THE M10 AMSTERDAM ORBITAL MOTORWAY:
EFFECTS OF OPENING UPON TRAVEL BEHAVIOUR

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SUMMARY

September 28, 1990, the motorway circle around Amsterdam was
closed officially. It has important consequences for the travel
and traffic pattern around Amsterdam and the rest of the
Netherlands.

Completion of this major infrastructure project provides an
outstanding opportunity to study the effects of infrastructural
changes upon travel behavior and traffic patterns. An extensive
before-and-after study has been carried out to analyse these
effects.

This paper gives an insight into the present and future traffic
situation. Solving bottlenecks in the trunk-road network often
causes a one-off growth of the traffic by car on that bottleneck
location during the peakhour. It is often assumed that this is
newly generated traffic. Most of the additional traffic at the
bottleneck, however, can be explained by shifts in time-of-day,
i.e. a return to the most preferred part of the peak period, as
well as a shift in routes used.

Special attention has been given to an explanation of this
"latent demand" phenomenon through measuring and modeling changes
in departure time, route choice, mode as well as destination
choice of the car and public transport users.

The Transportation and Traffic Research Division of Rijkswater-
staat investigates the changes and offers recommendations for
national and regional policy based on the results of the study.
1 INTRODUCTION

1.1. The context

It is expected that motor traffic will greatly increase during coming years in The Netherlands, particularly in and around the central area between Amsterdam, The Hague, Rotterdam and Utrecht, the so-called Randstad. Transportation policy is aimed at controlling motor traffic. Attention is being given, amongst other things, to the use of instruments in the short-term such as tolls and traffic guidance systems. The intention is also to offer good alternatives to the car by improving public transport and car pooling. Policy is also aimed, in addition to the measures mentioned above, at removing bottlenecks and realizing missing links in the Dutch trunk road system.

An example of this is the opening of the M10 Amsterdam Orbital Motorway on 28 September 1990 (Figure 1). The Zeeburgertunnel, which was opened at the same time, forms the eastern part of the Amsterdam Orbital Motorway. Amsterdam thus acquired, for the first time, a high quality orbital route round the city, so that pressure on one of the most serious bottlenecks – known as the Coentunnel – in the Randstad was considerably reduced.

Figure 1. The road network situation before and after the opening of the M10 Amsterdam Orbital Motorway.
As early as 1934 there had already been talk about establishing an Orbital Motorway in a development plan for the expansion of Amsterdam. Plans became definite in the '60s and the Coentunnel was the first part of the Orbital Motorway to be used. Half the Orbital Motorway had still not been completed however one year before the opening of the Orbital Motorway in 1990. That is partly the reason why the opening will have considerable consequences in a fairly short period of time for traffic and transportation in Amsterdam and in a wide area round about as well as for many other associated activities.

1.2. History

The situation before the opening.

For many years the traffic situation in and around Amsterdam has been increasingly characterized by traffic jams. A well known example of this is the Coentunnel which is number one on the Dutch top ten list of traffic jams.

More and more car drivers commute from their homes situated north of the North Sea Canal (connecting Amsterdam to the North Sea) to their places of work which are often situated south of this canal. The North Sea Canal cuts through Amsterdam from west to east and can be compared, from the point of view of a barrier, to the Thames in London and the Seine in Paris. The majority of this transitory shore-to-shore traffic is concentrated on the roads via three tunnels, namely the Velser, the Coen and the IJtunnel with an approximate total of 240,000 motor vehicle movements per 24 hour period. The Coentunnel accounts (in both directions together) for 93,000 of those 240,000 motor vehicles. All these existing tunnels consist double carriageways with 2 lanes per carriageway.

In 1980 75,000 vehicles per 24 hour period passed through the Coentunnel. The volume of traffic passing through the tunnel has increased by approx. 25% in ten years, or an average of 2.5% per year. Traffic jams have been forming since 1975 near the Coentunnel in both peak periods. The time spent waiting in a traffic jam has done nothing but increase since then.

If traffic in the Coentunnel is to move smoothly then the volume of traffic per direction must not exceed 3600 motor vehicles per hour. Traffic counts in 1989 indicated a one-directional volume of 4200 motor vehicles per hour. The national trunk-roads 1, 2, 4 and 9, which are access roads to the Coentunnel, also carry a high traffic volume.

