SBS and SOBETMA: ENVIRONMENTAL TRAFFIC MANAGEMENT AND THE SOUTH BIRMINGHAM STUDY

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1 INTRODUCTION

Set-backs to traditional approaches to urban road-building in South Birmingham have made it the crucible of city-wide transport policy:

- Birmingham Integrated Transport Study (BITS) was commissioned in 1988 to provide the City Council a more broadly-based and defensible transport strategy following rejection of proposals for a link to the M40 through the area.

- In 1991 massive public opposition to an alternative plan including widening several roads in the area caused the City' Council to establish the South Birmingham Study (SBS). The object was to reconcile local persepctives and strategic needs through a highly participative style of plan-making, and by integrating transport, land-use and urban renewal planning within the transportation framework of BITS. _

Within SBS, SOBETMA (South Birmingham environmental Traffic Management Study) considered strategies for environmental traffic management, taking account of bus operation and network capacity. SOBETMA concluded that traffic calming is desirable, not only for residential cells but also on distributors and environmentally sensitive parts of the Strategic Highway Network (SHN), where most accidents occur.

This paper very briefly summarises experience with relevant techniques from the “near continent" which have been included in the recommendations. It identifies the classification of the road network in terms of function and of use, notes the incidence of accidents and scope for their reduction on different parts of the network, and considers the need for and possibility of providing for full traffic capacity or substantial traffic restraint. It concludes with a recommended compromise treatment, and indicates the tools for achieving this.

In the course of the discussion, comments are made on some of the broader implications of SOBETMA conclusions for SBS (and Birmingham as a whole).

2 THE WIND OF CHANGE

2.1 Birmingham Integrated Transport Study (BITS) Background BITS was a strategic study, concerned with broad transport policy to support the city's major economic and environmental goals over 20 years (to 2010). The main conclusions relevant to this paper are:

- Road-building could not meet the transport demands of a successful city centre in the context of forecast increase of 32% in car-ownership: rail development (heavy and light) would be needed to meet this (mainly radial) demand;

- Road-building would be needed to cater for increasing orbital movements (especially around the city-centre): but in general radial routes (such as those through South Birmingham) should be designed to remove traffic from environmentally sensitive areas and to meet the access needs of their own corridor, not to facilitate 'end-to-end' movements; and

- Traffic management was seen as having an important supporting role: providing bus priorities, increasing network capacity (by perhaps S%) and providing environmental relief.

BITS did not make specific proposals - highway or public transport - for South Birmingham: this was not its function. However the strategic model work used to test the policies outlined above did incorporate substantial levels of road-building. When these were further detailed they proved no more acceptable publicly or politically than the earlier M40 link.

This raised a key issue for the subsequent work: since the levels of traffic modelled in BITS were based upon estimates of the city's population and employment capacity, it follows that lower future levels road capacity than the BITS tests requires either:

a) Acceptance of lower population and/or employment capacity

b) A distribution of activities making less intensive demands on transport (because of the scale of shift in locational choice perhaps only achievable in the longer term)

c) Acceptance of a lower level of service to road users (eg lower speeds and/or more congestion).

The first of these would constitute an unacceptable constraint on the city's economic aspirations, so SBS has concentrated on the latter two.

It is here that the results of SOBETMA have great strategic importance, because they facilitate reconciliation of local and strategic needs.

2.2 South Birmingham Study

The genesis of SBS was described in the introduction. The terms of reference required transport solutions to be sought in the context of a broadly-based planning study which would deal with economic and environmental regeneration: major road building was debarred.

The study area is a sector of Birmingham City bounded at the inside by the central area ring road and at the outside by the Solihull boundary. In character this includes both deprived inner areas and extensive suburban areas - and of course traffic is generated from outside this area as well. The scale is substantial: a population of around 250,000.

2.3 SOBETMA (SOuth Birmingham Environmental Traffic MAnaqement Study)

The function of SOBETMA was to explore the part that Environmental Traffic Management could play in meeting the broader aims of SBS. In this respect it stood alongside and into parallel concerns with physical planning and land-use, urban regeneration, bus, rail and light rail developments, cycling and park and ride.

