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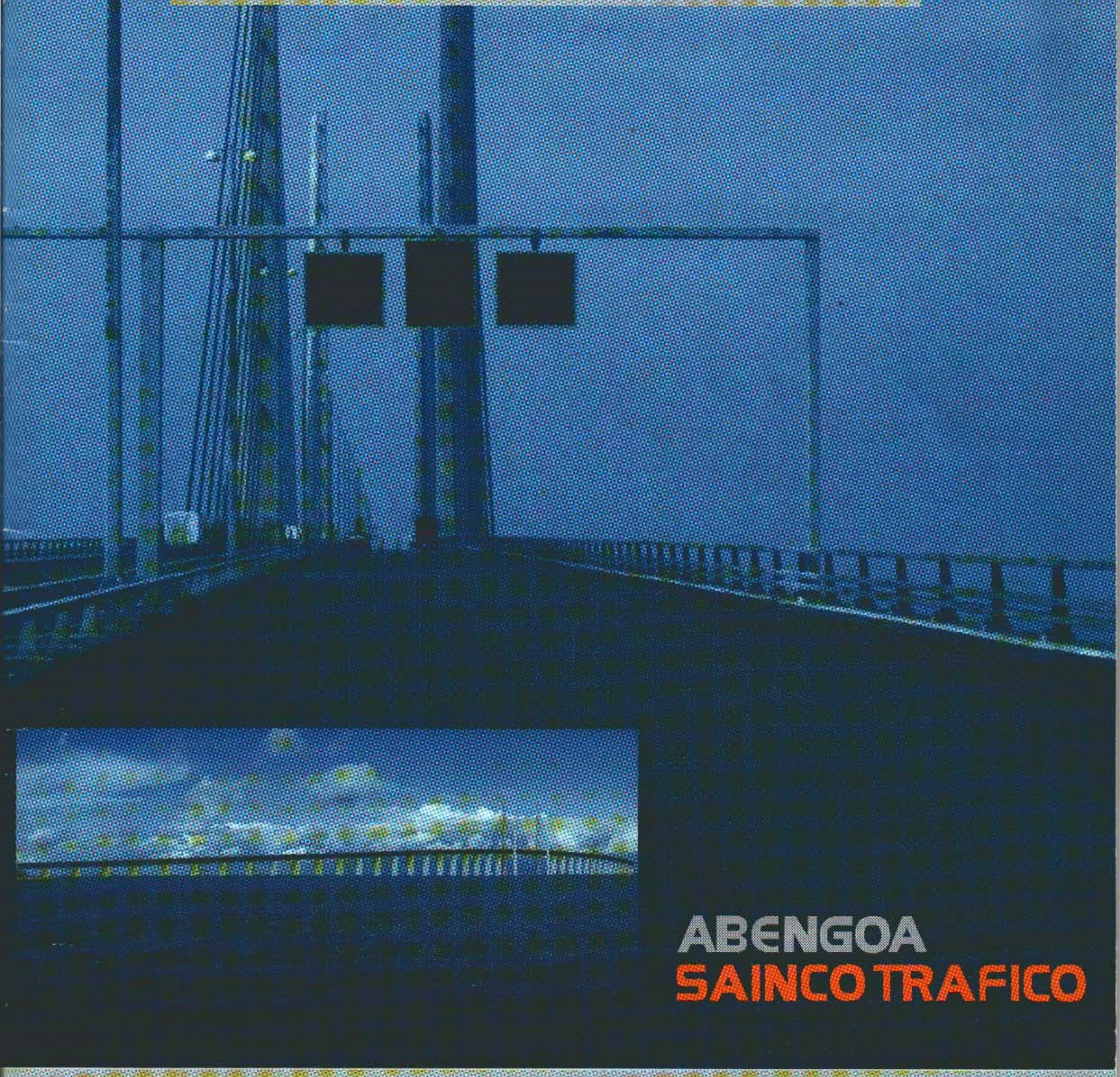


➤ Road safety in the developing world ➤ Public participation
Greenways good practice ➤ Assessing traffic calming techniques

contents

PAGE 440

PAGE 442

PAGE 455

Sainco trafico S.A.
Albarracin, 21
Spain
Telephone: +34 91 754 7200
Facsimile: +34 91 754 7202
e-mail: infoworld@saincotrafico.com
www.saincotrafico.com

Contact details for TEC can be found on Page 434

London's not working

Road User Charging is back on the agenda again in London. The technology to implement efficient charging mechanisms has been developed. The public are being converted. Government hasn't.

