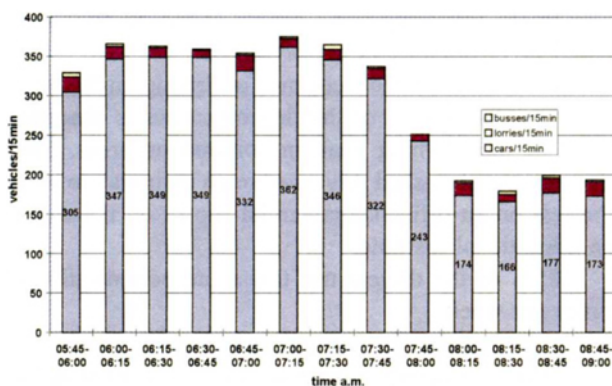


Fig 3. Accessing traffic volume on the B127 towards Linz (km 7.2); Monday 5:45 till 8:00 am

A very different performance is to be observed at the volume of traffic leaking away after the end of the HOV-lane (Fig 4).

- Until 6:00, the leakage at km 3.1 about equals the access at km 7.2; the traffic flow is undisturbed.
- From 6:00 till 8:00 am, while the access is constantly high, the leakage continuously diminishes. Two reasons are to be mentioned: (1) at the weaving of the two “regular” lanes heading towards Linz, a bottleneck

in traffic capacity appears and causes a fast growing congestion; (2) some of the drivers use the possibility to leave the B127 after this bottleneck on the street at km 3.35, which is accessible at this time. These vehicles are not documented in the leakage records.

- Shortly after 8:00 am the access is reduced by half, while the leakage rises to a peak. Therefore two reasons have to be mentioned as well:
 - It is not possible to leave the B127 at km 3.35 at this time anymore. All accessing vehicles are caught in the leakage records.
 - From 8:00 am on, parking is allowed on the second lane of the B127 bound for Linz. Therefore just one lane heading to the town centre is useable after 8:00. Shortly afterwards a defile in capacity is observed.
 - From 8:15 am on, the leakage is slightly higher than the access. The tailback at km 4.14, which has meanwhile grown to a length of a few hundred metres, is decreasing slowly, but remains until shortly before noon.

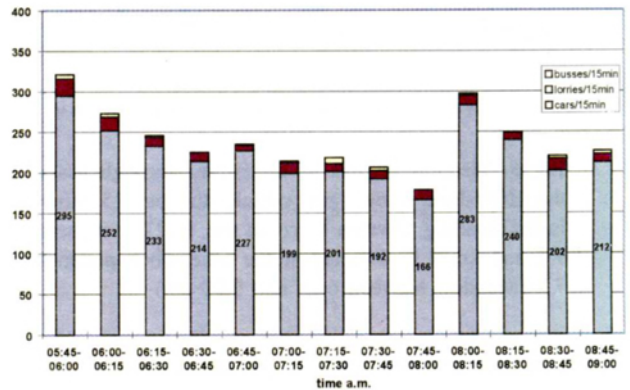


Fig 4. Leaking volume of traffic on the B127 heading towards Linz (km 3.1); Monday, 5:45 till 9:30 am

4.2. Travel-time / Possible savings

The tailback in the morning is to be seen obviously in the investigated travel-times of a good 3000 vehicles (cars, lorries, busses) on the 4.1 km long observed road section (Fig 5). In the undisturbed flow of traffic until

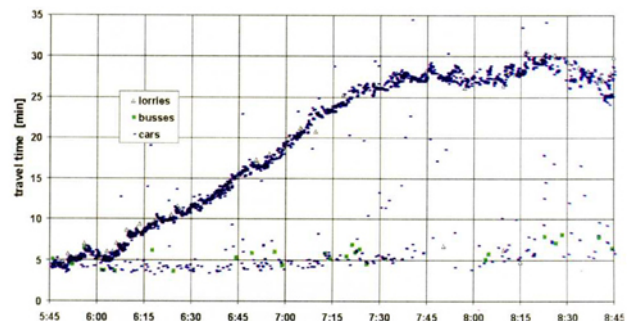


Fig 5. Individual travel-times of vehicles heading towards Linz on the B127 between km 7.2 and 3.1; depicted according to the time when passing km 7.2 and distinguished between types of vehicles (Monday, between 5:45 and 8:45 am)

6:00 am, the average travel-time for all vehicles amounts to 4-6 min. Afterwards it rises and reaches peaks between 25 and 30 min for vehicles, which use the “regular” lanes. This causes speeds of 8 to 10 km/h on average.