The consultancy study identified the broad implications in terms of traffic capacity, providing an input to the City Council's consideration of the related policy areas of:

- Provision for other transport modes; and
- sustainable levels of activity in central/inner areas.

Specific issues included in the City Council's brief were:

- Approaches to calming traffic flow on short sections of the strategic highway network (SHN) in environmentally sensitive areas;
- The implications for bus operations with particular regard to bus penetration off the SHN and bus priorities on it;
- The implications of the current road hierarchy within the area at a general level and any recommendations for change; and
- Comment on implementation.

2.4 Bus Priority Recommendations

MVA had recently carried out a study into bus priorities on two radial routes. These two studies identified a large number of bus priority proposals, the majority of which are now in the City Council's candidate list for implementation. There were some gaps for a variety of reasons. Some of these reasons would apply more forcibly to any on-street light rail system which was introduced, which could not have gaps.

2.5 Eventual Scope of Study

Whilst SOBETMA considered only the area of the South Birmingham Study, this area is a broadly representative cross-section of the city, and to this extent the findings are relevant where similar characteristics and issues are found elsewhere.

3 THE KEY ISSUES

3.1 Different Road Categories

Formally the road categories to be considered are motorways, trunk roads, other primary routes, distributor roads and other roads. There are no motorways or trunk roads within the study area. The primary route network has been marginally extended to form a Strategic Highway Network (SHN). There is then a defined set of district distributor roads and local distributor roads.

Transport strategies now recognise that the desired function of a road may conflict with the method of its use. In particular, motor traffic may not have full priority when there is a need to provide for the so-called "soft modes" (pedestrians and cyclists). There is therefore a need to distinguish roads with "living priority" from those with "traffic priority". A middle category of "mixed priority", as shown in Figure 3.1, is particularly important for this paper, and represents an innovative departure from standard road classification practice.

