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TRAFFIC CALMING: Policy and Evaluations in Three European Countries

Tim Pharoah and John Russell

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TRAFFIC CALMING:
POLICY AND EVALUATIONS IN THREE EUROPEAN COUNTRIES

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ABSTRACT

The report is based on information from published material and from study visits to Denmark, The Netherlands and West Germany in 1987 and 1988 including one funded by the Nuffield Foundation. It describes the purpose and practice of traffic calming in these countries, concentrating in particular on the policy context, finance, implementation and evaluation aspects. It concludes that traffic calming is widespread, popular, and effective in reducing the harmful effects of road traffic on urban communities. Furthermore, the safety and environmental improvements associated with traffic calming are seen to be part of wider transport and urban planning policies, including the regeneration of run-down inner city areas, housing renewal and the conservation of historic centres.

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1. INTRODUCTION

Since the early 1970's attempts have been made in various countries to redesign roads in built-up areas to reduce danger to pedestrians and cyclists, and to improve the local environment. The best known and earliest examples were the Dutch "residential yards", or "Woonerf" schemes, where traffic speeds were intended to be forced to walking pace and pedestrians were given equal priority over the whole of the street surface. A range of physical and legal measures were incorporated into the reconstructed streets to tip the balance in favour of the residential function of the street, and to reduce the domination of motor vehicles. These measures included speed humps, ramps, continuous footways, twists and turns, narrowed sections, designated parking spaces, planting, and various other means of visually reinforcing the message that the street is a "home" area where the motorist is allowed as a guest.

In the fifteen years or so since the birth of the Woonerf, the techniques have been developed to apply not just to individual residential streets, but to whole areas of towns, to main traffic arteries, to villages, shopping streets and town centres. This aspect of urban planning is fundamentally concerned with reducing the adverse impact of motor traffic on built up areas, usually involving a three sided approach of speed reduction, more space for pedestrians and cyclists, and evironmental improvements. In some cases these policies have been part of wider policies of traffic restraint and urban regeneration. The totality of the approach is referred to in this report as "Traffic Calming".

The work reported here deals exclusively with practice in continental Europe. Practice in the UK is by comparison rudimentary and undeveloped, as shown in T. M. Pharoah's earlier publications on the subject ("Improving the Safety of Local Streets" 1983; UK001, and "Adapting Residential Roads for Safety and Amenity", with Liz Beth, 1988; UK002). However, countries that have not yet embarked on a widespread programme of traffic calming have the potentially valuable advantage of being able to learn from the considerable wealth of experience gained in the Netherlands, West Germany, Denmark, and other European countries over the past fifteen years.

There is a danger, however, that particular examples of practice will be either misunderstood (and applied in inappropriate locations) or dismissed as being "unsuited to conditions in this country". Misunderstanding of practice can only be overcome by thorough study and exchange of views, as attempted in this study. The latter problem is largely illusory. Of course conditions vary from place to place, but so they do <u>within</u> the countries that have adopted widespread traffic calming. More importantly, the problems which traffic calming aims to alleviate are experienced universally, namely the danger, intimidation, severence, noise, pollution, dirt and visual degradation caused by motor traffic in urban streets.

It is therefore useful to present the policy frameworks within which traffic calming schemes have been implemented, the results of policy and scheme evaluation, and the financial and practical means by which they have been achieved. The practice of The Netherlands, West Germany and Denmark, the three countries with perhaps the most extensive experience of traffic calming, is considered in this report.

2. WHAT IS TRAFFIC CALMING?

Traffic Policy in Transition

Although transport and traffic policies vary widely between the different European countries and regions, and even between different cities, there is a common theme which has led to the "traffic calming" approach.

During the 1970's there was a growing realisation that policies aimed at providing roads and parking for fully motorised towns and cities had failed to produce a transport solution within the limits of environmental and financial acceptability. Indeed, the problems of accommodating motor traffic in established communities had been graphically demonstrated in Buchanan's "Traffic in Towns" as early as 1963. But the real turning point in most countries followed the oil crisis in the mid-1970's, when growing concern for the environment and doubts about the future of oil supply led to the abandonment of literally hundreds of major urban road projects, and to the emergence of various counter-initiatives.

The abandonment of wholesale attempts to adapt the city to the car, and the acceptance of motor traffic as an inevitable feature of urban life, has led to the growth of policies designed to influence the <u>behaviour</u> of traffic and its <u>distribution</u> on the road network.

A whole battery of measures have been developed and applied to limit the demands of motor traffic, and to reduce its negative impact on the urban environment. Such measures include parking controls, waiting restrictions, bus priorities, provisions for cyclists, pedestrian shopping streets and malls, and major investment in new or upgraded public transport services. They have been linked also to strategic land use plans seeking to concentrate development along public transport routes and around public transport interchanges, in order to achieve maximum use of public transport.

Many of these measures fall into the category of what is usually termed "traffic restraint", though this is a term which has an unfortunate negative ring. The aim after all is not to restrain traffic for its own sake, nor to prevent people from underatking reasonable travel by car. Extreme anti-car views have become as unpopular as extreme pro-road views. Moreover, to a considerable extent these measures can be pursued without necessarily reducing the overall <u>volume</u> of traffic. The wider aim is to influence or manage demand for travel to produce a better balance between the desires of people to use their cars, and the desires of people to live in towns and cities which are attractive, safe, and accessible to everyone (including non-car users).

This "transport management" has been associated in more recent years with measures to reduce speeds, improve safety, and improve the surroundings in which we live, in short with a set of objectives and methods which collectively have become known as "traffic calming".

Definition and Objectives of Traffic Calming

Traffic calming schemes are associated with a rich variety of planning, transport and environmental policy objectives. The main

objectives. Accordingly traffic calming is capable of diverse definitions as commentators focus on particular types of scheme or policies which most concern them. The approach taken here is to establish a definition which can serve as a common denominator and apply to most schemes, if not all.

The main concern is with the achievement of calm and safe conditions on streets, but given the strong association, in much Continental practice at least, with environmental improvements, it seems appropriate and necessary for the definition to encompass this. Accordingly traffic calming may be defined as "the attempt to achieve calm, safe and environmentally improved conditions on streets". This is the working definition for this paper.

In adopting this definition, however, it must be acknowledged that there are traffic calming schemes which are almost entirely concerned with improving road safety and for which environmental factors are incidental. An example would be simple schemes involving a few speed cntrol humps, such as are becoming more numerous in the UK. Even so, if a slower driving speed is achieved there are likely to be marginal reductions of noise and pollution, and it should be remembered that in Continental usage the term environment usually embraces the social as well as the physical environment. Since social environmental gains are associated with perceptions of safety in even these simplest of schemes it seems entirely appropriate that environmental improvements enter into any definition of traffic calming.

The main objectives of traffic calming are seen as fourfold:

(1) to reduce accidents and/or casualties;

(2) to reclaim space (from the carriageway) for pedestrians and "non-traffic" activities, and to reduce the barrier effects of motor traffic on pedestrian movement.

(3) to promote greater feelings of security, particularly among residents, pedestrians and cyclists ("slow" or "soft" traffic), and others engaged in "non-traffic" activities such as shopping or play;

(4) to create environmental improvements and/or to promote local economic activity.

Implicit in traffic calming is a shift in priorities to redress the balance in favour of the pedestrian (and the cyclist in much Continental practice) vis a vis motor vehicles, which are seen to have been overly and unnecessarily favoured in most earlier planning practice. Traffic calming does not necessarily imply any overall reduction in traffic volumes, however. Although schemes may and do often constitute elements within wider traffic restraint policies, there are also many schemes where no reduction of traffic is sought or intended.

Confusion can often arise in discussions of the role of traffic calming in traffic reduction. If speed reductions are achieved locally on one or more streets, or within a residential area, by traffic calming measures, this may divert traffic onto alternative routes, or may be sufficient to reduce total traffic. Such local

reductions in traffic are unlikely to have a significant impact on the level of traffic overall, unless combined with a comprehensive traffic restraint policy, though they may succeed in containing future traffic growth. This distinction is important to clarity of analysis, and it is for this reason that definitions of traffic calming imlying traffic reduction are resisted, and the narrower definition stated above is adopted.

Moreover there are many traffic calming schemes where an objective is "improved local accessibility", achieved by retaining or regaining direct routes to property, for example by returing one-way streets to two-way operation. Thus relative to alternative traffic segregation designs involving road closures and one-way systems, the traffic integration of traffic calming is permissive rather than restraining in its effect on traffic. Any level of restraint must therefore be set as an independent sceme design parameter, and the appropriate severity of treatment will be selected to achieve the required traffic reductions, whether or not traffic calming techniques are then employed to supplement or replace more traditional segregation methods.

Traffic calming objectives and the road safety objectives in particular are achieved through the redesign of the streetscape to effect speed reductions and to encourage a calm driving style. Surplus capacity or space released as desogn speeds are lowered is used to achieve the other three objectives..

Each of the four main objectives of traffic calming identified above has several components. The weightings on these component objectives will vary from scheme to scheme, just as the emphasis among the main objectives shifts with the nature of the scheme.

Casualty reduction, for example, can be broken down into reduction of numbers and reduction of severity, while certain categories of casualties may be specifically targetted for reduction, such as pedestrians or cyclists or children. Accident numbers rather than casualty numbers may equally be a specific objective.

Environmental improvements can be disaggregated into less noise, less pollution, better microclimate (planting) and better street or area appearance. The reduction of barrier effects may be subdivided into increased pedestrian crossing opportunities, reduced pedestrian delays, perceived safety of cro ssing opportunities, and reduced delays for vehicles from side streets. In major road schemes the reduction of barrier effects or severence often becomes a key objective in its own right, as distinct from reclaiming space for non-traffic activities.

Such distinctions are important in that criteria for scheme evaluation are inevitably focussed on the individual component measures, rather than the main aggregate objectives.

Policy Context in The Netherlands, West Germany and Denmark

In The Netherlands, Germany (hereafter used to refer to the Federal Republic of West Germany) and Denmark, authorities enjoy a large degree of autonomy from their respective state, federal or national governments, and freedom to implement their own local policies and

schemes. Conformity to nationally devised norms cannot often be enforced, though there are sometimes incentives in the form of financial and other assistance. Moreover, advice from national agencies is needed (and often sought) to help local authorities to avoid mistakes and to benefit from each other's experience. The advice itself, however, is based on research programmes linked to schemes implemented at the local level.

Traffic calming in all three countries is promoted at the National and Federal level as part of an integrated transport policy, and specifically as a means of improving road safety and improving the urban environment. The policy aim of reducing the total volume of traffic is less clearly stated, especially in Germany, except as a desired consequence of investment programmes in public transport and cycle facilities. Some individual city governments do, however, regard traffic calming as part of an explicit policy of traffic reduction.

We now look more closely at the policy framework for roads and traffic in each of the three countries. The late Dr Klaus Turke of the German Federal Research Institute for Regional Geography and Planning once acknowledged to the authors that "Holland is the mother of traffic calming". We therefore begin with the evolution of policy in The Netherlands.

3. TRAFFIC CALMING POLICY IN THE NETHERLANDS

In The Netherlands, where there is no significant motor manufacturing lobby, national policy openly promotes public transport, pedestrians and cyclists at the expense of the car. For example, "Henceforth other functions will be given priority over motor traffic," and "the car's dominance should be diminished by deliberately increasing travel times, by creating a less dense network of main roads, and by reducing speeds" (NL 029). There is a strong transport lobby, however, including road freight, given its historic and continuing importance within the Dutch economy. The Netherlands has, for example, the highest weight limits for lorries in the EEC.

The ANWB (Royal Dutch Touring Club), the equivalent of the AA or RAC in Britain, is broadly in favour of traffic calming policy, and indeed has done much to promote the Woonerf and subsequent initiatives (NL 032, 033, 034, 036).

To be effective, however, national policies depend on the active involvement of the provinces and municipalities, some of which are more enthusiastic than others. Groningen, Den Haag, Delft and Tilburg are examples of cities that have an explicit policy of promoting public transport and non-motorised transport at the expense of the car. Groningen, where 50% of all journeys are made by bicycle, has achieved a 25% reduction of car traffic in the city centre. In Delft, the provisions for cyclists are held to be responsible for halting the growth of motor traffic. With car traffic in The Netherlands generally increasing, a static trend in Delft may be regarded as a successful example of "traffic avoidance".

The Dutch "integrated transport policy" which has evolved since the mid-1970s includes (inter alia) the following features (Multi-Year

Plan for Passenger Transport 1976-1980, see NL 023):

- selective use of cars
- emphasis on public transport, cycles and pedestrians
- canalisation of traffic in urban areas
- reducing speeds in residential areas
- encourage cycling with the provision of better facilities
- rail improvements and new lines
- bus and tram priority at lights
- abandonment (1977) of many inter-city road schemes after public consultation.

Although policy initiatives by the municipalities are very important, the Ministries of Transport & Public Works and Housing & Physical Planning have directly promoted the integrated approach through a range of demonstration schemes and incentive grants. The main ones relating to traffic calming are:

- BREV research project "Experiments in Residential Areas";
- Area-wide traffic calming demonstration projects in Eindhoven and Rijswijk (Den Haag);
- Cycle demonstration projects in Tilburg, Den Haag, Delft;
- Parking demonstration project in Utrecht;
- Facilities for the handicapped demonstration project in Gouda;
- 15 demonstration projects for 30 kmph residential zones;
- "Action 25%" campaign including funding for road safety projects and special scheme awards, to reduce accidents by 25% from 1985 levels by the year 2000.

In addition the Government plays a key role in providing grants and subsidies for public transport, still in the region of 50-80% of operating costs and 80-100% of capital investment.

These wide-ranging but integrated policies have evolved as a product of many influences over a period of fifteen or twenty years. The Netherlands is the most densely populated country in Europe, a factor which has generated intense public awareness of the traffic-environment conflict, and loud public demands for action to tackle the problem.

There is general agreement as to the origins of the movement for converting residential streets to make them more "livable". Planners and engineers in the city of Delft in the early 1970s recognised the inherently dangerous layout of traditional streets, where people walk and children play within feet of solid objects travelling, quite legally, at 50 kilometres per hour, or illegally at even greater speeds. It was felt that "where frequent near-contact situations cannot be avoided (ie. where pedestrians and vehicles must share the same street) then the circumstances under which these contacts take place must be altered" (NL 031). This was the beginning of the "Woonerf" concept. In those early years, the policy was to identify streets with low traffic volumes and a purely residential function, and to redesign them so as to make driving at more than walking pace impossible, and to ensure that "traffic is not allowed to dominate", and to "emphasise their function as a place in which people live and have their home" (Minister for Transport & Public Works in NL 032).

Experiments in Residential Areas: BREV Research Project

In 1977 the Ministry of Transport and Public Works made available grants to local authorities to set up experimental schemes designed to improve road safety, especially for pedestrians and cyclists. The condition attached to these grants, which were for up to 85% of the costs of implementation, were that a "before and after" study be made of the effects of the measures. Several municipalities carried out a variety of schemes and the initial evaluation included 56 Woonerven and 13 other schemes such as village and shopping "Erven" and 30 km/h zones (see below). The objectives of the BREV project (of which final evaluation began in 1988) were to:

"1. implement pilot schemes in order to
   (a) find ways of improving road safety,
   (b) encourage highway authorities to take action;

2. gain expertise on the road safety effect of redesigning the infrastructure and to pass on that expertise;

3. supply information on developments concerning
   (a) the redesigning and restructuring of public space as living areas and traffic corridors (Government policy),
   (b) advising municipalities on policy."

(Quoted from NL 021)

An area-wide approach in Eindhoven and Rijswijk (Den Haag)

The Woonerf solution spread rapidly and many streets were converted in almost every Dutch town. It was soon recognised, however, that the problem of traffic domination of urban areas needed to be tackled on a wider scale than just individual streets. In 1976 the Ministries of Housing and Transport published a policy document which laid down a principle for urban traffic which has continued to be a foundation stone of Dutch traffic planning (referred to in NL 023 and NL 029). This principle is that public areas of towns and villages should be divided into two zones, namely living areas and traffic areas. This principle has since been elaborated in regional, structure and traffic plans, including the structure scheme for traffic and transport, which set out the integrated transport policies already quoted.

In order to gain experience of this reclassification of urban space into living and traffic zones, the Government set up two large-scale demonstration schemes. Areas of about 100 hectares were selected in Eindoven and Rijswijk (a district of Den Haag). The aims of these demonstration projects (NL 029 p. 9) were to:

"- investigate the possibility of dividing urban areas into living and traffic areas, using various measures (see below);
- carry out before and after studies into the effects;
- make recommendations on the restructuring and costs;
- gain practical experience with the statutory minimum requirements for pedestrian priority areas."

The measures used in the "living areas" were grouped into three "Options".

Option 1 - Very simple measures (eg. one-way streets) to exclude through traffic from residential streets
Option 2 - More extensive measures to exclude non-local traffic and to limit the speed of the remaining traffic, (eg. using ramps and narrowings)
Option 3 - Complete reconstruction as pedestrian priority areas (on the Woonerf model)

These three options applied to the "living areas". The projects also included measures in the "traffic areas" (main roads) to ameliorate the effects of motor traffic on vulnerable road users and the environment.