For users of the HOV-lane, the travel-time until 8:00 stays about the same as for undisturbed traffic (about 4 to 6 min). Afterwards it rises to about 7 min.

In Fig 6 the investigated medium of travel-time-saving per 15 min for every user of the HOV-lane is shown. Being not even notable before 6:15 am, it rises to 22 minutes by 7:45 am. The peak between 8:15 and 8:30 am is a good 24 minutes.

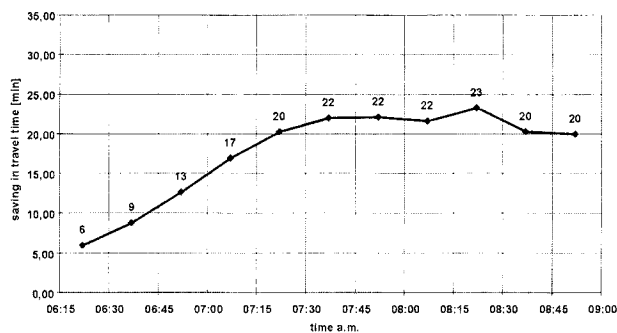


Fig 6. Medium savings of travel-time through usage of the HOV-lane, shown per vehicle and per 15 min, vehicles heading towards Linz on the B127, between km 7.2 and km 3,1; depicted at the time when passing km 7.2 (Monday, between 6:15 and 9:00 am)

4.3. Use of the HOV-lane by personal cars

About 10% of the cars in the morning traffic and all the buses use the HOV-lane, but the number of users varies strongly in the 15-min-intervals. The highest rates of HOV-lane users appear between 7:00 and 7:45 am, (13% up to 25% of all personal cars).

Most cars on the HOV-lane carry exactly 3 persons, about 15% of them even more than 3 people are seated (Fig 7). The average level of occupation is 3.2 persons

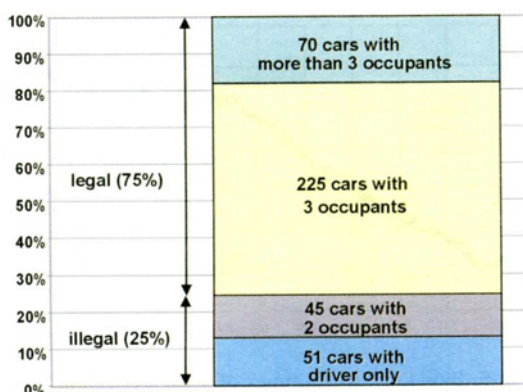


Fig 7. Distribution of the frequency of personal cars according to number of occupants on the HOV-lane; B127 at km 3.7; Monday, between 5:45 and 9:00 am

per car. However, about 25% of cars use the HOV-lane illegally, as they carry only 2 persons or even just the driver all alone. Under consideration of these illegal users, the average level of occupation of all personal cars on the HOV-lane is 2,6 persons per car.

In comparison: the level of occupation of all cars heading towards Linz on the B127 between 6:00 and 9:00 am was observed with 1,3 persons per car.

4.4. Economical effect

Altogether the persons in cars of legal users of the HOV-lane save a good 250 man-hours on a working day, between 6:00 and 9:00 am. Therefore a total saving of more than 60 000 man-hours per year through the installation of the HOV-lane can be assumed. Taken an average cost factor of € 3,- per man-hour [4] this means savings of about € 180 000,- per year.

The savings of travel-time also lead to a reduction of pollution. Taken the total sum of travel-time differences between the HOV-lane users and the same number of cars on the “regular” lanes, one gets a reduction of CO₂-emission per morning-traffic-peak of 0,5 t, resp a reduction of a good 125 t CO₂ per year. Taken an upper limit for costs following environmental damage given by [4] of € 650,-/t CO₂, this means a saving of € 80 000,- per year through the implementation of the HOV-lane.

Altogether the economic saving per year can therefore be estimated about € 260 000 through the HOV-lane.