For all its twists and turns the British government has had a love-hate relationship towards Road Use Charging since the 1964 Smeed Report into replacing Vehicle Excise Duty with a variable mechanism. Further studies have repeatedly advertised that lack of available technology to charge motorists accurately was the primary reason for doing nothing. Such an interpretation ignores the fact that the ramp up time from public consultation through evaluation to policy decision on Road User Charging is about as long as the political cycle in the UK. So, perceived as a vote loser, the decision was to defer decision, an option that has become increasingly untenable as London grinds to a halt – demonstrated by longer peak hour congestion and a transport infrastructure that is operating ever closer to the limit of its capacity.

As one of the most dynamic and business-friendly capital cities on the world arena, London needs to maintain a competitive advantage with other international hubs such as New York, Tokyo, Hong Kong and Singapore – all investing heavily in their transport infrastructure. The flow of goods and people in London is analogous to working capital in a business. Dotcoms and the Millennium Dome presently excluded, slowing down the flow of working capital results in an organisation that lacks the capability to trade. Through inaction London faces this future.

On morning radio, on the day that Ken Livingstone was installed as the new Mayor of London, came policy statements that Road Use Charging was back on the agenda – a reason for a few motorists to choke on their breakfast and for others to celebrate that something would actually be done in London to actively manage traffic demand through pricing mechanisms.

Implementations of all successful transport policies in London have recognised and reflected local needs so it is no less important that a London scheme will have to fit the context of an already complex, multi-layered, multi-modal transport environment. Charging, as a demand management instrument, has little value when applied in isolation but only as part of a balanced and integrated transport policy.

Off-peak travel is cheaper for many modes of transport but roads remain a free-for-all. Inducing modal shift requires investment to develop viable alternatives so maybe the government can explain why the lion's share of the £3.2 billion transport settlement for London has been deferred despite an urgent need to improve London's bus service? Continued underinvestment in the tube means that motorists will not yet have the incentive they need to leave their cars at home. An isolated threat of Charging cannot be classified as an incentive to take the bus. Perceived savings in travel time on less congested roads – possibly.

In real terms the cost of motoring is cheaper now than a generation ago and this decline is expected to continue, according to the government's 10-year plan, published in July. The termination of the fuel duty escalator leaves a £1 billion hole in revenues. So, whilst the recent ROCOL report concludes that public acceptability would be increased through hypothecation of Road Use Charges, the pressure to refill the public coffers from alternative sources has never been greater. Public attitudes towards Charging have been largely untested although, through consultation and announced discounts for business and residents, Livingstone is actively developing public acceptance, apparently ahead of demonstrated government support. Like paying for other modes of transport paying a fee to enter London may become a fact of life – the cost of getting London moving again.

Andrew Pickford
Transport Technology Consultants
andrew.pickford@dial.pipex.com

Do you feel strongly about a current issue? If you would like to contribute to the debate, email Carol Debell at: c.debell@hemming-group.co.uk

Traffic calming – a review of techniques and their effectiveness

Umberto Petruccelli, University of the Basilicata, Potenza, Italy

This paper proposes a re-examination of research and projects carried out in different countries and elaborates into various techniques for calming traffic and suggests some guidelines about the choice of the most suitable techniques to achieve particular aims. It deals with the effectiveness and feasibility of certain devices, looking also at their impact on emergency service vehicles, and it discusses suitable technical evaluation methods to analyse the effectiveness of projects that take into consideration an entire urban neighbourhood.

THEORETICAL AND APPLICATION ISSUES

The international term 'traffic calming' refers to the reduction of negative impacts produced by motorised vehicle traffic on residential areas by improving living conditions for non-motorised road users.