The demonstration projects began in 1977 and were mostly complete by 1985. Interim results had shown that the Option 1 measures had succeeded in reducing traffic volumes, but had done little to improve the "livability" of the streets concerned. Consequently the Option 1 areas subsequently have been upgraded to Option 2 areas with the provision of speed tables, ramps, humps, narrowings, chicanes and other measures. This upgrading was complete by summer 1988, so no Option 1 areas could be viewed during the author's study visit.

The Option 3 (Woonerf model) areas created some problems, especially in Eindhoven. Prior to the announcement of the demonstration project, an area of housing within the selected 100 hectares had already been converted to Woonerf. This area was one of relatively poor families living in mainly rented housing. Residents in the adjacent areas proposed for reconstruction to Option 3 standards were strongly opposed to having their streets converted to Woonerven, mainly because they had come to identify the Woonerf with poor areas. This reaction "was a new and unexpected element in the discussion" (NL 029 p19). The commonly held view based on earlier research (by ITS in Nijmegan, NL 002) that Woonerven were universally popular had thus to be qualified..

From Woonerf to Erf

From the mid 1970s onwards the Woonerf concept, originally confined to residential streets, was extended to shopping streets (Winkelerf) and village centres (Dorpserf). There was, however, no legal status for such schemes. This was one of several problems identified in a comprehensive review of Woonerf legislation undertaken by a Ministry working group in 1984 to 1988 (NL 001 p104 refers to "van Woonerf naar erf"; Min. van Verkeer en Waterstaat 1985), and resolved by new regulations that were incorporated in Dutch traffic law on 15th July 1988 (DVV 1988). Thus new "Erven" can be created not only in residential, shopping and village streets, but also around schools, hospitals, commercial areas or railway stations. Anywhere, in fact, where it is decided that pedestrians should be given priority over motor traffic. The new Erf regulations are also much simpler: the 14 Woonerf design regulations have been replaced by 6 Erf regulations. The basic changes (shown in full at Appendix A) are as follows:

- replacement of Woonerf by Erf, and the use of the internationally agreed sign (NL 001 p.620),
- removal of legal restrictions on the creation of vehicle-free areas within an "Erf" (the absence of separate footways in Woonerven had sometimes produced feelings of insecurity amongst pedestrians and residents),
- simplification of design standards and requirements (many Woonerven had failed to meet the earlier standards.

These changes are designed to give more freedom to local authorities who have sometimes opted for less drastic measures (such as 30kmph zones) to avoid the strict Woonerf regulations.

The Woonerf has been a great success, and by 1985 there were estimated to be 4,000 Woonerven involving 7,400 streets (NL 024).

In the development of a general policy for "living areas", the Erf solution is recognised at all levels of government as valuable but too costly and too drastic to provide a universal solution. At the other end of the spectrum, the simple removal of through traffic without supporting measures does not bring about significant improvements in living quality. A middle-ground of traffic calming was therefore needed which was both effective and cheap enough to be applied on a wide scale.

30 kmph Zones

These general considerations, supported by the findings from the area-wide demonstration projects, led to the introduction of a new 30 kilometre per hour speed limit in 1983. Streets and areas can be designated as 30kmph zones only if self-enforcing measures are in place to ensure that this speed is not normally exceeded. Especially since the publication in 1983 of a handbook of available techniques, (NL 003) municipalities throughout The Netherlands have been implementing 30 kmph zones in living areas.

This policy was promoted at Government level also with the setting up of 15 demonstration projects in a variety of areas throughout the country, the full evaluation of which was due in 1989. Meanwhile the handbook of measures is in its third edition (NL 001, 1988) and has been expanded to include all traffic engineering techniques. Teun de Wit, coordinator of the manual said that although its recommended standards cannot be enforced, the handbook is regarded by municipal engineers and planners as a "reliable source of information".

Traffic Area Policy

Policy development now focuses on how to improve conditions on through roads (ie. the "traffic areas"). A start has been made with the introduction of measures to slow traffic on through roads where they pass through smaller towns and villages. In some cases the speed limit has been reduced to 50 or even 30 km/h. The next step will be to develop techniques for speed reduction and reducing space for vehicles on the main urban road network. Some experience has already been gained from the Eindhoven and Rijswijk demonstration projects, which included main roads. Figure 1 is an attempt to summarise the relationship between speed limits and the policies

described above.

FIGURE 1 DUTCH LIVING AND TRAFFIC AREAS POLICY IN RELATION TO SPEED LIMITS

"Living Areas" (Verblijfs-gebeiden)	a.	"Erven" (pedestrian priority, no through traffic, traffic at walking pace)
	b.	30 km/h zones (with self enforcing measures)
	c.	Through roads, small settlements, 30/50 km/h
"Traffic Areas" (Verkeersruimten)	d.	50 km/h major roads (general built-up area speed limit)
	e.	70 km/h municipal major roads (dual c'way)
Non-urban area	f.	80 km/h through roads (general non-urban speed limit)
	g.	100 & 120 km/h limited access motorways

Derived from Dutch Road Safety Directorate information (NL 038)

Action 25%

A further road safety initiative, launched in 1988 by the Government's Road Safety Directorate, is "Action 25%", which aims at a 25% reduction of the 1985 level of road casualties by the year 2000. This apparently was prompted by an earlier initiative by the French government to reduce accidents by 10% in one year. The "Through Roads in Small Centres" programme referred to above is part of Action 25%, which also focuses on the following:

- Drinking and driving
- Safety features
- Traffic speeds
- Dangerous situations
- Elderly road users
- Young road users

The Action 25% programme is being promoted and coordinated by 11 regional (provincial) bodies (ROVO) which act as a focus for the activities of municipalities, Police, private organisations, local interest groups, schools, and others.

A controversial incentive scheme was set up in 1988 by the Minister whereby municipalities agreeing to improve road safety will receive an initial payment of one guilder (about 30 pence) for each resident in its area, and further payments for schemes which succeed in reducing accidents. Only 25% of municipalities were expected to take part but in fact over 85% are doing so. Other organisations that work hardest to improve road safety will receive a prize of 50,000 Dfl (about £15.000). Awards have also been made to municipalities for successful traffic calming schemes, for example Maastricht won an award in 1986.

Traffic Calming and Urban Regeneration

Traffic calming is not simply an element of Dutch transport policy, it is also an important element of a policy to regenerate the older parts of towns and cities, and to make them once again attractive places in which to live. For example in 1983 the Government published its "Compact City" strategy which emphasises traffic restraint, public transport and high density inner city living, and discourages further "out of city" development. A competition in 1985 ("Woonwens - Verkeerswens") encouraged traffic calming as part of this compact city (traffic avoidance) policy. This was interesting in that it was set up jointly by the Road Safety Directorate, the Dutch Institue of Engineers, and the League of Dutch Town Planners (BNS), ie. it promoted an integrated approach to traffic within urban regeneration projects (NL 016).

Housing rehabilitation is taking place in the older areas of most towns, many of which are of great architectural or historic interest. Between 30 and 40% of the housing budget for such work is devoted to street improvements. A large portion of this is accounted for by the relaying of utility services (underground pipes, cables etc.) but as the street surfaces are relaid the opportunity is taken to build in traffic calming measures - either "erf" or "30kmph" measures - and to introduce attractive street furniture, paving and planting. As one Ministry official explained "once the services have been laid, the cost of some bricks and trees is not so much".

An example is Leiden which has the largest old central city after Amsterdam with about 3,000 listed buildings, of which about 80 are restored each year at a cost of over £2 million via Government grants. This renovation is usually done street by street, and involves complete reconstruction of both underground services and street surface. The short distances between buildings in the older streets limits the extent of traffic calming measures, however, particularly because of the shortage of parking space.

The problem of over-intensive on-street parking in the older Dutch cities may be tackled in a new National Plan for Traffic in the year 2010. This includes a scheme to precept each street to the extent of 3,500 DFl (about £1,000) for each parking place, to pay for off-street garages, usually in under-used backlands.

An important feature of Dutch cities which needs to be emphasised is that many of them, especially in the West of the country, are built on peat. The instability of this sub-soil requires the carriageways in urban streets to be relaid every 10-15 years, and in very old quarters at even more frequent intervals. Thus within the space of, say, 20 years the Dutch can re-lay an entire network of urban streets. This certainly helps to explain how the Woonerf and 30kmph zones have spread so rapidly. Also, the fact that residents of Dutch towns are more accustomed to having their streets torn up and relaid may have meant less public resistance to changes in the street design. The official view, however, is that high living densities and the widespread concern about road accidents and environmental quality are the main factors which put The Netherlands in the lead in calming urban traffic.

4. TRAFFIC CALMING POLICY IN WEST GERMANY

It may seem surprising that a policy of traffic calming should have arisen at all in such a car-orientated country as West Germany. It manufactures more (and faster?) cars than any other European nation, has the highest car ownership rate this side of the Atlantic, has built a comprehensive network of motorways - most of which operate without speed limits - and has invested huge sums on major urban roads and ring roads since the last war.

Yet the German Federal ministries in Bonn have since the early 1980s been promoting integrated transport policies which favour public transport, pedestrians and cyclists rather than the private car, albeit with a less united voice than in the Netherlands. It is probably wrong to seek a simple explanation. On the one hand there are strong voices in Germany for stricter environmental controls, on the other hand there are those who fight any policy which they consider to be a threat to Europe's largest motor industry. But these opposing voices are not consistently aligned.

The principal German motoring organisation (ADAC) appears to support traffic calming and, like its Dutch counterpart (ANWB), has produced documents on the subject (eg. D 031, D 007 p56). The private chamber of trade and commerce in Cologne has published an attack on traffic calming as vitriolic as it is glossy (D 060). Some cities still have no explicit policy of taming the car *, whilst Berlin had (at least until a change of political colour in 1989) a deliberate policy of not taming the car. As in Britain and other countries, traders are typically conservative and often resist changes such as pedestrianisation and other traffic calming measures. Yet there are places where traders are asking for such measures, and are willing to pay for them. Estate agents often emphasise a property's location in a "traffic calmed" street as a selling point.

Thus there are trends and counter-trends and many apparent inconsistencies. John Ardagh in his book "Germany and the Germans" has this to say:

> "... if most Germans love their trees, a potent minority love their cars even more. The average German driver is highly disciplined and prudent in town, keeping carefully to the traffic lanes, and braking at lights even where there is no pedestrian in sight; but behind the wheel on an open autobahn, where there are no speed limits to hold him back, he becomes like a creature posessed, especially if he is in a fast car, tearing down the outside lane, lights flashing, at 200kph or more." (D 061 p126)

Nevertheless, German cities have been leaders in pedestrianising shopping streets, developing policies that began in Essen and Cologne during the inter-war period (D 062 p86).

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* In September 1988 an article in a West Berlin newspaper began: "Berlin, as everyone knows, is a car-friendly city" ("Schoneberger Stichel" No. 45). More positive moves towards traffic calming have followed the elections in 1989 which replaced the Christian Democrat (CDU) majority with a Social Democrat / Green Party coalition.

Since about 1975 traffic calming measures have been taken in virtually all German cities and in 1988 the first general autobahn speed limit (120kmph) was imposed on the A45 Dortmund-Frankfurt. It is clear that the (high) accident rate and environmental damage caused by motor traffic has compelled the "Lander" and municipalities to act. This is true even in cities with influential motor lobbies such as Ingolstadt and Stuttgart (where, respectively Audi and Mercedes Benz plus Porsche cars are made). Some cities actively promote public transport as a means of reducing car traffic, and there is evidence of reductions having been achieved (Hannover and Nurnberg for example). (EC 004 p133)

Several documents promoting traffic calming policy have been produced since the late 1970s by the Ministry of Regional Planning, Building and Urban Development. Some of these have been lavishly produced in colour in an attempt to reach a wide audience.

As in The Netherlands, the policy began with "spot treatments" of residential streets from which through traffic was excluded (D 002). The early schemes were based on the Dutch Woonerf and were labelled "Verkehrsberuhigung", which means "traffic pacification" or "traffic calming". The term is now applied to the wide range of policies and measures designed to slow traffic down, to achieve a calmer style of driving, and to improve the livability of streets. It is applied also to measures not just in residential streets, but to whole areas of cities, complete villages, and to major thoroughfares.

The transition of the traffic calming concept from a local traffic management technique to a major element of urban planning policy is clear from a document published by the Federal Ministry entitled (literally) "Town Traffic in Changeover" (D 001). This argues the case that accessibility can be just as good with slower traffic speeds, while slower speeds enable carriageway space to be given over to public transport, pedestrians, cyclists, and green space. The theme that "less speed equals less space" is given practical interpretation, of which we will explore examples in later sections. The term "Verkehrsberuhigung" (traffic calming) is said (D 001 p14) to embrace the following:

- improvements for pedestrians and cyclists
- more traffic safety
- improvement of the environment
- promoting inner city living and shopping
- less noise and fumes
- nicer appearance, fewer traffic signs
- more green
- less comfort and lower speeds for private motorised traffic

As part of the move away from the "spot treatment" approach, the Government set up six major demonstration projects for area-wide traffic calming. The associated before and after studies are particularly interesting covering as they do a wide variety of urban and village situations, and main roads as well as residential areas. (see Table 1)

Other policy developments follow a sequence similar to that in The Netherlands. The "Woonerf" model is also now thought to be too expensive, and in some ways too drastic an alteration to

TABLE 1 FEDERAL AREA-WIDE TRAFFIC CALMING DEMONSTRATION PROJECTS

TOWN (pop)	STATE	TYPE OF AREA	KM_2	POP	COST (Mio DM)
Berlin (1,900,000)	Berlin	19thC Inner City "Moabit"	1.2	30,000	5.1 *
Borgentreich (2,300)	Nordrhein/ Westfalen	Village (whole area)	2.5	2,300	6.5
Buxtehude (33,000)	Neidersachsen	Historic core and surroundings	2.5	10,000	5.0
Esslingen (87,000)	Baden/ Wurttemberg	Medium-sized town, edge of central area	1.5	11,000	15.0 **
Ingolstadt (91,000)	Bayern	Central area of medium-size town	1.2	5,500	18.0 **
Mainz (105,000)	Rheinland/ Pfalz	Suburbs and old village within large town	2.5	12,000	3.2 **

* Excluding main roads
** Estimated
Source: A. Doldissen "Environmental Traffic Management - German Interministerial Research Programme" PTRC 1988 (D 032c)

traditional townscape, to be the universal solution to residential areas. A provision was therefore drawn up in 1985 for the creation of areas with speed limits below the traditional 50 km/h. These were based particularly on experience in Hamburg which had "jumped the gun", and introduced 30 kmph limits ahead of the legality of the 30kmph sign! More than half of Hamburg's residential street network was covered by the 30kmph provision by 1986. This approach has been adopted on a wide scale in many other cities and by 1988 there were over 2,000 known 30kmph zones. These "Tempo 30" regulations were for an initial period of five years, but will become a permanent feature of new driver regulations at the end of 1989 (D 063).

There is pressure on Bonn particularly from Nordrhein-Westfalen and the Deutscher Stadtetag (an association of larger municipalities) to make 30kmph the general urban speed limit, with 50kmph roads being specially signed, rather than the reverse as at present. (There are similar calls from pressure groups in The Netherlands.)

The principle that 30kmph zones should only be designated where physical measures have been taken to make the limit self-enforcing, is less strictly adhered to than in The Netherlands. Indeed, some speed reduction has been achieved merely with the placing of 30kmph signs - for example in Nurnberg and Hannover - an experience not generally shared with other countries (D 050).

Calming measures have also been applied on some through roads in villages and some major roads in cities since the early 1980s. The

aims and techniques in these situations are concerned more with reclaiming traffic space for the benefit of non-motor traffic and, according to one senior official at the Federal Road Research Institute, speed reduction is less easily achieved than in residential areas. As in The Netherlands it is on these roads that the main work of policy development remains. Recommendations for the layout of urban and village roads (EAE'85) were issued by the Environment Ministry in 1985 (D 003) and recommendations for arterial streets (EAHV) will be issued in 1990.

Efforts have been made to reverse the decline in bicycle use that occured up to the 1970s. For example, the environment Ministry funded projects in two towns, Detmold and Rosenheim, in the early 1980s. In Rosenheim, bicycle trips as a percentage of all trips rose from 23% in 1981 to 26% in 1986. In Detmold, the decline in bicycle trips has been halted and there has been an increase in the use of the bicycle as a daily means of transport (Hulsmann, W. in NL 004 p. 90). According to Roberts (EC 004 p. 95) there was also a decline in car use associated with these projects, though Holzapfel (in NL 004 p. 60) comments that the general increase in Bicycle trips in Germany (from 8.6% in 1976 to 10.2% of all trips in 1982) has been at the expense of walking (which declined from 33.^% to 29.8% of all trips in the same period).

As in The Netherlands, there are more bicycles than cars in Germany and (according to Roberts, 1987 [EC 004]) the provision of bicycle facilities has become "the only activity which is not politically controversial... Everybody is in favour of bikes."

There are five main tiers in the urban road hierarchy and traffic calming policy becomes more tentative the "higher" the category of road.

- "Fussgangerzonen" (pedestrian zones), usually shopping areas, are removed from the traffic network.

- In "Wohnstrassen" (residential streets) traffic calming is relatively easy and widely applied, especially where through traffic is removed.

- In "Sammelstrassen" (collector roads) traffic calming can be achieved by reducing the space for motor vehicles. This achieves a more livable environment, but the effects on speed reduction and accidents are not yet fully researched.