5. Results of the driver-interviews

In the following some results of the questionnaire-based driver-interviews are presented.

- Cause for and frequency of driving on this street

The distribution of the driving causes is characteristic of the morning peak in conurbation areas. More than 90% of the asked drivers were on their way to work, the rest on an official/commercial trip or on the way to an educational institute.

85% of the drivers use this route periodically (≥ 5 times per week).

- Changing the reported travel-time

Drivers of cars with one or two occupants stated no significant loss of travel-time and could not recognise a change. Drivers of cars with three or more occupants – usually the users of the HOV-lane – essentially confirm the amount of saved travel-time which was measured. So, a good 60% of the interviewers stated to win more than 5 min travel-time. Most interviewers (39%) declared to save from 5 to 10 min through the bus-lane opening. A fifth of the questioned people stated to save more than 10 min regularly.

- Passengers

The passengers are mostly family-members, colleagues or neighbours (Fig 8). In nearly half of the re-

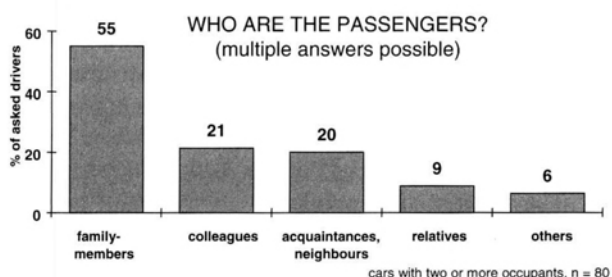


Fig 8. Composition of car-occupation in vehicles with two or more occupants on the B127 heading towards Linz

searched cases, the occupation of the car is five times a week.

The question, if they take additional passengers with them, would they be allowed to use the HOV-lane was answered positively by about 60% of the drivers (Fig 9). But about a third of the asked drivers did so with certain reservations. For example, they would take only people they know.

WOULD YOU TAKE OTHER PERSONS WITH YOU, TO BE ALLOWED TO USE THE HOV-LANE?

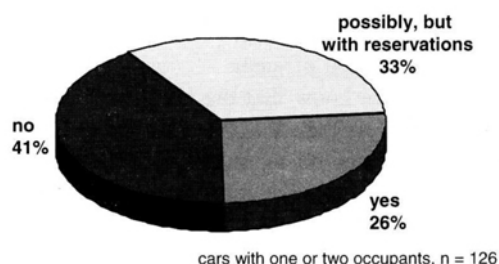


Fig 9. Relative frequency of the potential willingness to give additional passengers a lift in a private car on the B127 towards Linz

95% of all interviewed drivers stated that the number of occupants in their cars has not changed since the establishment of the HOV-lane. 63% of drivers with three or more passengers have told the same. They had already been travelling as car-poolers before.

But more than a fourth of the drivers with three or more passengers declared that the number of occupants changed, since the HOV-lane was established (Fig 10). With most of them their passengers were travelling alone in their cars or two by two. Only 5 of these drivers stated that they were giving a lift to people, who were travelling by train or bus before the installation of the HOV-lane. Altogether the measure has just a small influence on the car occupation.

• Acceptance of the measure

Basically the measure is judged positively by a majority of the car drivers, whereby the percentage of agreement under users of the HOV-lane is significantly higher (Fig 11). A hindrance of buses caused by cars on the HOV-lane could not be observed.

HAS THE NUMBER OF OCCUPANTS CHANGED DUE TO THE INSTALLATION OF THE HOV-LANE ON THIS STRETCH OF THE ROAD?

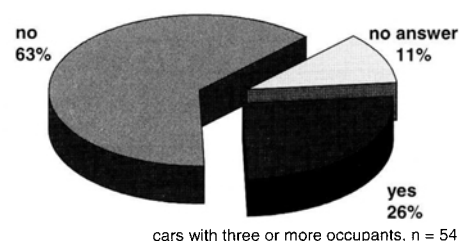


Fig 10. Relative frequency of change in the occupation in private cars ≥ 3 occupants since the installation of the HOV-lane on the B127 to Linz