In certain infrastructure, environment and traffic conditions the driver maintains a running speed that limits hazard risks and generalised costs within values acceptable to him. Stark [1] demonstrates that the driver who slows down because he perceives an increase in accident risk at any dangerous point of a road, does not reproduce the original accident risk.

The importance of speed in accidents is also linked, in inverse proportion, to traffic volumes and accident risks. The number and the gravity of accidents decrease with increasing vehicle flow consequent to higher vehicle density which in turn produces lower speeds. In accidents involving pedestrians, it is interesting to note that the inverse proportion existing between traffic volumes and accidents is more stressed in urban roads than in extraurban, proof that reduced speed is advantageous for security in the city [2].

Notwithstanding lower speeds permitted on urban roads compared to extraurban, different hazard factors brought about by the contemporary presence of different road users heighten the level of accidents. For example, in the EU member state's, from 25 to 75% of accidents that produce injuries occur in residential areas [3].

Table 1: Results of traffic calming measures obtainable with a 50 KPH speed limit [7].

	Upper limit of maximum speed (KPH)		Upper limit of 85th percentile speed (KPH)		Range of average (KPH) speed	
	before	after	before	after	before	after
Vertical shifts in the carriageway (humps)	100	40	75	30	45-65	18-25
Horizontal shifts in the carriageway (chicanes)	100	65	75	45	45-65	22-35
Road narrowing to a single lane	100	65	75	45	45-65	22-35
Roundabouts	100	65	75	45	45-65	22-35
Road narrowing to a reduced width	100	95	75	70	45-65	40-55
Central islands	100	95	75	70	45-65	40-55

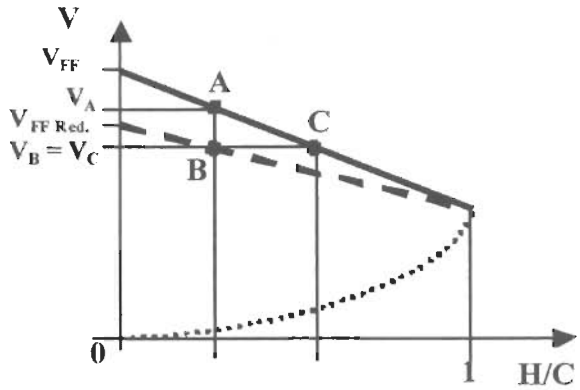
On the other hand, it is well documented that the enforcement of speed limits lower than those values induced by the road characteristics is ineffective, unless there is costly and continuous policing. 'Roads and traffic in urban areas' [4] recommends avoiding speed limits lower than those exceeded by 85% of the vehicles that pass by. If the recorded speed exceeds the acceptable limits with reference to the function of the infrastructure, lower speed limits, alone, are not enough to reduce speed. Structural interventions are needed to oblige the driver to respect the law.

A specific characteristic of traffic calming measures is to impose a self-enforcing action on drivers obliging them to maintain appropriate speed and behaviour, relieving the community from control costs.

The reduction of the maximum speed on a road usually implies a greater running time of the link, and therefore the associated generalised cost. A considerable increase in running time results in the detour of a significant volume of the cut-through traffic onto external alternate routes with minor generalised costs, therefore reducing traffic volume on the road where the vehicle speed reduction device was applied.

Generally, the following objectives can be pursued through traffic calming devices:

- Increase in real safety (reduction of accident frequency and seriousness) as well as in perceived safety of non motorised road users;
- Reduction of cut through traffic volumes;
- Reduction of acoustic and air pollution through lower traffic volumes as well as the containment of maximum speeds and accelerations;
- Improvement of the quality of life for those people who live along the road (mainly residents, shop keepers and service workers);
- Benefits for pedestrians, cyclists and transit services, and at the same time strengthening the appeal and commercial potential of the road as well as re-balancing modal split towards public transport and non motorised means;
- Reduction in the need for police control both of traffic rules (in particular of vehicle speed limits), and public



order and security which are more easily dealt with in roads occupied by pedestrians and slow vehicle traffic;
- The possibility of placing street furniture and green gardens.