- In "Hauptstrassen" (main roads) there are also traffic calming possibilities. The conflicts to be resolved are usually greater (because of the need to provide for through traffic, bus routes, shopping, servicing etc) but the benefits to be gained can also be greater.

- "Autobahnen" (limited access roads) have speed limits only in urban areas.

The approach of the Federal Research Institute for Regional Geography and Planning is to "get the techniques and guidelines for traffic calming into the consciousness of all road and traffic planners and engineers in the Lander and communities" (meeting with the late Dr Klaus Turke 1987). Apart from the six Federal area-wide

demonstration projects, the Lander have their own programmes. The Nordrhein-Westfalen Land is by far the most active in the traffic calming field. Its Ministry of Urban Development, Housing and Traffic estimates that 70% of all German traffic calming schemes are to found within its region. Of course, it is the Land with the largest population (17 million - 27% of the West German total), but it is by no means the richest region, nor the region with the most beautiful cities. A large programme of traffic calming research has been undertaken in Nordrhein-Westfalen, much of it by the Ministry's own research institute in Dortmund (ILS).

The leading position held by Nordrhein-Westfalen is almost certainly connected with its unique organisational structure, namely a combined Ministry of Urban Development, Housing and Traffic. Other Lander, like the Federal Government, have separate traffic ministries, often (as in Bavaria and Baden-Wurttemberg) closely linked with the motor industry. This serves to highlight an important feature of German traffic calming practice, namely the variations of approach between the Lander, and their relatively high degree of independence from Bonn. Thus Nordrhein-Westfalen has the most radical and comprehensive approach; Hamburg (a city-state) has concentrated on 30kmph zones; Berlin (also a city-state) until its 1989 elections denied any traffic calming policy yet allowed its planning ministry to implement one of Germany's most successful schemes (Moabit); and in Bavaria concern for transport centres on its role in expanding the economy, and traffic calming is promoted mainly as an aspect of beautifying its already-beautiful cities.

These are generalisations of course, but they illustrate the point. Moreover, the cities and smaller communities also enjoy a large degree of autonomy, so neither Federal nor Lander policies can convey a complete picture of traffic calming (or indeed other) policies throughout the Federal Republic, and there are exceptions to whichever general approach one describes. Dortmund, for example, is considered more resistant to traffic calming than other Nordrhein-Westfalen cities, while Nurnberg has pursued policies that seem radical compared to some other Bavarian cities.

Urban renewal schemes in city centres, and in older inner-city housing areas, frequently provide an opportunity and finance for traffic calming measures. In German cities it is noticeable that a high proportion of schemes are to be found in areas housing low-income families, often with a high proportion of immigrants. This seems to be a direct result of the link between street improvements and housing renewal programmes. A city planner from Nurnberg suggested that the poorer sections of the community are in fact more interested in traffic calming than middle-class Germans because they make more use of their streets. This is partly a cultural difference and partly due to the fact that poorer housing areas often have little open space other than the street itself. Schemes are funded not only from the city housing budget, but also by contributions from property owners.

Measures to reduce traffic speeds and volumes can thus be identified with broader planning policies to make the inner cities more livable, and thus to enable them to compete more effectively with suburban developments, in terms of both living quality and economic strength.

5. TRAFFIC CALMING POLICY IN DENMARK

Denmark, like the Netherlands, has no significant motor manufacturing industry and consequently a relatively weak motoring lobby. Accordingly it is in Denmark's economic interests, transport policies aside, to tax private cars heavily, and it does. Taxes on motoring constitute some 40% of all Danish customs and excise duties exclusive of VAT, while car purchasers face a car sales tax of up to 180% on top of the normal 22% VAT. As the Danes put it 'take one car and pay for three' (DK 003). Despite the fact that car manufacturers and suppliers partly off-set the high level of taxation by lower prices Denmark appears to have the highest taxes on car purchases in Western Europe.

In the early 1980s severe economic recession allied to these high levels of taxation actually resulted in a fall in car ownership, although in more recent years the upward trend has reasserted itself. nevertheless car ownership in Denmark remains significantly below the level which would be expected on the basis of economic indicators such as income per head of the population, and is currently below that in the U.K. for instance.

Support for public transport in the form of subsidies is substantial in Denmark, but does not approach Dutch levels. One reason for this is that central government grants and subsidies are not normally available for bus services. Support is provided through the counties and municipalities and must be funded through locally raised taxes, which include local income tax. It is noteworthy in this context that Denmark has not indulged in investment in expensive new Light Rapid Transit or other new public transport systems. The State owned railways, D.S.B., however, enjoys a privileged position as an integral part of the Ministry of Transport.

Cycling increased rapidly in popularity through the 1970s, and has been encouraged with the extensive provision of facilities. This has not prevented increased casualties, however, and increased accident rates have given rise to considerable concern during recent years.

Traffic calming, or "traffic integration" as it is also known in Denmark (DK 001), was originally inspired by the example of the Woonerf, but evolved quickly in a rather different direction, favouring schemes involving 30km/h speed limits rather than the inflexibilities of Woonerf style "walking pace" or similarly low speed limit designs (DK 002).

Quiet Roads and "Rest and Play" Areas

The insertion of Section 40 into the 1976 Danish Road Traffic Act allowed municipalities general powers to deviate from the normal rules for road traffic regulation where it was considered expedient to do so. It gave central government support for innovative traffic management schemes and stimulated the widespread flourishing of traffic calming practice throughout Denmark. A working party was established which in 1978 recommended two types of scheme: "rest and play" areas, analogous to Woonerven with a speed limit of 15 km/h and associated regulations; and "quiet roads" (Stilleveje) with a 30 km/h speed limit and signs but otherwise no regulations or standards (DK 004). An advisory report was also published in 1978 (DK 005).

Stilleveje provided a popular and flexible model which was enthusiastically taken up by the municipalities, which are responsible for the vast majority of urban roads in Denmark. Plentiful examples of these quiet street schemes exist all over Denmark, by far outnumbering the more rigid "rest and play" schemes. The latter tend to be used only for very short sections of street at sensitive points (outside school entrances for example), and are often set within wider "quiet street" schemes.

The role of the relatively decentralised structure of Danish local government has to be appreciated as a factor in this variegated practice. The lower tier municipalities have responsibility for the vast majority of roads, and have exploited their freedom from central government regulations or the doctrine of "ultra vires" to innovate and "learn by doing".

Safe Routes to School

Many Section 40 traffic calming schemes have been introduced on school streets or in areas surrounding schools as part of "safe routes to school" policies. This process has been assisted by the legal requirement, also in the 1976 Road Traffic Act, for roads authorities to take steps to protect children on their way to and from school.

Area Treatments

Quiet road schemes most frequently involve individual streets or small groups of adjacent streets in small area treatments. Area treatments of residential areas designed, inter alia, to shift traffic back onto designated traffic routes are also in evidence. Wider area treatments are very much the exception rather than the rule, however, despite the early implementation (in 1973-5) of an excellent area-wide scheme in Osterbro in Copenhagen, which served as a demonstration project and was extensively researched and shown to yield major safety benefits (DK 006).

More incremental approaches have been dictated by cost considerations, dependence on funding by residents where private roads are involved (and these are numerous in Denmark), and by the reduced potential for conflicts and delays which smaller schemes generally imply.

Main Road Schemes

A number of schemes have been implemented on important through traffic routes, both in urban areas and villages, where the objective in terms of speed reduction has been to achieve compliance with existing 50 or 60 km/h speed limits and/or to reduce speeds to 40 or 50 km/h over some sections rather than 30 km/h. Such schemes have been implemented on County Roads, notably by Copenhagen County, and on National routes. The Ministry of Transport, through its Road Directorate has been responsible for three impressive demonstration projects on routes through villages, which have been thoroughly researched and evaluated (DK 007, DK 008). This work won for the Road Directorate, jointly with consultants Anders Nyvig, the 1986 Volvo International Traffic Safety award.

Central Government Roles

National routes apart, the role of central government in Denmark is advisory and it undertakes and sponsors research. It does not normally finance local authority schemes, with the exception of occasional demonstration schemes funded as research projects (such as that in Ostebro). No other grants towards the costs of schemes are available.

Ministries other than the Ministry of Transport were closely involved and instrumental in the introduction of "Section 40" traffic calming in Denmark, notably the planning Ministry and the Ministry of Justice, which is responsible in Denmark for the Road Traffic Act. More recently, however, the Ministry of Transport has played a leading role, not only in the three village schemes and other research projects, but also in the revision of the roads standards for urban areas.

Road Standards

Roads standards have been thoroughly overhauled to incorporate traffic calming practice. A similarity with the Netherlands is that a two-fold functional hierarchy of roads is now adopted with a simple division into traffic roads and local roads. More importantly, however, roads are classed with reference to their speed category, from "high-speed" (70-80 km/h) through "middle-speed" (50-60 km/h) and "low-speed" (30-40 km/h) to "very low speed" (10-20 km/h) (DK 009). The intention then is clearly to design and redesign roads acording to the speed category adopted as appropriate, such that speed limits are as far as possible self-enforcing, with traffic calming becoming central to the design process.

6. FINANCE AND IMPLEMENTATION

The object of this section is to answer five questions about the finance and implementation of traffic calming schemes in The Netherlands, Germany and other European countries. Firstly, who initiates the schemes? Secondly, which bodies are involved in carrying them out? Thirdly, what are the sources of finance for the street works and the associated evaluation research? Fourthly, What is the rough order of magnitude of the costs involved? Fifthly, how are schemes maintained?

Who initiates traffic calming measures?

We have already seen that schemes may be initiated in a variety of ways. In both The Netherlands and Germany, early initiatives tended to be in individual cities, for example Delft as the pioneer of the Woonerf, and Hamburg as the frontrunner for the "Tempo 30" developments. But the widespread application of traffic calming techniques throughout these two countries cannot be attributed to multiple individual local authority initiatives. The involvement of regional and central government has encouraged local authorities to implement schemes. Such involvement has been particularly important when promoting policies (like traffic calming) which run against the grain of traditional or mainstream local practice. Central government involvement is regarded as crucial for at least four reasons.

1. It provides a source of reliable information, based on research beyond the scope of local authorities.
2. It provides advice on techniques, procedures and regulations, which can help avoid costly mistakes.
3. It provides a framework into which can fit research efforts by other agencies, such as universities and private consultancies.
4. It provides incentives to local authorities to act, for example through the provision of special grants and competitions.

It is important to recognise that initiatives are invariably a response to public pressure, either at the local or broader level. The impact of the mid-1970s oil crises on the shift towards traffic restraint policies is acknowledged by most observers. At the city level, local groups often pressure their council to take action in their areas to reduce traffic speeds and accidents. The civic autonomy already discussed often produces powerful mayors who can have a major influence. A senior planner in Nuremberg claimed that "no mayor in Germany can afford to ignore the public pressure for reduction in traffic speed in towns".

But it is the task of government bodies to translate the often rather vague public demands into specific and practical schemes. In this respect the true initiators of particular concepts or designs are more likely to be local authority officers, or their specialist consultants. There is thus a distinction to be drawn between the political origins of a scheme, and the initiator of its design. The transfer of knowledge from one authority to another (encouraged in both The Netherlands and Germany through central government action) means that schemes may be implemented even where there is no direct public pressure for action.

Which bodies are involved in traffic calming measures?

Most, if not all, schemes in The Netherlands and Germany have been designed and implemented by the local authority. The involvement of other parties is common but may be regarded as an input to the process. Higher levels of government may often be involved in the financing of schemes and may impose conditions. For example, Government grants in The Netherlands for Erven and 30kmph schemes are conditional upon the local authority having adequately consulted local opinion. Private or independent research consultants are frequently brought in (by all levels of government) to carry out specialist design work, or to undertake evaluation studies. At the local level, organised groups are often formally involved in the planning and implementation stages.

The restructuring of through roads in small communities in The Netherlands provides an example which is fairly typical (NL 020). Three groups of people are identified:

1. An official working party which carries out the planning and design, and coordinates implementation of the scheme. This will include professionals from the local authority, and representatives of the police and other services.

2. The local, county and Government authorities upon whom financial decisions rest.

3. Interested parties such as residents and shopkeepers who, if organised, may participate in the working party (as in 1).

The various national demonstration projects have involved a wider range of people. The six German area-wide demonstration projects were initiated at a conference in 1980 organised by the research institutes of three Federal ministries (the conference attracted 400 local authority delegates), and the work was funded by the local authorities with substantial grants from the Land and Federal governments. The extensive array of before and after studies of these 6 projects were carried out by about 20 independent research agencies (mostly private), and coordinated by the three Federal research institutes, who also met most of the costs. The research was directed initially at demonstrating the available techniques for area-wide traffic calming, and later at describing their effects.

The role of research institutes in developing traffic calming techniques and promoting good practice throughout the country needs to be emphasised. There are several such institutes in The Netherlands and Germany, many of which cover several policy areas, not just transport. These are funded by collections of local authorities - such as the 100 or so authorities in the "Deutsche Stadtetag" which funds the Planning Institute in Berlin * - or directly from central government or (in Germany) the Lander ministries. Some research institutes rely on project contracts - such as the Dutch Institute for Applied Sociology **. The "HUK Verband" in Cologne is funded by the association of motor insurers, and investigates road accidents and road safety.

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* Deutches Institute fur Urbanistik (DIFU), West Berlin.
** Instituut voor Toegepaste Sociologie (ITS) Nijmegan, Netherlands.

In addition there are many research organisations both private and within universities that undertake projects for government agencies, and sub-contracts from the research institutes. Most of the work undertaken by, for example, the Centre ROW * in The Netherlands and the German Federal institutes is actually parcelled out to independent research bodies. The Danish Council for Road Safety Research has played a leading role in research in Denmark, as has the Ministry of Transport's own Road Directorate.

The research effort is thus spread between a variety of civil servants, professional engineers and planners, academics, private consultants, and interest groups such as the motor insurers, motoring organisations, chambers of commerce, pedestrian and cycling organisations. These bodies together have generated a large quantity of research literature on traffic calming. The DIFU in Berlin, for example, holds more than 1100 titles on the subject.

The most interesting traffic calming schemes are those which tackle multiple objectives - a combination of, say, reducing accidents, improving safety and providing a more attractive environment. There is a lot of evidence to suggest that such schemes are most effective when they are the product of multiple-interest organisations or teams. In particular, traffic and transport functions need to be combined with urban planning functions, either within joint departments, or in multi-disciplinary working arrangements. Some examples will highlight the point.

In Germany, the initiatives for traffic calming at the Federal level have come mostly from the Ministry of Town Planning and its associated research institute, but the six major Federal demonstration projects were the product of collaboration between three ministries (Town Planning, Transport, Interior) and their respective research institutes (D 030).

In Nordrhein-Westfalen the successful widespread application of traffic calming has been attributed to the fact that it is the only Land with a joint ministry of planning, housing and transport.

At the local level, too, the point is clear. In Berlin the separate Town Development and Transport ministries have been in open conflict over traffic calming policy, as already described. The political change in 1989 seems likely to shift the policy in favour of traffic calming, however, and certain schemes which had been blocked (such as the Buessel Strasse) may now be implemented. In Nuremberg, the Director of Town Planning oversees three departments - housing, transport and general planning - and has the support of the Mayor in promoting a vigorous policy of 30kmph zones, pedestrianisation, and capacity reduction on the main radial roads, all in the the context of wider policies of car restraint, improved public transport and inner city housing renewal.

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* Centrum voor Regelgeving en Onderzoek in de Grond, Water - en Wegenbouw en de Verkeerstechniek (Centre ROW), or Centre for Research and Contract Standardisation in Civil and Traffic Engineering in the Netherlands. This institute produced the 1045 page manual of traffic engineering techniques (NL 001).

The multi-objective approach is equally a feature of Dutch practice, and this has been achieved through inter-disciplinary working, especially at local government level. There are separate planning, housing and transport ministries in The Hague, all of which have contributed to the national initiatives, though the transport ministry is criticised by some as having become less enthusiastic, apparently following a political shift to the right.

In Groningen the planning and building department of 700 staff is organised in multi-disciplinary teams, deliberately (according to one senior official) "to break down professional barriers and especially the blinkered approach of some traffic engineers". The process appears to have been aided by a political secondment from the department of a personal advisor to the Alderman in overall charge of planning, building and traffic.

The Public Works department in Delft, which pioneered the Woonerf, is now split into two sections, but between new projects and maintenance, rather than on professional boundaries.

The Eindhoven demonstration project was carried out by a multi-disciplinary team specially constituted by the city council which proved effective in reconciling different approaches to the work.

Generally at local authority level, planning, housing and traffic are often conducted by separate departments, and although projects are coordinated at chief officer and council level, problems have arisen. For example, some early Woonerven carried out solely as engineering projects were less attractive and less popular than those with an urban design input.

The conclusion must be that traffic calming measures to be fully effective in tackling environmental, traffic and urban development objectives must be implemented by multi-disciplinary teams. This can be effected through joint departments, or through special project teams located within existing highway of planning departments. This point has been underscored by Beth and Pharoah with regard to experience in the UK (UK 002).

Who pays for traffic calming?