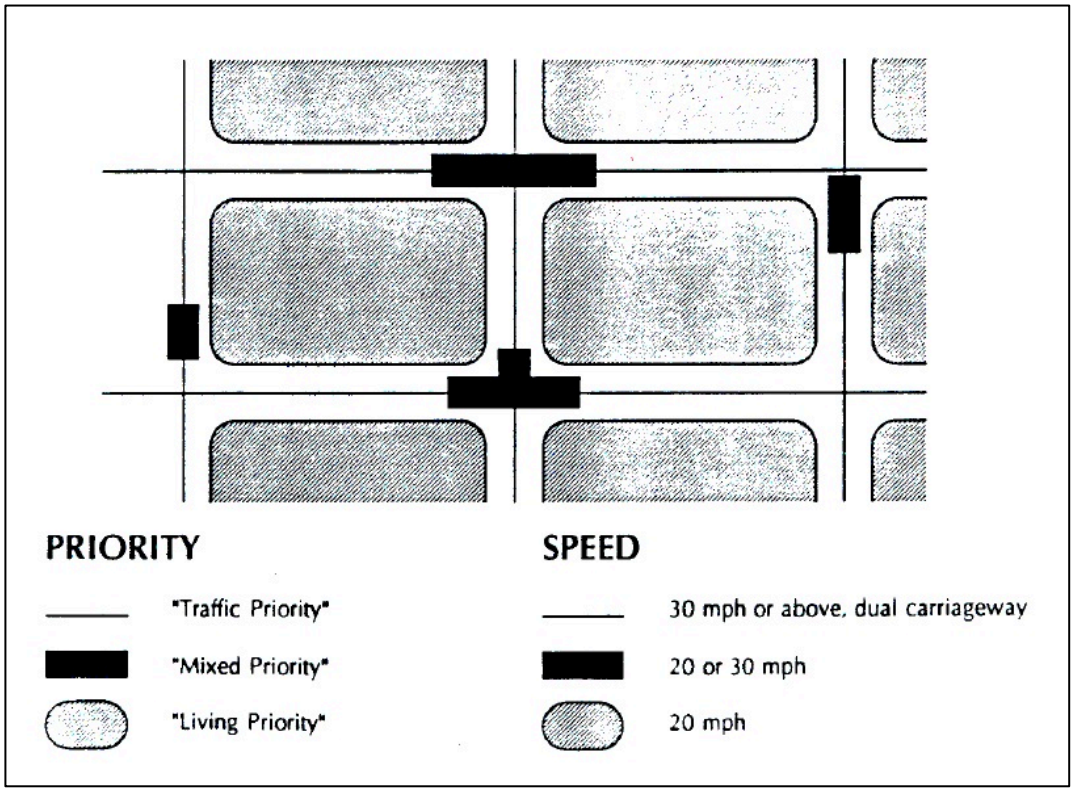


Figure 3.1 Schematic Re-classification of Roads / Areas
(Note, local streets not shown)

SOBETMA combined the functional and usage road classifications into four categories:

- Category 1 SHN with traffic priority

  This is intended to include those roads which are purpose-built for traffic considerations, or have been significantly modified, so as to largely avoid the problems of interaction with other users such as shopping or residential areas.

- Category 2 SHN with mixed priority

  This comprises the remaining sections of the SHN. These roads are generally of relatively low traffic carrying capacity and pass through environmentally sensitive residential areas or through significant shopping centres. The study area has several of these shopping centres that lie astride SHN roads, and only one is subject to a (controversial) bypass proposal.

- Category 3 Distributors with mixed priority

  There is a good network of distributor roads of various categories. In the inner part of the area, these roads may exhibit the sensitivity of parts of the SHN, passing through shopping centres. Elsewhere, long stretches of them are built to extremely generous proportions with very wide verges through residential areas. At the present time traffic travels on them very freely, and there is the possibility that this traffic could increase significantly and provide a major alternative to use of the SHN.

- Category 4 Cells with living priority

  The remaining roads between the distributor roads comprise cells in which there is relatively little through traffic. At the present time there are available through routes through these cells but there is little incentive for them to be used. Towards the outside of the City the cells have been laid out in Radburn-style thus discouraging through traffic anyhow.

3.2 Performance of the Network

Traffic capacity is determined by the performance of junctions. On the SHN, junctions have been designed to provide good capacity subject to the constraints. Within town centres these constraints are usually those related to road space. On the distributor network performance is quite variable.

Accident occurrence and hence the scope for accident savings varies between different categories of road within the network. Although accidents to younger child pedestrians cause concern, accident occurrence is relatively low within the cells. This therefore restricts the possibility of achieving large absolute accident reductions by traffic calming methods. This difficulty is

emphasised by the predictions of traffic calming in cells produced in a recent traffic calming study (for Sparkhill) shown in Table 3.1. Accident occurrence rises as one looks at roads carrying greater levels of traffic such as the distributors. The highest level of accident occurrence is on mixed priority parts of the SHN, as shown in Figure 3.2.

Table 3.1 Potential Accident Savings in Sparkhill Cells

Treatment	Current Accidents (5 years)	Potential Savings per year
Seven Streets cell traffic	41	40% 3.28
Five site-specific treatments	38	30-40% 2.46
Calming four distributor roads	115	30% 6.90
Calming two further cells	15	40% 0.90