Traffic calming techniques essentially influence three traffic factors: peak vehicle speed; traffic volumes; safety of non-motorised users. Increased safety of non motorised users, not only can be obtained by reducing speed limits and traffic flow, but also by reserving suitable spaces, such as cycle lanes and sidewalks, as well as clearly pointing out crosswalks to drivers and pedestrians.

In principal, speed can be reduced in two ways. Directly reducing free flow speed in the considered road section (thus also the speed consequent on a given traffic flow) by using some types of slowing devices that alter the road pavement uniformity (humps and acoustic and optic slowing devices) or the road path (roadway horizontal deflections), or alter the free view break implying a modification to the flow curve by reducing the intercept value on the speed axis.

The flow curve in Figure 1 is schematically represented by the solid line, changing to a dotted line, consequently the operative conditions represented by a generic point A are modified into those represented by point B on the new flow curve.

The alternative approach is to reduce capacity along the road link (usually greater than that available at the ends of the same link in correspondence to the intersections) by reducing the number of lanes. The flow curve rated to capacity remains substantially the same, but the increase of the flow-capacity ratio (H/C), due to the reduction of capacity (C), moves the operative conditions from point A to point C in Figure 1, characterised by lower speed. The effectiveness of these measures is clearly proportional to traffic flow and becomes insignificant in free flow operation.

Even though traffic volume reduction is the result of decreasing maximum speeds, this reduction is more sensitive to measures that reduce road network link levels (preventing turns) and are designed to cut the road off from routes which attract high cut-through traffic flows.

All devices that produce the slowing down of traffic streams can cause, as mentioned above, the diversion of some cut-through traffic onto other routes. Therefore, it is important to ensure that there is no incompatibility with roadway capacity and the environment of the alternate route. Compatibility of the new roadway capacity with the demand flow should be ensured before carrying out any measure that considerably reduces the capacity of a road network link. Furthermore it is particularly important to verify capacities and levels of service of those intersections which are affected by the traffic calming measures; these measures can vary the functional parameters of intersections.

DEVICES – USE AND EFFECTIVENESS

No slowing device is able to completely prevent motorists from exceeding the speed limit. The effectiveness of these devices can be evaluated utilising the following three parameters in combination, since alone they are not capable of measuring whether safety standards are reached:
- vehicle average speed;
- 85^{TH} percentile speed;
- maximum speed.

Figure 1: Representative situations of road flow without slowing devices (point A) and with them (points B and C)

Studies in different countries [5] have demonstrated that hump effectiveness is calculable by reducing the 85^{TH} percentile speed by 25 to 40% related to device form and size, as well as to specific road conditions and local driving styles.

In America, experience has revealed that, before installing any hump, the 85^{TH} percentile speed of the vehicles without the slowing device needs to be evaluated: the application of humps is not advised when this parameter exceeds by 20 - 25 KPH the speed of 30 -35 KPH for narrow humps of 4 -4.5 m and 40 -45 KPH for wider ones [5]; otherwise, the installation of more than one would bring about sinusoidal speed curve with periodic acceleration and slowing down producing acoustic and air pollution.

One of the main advantages of humps is represented by the fact that they do not have any influence on intersections, and do not involve the removal of parking space along the roadways. Impact on bicycles is negligible since their running speed is very modest. The Dutch research study [6] has established that speed humps with a sinusoidal profile are the most favourable to cyclists.

Figure 3: Balliol Street in Toronto after the start of the traffic calming pilot project [8] *

Horizontal deflections are particularly effective in maintaining a constant vehicle speed and avoiding vehicle various motion phases that come about with slowing devices and consequently, pollution. Furthermore, they have a minor impact on transit service compared to humps and improve landscape. On the other hand the horizontal deflections do require parking space to be removed and they generally cost more than humps.