Grants from the National government in The Netherlands and the Federal government in Germany have provided a major but not the only source of finance. Important though these have been in promoting policies and developing techniques, they are not regarded as a permanent feature of funding for local schemes. Government grants have been limited either to specific areas (eg. the 6 German area-wide demonstrations, and the 2 Dutch ones) or to fixed periods of time (eg. the 80% grant in The Netherlands for cycle facilities 1975-1985), or to special programmes (eg. the Dutch BREV experiments). Moreover, much of the money from central sources has been used to pay for associated research rather than for the street works themselves. The German Federal government has sometimes found it difficult to fund local schemes because of friction between the Lander and the local communities. In Denmark central government funding is restricted to demnstration schemes and associated research only, apart from schemes affecting national roads.

Where grants for local schemes are provided centrally, they usually have conditions attached, for example that schemes form part of an approved traffic and transport plan, or that a particular design is used, or that public consultation has been carried out. In all three countries there are non-specific grants from central to local government, and a proportion of this also may be used to finance local traffic calming schemes.

The Dutch Provinces and the German Lander also play a part in funding not least because they are responsible for the construction and maintenance of major road networks. The most adventurous is the Nordrhein-Westfalen Land which pays a large contribution towards local authority traffic calming expenditure; between 60 and 80% of total cost depending on the type of road and the size of the council (meeting at the Ministry 1988).

While attention is inevitably focussed on the special projects and demonstration schemes, it is important to recognise that the vast majority of traffic calming work has been carried out as part of ongoing programmes of maintenance and renewal. Such work is often financed from housing, urban renewal, conservation, and highway maintenance budgets.

The process of implementing Erven, 30kmph zones and other measures has been especially rapid where street reconstruction is necessary at frequent intervals due to unstable sub-soil conditions. As a result, it would in theory be possible to "calm" the entire Dutch urban street network in 20-30 years, and for highway maintenance budgets to meet the bulk of the cost. The contribution of road maintenance budgets to traffic calming schemes is substantial, though difficult to quantify since the distinction between "improvements" and pure "maintenance" is blurred, perhaps deliberately so. Increasingly, cities have adopted a policy of introducing speed reduction and other traffic calming measures whenever a street is dug up. This now seems to apply to a majority of cities in Germany and The Netherlands. As a consequence, it is common to find at least 50% of a city's streets covered by the 30kmph speed limit, supported by self-enforcing speed reduction measures.

Housing and urban renewal budgets often provide for associated street reconstruction and improvement. In The Netherlands this is usually 30-40% of the total budget. Of this sum, most goes on the reconstruction of underground utility services and road sub-structure. Redesigning the actual surface layout and paving may account for a relatively small proportion of the overall cost.

In Germany housing renewal budgets also provide for street improvement works, and most of the traffic calming grants in Nordrhein-Westfalen are linked to urban renewal objectives. In addition, a Federal law states that property owners contribute towards the cost of street works, though each town decides what proportion this is to be. In Ingolstadt (Bavaria) for example it is usually 30-40% of costs, though this was reduced to 5% for the area-wide traffic calming project in view of its experimental nature, and Federal contributions. In Ingolstadt and other cities it has been found that property owners are more likely to inject private money into renovation work when street reconstruction takes place. Thus publicly funded traffic calming measures can raise confidence in an

area and thus stimulate private investment.

Moreover in Denmark, and Copenhagen in particular, many schemes are on private streets where the property owners themselves pay the costs of the features included.

In summary, local authorities have used a variety of sources of funding to implement traffic calming schemes, and have taken the opportunity to redesign streets to meet this objective as part of maintenance as well as capital programmes. Local budgets have been supported by (often substantial) contributions from regional and central governments.

How much does traffic calming cost?

The early "spot treatment" street reconstructions (Woonerf and similar schemes) were expensive, and often very expensive, typically over £25 per square metre of road and in some cases £150 per square metre or more (Delft Public Works Department and Dutch Road Safety Directorate 1988). The the use of high quality materials for the mixed precinct scheme in the historic centre of Ingolstadt pushed the cost up to £150 per square metre.

Simple traffic calming measures using cheap materials such as temporary signs and planters and prefabricated humps and ramps can produce effective speed reduction at a cost of about £1,500 per hectare of housing, though such schemes can be unsightly and unpopular with residents (for example the initial 30 km/h demonstration project at Heerde, Netherlands).

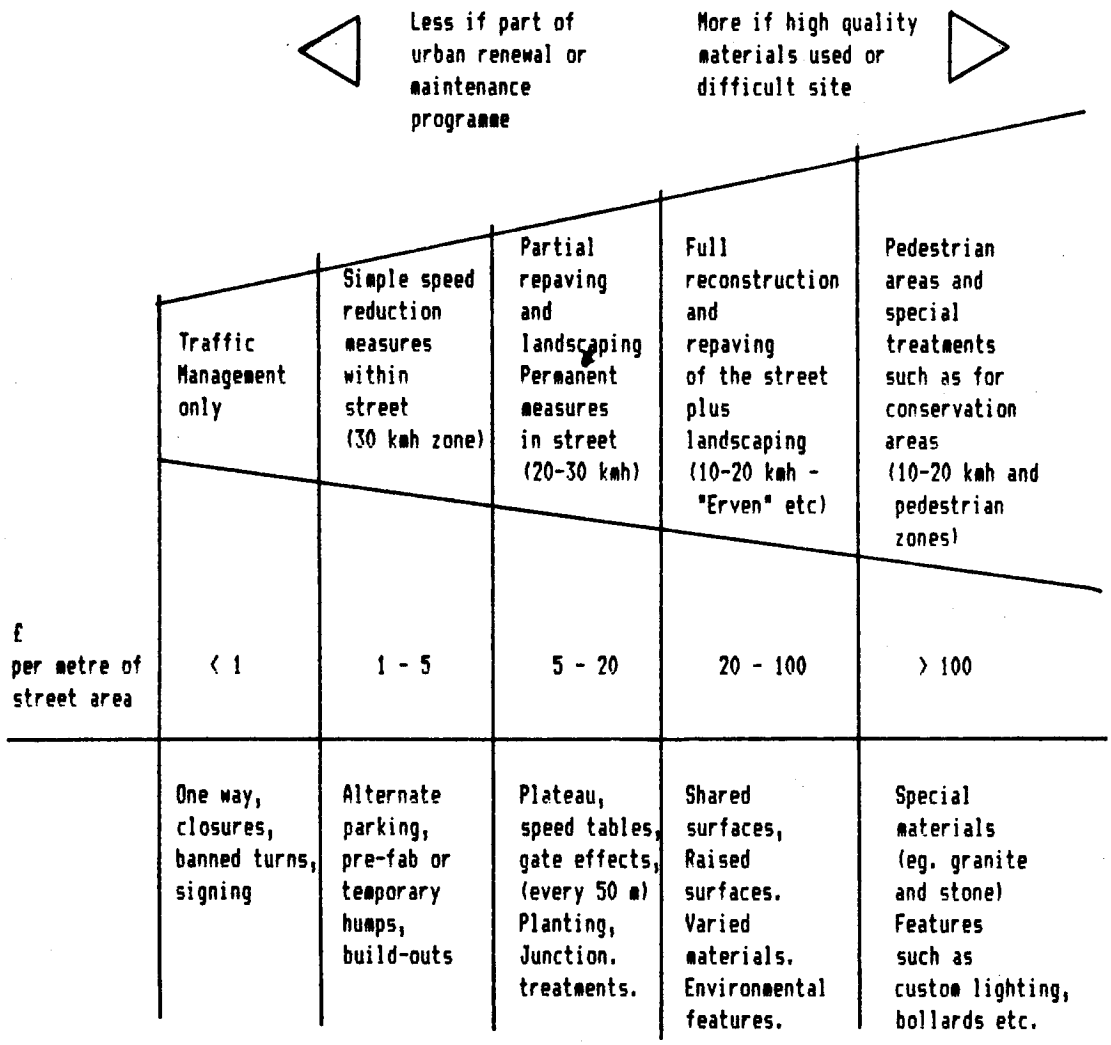
More permanent and attractive 30kmph zones can be achieved including ramps, chicanes, plateau and planting for around £2,500 per hectare. This was achieved in 5 of the 15 demonstration zones in The Netherlands, the remainder spending more either to achieve a better environment or to cope with special constructional problems (NL 017). The Moabit area scheme in Berlin demonstrates that safe and attractive streets can be created for around £10 per square metre of street space, including a third for planting.

The differences in cost have a number of explanations. For example costs can be minimised where traffic calming is achieved by inserting measures at intervals along a street. If total reconstruction of the street surface is undertaken total costs will be much higher. On the other hand costs attributed to traffic calming will be reduced if the reconstruction was needed anyway to maintain engineering standards. The quality of materials used also has an impact on overall costs, but again it is difficult to lay down rules of thumb. For example the Moabit scheme used granite setts which would normally be expensive, but which in this case were already available from the existing street paving.

Where schemes have been implemented to meet a "city beautification" objective, costs have been much higher, for example in Ingolstadt where the overall cost was three times the Berlin Moabit figure for a similar sized area. This was the result of using granite setts and other expensive materials, most of which had to be purchased specially for the project. (As a condition of financial contributions, granite was insisted upon by Bavaria and Bonn, despite the fact that Ingolstadt is a producer of concrete!)

To provide an indication of the rough order of magnitude of overall costs, Figure 2 shows in diagrammatic form the costs in relation to some of the factors discussed, with actual schemes mentioned by way of example. It must be stressed, however, that a variety of budgets can be involved, and the costs do not necessarily have to be attributed entirely to traffic calming.

FIGURE 2 AN INDICATION OF TRAFFIC CALMING COSTS (mid-1980s prices)



[Costs are indicative, based on mid-1980s prices for a selection of schemes in The Netherlands and Germany]

Derived from information on Dutch and German demonstration projects (NL 017, NL 025, D 032c) plus interviews with project staff 1987 and 1988.

How are traffic calming schemes maintained?

Keeping traffic calming schemes up to standard requires, firstly, the maintenance of paving, humps, ramps, bollards, seating, greenery and other features introduced to achieve the "calming" objectives. Secondly, such features need to be properly reinstated following repair of underground utility services.

Consideration of how this work is to be carried out, and by whom, is an important consideration at the planning stage, and indeed has helped to shape traffic calming policy in both The Netherlands and Germany. Generally speaking, the more elaborate schemes involve higher maintenance and reinstatement costs. It is partly for this reason that many cities have curtailed their programme of creating Woonerven. For example Groningen and even Delft no longer convert streets to full Woonerf standard, although new housing may be laid out on the Woonerf model. German cities also have now abandoned the creation of Woonerven-type schemes as a general policy for residential areas.

To some extent the use of high quality materials can reduce maintenance costs, and this has been adopted especially where grants are available to meet the higher initial cost. An example of this is the use of granite setts in the Ingolstadt demonstration project. Street furniture needs not only to be strong, but also well placed. Maintenance costs rise dramatically where poor design leads to bollards, trees etc. being damaged by vehicles. Simple design is usually cheaper and aesthetically more pleasing, but enough needs to be built to achieve a traffic calming effect. A balance thus needs to be struck between the objectives of economy and effectiveness.

Reinstatement is also affected by the design of the scheme. Problems can arise if non-standard features are used, or where those carrying out the reinstatement work may be unaware of, or not properly briefed about the design required. An example of this was the use of coloured aggregate at some road junctions in the Eindhoven demonstration area; the effect had been destroyed by reinstatement work using grey asphalt. With traffic calming becoming more widespread, however, an ever larger range of materials and street furniture is becoming readily available, making the tasks of reinstatement and repair easier.

The problem of reinstatement works is greatly reduced by coordinating traffic calming works with the renewal of underground pipes and cables. Where it is proposed to reconstruct a street, the local council discusses with the public utility authorities the possibility of renewing sewers, pipes and cables at the same time. Very often a programme of priorities for street reconstruction can be designed to coincide with priorities for utility renewal. It is in the interests of the utilities to cooperate because they can avoid the cost of pulling up and relaying the street. If they do not take the opportunity to relay services when the street is reconstructed, they are more likely to face ad-hoc repairs, and the consequent costs of reinstatement. In some places (Groningen for example), the problems are minimised by the fact that the local council is responsible for sewerage and water supply, as well as street maintenance.

Schemes which involve inserting measures at intervals along the street (eg. most 30kmph zones) rather than total street reconstruction are cheaper to maintain, but a judgement still needs to be made about whether to renew services and street surfaces at the same time. Measures can often be designed which do not alter the existing pattern of surface water drainage (eg. Berlin Moabit) and this helps to keep costs to a minimum.

Planting can be designed to be virtually maintenance-free, and the inclusion of a landscape architect in the project team will help to achieve this. Sometimes the design can incorporate greenery in such a way that residents take on resonsibility for maintenance. In Ingolstadt, for example, the provision of small front gardens was popular, and helped public acceptability of the traffic calming scheme.

7. PUBLIC INVOLVEMENT

Public involvement in the planning process is an important aspect of traffic calming practice in all three countries. Unlike many municipal affairs which to many citizens often seem rather remote or abstract, traffic calming measures involve changes in the immediate environment of people's homes and often directly affect their daily lives. The route by which drivers reach their home, the safety with which the children can play in the street, the convenience of parking places; these and many other issues are raised whenever traffic calming measures are proposed. Involving the public at an early stage can ensure that problems are properly defined, and that a satisfactory design is achieved. This is vital if the measures are to receive support and acceptance. The lesson has been learnt in Dutch and German towns that without that general support, schemes can be severely delayed or blocked completely by organised public opposition. No matter how experienced a council may be in matters of street design, public reactions are often unpredictable. Indeed, even the feeling of having change thrust upon them can lead residents or shopkeepers to reject even the best schemes. Often the emergence of a residents' leader or opinion-former in the local area has been the key to the progress of schemes.

In The Netherlands, government grants for traffic calming schemes are usually conditional upon adequate public consultation. For locally-funded schemes there are no statutorily defined consultation procedures but preferred methods are laid down in a "Municipal Consultation Order" (NL 011, p23) which applies in many municipalities. This Order includes the following provisions:

- The project team may include representatives from local organised groups such as residents' associations.

- Advisory organisations may be consulted, for example the national organisations for motorists (ANWB), pedestrians (VBV), and cyclists (ENFB).

- The municipal traffic committee should be involved before and after public consultation.

- Individuals may participate in public inquiries and hearings, consultation meetings and information meetings.

- Public hearings should be held only as a last resort.

- Consultation meetings are preferred, where members of the public can react to specific plans, and be guaranteed the possibility of influencing them.

- Information meetings must be supplemented by other media, in order to reach as wide an audience as possible.

The area-wide demonstration project in Eindhoven serves to illustrate a number of important points. There were initially problems with public acceptance of the traffic calming proposals. When an outline plan of the proposals was presented, local people and the community council thought the city was imposing a solution.

As a result a two-stage consultation procedure was developed.

Stage 1 dealt with the specific problems in the area and the possible means of tackling them. This allowed people in the community to describe the problems as they perceived them. In this way agreement was reached with the Council as to what the problems were before design work began.

Stage 2 took place after the production of the draft design, and was confined to discussion of how well the design met the problems already identified. For example residents who complained that a junction design removed parking spaces were reminded that they had previously identified parking at junctions as a main source of danger. Thus the safer junction was accepted, despite the reduced convenience for parking.

The Eindhoven demonstration project team were often surprised by views expressed by residents. For example it was initially feared that expensive designs in some streets would be resented by residents in other areas. In the event the reverse was sometimes the case. Architect's designs for the reconstruction of a public square in front of a church were rejected in favour of simple and uniform paving with no planting; residents in streets earmarked for expensive Woonerf treatment insisted on simpler measures being used to reduce traffic speed; and residents along part of the outer ring road insisted that the dual-carriageway should be retained in front of their homes, despite the fact that the adjoining section of the road had been converted to a single carriageway and moved well away from the houses. No planner, however experienced, could predict reactions of this sort and the only way of avoiding hostility to proposals is to involve the people who will have to live with them.

Similar lessons have been learnt in Germany, and concern now focusses on finding the best way of encouraging public participation. As in The Netherlands, competitions and cash prizes are sometimes offered to groups who promote road safety schemes. It is also considered important to seek the views of residents after the implementation of schemes, as well as before. This is true especially of the major demonstration projects. Through careful monitoring of the effectiveness and popularity of various measures, future designs are improved and mistakes avoided. This may seem a simple point, but it is one that is often missed in the UK.

In Germany it has been found that public involvement needs to be more intensive in rural communities, where one needs to speak to everyone. Designs must also be different from those used in towns. For example consultation in Borgentreich (one of the area-wide demonstration areas) found strong opposition to road narrowings because of the need to accommodate oversize farm machinery, and to extra trees in the street because they would entail farmers in extra leaf-sweeping in the Autumn. The latter is particularly interesting because in towns it has often been found that extra planting greatly increases the popularity of traffic calming measures.

It has sometimes been harder to get public acceptance of traffic reduction on main roads than on purely residential roads, particularly when shopkeepers' interests are affected. Yet the difficulties are as likely to be between rival local authority departments as between the public and the council. This was true in

Berlin, for example, where a majority of shopkeepers in Buessel Strasse (Moabit) want traffic calming measures designed by the Development Ministry, but the city's Traffic Ministry blocked the scheme (see chapter 4).

The two-stage approach adopted in Eindhoven has also found favour in Germany (Keller in D 030), with consultation on the problems before design work is undertaken, and public involvement in the design work itself.