One can easily guess what the consequences for accessibility will be. The area north of the North Sea Canal, including Amsterdam North, is particularly threatened with problems of accessibility because of the road links which become blocked, primarily during peak periods. Commuter traffic suffers problems of daily traffic
jams. The accessibility of Amsterdam (Schiphol) Airport, one of Holland’s mainports, is also threatened.

The direct costs caused through travel time losses due to traffic jams in the Amsterdam area increased from 1985 to 1989 by 210 to 295 million guilders (1 guilder = approx. US$0.50) per year. These costs in the Amsterdam area amount to approximately three tenths of all direct costs incurred through traffic jams on Dutch trunk-roads. Indirect costs caused by traffic jams are a multiple of the direct (quantifiable) costs mentioned above.

The situation after the opening.

As of 28 September 1990 the circle of M10 Amsterdam Orbital Motorway was complete. The Orbital Motorway, with a length of 32 kilometers, is all motorway (almost completely 2 x 3 lanes) and has two links over the North Sea Canal: the Coentunnel (with a only 2 x 2 lanes) and the Zeeburger bridge-tunnel combination. Several additional access and egress ramps will be completed during 1992. The total number of junctions and access and egress ramps from the Orbital Motorway will then amount to 20.

Objectives of the M10 Amsterdam Orbital Motorway are:

- Improving accessibility of the Amsterdam area aimed at reducing congestion and travelling times.
- Relieving the pressure on the subsidiary (city) road network. Through-traffic (long distance) is redirected round the city as far as possible. Trips from and to Amsterdam, inner city traffic can use the Orbital Motorway. Reducing the volume of traffic and the unsafety associated therewith, together with noise nuisance and air pollution impact on the Amsterdam main networks constituted central planning themes. The Orbital Motorway should have on these problems is known as the "suction effect".
- Stimulating the economic development in the Amsterdam area. Due to the Orbital Motorway accessibility has improved.

The new eastern leg of the Orbital Motorway forms an alternative for existing shore-to-shore connections for north-south traffic. The northern part of the Orbital Motorway can now be used for east-west traffic which previously travelled via the M9. The part of the Orbital Motorway between the M1 and the M2 is a good alternative for the link up of these trunk-roads via the M9 (see figure 1).

Six new bus lines, and two existing ones, use the new Zeeburger connection. These are exclusively peak period connections between the northern part above the North Sea Canal and Amsterdam Southeast.

1.3. M10 in a regional context

The development of town and country planning in the Province of
North Holland was characterized during the period 1970-1990 by the decentralization of housing and employment. The Municipality of Amsterdam has lost more than 200,000 inhabitants in 18 years due to inland migration. Increasing opportunities for employment have been expanding much faster during the past few years on the southern side of Amsterdam (Amsterdam South and Southeast, as well as Schiphol).

The decentralization of housing to northern North Holland in the period 1970-1984 as well as the new opportunities for employment in the south in the period from 1984 have caused a strong increase in commuting over the North Sea Canal. During the period 1979-1989 car kilometers in North Holland increased by 26% compared with 13% nationwide. Public transport, as opposed to this, increased by 14% in North Holland and decreased by 8% nationally. Car occupancy in North Holland decreased by 9% only by 3% in the rest of The Netherlands. This can be explained by the growth in commuting by car.

1.4. **Aims and set-up of the before and after study Opening Amsterdam Orbital Motorway**

The Transportation and Traffic Research Division is carrying out a large study aimed at measuring the effect of the opening of the Orbital Motorway with the Zeeburgertunnel. The aim of this integral study is:

> The actual measurement, quantitative analysis as well as determination of nature and size of the effects on traffic and transport in the Amsterdam area as a result of the opening of the M10 Amsterdam Orbital Motorway with the Zeeburgertunnel for persons and goods movements.

The study is taking the form of a before and after study in which, by careful measurement of the traffic and travelling characteristics before and after the opening conclusions will be drawn as to the effects.

The study has been split up according to seven main themes. The main themes are:

- traffic development
- travel behaviour
- public transport
- goods transportation
- environmental quality
- monetary evaluation
- spatial distribution

Eventually, an integral final report of the study is to be published in September 1991, entitled "The effects of opening the Amsterdam Orbital Motorway". This report can be considered as a synthesis of results obtained from part-studies.
In this paper attention is given to research carried out into behavioural changes in personal travel (section 3) and to research into changes in road traffic conditions (section 4). Section 5 contains a summary and conclusions.