Table 1 reports on values obtainable for each traffic calming measure before and after its installation at a 50 KPH speed limit [7]. It is clearly shown that devices producing vertical shifts in the carriageway (humps and tables) are generally the most effective, particularly in reducing speed from 100 to 40 KPH. Horizontal shifts in the carriageway (chicanes), road narrowing to a single lane and roundabouts give

Table 2: Results of the Balliol Street traffic-calming pilot project in Toronto [8]

	Traffic volume (vehicles per day)	Percentage of vehicles exceeding the speeed of			Average speed (KPH)	85 th percentile speed (KPH)
		30 KPH	40 KPH	50 KPH		
Before	1.300	86	54	13	40	47
After	1.200	45	9	2	30	36

Vehicle	Overall Length (m)	Wheelbase (m)	Weight (t)	Power (kw)	Power/Weight Ratio	0 to 60 KPH Acceleration Time (s)
1 (Engine 18)	9,1	4,7	13,01	136	10,5	19
2 (Rescue 41)	6,4	3,5	-	136	-	12
3 (Squad 1)	8,2	4,4	8,64	202	23,4	17
4 (Truck 1)	14,6	6,4	19,78	331	16,7	20
5 (Truck 4)	17,4	4,0	20,14	331	16,4	22
6 (Truck 41)	11,4	5,1	15,71	258	16,4	27

Table 3: Fire vehicle specifications [11]

an intermediate effectiveness.

The reduction in speed produced by integrating different devices is clear from the experience accumulated in many countries. A 30% reduction in speed average was registered along the road section in Portland, Oregan, where traffic calming measures included both road humps and circles [5].

Table 2 shows the average speed values obtained in a specific traffic calming pilot project [*] in Toronto Canada in October 1994. Results were encouraging for both speeds and traffic volumes, even though the latter strictly depends on alternate routes offered by the road network. There also seems to be a positive impact on landscape (Figure 3). Another important note is the great satisfaction of the street residents. A survey conducted after 6 months from the start of the pilot project revealed that 60% of the residents were favourable, 14% were indifferent and only 26% were negative [8].

The effectiveness of traffic calming in relation to factors other than speed reduction can only be calculated with regard to projects that involve the remake of a definite urban area. With this type of project it is possible to measure, before and after installation, the level of accidents, gas emissions, noise level and other parameters that are usually insignificant unless referred to a specific point of a road network where single measures are possible.

Table 4: Typical impacts of 6.70 m speed humps, 4.25 m speed humps and traffic circles on fire vehicles [11]

Vehicle (tab 5)	Slowing Devices: 6,70 m Speed Hump				4,25 m Speed Humps				Traffic Circle			
	A (KPH)	B (KPH)	C (s)	D (m)	A (KPH)	B (KPH)	C (s)	D (m)	A (KPH)	B (KPH)	C (s)	D (m)
1	32	38	0,8	41	20	38	2,3	72	21	38	2,8	80
1	32	46	1,7	98	20	46	3,7	122	21	46	4,3	149
1	32	53	3,0	154	20	53	5,2	177	21	53	6,1	205
1	32	61	5,0	229	20	61	7,7	248	21	61	8,5	248
2	52	38	0,0	0	26	38	1,0	45	24	38	1,3	52
2	52	46	0,0	0	26	46	1,7	82	24	46	2,3	92
2	52	53	0,3	36	26	53	2,9	147	24	53	3,1	142
2	52	61	1,5	80	26	61	4,9	191	24	61	5,1	187
3	37	38	0,4	24	18	38	2,7	74	26	38	1,2	52
3	37	46	1,0	65	18	46	4,1	133	26	46	2,3	99
3	37	53	2,1	132	18	53	5,9	186	26	53	3,7	153
3	37	61	3,4	216	18	61	8,3	260	26	61	5,3	237
4	34	38	0,6	42	17	38	3,4	82	15	38	4,8	97
4	34	46	1,4	98	17	46	4,9	139	15	46	6,4	160
4	34	53	3,0	183	17	53	6,6	197	15	53	8,4	228
4	34	61	4,9	270	17	61	9,4	284	15	61	10,7	315
5	24	38	1,8	77	18	38	3,4	96	17	38	4,3	98
5	24	46	3,4	137	18	46	4,9	148	17	46	6,2	167
5	24	53	5,9	205	18	53	6,8	223	17	53	8,1	244
5	24	61	7,7	317	18	61	9,1	321	17	61	10,3	347
6	21	38	3,0	96	18	38	3,5	100	17	38	3,9	103
6	21	46	4,8	190	18	46	4,7	144	17	46	5,2	169
6	21	53	7,2	278	18	53	6,6	232	17	53	7,3	258
6	21	61	9,2	403	18	61	8,6	351	17	61	9,2	383