In Ingolstadt, consultation started late in the process, indeed after the first street had been reconstructed. The first publicity leaflets were rather diagrammatic and were misunderstood by some. Shopkeepers in particular mounted a campaign of opposition, and got a 15,000 signature petition within two weeks. This rather poor start led to considerable delays in the implementation of the area-wide measures to the extent that at one point the Federal government threatened to withhold grants. Later consulation leaflets were redesigned to include detailed plans which allowed residents to identify their own properties, and eventually a more constructive dialogue was achieved. Local groups, especially those representing traders, exerted a lot of influence on the eventual designs. This led to more parking provision in the town centre than desired by the scheme's designers and this, in the author's view, has compromised environmental quality to a considerable extent.

The Ingolstadt city council has learnt these lessons, and now finds it very much easier to "sell" traffic calming schemes to the public. This is helped by being able to show residents successful schemes elsewhere in the town, and indeed coach visits to these have been organised as part of more recent public participation exercises. Hostility in the beginning was perhaps due to a fear of the unknown, and public attitudes have become more favourable to traffic calming as more schemes have been introduced. In a few streets where persistent opposition has been encountered, plans have been put on ice and priority transferred to other streets where residents are more enthusiastic. Public consultation has had a considerable influence on the design of schemes in Ingolstadt. One example was the removal of "rumble strips" designed to reduce traffic speed on the inner ring road, which proved very noisy for nearby residents. Another example was the provision of smooth paving footways in mixed precinct schemes: separate footways are not strictly part of the shared surface principle, but many residents complained that the surface of granite setts was difficult to walk on.

The difficulties with public opposition in Ingolstadt were compounded, at least until 1986, by the anti-traffic calming views of the local newspaper, which did much to inhibit progress of the scheme. It is sometimes said that the editor of the town's only newspaper is more powerful than the mayor. The mayor himself is powerful, directly elected (as in all Bavarian and Baden-Wurttemberg cities) with 70% of the votes. He had to tread a fine line between support for the Federal experiment, and concern for those who felt that their interests were threatened by it. The senior planner in charge of the scheme quoted a German saying which sums up the dual thinking of those who appreciated the principle of traffic calming, but who did not like the measures needed to achieve it: "Wash my fur, but don't make me wet"!

Opposition by traders also created problems in another of the Federal demonstration projects in Esslingen. The proposed measures had to be substantially redesigned to meet traders' objections, resulting in a delay of more than two years. Indeed the measures were still being installed in the Autumn of 1988.

These problems underline the importance of involving the public at the earliest stage, before there is any substantial commitment to a particular design. This was the approach in the Berlin Moabit scheme, which proceeded on target with public support. Provision in the traffic calming scheme for the introduction of planting to the streets proved particularly popular, and residents have become involved in maintenance of the new trees and plants.

In undertaking the Gostenhof area-wide traffic calming project (a city project), Nuremberg city council encouraged public involvement by opening a cafe in the area to act as an advice centre and meeting place. Planners, architects or politicians were available to answer questions every day, and the cafe remained open throughout the three years of the urban renewal programme. Most of the problems dealt with related to the housing improvements, but residents' comments also led to design modifications of the traffic scheme.

Most German cities have produced publicity documents on traffic calming, most dealing with local projects but some with a broader educational or promotional purpose. A report by Cologne city council includes examples of bad as well as good traffic calming practice within the city (D 046).

8. EVALUATIONS

The earliest traffic calming schemes were experimental or "acts of faith", but as schemes have been investigated, the ability to predict the effects of various measures has greatly improved. An attempt is made in this section to summarise the more robust findings of the major research projects in The Netherlands, Germany, and Denmark, notably the various area-wide demonstration projects and the large scale evaluations of individual measures. It should be noted that a great deal of additional research has been carried out by individual municipalities or by independent consultants, but collation of this additional material (most of which is not available in English) is not included here.

The results of evaluation studies are valuable to those introducing traffic calming measures, but they need careful interpretation.

Firstly, the effects of individual measures (such as a speed hump or a chicane) cannot easily be evaluated in isolation from the scheme in which they are embedded. The particular combination of measures in a street has a powerful influence on the behaviour of drivers and others, and on the perception of safety and other aspects. Thus an individual measure may be ineffective or have a different effect when implemented in isolation, but both effective and popular when used in conjunction with other measures.

Secondly, intervention in one street may affect conditions in neighbouring streets, especially if traffic is diverted. Consequently, and quite rightly, most evaluations have been carried out for whole areas, including surrounding roads. This helps to spot any migration of problems from one place to another, but the larger the area under evaluation, the less homogeneous it is likely to be.

Thirdly, there are the comlexities of the objectives of traffic calming schemes discussed earlier.

Thus in all three ways it may become difficult to say what precisely is being evaluated! A pragmatic approach is to rely on the skill and experience of the designer to produce a scheme which addresses the stated traffic calming objectives. Information on the performance other schemes thus becomes part of the designer's "toolkit" rather than a set of prescriptive rules.

Monitoring of aspects that are crucial to a scheme's acceptability is nevertheless required, to check that problems have not been made worse and to provide information so that remedial action can be taken if necessary. For example, a chicane of a particular design put into a distributor road in the Eindhoven demonstration area was observed to have created potentially dangerous conflicts between vehicles and cyclists, and was reconstructed prior to the full area-wide evaluation. The "bottom line" in terms of road safety is usually regarded as casualty frequency and severity. Gains in safety are not always easy to attribute to schemes, for example because of "regression to mean" effects (see UK 003) and small data sets. but the situation is often acceptable so long as casualties have not increased and other objectives have been met.

The point here is that failure is easier to measure than success. If there is a clear failure then objective results will confirm the

concerns expressed by residents and road users, and the scheme can be modified or withdrawn. If there is no measurable or perceived failure, then the debate centres on the degree of success or value for money, or other aspects which although important are usually considered less crucial in shaping policies and programmes.

As indicated in Chapter 2, evaluations of generalised objectives are problematic. Evaluations have usually been undertaken at a disaggregated level, and specific criteria established in order to measure the effects of a scheme in relation to component objectives. At this level both objective and subjective criteria can be employed in studies under a number of headings. The remainder of this section discusses evaluation research carried out into the effects of traffic calming schemes on the following:

Objective Studies

a. Speed
b. Volumes of traffic
c. Accidents
d. Noise
e. Air pollution
f. Parking
g. Pedestrian and street activity (including "staying")
h. Economic and other neighbourhood effects

Subjective Studies

i. Perceived Safety or Security
j. Popularity with residents
k. Popularity with user groups
l. Visual appearance and ecology

a. Speed

Speed reduction is used as a key evaluation criterion for traffic calming schemes. This reflects the fact that it is, although not an objective in itself, the principal means of achieving road safety objectives. It is also easy to measure. Moreover, since small data sets make the direct evaluation of accident reductions very difficult for most individual schemes, speed reduction is often used as a kind of surrogate for measurements of reductions in casualties or their severity, on the assumption that such accident benefits follow automatically if speed reductions are achieved.

An important feature of traffic calming in Europe is that measures are related to target vehicle speeds, usually reinforced by a legal maximum limit. The various speed limits, together with indications of the speeds in practice not exceeded by 85% of vehicles, are shown in the Table 2.

It has proved difficult to design Erven and other "mixer court" schemes so that drivers keep within the legal maximum speed of "walking pace", which would be 7-8 km/h. But maximum speeds of 15-20 km/h are more easily achieved, and appear to have become accepted. Indeed, Denmark's "rest and play" area regulations specify a 15 km/h limit rather than the vague "walking speed" limit, which is considered unrealistic and unnecessary. A 15 km/h limit is also specified, for example, in the shopping "erf" in the Rijswijk demonstration area (Den Haag, Netherlands).

TABLE 2. SPEEDS AND TRAFFIC CALMING MEASURES

	Legal maximum	In practice (Usual V85% values)
"Erven", "Rest and Play" or "Mischflacher" (Mixed precincts)	Walking pace	12-20 km/h (Up to 25-30 km/h in Denmark and Germany)
30 km/h zones	30 km/h	30-35 km/h
Through roads in villages	30, 40 or 50 km/h	>30, 40 or 50 km/h
Urban distributor roads	50 km/h (occasionally 40)	>50 km/h

Source: Results and observations from area-wide demonstration projects referred to in chapters 3 and 4.

There is a fear that very low speeds create driver frustration and thus greater dangers if they are required over long distances. The maximum distance from any part of an "erf" is usually set at 400-600 metres (NL 001 p. 620).

Driver acceptance of and compliance with low speed limits depends not only on the physical measures themselves but also on the visual appearance of the street as a "living area" rather than a "traffic road". The two aspects reinforce each other, and both are necessary for a satisfactory result.

In the only known case in The Netherlands where a motorist successfully sued a local council for vehicle damage caused by a speed reduction measure, the court judged that the intended speed was not sufficiently well indicated by the street's design - in this case poor lighting of a chicane which the driver failed to negotiate.

In "erven" and similar shared-space schemes speeds are kept below 20 km/h mainly by the use of two-way traffic operation, humps, ramps, and chicanes, together with various reinforcing measures such as narrowings, gate effects and vertical elements. Effectiveness depends on the design of the individual elements, their combination, and their frequency or intensity. The major problem has been with mopeds (bromfiets), whose speeds invariably remain 5-10 km/h faster than those for cars (N030). (See, for example, Vissers, 1982, "Evaluatie onderzoek in Verblijfsgebieden, wat doen we ermee?") This is partly because a chicane designed to accommodate four-wheel vehicles is less likely to slow a two-wheeler. Moped riders also use "footway" and other parts of the street not available to cars, thus causing more irritation. The problem is also partly attributed to the fact that a majority of moped riders are young people, who sometimes regard the Erf as a challenging obstacle course!

The German equivalent of the "erf" is known as a "mischflacher" (mixer court or mixed precinct), but it is not always designed to reduce speeds to below 20 km/h. Nor are some of the design

regulations strictly adhered to, notably footways are often retained. As Bowers (D 010) has pointed out, this could potentially give rise to confusion since speeds in excess of 20 km/h can hardly be compatible with the legal "walking speed" maximum. In practice, however, the behaviour and perceptions of safety by road users is determined not by the legal speed limit but by the design of the street. (When did a parent ever say to a child "it is safe to play in the street because there is a 30 miles per hour speed limit"?) So the confusion seems to be more a matter of the appropriateness of the "verkehrsberuhigung" (traffic calming) sign and its associated regulations when applied to schemes which allow speeds of 20 - 30 km/h. A similar problem exists in relation to "Rest and Play" area schemes in Denmark.

The Federal demonstration project in Berlin's Moabit district provides a useful illustration. The standard traffic calming sign is used for a scheme which does not conform to the regulations. The streets are not true "mixer courts" because footways are retained in many areas, parking spaces are not designated, and the design allows speeds of 20 - 30 km/h. Nevertheless, the scheme has proved to be one of the most effective in creating a safe and pleasant living environment, particularly because a "calm" style of driving has been achieved whereby drivers maintain a steady 20 or 25 km/h rather than accelarate and decelerate between speed reducing measures. The average speed of unhindered vehicles has been reduced from 39 to 20 km/h and the V85% speed went down from 51 to 25 km/h (D 032c). This has been achieved by the frequent use of narrowed carriageway sections combined with planting, and small raised sections or "cushions". The term "cushion" rather than "hump" is appropriate because speed reduction is achieved without the aggressive jolt associated with most humps, largely because the cushions are 5-8 cms in height as opposed to the more usual 10 cm for humps.

Many German cities in recent years have attempted to avoid the problems of "erven" (see above) by confining the use of mixer courts only to areas where street activity is intense, and lengths of street are short. In Nordrhein-Westfalen, the ILS * suggests the following circumstances where "mischflacher" might be appropriate:

Shops <u>both</u> sides of the street
High percentage of children
Lack of off-street play/open space
High percentage of residents likely to use the street for social purposes (eg. certain social or ethnic groups)
High housing density
High pedestrian relative to vehicle traffic (eg. school routes)

Where none of these conditions apply, 30 km/h zones are usually now preferred to mixer courts. In some cities (eg. Stuttgart) mixer courts are being modified to reintroduce the distinction between footways and carriageways, though not by reverting to the traditional street layout. Similar trends are observable in The Netherlands where "feelings of unsafety" are sometimes reported where no separate area for pedestrians is provided in the street. But where pedestrian activity is intense, there is no problem of mixing cycles, mopeds and low volumes of motor traffic. The market

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* Institut fur Landes und Stadtentwicklungsforschung.

streets in central Groningen provide an excellent testimony to this. Motor traffic volumes of 100-200 per hour are thought to be the maximum compatible with "erven" or "mischflacher" (eg. NL 001 p.620 and D 024 p.11). The main focus of attention has now shifted to the "intermediate" speeds of 30-50 km/h.

In Denmark "Rest and Play" areas are the near equivalent of the "Erf". from the outset, however, they appear to have been confined to short stretches of streets where pedestrian activities are concentrated, for example around scheme entrances, in squares containing parks or play facilities, and residential courtyards in new developments. Frequently these small "Rest and Play" schemes are set within wider "Quiet Road" areas with a 30 km/h speed limit. The 30 km/h "Quiet Road" model has dominated Danish traffic calming practice throughout.

The 30 km/h zone is now commonly found throughout The Netherlands and Germany, where it has been proved that streets can easily and cheaply be modified to achieve speeds of this order.

Although not yet fully complete, evaluation of the 17 test 30 km/h areas in The Netherlands has shown positive results. The De Vliert area in s'Hertogenbosch provides an example. Traffic in the area was reduced by 20%. Rat run traffic was reduced by a third, despite a doubling of through traffic in the corridor caused by the opening of a new road. The scheme included street and junction closures, and speed reduction was achieved with humps and junction plateau. After results in three of the 30 km/h test areas are shown in Table 3.

TABLE 3. AFTER SPEEDS IN THREE DUTCH 30 KM/H ZONES

	SPEEDS (V85%)	REDUCTION OF THROUGH TRAFFIC
De Vliert (Den Bos)	20-30	33%
Poptahof (Delft) - with humps	20	}
- with chicanes	30	} 10%
Heerde	30	small reduction

Source: NL 014 and NL 017

Similar results have been obtained from evaluations of schemes in Denmark. In "Quiet Road" schemes evalated by the Ministry of Transport's Road Directorate for instance, average speeds were reduced to well below 30 km/h in well-designed schemes, with virtually no vehicles exceeding 40 km/h (DK 010). Schemes involving no humps or other changes in vertical alignment of the carriageway performed notably less well, however.

In the German town of Buxtehude near Hamburg, where the entire northern half of the town has been converted to 30 km/h (except a surrounding regional road and one other road), speeds have been reduced to just above the 30 limit. This is accepted on the grounds that 30-35 km/h allows the use of low engine speeds in third gear, while not infringing the spirit of the 30 km/h limit (D 010).

Average speeds on the distributor roads were reduced from 51 to 31 km/h while V85% fell from 59 to 38 km/h. In smaller residential streets "no great speed reduction was achieved, nor needed; the speeds before and after were around 30 km/h" (D 032c).

The speed-reducing effect of physical measures depends particularly on the severity of the elements themselves, and the distance between them. For example, speed reducing elements must be placed no further than 50 metres apart, and preferably 30 metres apart or less, to prevent drivers speeding up in between (eg. D 029a). In terms of achieving a "calm" style of driving, the best results are obtained when the street can be driven at a fairly constant speed, without the driver experiencing any major discomfort, or having to make frequent use of gear shifts, brakes or steering. The use of severe-profile humps every 50 metres may produce slow average speeds, but the driving style and ambience of the street will rarely be described as "calm".

In Germany the speed "hump" has been firmly rejected, perhaps because it is considered to be illegal in most Lander. Preferred instead are changes in carriageway level achieved by ramps, plateau and raised "tables" or "cushions". Such raised portions are usually longer than the wheelbase of cars, and are thus experienced as "two changes of level" rather than "two jolts". The height of the raised portions may be as little as 5cm, or the ramp may be slight. Increasingly, raised sections are limited in width (as in Berlin Moabit, and in some Nordrhein-Westfalen towns) rather than from kerb to kerb. This allows cycles to pass unimpeded, and the design may allow the wheels of larger vehicles (buses, ambulances etc) to straddle the raised portion. A further benefit is that surface water drainage does not need to be modified, and this proved a major factor in limiting the cost of the Moabit scheme. Such a design is useful for bus routes or other main routes where conventional humps may be unacceptable. Full width ramps and raised carriageways have been used successfully, however, on a main route carrying buses in Buxtehude. Ramps or cushions are acceptable at compulsory bus stops, where buses are travelling slowly anyway.

By contrast speed humps are employed extensively in both Denmark and the Netherlands, and humps (or other vertical features such as ramps and raised sections of carriageway)) of sufficient severity are regarded as necessary for effective speed reduction. As already noted, Danish schemes involving no humps or changes of level performed notably less well in reducing speeds (DK 010).

In The Netherlands the speed control "hump" (drempel) has been the subject of rigorous design investigations (NL 008), and recommendations have now been issued for optimum designs. Three kinds of hump are recommended, two with a "sinewave" cross-section section, but with dimensions varying according to the desired speed of 20 or 30 km/h, and one of trapezium cross-section for 50 km/h (NL 001 pp.637, 634 and 633 respectively).

The Dutch SVT recommended speed hump is effective because discomfort to the driver is minimal below the prescribed maximum speed, but increases exponentially as speed increases, discomfort being measured in terms of vertical acceleration. Similar humps (circle cross-section, however) are recommended by the Danish Ministry of Transport and are extensively used, but in both countries the

"standard" hump is advisory only and other designs are employed.