2. LATENT DEMAND VERSUS INDUCED TRAFFIC

It appeared in the past when removing bottlenecks in the trunk-road network that there was often a strong once-only "growth" in car traffic, at that bottleneck and particularly in peak periods. Two notions recur time and time again during discussions on the removal of bottlenecks and these are: "new, induced traffic" and "latent demand". These terms are often mis-used and that is why it is desirable to describe the differences between them (Table 1).

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<th>TABEL 1: DIFFERENCES BETWEEN LATENT DEMAND AND INDUCED TRAFFIC</th>
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<td><strong>LATENT DEMAND</strong></td>
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<td>When In case of:</td>
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<td>- removal of bottleneck</td>
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<td>- major reductions in travel distance</td>
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<td>- increased car speed</td>
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<td>- major reduction in travel time</td>
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<td>Time Peak periods</td>
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<td>Where Bottleneck (location dependent)</td>
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<td>Growth by Shifts</td>
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<td>Example Expansion Schiphol tunnel Removal of bottleneck Woeste</td>
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Latent demand

The term "latent demand" as used in The Netherlands (McKinsey & Company, 1986) applies only to bottlenecks and concerns those travellers who are avoiding traffic jams. Latent demand consists of travellers who, if there were no traffic jams, would travel through the bottleneck during a particular period of time. Latent demand manifests itself at the moment when a lack of capacity is removed and can then be measured as the difference between the volume in the period concerned before and after the removal.
Latent demand comprises four components:
1. Travellers who choose another route;
2. Travellers who adapt their times of departure;
3. Travellers who choose another mode of transport;
4. Travellers who change their destination or decide not to travel at all.

All the above being a consequence of the presence of the bottleneck. This manifestation consists therefore of the shifting of trips back to the desired travel route (via the old bottleneck) during the period desired.

Induced traffic

Improvements made to the transport system mean that changes take place in the travel pattern. Opening a new, faster route causes e.g. an increase in through-traffic. An increase in speed and frequency of public transport causes an increase in the total number of passengers. One can talk of new, induced traffic in a particular relationship and with a specific transport mode but the term can also be related to total mobility. The following definition is used given the fact that discussion often concentrates on car traffic: If the total number of (car) vehicle kilometers after a change in the transport system has increased (and, within reason, as a consequence of the change) then the difference is referred to as new induced (car) traffic.

Induced traffic comes into being in situations where travel time gains are coupled with increased travel speeds. A shorter travel time is, in practice, partly converted into new trips or travelling over longer distances. One can also say that part of the original profit gained on a journey lies in shortening the distance. Induced traffic comes into being whenever, on balance, the "new" kilometers are covered at a higher speed than the kilometers "replaced".

Removal of a bottleneck causes the 4 components of the latent demand to become visible. However, a large number of the travellers covered in this travel via another route or at another time or to another place. The built up of latent demand varies therefore from case to case. The first 2 components (shifting of route and time of departure) are the most important where bottlenecks in traffic are concerned. These 2 components form e.g. over 80% of total latent demand measured in a survey referred to in "Striking the balance with traffic jams" (1986).

The report "Striking the balance with traffic jams" (1986) stated that the size of latent demand was estimated to be an average of 27%. This estimate relates only to the busiest hour of the evening peak period and to the structural congestion areas of the Randstad in 1985. No estimate was made of the total amount of induced traffic which could be expected. Information about the way in which a bottleneck is removed is also required for this;
but if that were to be done only by expansion in situ then it can be deduced that new, induced traffic would amount to about 5% of the peak period traffic. This is no more than 1% of the total traffic volume. Thus, expansion of road capacity at a bottleneck most certainly does not cause a sharp increase in car traffic.

3. EFFECTS ON TRAVELLING BEHAVIOUR

3.1. Research method

Traveller is preference for certain routes or travelling times changes greatly after opening. The most important shifts in commuting behaviour which might be expected concern the components already mentioned above:
- time of departure
- route
- transport mode
- destination and journey frequency.