Notes: A = Lowest speed: the lowest speed a vehicle travels when crossing the slowing device
B = Desiderable speed: the speed a driver might wish to travel if there were no slowing devices (due to the road specifications)
C = Travel time delay: the additional time requered to travel to a destination due to a slowing device
D = Impact distance: the length of street where a given vehicle cannot be driven at a given desiderable speed because of the slowing device's influence

The reduction in accident levels and their gravity is a direct consequence of the slowing down of traffic streams, but is also linked to specific situations. Here are a few examples:

- A specific project in Berlin produced a 41% reduction in accidents and pedestrian fatalities, decreasing deaths and serious injuries by 57% and 45%, respectively [7];
- A survey conducted on 600 traffic calming schemes in Denmark showed a 43% reduction on average in accidents [7];
- The Transport Research Laboratory (TRL) of Great Britain conducted a survey on 34 traffic calming projects in Great Britain and reported a 70% reduction on average in accidents [9].

Noise and gas emissions are reduced with contained and constant speeds along a route. In particular, a reduction of the average speed from 50 to 30 KPH corresponds to a 4 – 5 dBA decrease in noise, unless rumble strips are used to reduce speed. Speed reductions to lower than 10 KPH do not sensibly affect this type of pollution [7].

Driving styles have a notable influence on gas emissions. A traffic-calming project conducted in Buxtehude in Germany reported a reduction in carbon dioxide, hydro carbon and nitrogen oxide levels of 20%, 10% and 33%, respectively [7].

With reference to the feasibility of the slowing devices, the problem of service response delay caused to emergency services is quite consistent. Studies conducted on humps of 3.70 m wide and 10.2 cm high in Thousand Oaks (California) in 1980, on 3.70 m wide and 7.6 cm high humps in Portland (Oregon) in 1991 and in Austin (Texas) in 1996 have established that the maximum speed at which fire vehicles can pass them, taking into account the equipment and personnel on board, is 24 KPH in the Oaks study and 32 KPH in the other two cases [10].

An experimental study conducted in Portland [11] compared response times of fire vehicles recorded along routes with and without slowing devices. The analysis was carried out modifying four variables that induced the slowing down of the vehicle: the driver – since this expresses different driving styles the resultant change was insignficant; the type of fire vehicle (Table 3); the desired vehicle speed, that is the speed of the vehicle would run at without slowing down devices and with the pre-existing road characteristics; types of traffic calming devices.

Thirty-six drivers were employed driving 6 different types of fire vehicles on three groups of streets each composed of two roads. These roads were equipped with either 4.25 m humps or 6.70 m humps or traffic circles. The average response delay induced by each device referring to different parameter combinations is illustrated in Table 4. This table also shows the impact distance, that is the distance at which the effect of the slowing device is produced. The maximum response delay of fire vehicles is produced by traffic circles followed by 4.25 m humps and lastly 6.70 m ones.

The delay caused by more than one slowing device, even different ones, located on the same route, can be calculated by superimposing the effects provided that the distance of the two reciprocal devices is at least equal to the impact distance.

Table 5 summarises the feasibility of each slowing device discussed, indicating the most suitable to reach the aim of a given element of the urban road network. These indications are general in nature and therefore only valid for a preliminary definition of the intervention.

EFFECTIVENESS OF PROJECTS

The integration of different traffic calming devices, realised through an organic project, multiplies the effectiveness of each one. The use of individual devices one by one does not contribute to more complex aims such as pollution reduction or urban environment improvement.