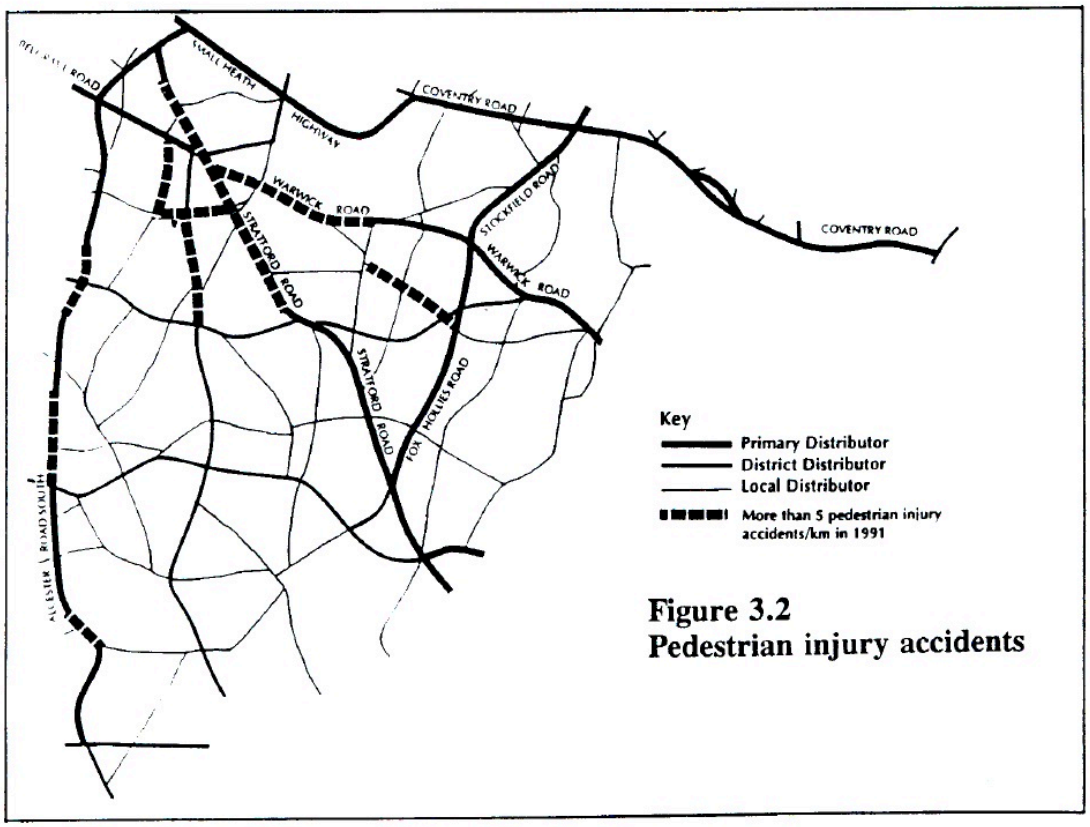


Figure 3.2 Pedestrian injury accidents in South East Birmingham, 1991

Most bus flows occur on the SHN. However, there is a significant degree of penetration into lower levels in the highway network, so it is important for buses to be able to use these other feeder roads. This could restrict the

effectiveness of traffic calming if the measures have to be "bus friendly", such as speed cushions.

There is also a need to provide comprehensive networks for "travel cyclists" and to provide a fine mesh of routes and parking facilities for "access cyclists".

3.3 Variation Throughout the City

The characteristics of all classes of roads vary significantly according to how close they are to the city centre. It is most noticeable in respect of distributor roads and other roads in cells. Towards the centre, the accident experience is almost as bad as on the SHN. Further out from the centre the distributor network is relatively quiet and experiences fewer accidents.

Proximity to the city centre often correlates with different population characteristics. Of particular interest to traffic engineering is the preoccupation with crime prevention. Residents, shopkeepers and other workers are very concerned to be able to see their possessions, including cars, at all times. This increases the pressure to provide parking space for them immediately adjacent to their premises even though this can often be intrusive in terms of other road users.

4 EXPERIENCE FROM THE NEAR CONTINENT

There is considerable experience on the "near continent" of integrated traffic calming, which includes main road calming as well as residential area calming. There has been considerable debate on the issues of network planning (public transport, safety, environment, road hierarchies and so on) in Denmark, France, Germany, The Netherlands, and other countries. There are also many schemes which provide examples of the various approaches. Schemes which are relevant to UK urban areas, and particularly to reducing traffic dominance on main roads are relatively unusual in countries other than those listed.

It is not possible to copy design solutions from one location to another, or to adopt standard "off the peg" solutions. All successful designs are specific to the particular set of local circumstances, and to the specific objectives identified. In most cases schemes are the product of a great deal of planning effort and public involvement. To attempt to short-cut these procedures is to invite failure or public rejection, or both.