It is important that an insight be gained into the size and direction of all four types of change. Previous studies have shown that above all departure time and route choice are greatly influenced by a high congestion level. These two kinds of change are central in the research carried out into the effects on travelling behaviour. The other changes are also determined.

The most efficient way of measuring changes behavioural of a travelling population which, in principle, remains constant, is the use of a panel set up. 12,000 households in the target group (resident north of the North Sea Canal and travelling to Amsterdam and surrounding municipalities by all modes) were approached and interviewed about their travel behaviour before the changes in the transport system took place. The same households were interviewed again after the Amsterdam Orbital Motorway was opened.

In addition to the panel interviews in households, a road-side origin and destination study was carried out, amongst 50,000 road users from all shore-to-shore connections over the North Sea Canal. Road users were chosen at random and asked to fill in a questionnaire about trip purpose and route used. Both studies give a complete picture of the changes which have taken place in travel behaviour and of the reasons for which travellers have made those changes.

3.2. Changes

There is a six month interval in some cases between the before and the after study. The following autonomous changes can be expected during such a period:
- small population growth,
- upward movements in age groups,
- increase of driving licences,
- car ownership increase, particularly due to the licence increase also as a result of increased incomes (approx. 2%),
- slight increase in the total working population (also approx. 2%),
- spatial separation between living and working will continue to increase.

Choice of route: shifts up to 25%

Some 25% of all private car users (drivers) have diverted their route as a result of the opening of the M10. Route diversions have, on balance, led to a share of approx. 17% in the new tunnel, the Zeeburgertunnel, for all car movements north – south.

The most important shift is from the Coentunnel to the Zeeburgertunnel. There is also a shift in long distance travel from the Velsertunnel to the Zeeburgertunnel. It is worth noting that it is not only a matter of changes towards the newly opened eastern part of the Orbital Motorway, but that there are also "opposite shifts" taking place in a westerly direction to the Coentunnel (Figure 2). The Coentunnel was avoided by road users before the opening because of the high congestion level but now, after the opening (which caused a reduction in congestion), they no longer avoid the Coentunnel.

Figure 2. Shifts in route choice on the North Sea Canal screenline (from 06.00 – 10.00 a.m. and 12.00 – 04.00 p.m.)
Choice of departure time: shifts up to 30%.

Almost 30% of all road users (within the target group) changed their departure time to some extent. Changes have taken place in both directions (earlier as well as later departures). Many of these shifts concern relatively small changes limited to within the peak period itself. This led among other things to an increase of 16% in the total number of journeys by road users over the North Sea Canal during the morning peak period (7.00 - 9.00 a.m).

The total number of journeys meant above decreases directly before and after the peak period. A "return to the peak period" effect has therefore been noted amongst travellers who presumably chose - before the opening of the M10 - departure times (much earlier or later) against their preference. Because of the improvements brought about in the conditions (travel times and less congestion) as a result of the opening, it is now possible to travel at the times one prefers. There are also travellers who have changed both their route choice and their departure time jointly.

Choice of transport mode: little or no change.

Shifts in mode choice have taken place in various directions (from train to car, from bus to train and from car to train amongst others). In the new situation, slightly more travellers appear to use, on balance, car in stead of public transport (only 1% of the total number of commuter trips). The majority of the shifts noticed are due to autonomous developments. A significant decrease can however be noticed in the number of car passengers, several of whom became a solo driver after the opening.

Destination and frequency of journeys: little or no change.

As a result of autonomous developments, an increase of 2% can be expected in the total number of journeys. The actual increase (3%) is not very much larger. Therefore, during the observations period there was no clear increase in the total number of journeys made by the target group to Amsterdam and the surrounding area as a result of the opening of the Amsterdam Orbital Motorway.

4. EFFECTS ON TRAFFIC CONDITIONS

4.1. Research

The volume, composition and average speed of traffic flows on the distinguished links, routes and different roads will change as a result of the opening of the M10. Empirical data have been collected for this at different locations on the road network
(links, access and egress ramps etc.) by means of a before and after study. Link travel times were measured on the trunk-roads both during and outside peak periods. The changes in waiting times on all notorious bottlenecks in the Amsterdam area were measured in order to determine, together with other investigations, the quality of traffic conditions as well as effects on accessibility.