Some alternative designs are intended to cope with the problems caused for larger vehicles such as buses by the standard hump, with larger vehicles being slowed excessively compared with smaller ones. Less severe slopes on speed tables or lower height humps will, ceteris paribus, simply result in increased speeds for cars, but two other approaches can be taked. One is to design humps which (like the German speed tables or "cushions") have a tilting effect on cars but do not extend accross the full width of the carriageway and consequently do not impede vehicles with a wider track. Alternatively hybrid designs have been developed in Denmark which present large and small vehicles with different slopes (DK 012). For effectiveness, much depends on frequency of the measures and the success of the particular combination of measures used in creating an environment which induces appropriate psychological reactions in drivers. Less severe vertical features can, German experience suggests, sometimes be as effective as those of greater height or gradient, if deployed intensively and if sufficiently well supported by other measures.

The effectiveness of chicanes in reducing vehicle speed depends on the particular design, and is much more susceptible to design failure than changes of level. Some design rules which have emerged are as follows:

(i) The view ahead should be restricted, especially where two- way traffic is retained, otherwise speeds will increase when the way ahead is clear. A general rule now adopted is that the horizontal shift should be at least equal to the total available carriageway width (ie. not including parking space).
(ii) The chicane must require the driver to turn through an angle of not less than 45 degrees.
(iii) The chicane must be created by a permanent feature (kerb build-outs, planters etc.) and should not depend on the presence of parked vehicles. This is to avoid speeds rising when parked vehicles are absent.
(iv) The wider the carriageway, the greater the possibility for the driver to take a "racing style" line through the chicane, thus undermining the speed reducing effect.

On the whole, chicanes are less effective and more subject to driver abuse than humps and other changes in level. The use of both techniques together, however, has been particularly effective.

The speed-reducing effects of narrow carriageways and driving lanes have not been precisely determined, but research in Nordrhein-Westfalen has found that speeds are related to street width, and are reduced by two factors:

(i) the <u>perceived</u> higher risk of collision in narrower streets and driving lanes
(ii) the appearance of narrowness created by vertical elements of the street (buildings, trees etc.), the so-called "optical effect"

Where driving speeds are subject to a legal maximum of 50 km/h (ie. the usual urban limit) a 6 metre width is sufficient for a two-lane,

two-way road, and this has been widely adopted in towns and villages in The Netherlands and Germany. However, this width can create problems for cycles when mixed with heavy traffic, and separate provision is usually made.

The problem of larger vehicles requiring wider driving lanes has traditionally meant the provision of over-wide roads which encourage cars to be driven too fast. In Germany this problem is being tackled on main (50 km/h) roads by building one metre "occasional" strips either side of narrow driving lanes, which can be used when two large vehicles need to pass. If these strips are in setts or other rough surface, car drivers will avoid using them. Thus the effective width of the street can be reduced whilst still accommodating wider vehicles.

Such occasional strips can be shared with bicycles, depending on overall volumes, but then a smooth surface must be used, and the difference achieved with different colour paving (eg. in Lunen near Dortmund). The smooth surface, however, is much less likely to deter speeding and colour differences appear to be less effective at night or in poor light.

This problem has been investigated in the village of Borgentreich demonstration project. Here a 6.5 metre carriageway had to be provided to accommodate oversize agricultural machinery. Reduction in the "optical width" by one-metre side strips in a different colour paving has not prevented occasional excessive speeds. Average speeds in the village centre were reduced by 3 km/h and the V85% fell from 61 to 57 km/h. High speeds are still experienced at the entrances to the village (90 - 100 km/h) despite the "gate effect" created by central dividing strips, mild chicanes and planting (D 032c).

Excessive speeds, especially those associated with aggressive overtaking, can be reduced or eliminated by the restriction of the view ahead, for example by chicanes, and by introducing central islands. These again create hazards for cycles if widths are restricted, and separate cycle paths must be provided.

Some one-way streets have been built deliberately narrow (2.25m) so that cars must follow behind cyclists. This is an effective speed reduction measure where a steady flow of cyclists is expected. Good examples are found in the centre of Groningen. On the outer ring road in Eindhoven a carriageway and cycle lane are sufficiently wide to allow cars to pass cycles, but larger vehicles (eg. buses) must use part of the cycle lane and thus are limited to the speed of cyclists using the lane. These designs operate without generating any apparent driver frustration, though it needs to be said that cyclists are tolerated in The Netherlands to a much greater extent than in the UK.

Bus stops can also be located so as to force other vehicles to slow down, creating additional or more intense chicane effects in the presence of a bus, similar to the effect of alternated car parking. In more extreme single carriageway designs bus stops have been used to hold up other vehicles at points where conflicts between road users are greatest for example in Alborg, Denmark and Mainz (Bretzenheim) in Germany.

Research in Nordrhein-Westfalen has found correlation between speed and the following factors:

- use of lane and centre-line markings
- restriction of parking (eg. totally or on one side of the road)
- lane/carriageway width
- "optical width" (width of street divided by height of buildings)
- smoothness of carriageway surface
- forward visibility (especially in two-way streets)
- one-way operation

All of these can be changed or modified to achieve a reduction in average or 85% speeds. The more factors that are modified, the lower the speeds achieved. However, consideration must be given to the predictability of vehicle speeds. A road quickly becomes unsafe (and is perceived as such) if drivers have the possibility of driving excessive speeds. Preference should therefore be given to measures which minimise the difference between minimum and maximum speeds.

Measures or factors which create a direct and perceived risk or discomfort to the driver are those which are most effective in ensuring slow speeds.

In Nuremberg, speed reductions have reportedly been achieved simply by imposing a 30 km/h limit indicated with 30 km/h zone signs (D 050), and small reductions have similarly been indicated in Hannover, but this experience has not been discovered elsewhere. Results in Denmark when reduced 40 km/h limits were introduced on urban traffic routes simpl by signing showed virtually no change in the speed of traffic. The concensus is that speed reduction requires the introduction of self-enforcing physical measures as described above.

b. Traffic Volumes

Reducing traffic volumes creates more possibilities for traffic calming measures though, like speed reduction, it is a means of achieving safety and environmental objectives and not an end in itself. The most usual method of traffic reduction is to use conventional traffic management techniques (closures, no entry etc.) to exclude through traffic from residential or other sensitive areas. Traffic reduction may also be achieved on the main road network, examples being Kalker Str in Cologne, Munster Str in Dortmund, and Further Str in Nuremberg. In all these examples, traffic reduction has been associated with upgraded public transport and/or the existence of alternative major roads. The smaller the maximum traffic volume, the greater the opportunity for speed

reduction and carriageway reduction. If such measures are not introduced, however, traffic reduction can have a negative impact by allowing higher speeds to be driven.

Traffic calming measures themselves may, of course, be sufficient to reduce traffc on treated routes or to divert it to alternative routes which are less sensitive environmentally.

There are differences of view as to whether traffic reduction should preceed traffic calming measures, or whether traffic calming

measures should be implemented first to see if these in themselves bring about a traffic reduction. National and Federal policies tend to emphasise traffic reduction first, but there are examples to the contrary. The major traffic calming demonstration in the village of Borgentreich was implemented at least three years before the village by-pass was opened. The main through road in the small town of Bergisch Gladbach near Cologne was narrowed to half its width and bus priority introduced before the completion of alternative road capacity.

The extent to which traffic calming measures reduce and divert traffic depends on a combination of factors such as:

(i) level of congestion on and directness of alternative routes,
(ii) the degree of speed reduction achieved, and the relative speed on alternative routes,
(iii) the proportion of "marginal traffic" such as short trips that might cease to be made. An example might be school escort trips which may be rendered unecessary if the walk or cycle route to school becomes sufficiently free of hazards.

The practice most frequently encountered in the three countries considered here is to first decide the target traffic volume, and then seek a traffic arrangement to achieve it. The speed reduction and calming measures are usually designed according to the expected or target traffic volume. Interaction between conventional traffic management measures to control traffic volumes, and traffic calming measures to control the speed and behaviour of the remaining traffic makes evaluation especially difficult where they are so combined.

The composition of traffic is also an important consideration. All streets need to accommodate the occasional larger vehicle for emergency, refuse and other services, but the practice of designing streets to uniform width to allow large vehicles to pass in all circumstances has long since been abandoned.

It is sometimes thought that rat-run drivers drive faster than those on local business (because by definition they are seeking to minimise journey time). Research in Nordrhein-Westfalen does not support this view, however. Local drivers also drive fast, perhaps encouraged by their detailed knowledge and familiarity with road layout, and usually do not slow until within 50 metres of their destination.

c. Accidents

Speed is the crucial factor affecting casualties when accidents occur, and the incidence of pedestrian casualties in particular. Other things being equal, greater speeds mean greater numbers of injuries and higher proportions of serious injuries and deaths. Conflicts involving vehicle speeds of 50 km/h or more are likely to result in serious injury or death for pedestrians, whereas at speeds below 30 km/h the risk of serious or fatal injury is greatly reduced. Traffic calming therefore, in so far as it achieves speed reductions, is certain to yield accident benefits in terms of casualties, unless the risk compensation mechanism (see Adams, UK 003) were to operate to completely offset such gains. There is no

evidence to suggest that is does.

Reduction of accidents is one of the objectives of traffic calming, though certainly not the only objective. Success has varied between schemes, and indeed there is no single criterion of what constitutes success. For example, if the number of serious accidents is reduced but the total number of accidents increases, is this an improvement? There are also difficulties in evaluating the effects of specific schemes. On residential streets in particular (where most traffic calming has been carried out), accidents are so scattered, and "before and after" data sets so small that it is often difficult to attach statistical significance to the results. Nevertheless, if the practice of traffic calming is taken as a whole, it is clear that there have been more positive results than negative ones. Traffic calming schemes which produce increased accidents are exceptions that prove the rule.

An overall evaluation has been conducted of over 600 traffc calming schemes in Denmark by the Danish Council for road safety research in order to overcome this small data set problem. Results indicate reductions in casualties of 45% compared with a control sample of untreated roads over similar 3-year before and after periods (DK 013). Work on this study is continuing in order to control for the effects of any traffic reduction on the calmed sample of roads. Since for many of these schemes traffic reduction is likely to be slight, and since also a substantial proportion of the schemes included are almost certainly substandard designs in terms of achieving speed reduction, these results are impressive.

In Alborg (Denmark) the possibility of increased numbers of minor collisions appears to have been accepted in order to reduce casualties in a complex juntion scheme described as creating "safety through panic". Results for this scheme show injuries reduced from 14 to 2 in the three year before and after periods, but minor collisions and near misses may well have increased (DK 014, DK 002).

In Buxtehude (Germany) there is evidence of big reductions in serious accidents, but slight injuries and injuries to cyclists have not reduced significantly. It is not yet clear whether recent increases in the latter are due to increased cycling or to factors unrelated to the scheme (D 032c). Annual accident costs are calculated to have reduced by 37% (D 037 p.15). Elsewhere, despite only partial observance of the lower speed limit, 30 km/h zones have succeeded in reducing injuries varying between 27% in Hamburg and 44% in Heidelberg (D 063).

Planners in Berlin have calculated that the Moabit scheme has already paid for itself through reduced accident costs, due in particular to the large reduction in fatal and serious injury accidents as shown in Table 4 (D 032c).

Erven and similar schemes usually succeed in preventing serious accidents, though they are not always perceived as being safe (see below). A study of 30 residential area traffic calming schemes in Nordrhein-Westfalen showed a fall in accidents compared to residential areas generally of 11%, while injury accidents fell by 44% and serious injuries by 53%. Injuries also reduced on the surrounding roads, though total accidents increased by 8% (not necessarily due to the residential area schemes) (D 024 p.36).

TABLE 4. ACCIDENT REDUCTIONS IN BERLIN MOABIT
(comparable before and after periods)

All traffic	Fatal	- 57%
	Serious	- 45%
	Slight	- 40%
	Accident costs	- 16%
Non-motorised traffic		
	Pedestrians	- 43%
	Cyclists	- 16%
	Children	- 66%

The majority of calming schemes implemented to date have been in residential areas, which usually account for less than 20% of injury accidents (and which usually carry less than 30% of total traffic). Nevertheless, accidents to children are heavily concentrated in residential roads, and it is these that traffic calming measures are expected to reduce (see the figures for Berlin above). Major reductions in overall accident totals can only be achieved with measures on the main road network.

For the area-wide schemes in The Netherlands (Eindhoven and Rijswijk) data indicates that accidents have been reduced in the long term. A reduction in accidents involving injury (per million vehicle kilometres) is quoted of 50% in residential areas and 20% overall (EC 001 p.26). Also important is the finding that accidents have not increased in the surrounding areas; ie. the problems have not simply migrated to other streets. The only remaining problem, as with speed, relates to moped riders who appear to be more at risk since the reconstruction. This may be associated with higher levels of moped use (NL 018).

Danish results for the Ostebro area scheme in Copenhagen also indicate substantial accident benefits with numbers down by 15% and casualties down by as much as 32%, these being reductions attributed to the scheme after allowing for displaced traffic (DK 006).

Results from traffic calming schemes on important traffic routes such as the Danish "Three Village" studies also indicate substantial accident savings although a longer period of evaluation is required to confirm the pattern (DK 015). Results in Denmark from urban schemes on major traffic routes where conflicts between users are at their mst intense, are rather less imressive to date in terms of accident reduction, but again more time for evaluation is needed. In any event other objectives such as reducing barrier effects for pedestrians and increasing pedestrian mobility are also prominent in such schemes, and these tend to conflict with safety objectives expressed in terms of casualty reduction. A more exacting evaluation framework is required.

Increasingly, safety is regarded not simply as an absence of accidents, but as being related to perception and use of the street, and this is discussed under the heading of subjective studies.

d. Noise

Changes in traffic noise result from five aspects of traffic calming measures:

- changes in traffic volumes and composition
- changes in carriageway layout
- changes in carriageway surface
- changes in vehicle speed
- changes in driving style (changes of speed, use of gears etc)

Reductions in traffic volumes by removing through (rat run) traffic from residential areas usually results in overall noise reduction ordinarily. This has not usually been accompanied by higher noise levels on the surrounding main roads, where traffic density rises only slightly in relative terms. For example, in the Dutch area-wide experiments, day-time noise levels in the residential areas dropped by as much as 6-10 dBA. The proportion of dwellings requiring noise insulation (threshold set at 60 dBA) dropped substantially as shown in the Table 5 (NL 018).

TABLE 5. % OF DWELLINGS EXPOSED TO MORE THAN 60 dBA IN DUTCH DEMONSTRATION PROJECT AREAS

	Eindhoven - option			Rijswijk - option		
	1	2	3	1	2	3
Before	13	19	15	33	31	18
After	9	7	1	10	5	7

Reducing carriageway widths on main roads (as carried out for example in Eindhoven, Buxtehude and Cologne) can reduce noise levels in buildings and on footways by taking traffic further away. High frequency sound may also be absorbed by the introduction of trees and planting, though this factor does not appear to have been separately evaluated.

Commonly expressed fears that slower speeds lead to increased traffic noise through more gear-changing and speed changes have proved to be without foundation. Vehicle speed correlates positively with noise level. Evidence collected by the ILS in Dortmund shows that a 4-5 dBA noise reduction can be expected if speeds are reduced from 50 km/h to 30 km/h (D 029c). The Buxtehude demonstration scheme produced noise reductions ranging from 1 to 7 dBA, with two 30 km/h streets measured over a six month period showing an average 4 dBA reduction (D 032a).

For schemes with higher design speeds such as the Danish schemes on routes through villages, evaluation indicated no significant changes in noise levels generally, with speeds reduced by 7-10 km/h (DK 008, DK 007).

Carriageway surface has a significant effect on noise. Granite setts produce noise levels about 3-5 dBA higher than smooth asphalt even if laid only in short sections. Rumble strips made from granite

setts were removed from the inner ring road of Ingolstadt (Bavaria) because of complaints from nearby residents about increased noise. Rumble strips employed at Vinderup, one of the Danish Road Directorate's three demonstration projects on routes through villages, have been removed for similar reasons. The noise difference between setts and asphalt diminishes with speed, however, and is virtually unnoticed at speeds of below 20 km/h.

e. Air Pollution

As with noise, many believe that speed reductions will increase pollution, but again this is not borne out by scientific tests. The Buxtehude study, for example, found that emissions were lower at 30 km/h than at 50 km/h. The extent of the reduction depended on which gear was used, and driving style. In the Buxtehude 30 km/h zones drivers often adopt a "calm" style with low engine speeds in third gear, travelling at speeds slightly in excess of 30 km/h. If second gear is used a less calm effect is produced and fuel consumption increases (though noxious emissions are still lower than at 50 km/h) (D 032a). As shown in Table 6, emission reductions resulting from slower driving are greater if a calm style is adopted, with the exception of carbon monoxide.

TABLE 6. CHANGES IN VEHICLE EMISSIONS WHEN SPEEDS ARE REDUCED FROM 50 TO 30 KM/H

	Driving style	
	2nd gear "aggressive"	3rd gear "calm"
CO	- 17%	- 13.4%
HC	- 10.4%	- 21.9%
NOx	- 31.8%	- 47.6%
Fuel consumption	+ 7%	- 6.7%

Source: Results of Buxtehude project reported in D 032a

However, these improvements relate mainly to the residential streets which carry only 20 - 30 % of total traffic and are therefore unlikely to have a major effect on air pollution problems on a regional scale.