THE INSTALLATION OF THE HOV-LANE IS A USEFUL TRAFFIC MEASURE

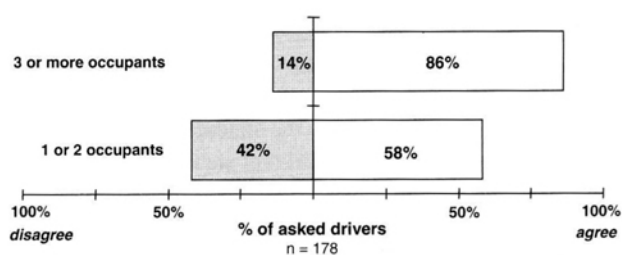


Fig 11. Agreement with the installation of the HOV-lane on the B127 towards Linz, split for drivers of cars with 1 or 2 occupants and ≥ 3 occupants

A substantial annoyance for many car drivers is the abuse of the HOV-lane (Fig 12). 66% of all drivers travelling alone or with just one passenger stated that the present HOV-lane is more often abused by car drivers than the former bus-lane.

DUE TO THE OPENING OF THE BUS-LANE FOR HOVs IT IS ABUSED MORE OFTEN

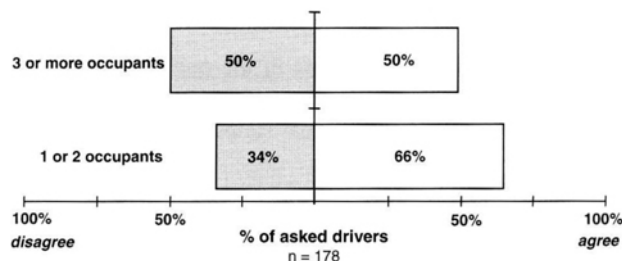


Fig 12. Judgement of the frequency of abuse of the HOV-lane on the B127 towards Linz, split for drivers of cars with 1-2 occupants and ≥ 3 occupants

As a logical consequence there exists a great demand for stronger police controls, especially from drivers of cars with just one or two occupants (Fig 13). These drivers are not allowed to use the HOV-lane and are especially annoyed by cars with one or two occupants

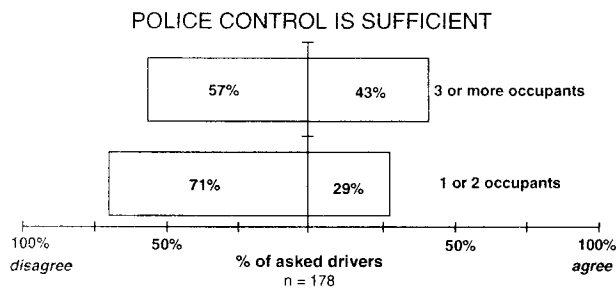


Fig 13. Judgement of police control of the legal/illegal using of the HOV-lane on the B127 towards Linz, split for drivers of cars with 1-2 occupants and ≥ 3 occupants

passing them illegally on the HOV-lane, while they are waiting in the congestion.

- Level of information about the measure

The information campaign of the local population by the media (newspaper, radio, TV) about the installation of the HOV-lane was very successful. Nearly two thirds of the interviewed drivers declared to have heard of the new measure through the media (Fig 14). On the other hand, just 18% of the drivers stated to have gained their information through the newly established traffic signs. This is a clear sign that the content of information in these signs is not sufficient in the present form.

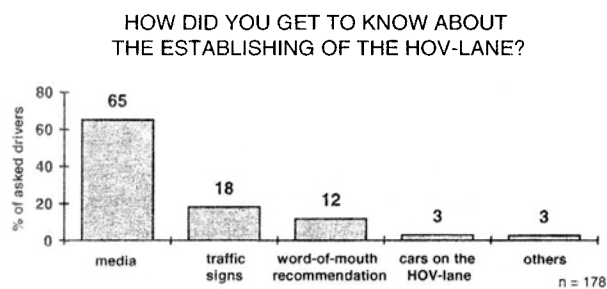


Fig 14. Relative frequency of the different sources of information about the installation of the HOV-lane on the B127 towards Linz

- Individual statements in the questionnaires

At least 37% of the interviewed drivers used the possibility to declare individual statements on their questionnaires.