4.2. Changes

Screenline North Sea Canal: a volume increase of 6%, primarily due to shifts.

All traffic flows via the existing North Sea Canal connections show decreased levels after the opening (Figure 3). 52,000 motor vehicles pass through the new Zeeburgertunnel per 24 hour period. The volume through the entire screenline has increased by 18,000 vehicles (6%). There is an increase of 10% during the morning peak period. The peak periods have also altered: the morning peak period is somewhat later and the evening peak period somewhat earlier than before the opening.

Figure 3. Changes in traffic volumes on the trunk-road network in the Amsterdam area as a consequence of the opening of the Orbital Motorway.
Road network use: diversions from west to east, and from south to north.

Reductions in traffic volume amounting to -8% and -5% have been recorded on the western and southern part of the M10 respectively. Part of this traffic chooses a route along the - new - eastern branch. Subsequent to the opening of the Amsterdam Orbital Motorway, no changes in volumes were recorded on the southern access roads M4, M2 and M1, except for the link-up with the "outer ring" formed by the M9. Traffic volumes on the M9 itself as a part of the "outer ring", decreased by 5-10%.

A change is observed in the square formed by the M1, M2, M9 and the M10 (see figure 3), which leads to a volume increase on the A1 and a decrease on the M2 (-25%).

Main urban road network: the Orbital Motorway’s suction effect.

Traffic volumes on the urban road network of Amsterdam have decreased (-20%), particularly in the south east. This change is not so pronounced in other parts of Amsterdam - some 0-10%. On a large number of (composite) screenlines on the urban trunk-road network the decrease of motorvehicle traffic amounts to (-) 10%.

In connection with the effects on commuting behaviour, a shift can be seen in the traffic streams from west to east for north-south traffic and a change from south to north for the east-west traffic volumes. Increases in crossing traffic volumes on the North Sea Canal can also be explained for the most part by the shifts in long distance trips (diverting from other routes e.g. dikes in the North of Holland) and by so-called "double crossings". These are the detours made by traffic that crosses the canal twice via the Orbital Motorway. This is not only done by through-traffic but also by traffic having Amsterdam city as origin or destination, collecting on and then splitting off from the Orbital Motorway. Traffic between the various suburbs can now use the Orbital Motorway as a connecting road (round the outskirts).

Journey time losses resulting from congestion: a decrease of 31%.

Journey time losses resulting from congestion at the major bottlenecks on the trunk-road network in the Amsterdam area has decreased by over 30% from 26,000 to approx. 18,000 vehiclehours/per 24 hour period (Figure 4) as a result of the opening of the M10. This reduction at the Coentunnel amounts to approx. 40% (from 6,200 to 3,800) and at the Velsertunnel even 60% (from 4,800 to 2000).

Measurements of travel times show that almost all road users gain time, varying from several minutes to a quarter of an hour, subsequent to the opening of the Amsterdam Orbital Motorway.
Figure 4. Decrease in travel times summarized per road section before and after the opening (expressed in vehicle hours per working day).

5. CONCLUSIONS

The consequences of the opening of the M10 Amsterdam Orbital Motorway have been measured empirically by means of an extensive before and after study. This study shows that 25% of car users commuting from the North (above the North Sea Canal) to Amsterdam and the surrounding area changed their route and 30% changed their time of departure. Changes in the choice of mode, destination and frequency of journeys are negligible. Reduction of pressure on (and not the removal of) existing bottlenecks at the North Sea Canal does indeed cause a once-only increase in car traffic during the peak period (10% in the morning), and this is wrongly entitled by many as "induced traffic". This is rather a "return to the peak" effect.

With regard to the North Sea Canal and during a 24 hour period, an increase of 6% in car traffic has been observed which can for the most part be explained by diversions of trips from other routes (several dikes in the North of Holland) to the North Sea
Canal and by a more intensive use of the shore-to-shore links by through-traffic and internal (urban) car traffic which use the Orbital Motorway as a connecting road.

The accessibility of the Amsterdam area, expressed as a reduction of congestion and shortening of journey times, has been improved considerably. The amount of time lost in queues due to congestion has decreased by 31% in the entire area, and considerable time savings have been achieved in a large number of aspects.

REFERENCES

A detailed list of references of sources mentioned can be found in:

Loos, A.L. et al.,