SOBETMA drew on expert experience from overseas, collected by Mr Tim Pharoah and Prof. Hartmut Topp and augmented with video recordings of recent study tours.

4.1 Canalising Traffic onto Main Routes?

It is neither socially just, nor usually practicable, to traffic calm residential cells by diverting traffic (and the attendant problems) onto traffic routes which also have "living" functions.

Equally, traffic calming on the main traffic routes (discussed below) cannot realistically be achieved by diverting traffic into residential areas. An approach to which local people could not readily object is that conflicts in each type of road must be resolved without traffic diversion.

An alternative, perhaps more logical approach is that the traffic which has to be carried should be concentrated on those roads where the extra traffic adds least to the disbenefits. Some measures of intrusion, such as noise and severance, rise to undesirable levels at moderate traffic flows, and are then only slightly changed when much more traffic is added. A supporting argument for this "concentration" approach is that special provisions can be made on a limited network, to handle the traffic more efficiently. Therefore traffic should be concentrated on those routes already subjected to it.

The dilemma between concentrating or spreading the traffic load remains a serious item of debate in Germany. It is important to realise that Holland and Germany have a more extensive network of high quality bypass roads than is available in South Birmingham, where the balance could be tilted further towards spreading the load.

4.2 High Streets ("Traffic" and "Mixed" Priority")

German experience exists of a large number of high streets with relatively narrow lanes so as to reduce the speeds of traffic. Typically lanes of some 4.5m are used so that cars may travel side by side but any larger vehicles would need to spread into both lanes. This is Prof. Topp's "almost 4 lane" concept. Meanwhile the centre of the street may be planted and the side of the street may be managed to allow for loading and unloading with built out kerbs.

The effect of such rebuilding of streets is to produce accident reductions. This may be partly due to lower speeds caused by visually removing long straight vistas and by having the visual width less than the vertical scale.

In the Context of SOBETMA, there are already examples of "almost 4 lane", at least in the way the roads operate, even if not designed with such use in mind.

An alternative, also used on the continent, is the "2 plus turns" approach, which may be more appropriate in the SOBETMA context. The advantage is that a single running lane (in each direction), especially if divided with a central strip, is readily identified by drivers as a place where one cannot stop, even for a short time, because of the immediate interruption caused to following vehicles. This is emphasised by well identified traffic lanes (see Figure 4.1 below). Single file traffic maximises the side areas available for other purposes (including parking). Capacity of a "2 plus turns" layout in theory may be lower than an "almost 4", but in practice will be very little different.