- About a quarter of them does not regard the measure as being sufficient to solve the congestion problem in the morning traffic on the B127 towards Linz.
- 18% of the drivers again stated their annoyance about the abuse of the HOV-lane and requested more enforcement.
- 13% of the drivers regarded the installation of the HOV-lane as a good idea. There are proportionately more drivers than the ones allowed to use the HOV-lane and shows a generally high acceptance of the measure.
- 6% of the drivers stated, without being asked, that the HOV-lane should become a permanent installation.

6. Results of the interviews with experts

In the following, a summary of the most substantial results of the interviews with executive government officials, bus drivers and officers of the executive is given.

- Executive officials of the road administration

They regard the installation of the HOV-lane as basically useful, given there is no delay for public buses or emergency vehicles caused by HOVs. A general solution of the traffic problems on the B127 close to Linz through this measure is not expected though.

- Bus drivers

The interviewed bus drivers admitted that they had had reservation about the opening of the bus-lane to HOVs. But the practical experiences did not prove this scepticism.

A loss of time for busses through cars on the HOV-lane did never occur.

Sometimes hindrances occur through cars, which suddenly change to the HOV-lane from the congestion on the "regular" neighbouring lane, right in front of a bus. Very often these are drivers alone in their car, which means drivers abusing the HOV-lane. That is why bus drivers would wish a separation between the HOV-lane and the neighbouring lane, which is optically more effective than the white line.

- Executive officers

The police know that the HOV-lane is often abused by cars with less than 3 occupants. But a useful enforcement is just possible by stopping those cars, because a charge against passing abusers is (often successfully) appealed against.

Along the whole stretch of the HOV-lane there is nearly no possibility to stop a car. So, a permanent, efficient monitoring is not possible. Although spot checks are performed, they are difficult, need much personnel and are, because of high velocities on the HOV-lane, often even dangerous.

The officers would like to have more staff and the creation of enough space to stop cars. Maybe an increase of fines (currently € 21.-) would act as a deterrent.

7. Opening of the HOV-lane also for vehicles with two or more occupants (2+)?

The in principle conceivable variant to open the HOV-lane not only for vehicles with three or more occupants (3+), but also for vehicles with two or more occupants (2+) was tested in a model using the results of the traffic investigation. In this case, 31% of all private cars would be allowed to use the HOV-lane legally.

With a total morning peak in traffic, the small average save of time is about 1%, if one just looks upon the car occupants. It means that the potentially gainable time saving for people in a car with two occupants is about as high as the resulting loss of time for people in a car with three occupants and single drivers.

Looks also upon the busses, the total amount of loss

of time per person would be about 12%. It means that the additional opening of the HOV-lane for cars with two or more occupants (2+) would especially rise the travel times of bus passengers and thereby be at the expense of public transport.

The opening of the HOV-lane for cars from two occupants on up would therefore be of no advantage.

8. Judgement of the measure

8.1. Disadvantages of the HOV-lane

Through the opening of the bus lane for vehicles with three or more occupants (3+) no loss of travel time for busses (of the public transport) could be recognised. Neither was a significant change of the source of transport of users of public transport (bus or train) to individual transport means observable.

Quite a high grade of annoyance of drivers about abusers of the HOV-lane was to be recognised. At least about every fourth private car did use the HOV-lane illegally - with less than three occupants.

A certain risk potential occurs, when vehicles from the congestion change at low speed to the HOV-lane, where vehicles at high speed approach.

The level of information about the HOV-lane is quite low, especially among drivers, who do not use this road periodically. By rising the quality of information transfer, the advantages of the HOV-lane, as described in the following, could be exploited in a better way.

Altogether no significant disadvantages could be observed through the installation of the HOV-lane.

8.2. Advantages of the HOV-lane

Saving time for the users at a high volume of traffic is the most significant advantage. This saving results from long congestion-queues that fast build up at rising traffic volumes between Puchenau and Linz. These can pass on the HOV-lane. The investigated time saving per vehicle was on a scale of 20 minutes and more. Projected for a year this amounts to a good 60 000 man-hours.

The amount of the estimated yearly economic saving, resulting from travel-time saving and reduction of CO₂-emission is about € 260 000. This alone shows that the established measure is useful.

The principal acceptance of this newly established measure is high among the drivers. However, the advantage of a reduction in traffic volume through enforcing active car-pooling is just recognisable in very first tendencies. The possibility of saving a few minutes travel time seems not to be sufficient, to move enough drivers to pool their cars on their daily commuting trip to work.