Traffic calming projects need to be evaluated to justify both their costs and the inconvenience experienced by some road users and since these measures are controversial, their validity has to be demonstrated by accurately estimating both the advantages and disadvantages to road users and to the community that has to finance its execution.

Evaluating the effectiveness of a measure aimed at a single objective such as speed reduction along a road section is fairly easy. More complex projects such as traffic calming ones are more difficult to evaluate, since they involve more than one objective, each of which will impact differently on the area. Even though the quality of many environmental components can be easily expressed by physical parameters, nevertheless the concept of 'liveableness' involves different subjective judgements that cannot be evaluated by universal parameters.

Even if one were able to estimate the effects produced by the projects using universal parameters, the units of measurement would not allow the expression of a comprehensive opinion on the effectiveness of the project without using specific evaluation methods.

Technical evaluation methods that compare the economic advantages and disadvantages of traffic calming projects to measure their validity aare not totally appropriate, since the majority of the achievable benefits cannot be expressed by universal values.

However, cost/benefit evaluation techniques can be used on the condition that they are able to express in money terms some subjective effects produced by such projects. Some researchers [12] suggest that this difficulty can be overcome by calculating the benefits pedestrians receive by a route amenity gain resulting from the elimination of goods vehicles from town centers or the pedestrianisation of roads.This assumes that this objective willingness to pay is measurable through the individual value time resulting from the improvement or worsening of environment quality. Naturally, the time value will be different for diverse trip purposes divided among work, shopping, tourism and access to car parks or public transport terminals.

The same researchers suggest the First Year Return Rate (FYRR) as a convenient gauge, expressed by:

FYRR = Net benefit/Capital cost
Where net benefit = 1st year benefits – 1st year costs.

This gauge leaves out management benefits and costs for the year following the first one and privileges investment capable of producing quick rapid benefits.

Delicate cost/benefit analysis points applied to these projects are:

- Evaluating pedestrian route amenities;
- Evaluating costs for goods vehicle operators;
- Evaluating the willingness to pay for parking;
- The development of parking demand models that take into account parking charging, space availability and trip purposes;
- The development of a deterrent model for parking enforcement.

PURPOSE	Measure's location – Streets: Urban local streets and parks (*Without transit service*)	Streets: Others urban streets (*With transit service and intense urbanization*)	Streets: Suburban streets (*With transit service and sparse urbanization*)	Intersections: Urban intersections	Intersections: Suburban intersections
Speed Reduction	Bumps Humps	6.70 Humps (or Cushions) Chicanes	Circle Rubber strips	Roundabouts Tables	Roundabouts
Traffic Volume Reduction	Dead ends Choke points Humps	Median barriers Exclusion lanes Curb extensions		Diagonal diverters Semi-diverters	
Pedestrian Safety Improvement	Raised crosswalks Curb extension	Curb extensions Raised crosswalks Pedestrian refuges	Raised crosswalks Curb extensions Pedestrian refuges	Tables Raised crosswalks Pedestrian refuges Entrance treatments	Pedestrian refuges Curb extensions

Table 5: Measures suitable for a given purpose in a particular location

Multi-objective or multi-criteria techniques [13], [12] are decisively more appropriate in evaluating the effectiveness of traffic calming projects as well as traffic management and parking schemes, because they do not necessarily use monetary units to measure the effects produced by the project. As is well understood, the multi-criteria analysis makes it possible to evaluate the effectiveness of alternative projects compared to the objectives, or through prefixed criteria in order to identify the best project.

The multi-criteria evaluation technique, which in itself is more complicated than that of cost versus benefit, requires an accurate choice of evaluation criteria and requires some reference limit of the respective measurement parameters.

The main steps of the method, whose knowledge is taken for granted (refer to text on it), are as follows:

- Project selection; selection of objectives and criteria for project evaluation;
- Formulation of the project - objective (or criteria) matrix;
- Matrix normalisation through the introduction of utility functions and eventually choosing the referring medium indices system [14];
- Introduction of a weight system;
- Researching for the best project using a single utility value associated to each project;
- Possible research of the result stability through possible changes to the weight system [14].