The nature of the speed reduction measures, and the styles of driving which they engender are of crucial importance. The benefits of a "calm" style of driving with low engine speeds in third gear are shown in the Buxtehude results. Lower speeds such as those achieved in Erven schemes can actually increase emissions if they involve more acceleration and deceleration, and greater use of 2nd gear. This was found, for example, in the Woonerf (Option 3) streets in the Dutch area demonstration projects where although nitrogen oxide levels fell, the emission of carbon monoxide and hydrocarbons by individual vehicles rose noticeably. Usually in such streets the volume of traffic is reduced so that there is no overall increase in air pollution (NL 018).

Danish studies of the "3 village" schemes indicate no significant changes in pollution (DK 007)

Thus evidence so far suggests that schemes designed to encourage steady driving speeds are more effective in reducing emissions than slow speeds per se. Thus frequent use of shallow ramps and speed "cushions" (as used in Buxtehude and Berlin Moabit respectively) seem better than schemes involving sharp changes of level or direction.

f. Parking

Changes in parking provision are not usually specified as an objective of traffic calming, but the impact of schemes on parking is often an important issue.

Surplus carriageway width (eg. when lanes are reduced, or traffic is converted to one-way operation) can be used for additional parking. Angled parking (45 or 90 degrees to the kerb) can be used instead of lateral parking. Angled parking on one side of the road provides roughly the same capacity as lateral parking on both sides. Thus chicanes can be achieved by the use of angled parking on alternate sides of the street without loss of parking capacity. There are also safety benefits claimed from this arrangement because it reduces by half the chance of children being masked by parked cars, as well as reducing the speed at which any impact occurs. This system of parking is now common in Erven and Mischflacher schemes, and in 30 km/h zones in high density residential areas (but see section on "visual appearance" below).

In Cologne's Kalker Str, a principal radial route and district shopping centre, an innovative solution has been found to the problem of short-period stopping for shopper's cars and delivery vehicles. A double line of lateral parking has been introduced on both sides of the road, and the main carriageway reduced to two 3.5 metre lanes. Meter parking is provided in the parking lane which lies adjacent to the footway, while a short-stay stopping lane for deliveries is provided between the meter spaces and the carriageway. This unconventional layout operates without undue obstruction to vehicles on the "inside" meter bays. The vehicle manouvering involved is thought also to have reduced day-time speeds on the carriageway (D 006 p. 166).

On another main radial route, the Leenderweg in Eindhoven, the main carriageway has been reduced from 12-16 metres to a constant 6.45 metres width, and the space used to provide a service and parking road parallel to the main carriageway. Capacity of the road has been maintained by retaining additional turning lanes at junctions (sometimes doubling as bus bays).

g. Pedestrian and Sreet Activity

If "calmed" streets become safer and more pleasant to be in, a measure of this success will be that street activity other than motor traffic will increase in response to the higher quality environment. The quality elasticity of demand for such activity will vary according to a number of factors. Among these might be the extent to which activities were suppressed by previous conditions, the density of development, the social composition of inhabitants, the potential for development of street activity (eg. for pavement cafes or children's play), micro climate, architectural character,

and so on.

Sometimes major beneficial changes in street activity can be achieved where more space is given to "staying" activities. This involves the inclusion of space where children can play and adults can linger to chat or to rest, rather than being in the street simply as pedestrians walking from one place to another. In other words the enjoyment of the space itself rather than simply access to the activities which line it. The deliberate reallocation of carriageway or "movement" areas to "staying" areas has become a major feature of European traffic calming practice.

In Berlin Moabit street activities are reported to have increased by 60%, and cafes, restaurants and shops have moved out onto the (larger) footways. A small annual payment is made to the city for this facility. Increases in non-motorised traffic (pedestrians and cyclists) were recorded on all streets where traffic calming measures had been applied, with the exception of Bremer Str (D 041):

TABLE 7. CHANGES IN NON-MOTORISED TRAFFIC IN BERLIN MOABIT (AFTER STUDY)

Wiclef Str (outer)	+ 32%
" " (inner)	+ 54%
Oldenburger Str	+ 27%
Bredow Str	+ 114%

A few examples of major urban streets where a pleasant "staying" atmosphere has been created are:

Leenderweg (Eindhoven)
Walder Str (Berlin Moabit)
Kalker Str (Cologne)
Further Str (Nuremberg)
Bahnhof Str (Buxtehude)

Surveys in the Danish "3 villages" indicated substantial increases in outdoor activities along the main road after treatment; in Vinderup the increase was as much as 47% (DK 007).

Similar effects have been noted in both residential areas and main roads where the pedestrian environment has been improved (eg. inner areas of Bonn and Gostenhof West district of Nuremberg). Such changes are much less apparent in low density suburban areas such as certain of the 30 km/h zone demonstration areas in The Netherlands and in Danish "Quiet Road" schemes.

Evidence as to whether traffic calming stimulates more outdoor activity in residential areas then is mixed. A study by Guttinger (1979, "Spelen en lopen in een woonwijk; onderzoek in Gouda Bloemendaal-Oost" reported in NL 030) found that street activities were more diverse in Erven than in traditional streets. In studies of Mischflacher in Nordrhein-Westfalen it was found that the pattern of street crossing activity, and where people walked within the street became much more diversified (ie. using a greater part of the street, not just footways as formerly) (D 024 p33). Early studies of Woonerven in Delft also found that pedestrian activity "spread" accross the street after conversion (NL 031). An opinion poll among Woonerf inhabitants in 1982 found that only a few are encouraged by

the measures to spend more time out of doors. (Neeskens, 1982 "Woonerven: bijdrage aan een beter woonmilieu" reported in NL 030).

On main shopping streets where carriageways have been narrowed or central islands provided, pedestrians and cyclists can cross more quickly and thus may do so more frequently (NL 018). This reduction of the community severence effect of the road is regarded as a benefit of such schemes.

Traffic calming measures give high priority to pedestrian safety, to enable them to be in the street and to cross it without exposure to risk of injury or harassment from drivers. If this greater freedom leads to increased pedestrian activity, there is the possibility that potential accident reduction benefits will be eroded. For example, double the number of pedestrian crossing movements undertaken with half the risk will in theory result in no accident reduction, but the street may still be regarded as safer. Accident evaluations which take no account of changes in pedestrian activity are likely to be misleading. This is particularly likely to be the case on main shopping streets.

Traffic calming provides a benefit which may then be "consumed" in the form of accident reduction or greater pedestrian freedom. While recognised, this concept has not yet been adequately discussed or investigated, but it is of great importance to the evaluation of traffic calming schemes..

h. Economic and Other Neighbourhood Effects

If traffic calming is successful in making streets safer, more attractive and more popular, higher property prices and rents relative to non-calmed areas might be expected. As far as retailing areas are concerned, it is known that rents are on average higher in pedestrianised streets and malls. There is less firm evidence relating to residential property, but there are some interesting pointers.

In Ingolstadt it has been found that private property owners have invested more heavily in their buildings in the reconstructed streets. Moreover, in Ingolstadt as in many other towns, residents have been keen to exploit any opportunities presented for increasing planting in their streets, especially if the unsealed areas available can be adopted as semi-private space. This indicates increased pride in the street brought about by the traffic calming measures. In many towns estate agents often refer in promotional literature to traffic calming as a positive feature. Logic would suggest that this would be reflected in property prices, but the extent of this effect compared to other factors determining property values is not known. Further research on private investment, property prices and rents is still being undertaken, especially in Germany.

A more direct effect may result from the requirement in German cities for property owners to contribute to the cost of street works (Chapter 6). This may be translated into higher rents which could be a problem for low income families. In wealthier districts residents may be more willing to pay for safer and more attractive streets. Discussions with local authority officials in several cities on this

point did not reveal any major difficulties, but there seems to be little quantitative data on the subject. One reason for the lack of data is the fact that many if not most traffic calming schemes have been implemented as part of wider housing rehabilitation work, which also tends to lead to changes in rents and prices. It is therefore difficult to disentangle the specific effects of the traffic calming measures.

The effect of traffic calming and pedestrianisation on retail turnover has been the subject of an investigation funded by the Anglo-German Foundation (Hass Klau, C. 1988). The evidence collected for this study found that traders are almost always opposed to measures prior to implementation, but are in favour of them afterwards. Fears of loss of trade are usually proved to the contrary. There are, however, variations between different retail sectors, and possible impacts on retailing in untreated areas that need to be studied.

In Berlin's Beusel Str (in the Moabit district) 75% of traders are reported to be in favour of the traffic calming scheme proposed by city planners, rather than a less ambitious scheme advocated by the traffic department.

In the two Dutch area-wide demonstrations it was found that trade had increased except in the food and drink sector, in which turnover lagged behind the national trend.

SUBJECTIVE STUDIES

i. Perceived Security or Safety

For traffic calming to be judged successful it is important that the level of risk is in reasonable accord with public perceptions of safety. If residents perceive a street as being safe but their resulting behaviour exposes them to danger this may aggravate the accident problem. Conversely a street which is perceived as being more dangerous than accident figures suggest, is unlikely to have a calm or pleasant atmosphere.

Nonetheless it is important to fully acknowledge psychological benefit in terms of subjective perceptions of security as a valid objective in its own right. Easing people's minds by reducing their fears is, other things being equal, a benefit in itself. This is recognised in much continental practice of traffic calming, although it hardly registers yet in the UK. Thus even in situations where casualty rates remain unchanged, if people are less afraid to cross the street or less worried for the safety of their children, then real benefits have been realised, albeit psychologicl ones.

Obviously if a false sense of security were to be induced which resulted in increased accident and casualty rates a negative overall effect would result. Since traffic calming schemes generally result in lower vehicle speeds, and less serious consequences when accidents do occur, it is highly unlikely that such a negative situation would arise. For particular user groups such as cyclists and moped riders, however, whose speed may be increased rather than reduced in some types of scheme, such negative effects can become a possibility.

Perceived security is still in its infancy in terms of measurement and evaluative criteria, but some pointers are given. Guttinger (1980, "Met het oog op hun veiligheid; de ontwikkeling van een conflictobservatietechniek to beoordeling van de verkeersveiligheid van woongebieden voor kinderen" - see NL 030) suggests that subjective unsafety as regards children can be investigated using the following indicators:

- the extent to which child pedestrians are accompanied by adults
- the extent to which children are allowed to play outdoors
- the extent to which children are allowed to cross the street
- the parents' judgment of the safety conditions of specific street sections

According to Van der Colk (1979 "Verkeersveiligheid in stadelijk gebeiden: opinies van ouders en gedrag van kinderen") the feelings of inhabitants about their area's traffic safety are based on accidents, near misses and other occurances which frighten them. There is a clear difference between the concern of adults for their own safety, and their concern for the safety of others. Adults and children also vary greatly in their perception of risk, and in their acceptance or tolerance of unsafe conditions (NL 030).

Surveys of residents, such as those conducted as part of the Danish "3 villages" schemes evaluation, show large positive effects on feelings of security, for residents as pedestrians and cyclists in particular. In Vinderup, for example, 80% of adult road users felt safe as pedestrians and 75% as cyclists afetr implementation of the scheme, compared with 51% and 17% before respectively. Even as car drivers a 20 percentage point increase in the proportion feeling safe was indicated, rising from 56% to 76%.

The major area-wide demonstration projects have investigated not only objective measures discussed in a to h above, but also subjective evaluations based on interview surveys. Indeed, because objective measures of accident rates are so difficult on residential streets (where most traffic calming has taken place) it is argued that "subjective unsafety has taken the lead from objective unsafety" in the evaluation of traffic calming schemes (NL 023 p25).

j. Popularity with Residents

The Dutch demonstration projects in Eindhoven and Rijswijk produced some unexpected results. A majority of people in the Option 3 (Woonerf) areas described their street as being less pleasant to walk in than before. In these cases the designs including chicanes and absence of separate areas for pedestrians meant that people were often forced to walk zig-zag fashion and sometimes to cross where visibility was poor. However, in view of the general popularity of Erven in other areas, some doubt must be cast on the results. One possibility is that the rather bad start to the public consultation exercise may in itself have led residents to give a negative response (see Chapter 7). Another is simply bad design..

The wider evaluation of 2000 residents of Woonerven in The Netherlands (undertaken by the Institute of Applied Sociology in Nijmegan), found that despite concerns about the absence of

footways, 84% of respondents said that their street was more pleasant to live in than before. This accords with objective studies of 56 Woonerven which indicated a considerable reduction in injury accidents (NL 024).

The general conclusion from the two area-wide projects was that in terms of reducing the pedestrian-vehicle conflict, the Option 2 areas (ie. those with self-enforcing 30 km/h speed control measures) produced as much if not more resident satisfaction than the more elaborate Option 3 (Woonerf) areas. The additional advantage of Erven is of course their ability to create a more attractive living environment that can be used as an extension of the dwelling space, but it is clear that popularity with residents cannot be taken for granted (NL 015).

The popularity of "Section 40" schemes in Denmark is very evident in the willingness to pay of many residents in private streets, and in the continuing demand for such schemes (DK 002), as well as in the results of surveys (eg. the "3 villages" schemes, DK 007).

There appears to be a strong (though subjective) correlation between residents' satisfaction with schemes (of whatever type) and their involvement in the planning, design and implementation process. This is true particularly of measures in residential streets, and therefore has implications for local authority participation procedures. Traffic schemes have traditionally been focussed on main traffic streets where public involvement has often been minimal. Such an approach in residential streets is much more likely to create a feeling among residents that the council is trying to impose its wishes on citizens. Once this has occurred (as happened for example in the early stages in the Eindhoven and Ingolstadt schemes), it can be extremely difficult to build a constructive dialogue between residents and the local authority. Proper involvement at the earliest stage is both necessary and helpful to the success of the scheme.

k. Popularity with User Groups

User popularity of schemes for slow traffic, that is pedestrians and cyclists, is perhaps best assessed by the extent of increased activity, which is discussed above. Additionally there is inevitably considerable overlap between the pedestrian user group and residents. The general popularity of traffic calming schemes with those user groups is to be expected given that such schemes are designed to give greater priority to their needs.

Of greater interest perhaps are some of the results done on other vehicle user groups, such as car drivers and bus users. Where surveys have been conducted, driver resistance is less than might have been anticipated, even where schemes are on main roads carrying a high proportion of through traffic. For example in the Danish "3 villages" study surveys indicated 50% support for the schemes from cr drivers, with opposition concentrated as expected on those driving through the villages rather than resident in them (DK 007).

An interesting and effective evaluation was made in 9 streets in Nordrhein-Westfalen measuring the reactions of drivers to a pair of badminton players in the street. These measurements were made before and after traffic calming measures were introduced. The "before"

observations found that drivers approached the players quickly, slowing at the last second, and often reminding the players of the driver's right of way by sounding the horn. "After" studies found a big change in driver behaviour, with drivers slowing as much as 40 metres before the game, and gently giving the players time to move away. Where the traffic calming scheme changed the street scene vehicles were not only driven more slowly, but with greater preparedness to slow down further. Fewer drivers drew attention by hooting. Drivers also did not "tear away" after passing the players. In other words the drivers' became more tolerant of interruptions (D 024 p32,66). What this demonstrates is that the design of the street affects the driver's expectation from it. If a street gives the appearance of a residential environment then drivers are more tolerant and careful of pedestrian activity within it.

Schemes on bus routes have been unpopular with bus operators in Denmark and elsewhere, particularly where vertical features such as humps have been used which disproportionately slow large vehicles. In some cities this has resulted in their being banned on bus routes but in others such as Alborg (Denmark) they are accepted and are in use on a number of bus routes, and special hump designs have been developed to offset their disadvantages for larger vehicles (DK 002, DK 011). In some German cities, too, speed tables have been developed which allow buses to pass unhindered, and ramps are accepted at compulsory bus stops.

1. Visual Appearance and Ecology

Redesigning streets to calm traffic inevitably alters the appearance of the street, and great efforts have been made in The Netherlands, Germany, and other countries to introduce designs which enhance rather than detract from the street scene. Indeed, it is increasingly difficult to say whether traffic calming is an aspect of traffic engineering or of urban design. Most practitioners believe it to be a successful combination of the two. There are indications that the popularity of traffic calming is strongly dependent on the quality and appearance of the various elements. Equally important is the fact that the effectiveness of speed reduction measures is also enhanced by visual reinforcement (eg. trees or other elements which affect the character and "optical width" of the street).

Certainly there are many beautiful schemes. Materials are often of a high standard, especially in the schemes involving shopping streets, erven, and conservation areas.

The reactions against the Erf in terms of pedestrian perceptions of safety are also in some places matched by reactions against their appearance. Perhaps led by German designers, many now believe that the Dutch Erf, with its intensive use of coloured paving, frequent visual blocks, different textures and plethora of street "furniture", is often too fussy and destructive of traditional street character.

The product of this reaction is the move towards schemes with clean lines, minimum signing and minimum use of colour and texture changes. The Berlin Moabit scheme again provides an excellent example. The view down the street is not interrupted, there are no surface markings (as are found on Dutch and UK speed humps for

example) and no departure from the granite and asphalt textures that pre-existed in the area.