Maybe the time-period to get used to this in Austria still quite unknown, the measure is not sufficiently long enough yet. From the psychological point of view it would be not surprising, if the tendency to form car-

pools would rise with the time. The more often a driver, who is waiting in the traffic jam, is passed by an HOV, the stronger the will grows to use it too and therefore to become a car-pooler.

At the moment, the opening of the HOV-lane for cars with two or more occupants (2+) seems not to bring any further advantages, but, on the contrary, serious disadvantages, especially for bus-passengers.

9. Conclusions

In summary, it can be stated that the opening of the bus-lane for high occupancy vehicles (HOV) is, altogether, a measure to be welcomed. In peak hours, the HOV-lane is of a significant advantage for occupants of HOVs and of no disadvantage for passengers of buses. This broadly corresponds to international experiences with similar measures (eg [5]).

Analysing the gained knowledge of this - for Austria new - measure, some items for similar projects in the future can be gathered:

- When opening an existing bus-lane for HOVs, a broadening of the road is not necessary. Therefore the measure is much cheaper than building an additional lane would be.
- The measure should be established where it really leads to a significant and regular time saving for users of the HOV-lane. This shall inspire drivers to form car-pools.
- Early and intensive information about the measure in local media is a must.
- The information transfer in place must be clear and easy, also for drivers who are not using the road periodically. Big signs should inform about the measure. The information of the traffic signs must not be complicated but easily readable and understandable. Additionally, pictographic markings should be painted on the HOV-lane at continuous distances in any case (Figs 15, 16).

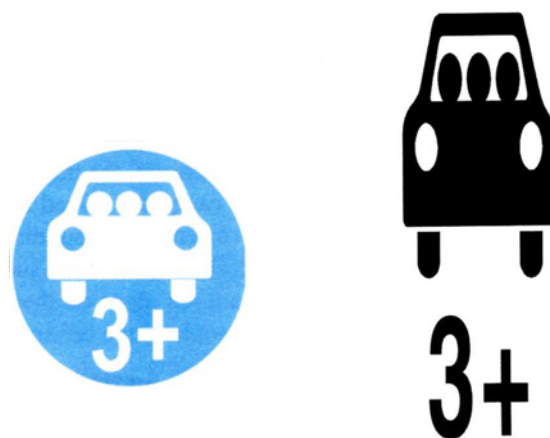


Fig 15. Proposals for a new traffic sign (left; cp. [6]) and a pictographic on-street-marking (right)



Fig 16. International examples for sign posting and on-street-markings at HOV-lanes (Leeds, UK)

- The demarcation between the HOV-lane and the neighbouring “regular” lane should be very significant (Fig 16). Especially in places with congestion, a changing over from the “regular” lane to the HOV-lane is dangerous and should be prevented in any case.

- A well working monitoring of the legal using of the HOV-lane is very important. It rises the acceptance of the measure and helps building consciousness of the traffic members. To be able to control the number of occupants effectively, the cars must be stopped. It means that enough space must be available or, if not available yet, prepared, to do so in a safe way for officers of the executive.

- The installation of an HOV-lane as a single measure is innovative and creates advantages for the users as well as for the community, if established in a suitable way. With just this one singular measure, the traffic problems in and around conurbation cannot be solved though. But setting the measure can contribute to building the car users' consciousness. At least it is a small success, when again and again drivers are not alone on their trip, but together with two or more people in the car and leave their own car at home or at a meeting point.

10. View

To gain permanent success in traffic reduction in a certain region, HOV-lanes must be seen as one part of a whole bundle of measures. Some of these were, for ex-

ample, investigated in the demonstration project “Salzburg tests car-pools” [5] and should contain the following:

- intensive information of households in the target-areas,
- the installation of “matching centres” to manage the car-pools (eg by automobile associations),
- mounting of big information signs along the inbound roads towards the conurbation,
- building of explicitly pointed out car-pool parking lots along those roads in the surrounding of conurbation,
- creation of additional benefits for declared HOV-users (eg reserved parking lots close to their work, reduced prices for tickets for their trip home by public transport),
- establishing restrictions for single drivers (eg parking restrictions in conurbation).

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