Groups	Subgroups	Subgroups subdivisions
Users of Vehicles and Operators	Traffic	Through / Terminating
		Cars / Goods /
		Legal / Offending
		Link / Network
		All Traffic
	Special Groups	Emergency Services
		Mobility Handicapped
Non Users of vehicles	Cyclists	
	Pedestrians	Shopping
		Access to / from transport
		Tourists
	Local residents/business	
Operators of System	Local Authority	Traffic operations
		Parking operations
		Enforcement
	Police	
	Central Government	

Table 6: Impact groups

Table 7: Impact fields

Fields	Subfields
Quality Impact	Environment / Natural Built
	Accidents
	Time
Resource Impact	Vehicle Operations
	Design & Implementation
	Scheme Operations
	Maintenance
Financial Impact	Economic Activity
	Fines
	Operating Costs
	Fiscal Revenue

Suitable criteria and objectives can be identified in order to evaluate all types of traffic or parking patterns, such as traffic management schemes, parking schemes, parking restrictions, policies to reduce driving offices, no entrance and parking restrictions to goods vehicles, pedestrianisation measures. The impact of any project has to be estimated by taking into consideration the former criteria. It is absolutely necessary that objectives (or criteria) vectors contain not only monetary evaluation parameters, or referable to these, but also those aspects modified by the project especially if they present an important subjective component.

The most suitable criteria to carry out an analysis are [13]:

- Level of accidents;
- Type and distribution of accidents;
- Level of vehicle to vehicle conflicts;
- Perceived safety;
- Vehicle speeds;
- Traffic volumes;
- Traffic emissions;
- Traffic noise;
- Popularity with residents and user groups;
- Level of street activity;
- Amount and type of citizen participation;
- Extent to which problems have been transferred elsewhere;
- Demand for local properties;
- Visual appearance and ecology.

The most delicate aspect always consists of measuring the fulfilment of the qualitative objectives such as perceived safety, visual appearance and ecology which represent the main evaluation criteria of a traffic calming project. This estimation is more reliable if expressed in utility terms, that is through a dimensionless variable, instead of monetary units as in a cost/benefit analysis.

An impact evaluation method that looks at these aspects from the residents' perspective is based upon using two types of questionnaires [13]. The first one asks questions such as 'in your opinion how has the traffic calming project in your area affected each one of the following issues'. A middle value represents indifference and higher and lower values represent positive and negative opinions respectively. The other questionnaire apportions no, low, medium, high and very high priorities to each aspect and provides a weight scale to associate to the different analysis criteria. The impossibility of applying this procedure to non-realised projects is its first obvious handicap, since the results of the questionnaires are unreliable because they ask about hypothetical situations. Other criticisms are based on the difficulty that interviewees have in identifying the cause /effect relationship between the project and the changes in the analysis criteria, as well as only taking into consideration the opinions of the residents who are not the only people affected by a project.

Brown [12] proposes to estimate quality, resource and financial impact fields in reference to three impact groups: vehicle users and operators, non-users of vehicles and system operators. Tables 6 and 7 report on the subfields and subgroups that have been identified in each impact fields and impact groups. The evaluation framework is made up of impact groups and subgroups indicated on the lines, and impact fields and subfields in the columns. This type of framework makes it possible to identify the different impacts that the project has towards each group of persons interested by it.

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* The Balliol street traffic calming project consisted of five raised intersections with curb extensions and 8.5 m to 5.0 m carriageway narrowings, the reduction of speed limit from 40 to 30 km/h, the elimination of the stop sign in correspondence to three 'T' intersections, and carrying out some segments of different coloured pavements and more green space along a 750 m road section.

The author

Dipartimento di Architettura, Pianificazione e Infrastrutture di Trasporto (DAPIT), Universitá della Basilicata, Macchia Romana, 85100 Potenza, Italy
Tel. +39 0971 205119, fax: +39 0971 205185
email: pu266ing@unibas.it or petrumb@tiscalinet.it