The change in approach, from an urban design point of view, is neatly illustrated by the early and more recent schemes implemented either side of the Neusser Strasse in Cologne. The later schemes do not include chicanes and are of a much simpler design, but high quality finish and attention to detail remains a significant characteristic. This change is apparent in The Netherlands as well. Phase I of the new housing area of Tenthof in Delft was developed as a Woonerf with a complex layout and many corners, twists and chicanes. The later Phase II, however, adopts a more simple grid layout of streets which is simpler to navigate.

Far from being an afterthought, the environmental design of traffic calming has in some cases been the sole means whereby the measures have gained political and popular support. Bavarian cities, for example, have generally been less enthusiastic, but have implemented numerous schemes in the name of city beautification (see Chapter 4).

Traffic calming measures also tend to be more readily accepted by residents if tree and other planting is provided as part of the design. This is especially true where residents are allowed to express themselves through the use and enjoyment of patches they can plant and maintain themselves. This was specifically mentioned as an important factor in Ingolstadt and Cologne.

In Berlin Moabit the "greening" of the area was an integral and major objective of the area demonstration project (D 041). The aim was to introduce more planting in order to improve appearance, micro-climate, wildlife and other aspects. Major portions of the wide Moabit streets were taken from carriageway use and unsealed to allow plant growth and planting.

Unsealed area before 1,006 sq m after 7,536 sq m (+ 649%)

Footway space before 4.4 hect after 6.2 hect (+ 19%)
(increased at the expense of the carriageway)

The increase in the unsealed areas led to a 10% quicker drying out of streets after rainfall. The number of trees in the area doubled and trees were introduced into narrow streets which formerly had no vegetation. In some wider streets the number of trees has been trebled. The performance of newly planted areas (shade, evaporation, capacity to filter dust) will take time to match the performance of streets with mature trees.

The 220 hectare Buxtehude project included the planting of 303 trees and the planting of open areas amounting to 3425 square metres.

In the village of Borgentreich, another of the German Federal area-wide projects, farmers objected to initial proposals for extra trees since they are responsible for leaf sweeping in Autumn. Nevertheless, trees have been planted in large quantities in this and other village schemes, especially on the approaches to the village and to create a "gate effect" at village entrances. Any effect of this on the "optical width" of the street and thus on vehicle speeds may increase slowly with the growth of the trees.

9. GENERAL CONCLUSIONS

Traffic calming is no longer a limited or isolated traffic engineering technique for tackling localised problems in residential streets. Over the past fifteen years it has developed into a widely-practised and well-articulated procedure for reducing the damaging effects of road traffic in built-up areas. It is often integrated in continental European practice with wider strategies for traffic and transport, and for urban renewal and regeneration.

The practice of traffic calming is aimed not just at reducing road accidents, but at creating a more "livable" environment. This involves the adoption of multiple objectives including reduced accidents, greater safety, a more attractive streetscape, more planting, more space for walking and playing, and priority for "staying" activities rather than movement. The particular set of objectives and the emphasis between objectives varies markedly from scheme to scheme, and this is reflected in the variations in scheme design.

While the aim of traffic calming is to resolve these new urban traffic priorities, many schemes go beyond this in terms of design, quality and expense, and together represent a major civic investment to achieve broader planning and development objectives. In the older parts of cities throughout Western Europe, traffic calming schemes can often be seen as part of urban regeneration projects.

Traffic calming techniques have been developed and evaluated to the point where it has become a major field of urban traffic engineering, and also of urban design. Its justification and implementation, however, it must be seen alongside other aspects of urban planning and development. For example, schemes in older areas are more often than not paid for out of housing renewal, conservation or highway maintenance budgets.

An important feature of European practice is that measures are related to and reinforced by new statutory speed limits. The range currently includes maximum speeds of "walking pace" or somewhat more realistically 15 km/h; 30 km/h zones, which now cover a substantial proportion of residential areas; 40 km/h for some local distributor roads; and of course 50 km/h which still remains the standard urban limit, and which is retained on the main traffic routes.

Measures and combinations of measures have been developed to ensure that motor vehicles are driven no faster than the legal maximum. However, slightly faster speeds are often tolerated, especially in Germany, providing that a calm style of driving is achieved. While designs to achieve slow speeds have been proven, techniques for enforcing the 50 km/h maximum on main traffic streets are not yet so well developed. The principle difficulty appears to be that changes of level on main routes are often regarded as unacceptable, though examples do exist.

The imposition of speed limits is regarded as important since it removes the possible liability of the council for damage caused if drivers travel at excessive speed through speed reduction measures. Although legal speed limits are valuable in this respect, the philosophy is that the appropriate speed should be obvious to the driver (and other road users) by virtue of the design of the street

and the measures within it. Successful self-enforcing speed control measures render the legal speed limit sign unecessary, except as a further indication to drivers of what to expect, and in the rare cases of litigation. This is the aim of traffic calming: to inculcate desired behaviour through design rather than regulation.

The various techniques employed are well known in themselves (humps, ramps, narrowings, chicanes, build-outs, planting etc.) but, as the report has attempted to show, the designs vary enormously according to the type of street, traffic composition, function, objectives and so on. Schemes are increasingly applied not just to residential areas but to main traffic streets. From local distributor roads to through roads in towns and villages, it is now possible to find examples of traffic calming in virtually every kind of street. In Germany and The Netherlands attempts are being made to collate and classify the vast amount of information on individual schemes. This will help in the design of future schemes.

Evaluation is rarely confined to an individual measure such as a hump or a chicane. It is recognised that effective traffic calming requires a combination of techniques applied to achieve objectives set for the scheme as a whole.

An obvious general question is which types of scheme are most successful. Although the answer to this is partly a matter of judgement, the authors' view is that for residential areas two approaches have proved their superiority. The first is the self-enforcing 30 km/h zone or street. This is cheap enough to be universally applied throughout urban areas and brings a high proportion of the benefits of the much more elaborate and expensive "Erven" schemes. The Erf remains appropriate in certain circumstances, especially where pedestrian volumes are high in relation to vehicle volumes, but it requires too much modification to the street to be a general solution. Moreover, it is now recognised that identifiable footways should be retained in mixer courts where possible, and this brings us to the second approach, which might be called the "Moabit Model".

The Berlin Moabit scheme is regarded as highly successful in achieving the multiple objectives of traffic calming at small cost. The design strikes a balance between the advantages of slow speeds and the advantages of simplicity of design. Speeds fall between the very slow speeds of Erven and the 30-35 km/h achieved in 30 km/h zones, while driving style is calm (minimum braking and acceleration). Problems of pedestrian feelings of insecurity in Erven are avoided by the retention of separate footways and straight carriageways. Observation of daily life in the streets of Moabit is a delight, and serves to show how high density inner city streets can become safe and pleasant places in which to live.

The 30 km/h zone has also been very successfully applied as an accident blackspot treatment on more important traffic routes outside residential areas.

Traffic calming on main roads in both urban areas and villages has also been developed, though not yet to the same degree of sophistication as for residential areas. Reliable speed reduction has not proved easy to achieve, and overcaution in terms of the severity of treatment appears to have contributed to this, but there

are plenty of schemes which demonstrate how average speeds and traffic annoyance can be dramatically reduced. The Danish "3 village" demonstration schemes provide notable examles. Even for these successful schemes, however, survey results showed 26-27% of residents still considered traffic speeds to be unacceptably high (DK 007). The majority of main road schemes appear to have been applied on routes carrying up to 20,000 vehicles per day, though the Further Strasse scheme (Nuremburg) brought about a reduction from 33,000 to 24,000 vehicles per day.

Main road schemes have usually not set out to reduce overall network capacity. The traditional approach of building roads to uniform width throughout their length has led to gross over-provision of carriageway space in sections between junctions. Most traffic calming schemes on main roads have sought to "reclaim" this carriageway space for pedestrians and cyclists and for "living" or "staying" purposes.

The great majority of traffic calming schemes, on all types of road, have proved to be both effective in terms of some if not all of their objectives and popular with users. Schemes which produce major adverse reactions are usually quickly modified; few have been withdrawn altogether.

As far as objective measures of success are concerned, schemes have led to reduced traffic volumes, reduced accidents, reduced severity of injuries, reduced noise and reduced air pollution. These benefits have been achieved without the creation of compensating problems on surrounding untreated roads. The relative success of these various objective measures varies greatly from scheme to scheme.

Much importance is now attached to the evaluation of "subjective" measures of success. These relate primarily to "livability" as perceived by residents and other road users. This involves methods of social investigation which lie beyond the traditional training and competence of traffic engineers. But there is strong evidence that the effectiveness and acceptability of traffic calming schemes is determined as much by the overall "feel" of the street or area as by the individual physical elements within it. People perceive the success of the street in much broader ways than accident statistics or speed measurements. There seems to be a powerful syntax effect. The most popular schemes are those which are effective not only in reducing speeds and other sources of nuisance, but at the same time in converting a traffic corridor to a living environment. Successful traffic calming thus requires a combination of traffic engineering and urban design and, as one Dutch engineer put it, "if a scheme is to work right it must look right".

This raises important evaluation issues affecting the weightings of environmental as opposed to road safety objectives. As environmental benefits (physical and social) markedly improve the acceptability and popularity of schemes, they can also reduce the costs associated with implementation. Even for schemes where the raison d'etre is road safety, therefore, environmental considerations are important to success and improvements should be incorporated in to the design; but at what level? Environmental improvements ought arguably to be funded out of budgets other than the meagre ones currently allocated to road safety. Inefficient co-ordination of separate environmental improvement and road safety budgets, however, leads to a waste of

resources and ugly and unpopular road safety schemes.

Other issues arise where there is potential for conflict between objectives. It seems clearly the case, for example, that a degree of conflict can exist between reduced barrier effects and increased mobility for pedestrians on the one hand, and accident or casualty reduction on the other. In schemes on major urban traffic routes which double as shopping streets these problems are at their most acute. If slower speeds are achieved, the severity of casualties and casualty rates expressed in relation to the increased pedestrian activity levels seem certain to fall. This may not necessarily imply a reduction in the total numbers of casualties, however. In such circumstances is a scheme worthwhile? The answerr is critically dependent on the weight given to the different objectives and the measurement criteria adopted.

A further set of issues surround area-wide treatment. If, as is usually the case for example with 30 km/h zones, "area" is defined simply as the group of streets which make up a scheme there are no difficulties. For the treatment of larger areas such as a large sector of a city as in, say, the UK Urban Road Safety Project schemes or the two large Dutch demonstration projects, there is a need to set a strategic policy framework for traffic calming (and for other aspects of transport and land use policy). What this entails is open to question, however, and in general the scope for conflicts of interest expands with the size of the area under consideration. If implementation has to await the preparation of agreed area schemes, therefore, delays are likely and costs may rise because of the extent of the consultations and participation required to resolve the various conflicts. It seems more than possible that incremental implementation within a loose policy framework might achieve as much or more than a grand plan design. The appropriate scheme size, however, is likely to vary in differing circumstances. With the arguments restricted to a consideration of road safety, however, the evidence as yet is far from clear as to the merits of area-wide as opposed to more incremental approaches to implementation. It is also perhaps of some significance that almost all of the larger area schemes have been funded, at least in part, by central government grants.

Two conclusions from the evaluation issues raised must be simply that their variety reflects the varied aims and roles of traffic calming, and that generalisation in these circumstances is therefore difficult. For individual schemes the crucial requirement is for clarity in the definition of the particular objectives and priorities, and the involvement of residents and other users in this definition process.

It can be concluded that satisfactory and popular solutions have been found to the problem of traffic nuisance in residential areas. The future development of traffic calming, apart from the treatment of more residential areas, is directed towards the main traffic roads. Schemes and research programmes are in progress for local distributor roads and main traffic arteries that pass through shopping, village, and other areas that have a "living" function. Considerable refinement and improvement of calming techniques for such roads are in prospect for the 1990s. The pace of this development, at least in the larger urban areas, given capacity constraints, will depend on whether or not total traffic volumes can

be contained or reduced. This is recognised in The Netherlands, for example, where a strategy of road pricing restraint for the Randstadt is currently being investigated.

Finally, traffic calming still has its critics even in Holland and Germany where its practice is firmly and widely established. The last word is left to Dr.-Ing Volker Meewes of the HUK-Verband in Cologne.

> "Representative enquiries among the population show, and have done for years, that the majority is in favour of traffic calming. This means that it will continue, even if the few who oppose it make a lot of noise and some press media create the impression that this minority is the majority."
>
> (D 046, translation A. C. Clater)

APPENDIX A

DUTCH "WOONERF" AND "ERF" REGULATIONS AND STANDARDS

(Source: Dutch Ministry of Transport Road Safety Directorate 1988)

In 1976 the "Woonerf" idea was embedded in the Netherlands Highway Code (RVV). The following five rules of conduct and 14 design and street furniture requirements were then applicable to "Woonerven".

Rules of Conduct:

1. You may walk anywhere on a road within a "woonerf" and children may play anywhere.
2. Cars must be driven at walking pace, as must mopeds and cycles.
3. Within a "woonerf", traffic from the right always has priority and this applies to mopeds and cycles as well.
4. Anyone who drives a car or rides a moped or cycle within a "woonerf" must not impede pedestrians. But pedestrians and children at play should not obstruct or unnecessarily impede cars.
5. Parking is only permitted where indicated by the letter "P".

Design and Furniture Requirements (abbreviated):

Article 1. A "Woonerf" must be primarily a residential area.

Article 2. Roads, or the road network, within a "woonerf" must carry only vehicular traffic with an origin or destination within that "woonerf"; through traffic should be excluded.

Article 3. No road within a "woonerf" should carry a flow of traffic which will affect the "woonerf" character.

Article 4. The impression that the highway is divided into a separate roadway for motor vehicles and a footpath mst be avoided.

Article 5. Verticle elements such as plant tubs must not restrict visibility.

Article 6. The entrances and exits of a "woonerf" must be so designed that they can be clearly recognised.

Article 7. The boundaries of the parts of the highway intended for parking should be clearly shown, and the spaces signed with the letter "P".

Article 8. There must be adequate residents' parking facilities within or in the immediate vicinity of a "woonerf".

Article 9. On those parts of the highway intended for use by motor vehicles, features must be introduced which will restrict the speed of all types of vehices. These features should not be more than 50 metres apart.

Article 10. The features referred to in Article 9 should not be located so as to cause vehicles to pass close to houses fronting the road.

Article 11. The features referred to in Article 9 should create no danger to traffic passing over them.

Article 12. Adequate street lighting must be provided to ensure that all features are fully visible at night.

Article 13. Areas specially designed as play areas must be clearly distinguished from those areas which can be used by vehicles. Where possible, play areas should be physically separated from those parts of the highway

used by vehicles.

Article 14. The word "Woonerf" should be displayed below the appropriate traffic sign (57c)

Seven years after the introduction of the "woonerf" legislation the Under Secretary for Traffic and Public Works thought it desirable to have the "woonerf" regulation and its application assessed. To that effect a working group was set up in 1984.

The objective of this working group was to recommend improvements to the "woonerf" legislation and an exension of its application to areas other than residential areas.

Among other things the following data were brought out from the available research:

(i) It appeared from an inquiry made by the Institute for Road Safety (SWOV) in 69 woonerf-like areas that the construction of such an area results in a striking reduction in the number of accidents, in particular the accidents involving pedestrians and moped riders.

(ii) From a number of inquiries into the quality of life it appears that the inhabitants in general are satisfied with their living surroundings after the construction of a woonerf-like area.

(iii) Following evaluations of "woonerven" the Road Safety Directorate (DVV) indicated the following problems:

- The absence of a legal regulation for "woonerf-like" precincts which were not locted in residential areas, for instance in shopping streets and in village centres.
- The legal prohibition to create "vehicle-free" parts of the road for pedestrians.
- The fact that many woonerven do not come up to the legal design and furniture requirements (in particular Articles 4, 9, 10, and to a lesser extent Articles 6, 7, 14 are not met).
- The large number of design and furniture requirements.

On the basis of these indicated problems the working group discussed how the "woonerf" regulations could be extended and which rules should be modified or left out. In this process the efforts of the Netherlands government to reduce regulations, and the agreements made with other European countries were taken into account.

This led to the following proposals, which were incorporated into Dutch traffic law on 15th July 1988:

a. Replace the word "Woonerf" by the word "Erf".
b. Use the international sign for "Woonerf"-like areas.
c. Leave the other traffic regulations unchanged.
d. Reduce the design and furniture standards from 14 to the following 6 Articles.

1. The "Erf" must be mainly designed for "living" activities. This means only traffic with an origin or destination in the area, and not too much traffic.
2. The surroundings must compel people to drive at walking pace.
3. There must be no difference between a carriageway and a footway, but a traffic-free space for pedestrians is allowed.

4. The entrances and exits of an "Erf" must be designed as access roads and must be located at a minimum distance of 20 metres from a through road.
5. Parking space should at least be indicated by a marking of the corners, as in the old regulations.
6. Facilities for parking and for loading must be created after talks with the users.

DUTCH WOONERF SIGNS
(start and end of
Woonerf area)

57c

58c

INTERNATIONAL SIGNS TO
REPLACE WOONERF SIGNS
(Start and end of areas
with "walking speed"
regulations)

nieuwe borden

APPENDIX B

REFERENCES

Reference prefix denotes country to which it applies. Numbers refer to references selected from authors' database and are not therefore sequential.

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D = Federal Republic of West Germany
DK = Denmark
EC = more than one European country
UK = United Kingdom

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