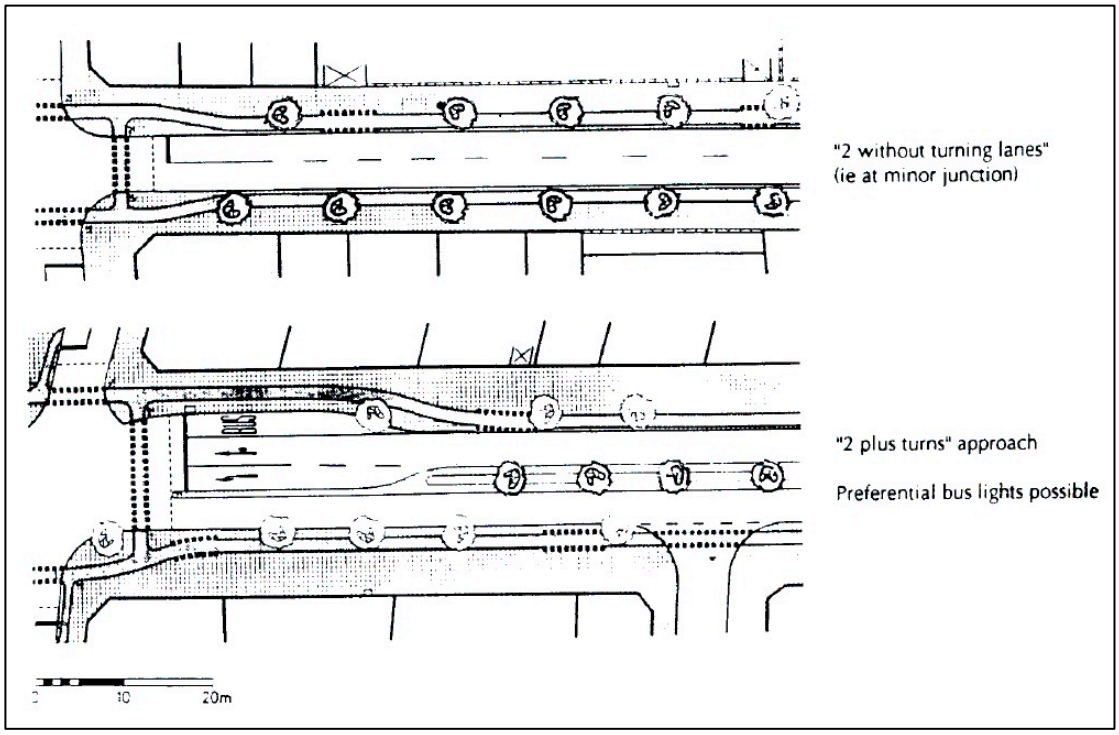


Figure 4.1 "2 plus turns" approach

Whichever layout is adopted, space is gained for other uses either side of the running lanes, except at junctions where extra lanes are retained/provided for turning traffic, or for reducing queue lengths. This extra space can be used in a number of alternative ways, separately or combined:

- Centre islands (for pedestrians or planting)
- Side areas (various purposes, e.g. cycles, pedestrians, planting, parking, loading)
- Multi-purpose strips at side
- Multi-purpose strip in centre

4.3 Residential Area Calming ("Living Areas")

During the last twenty* years the Dutch have pioneered the extreme treatment of residential areas to remove the dominance of the motor car and to provide joint areas for all forms of living. These are known as “woonerven". Woonerven have undoubtedly been extremely well received, have significantly reduced traffic speeds and in most cases have reduced accidents. Their success depends very much on the circumstances in which they were introduced.

The major problem with woonerven has been their high cost. Consequently current Dutch attitudes are to use to a greater extent 30kph zones enforced with road tables and road humps. The position in the UK is similar. For example in New Malden an area was treated with traffic calming measures at

a cost of £100,000 and had relatively little impact on traffic speeds. These measures were then supplemented with road humps at a quarter of the cost and this significantly reduced traffic speeds to the target level of under 2Smph. Traffic calming of residential cells may therefore be seen as predominantly related to the use of vertical shifts in the carriageway to curb speeds.

Three broad approaches have evolved for residential areas:

- Environmental Traffic Management
- 20 mph Zones (30 kph Zones on Continent)
- Shared Surface Pedestrian Priority

The three approaches reflect the "strength" of action taken. By far the most widely used on the near-continent is the 20 mph zone, which offers most of the safety and environmental benefits expected from shared-surface schemes, avoids the problems of traffic management schemes, and which can be achieved at reasonable cost. It must be recognised that the development and implementation of comprehensive 20 mph zones will take considerable planning and resources and must therefore be phased over a period of years.

5 RECOMMENDED TREATMENT

5.1 Level of Restraint

The feasible treatments are considerably influenced by the level of traffic restraint attempted. The resultant traffic levels on different categories of road were estimated for a range of three possible treatments:

- One extreme considered attempted to permit full traffic capacity, albeit with due concern for the impact of traffic on the environment.
- At the other extreme a restraint option was considered, with a requirement to provide major enhancements to public transport. Continuous or boundary control systems were considered. The study considered that road use charging systems would not be available in time, so physical restraint techniques would be necessary.
- A middle solution was considered which allowed traffic increase on the SHN and selected distributor roads only to the extent that provision could be made in mixed priority areas. This solution was recommended.

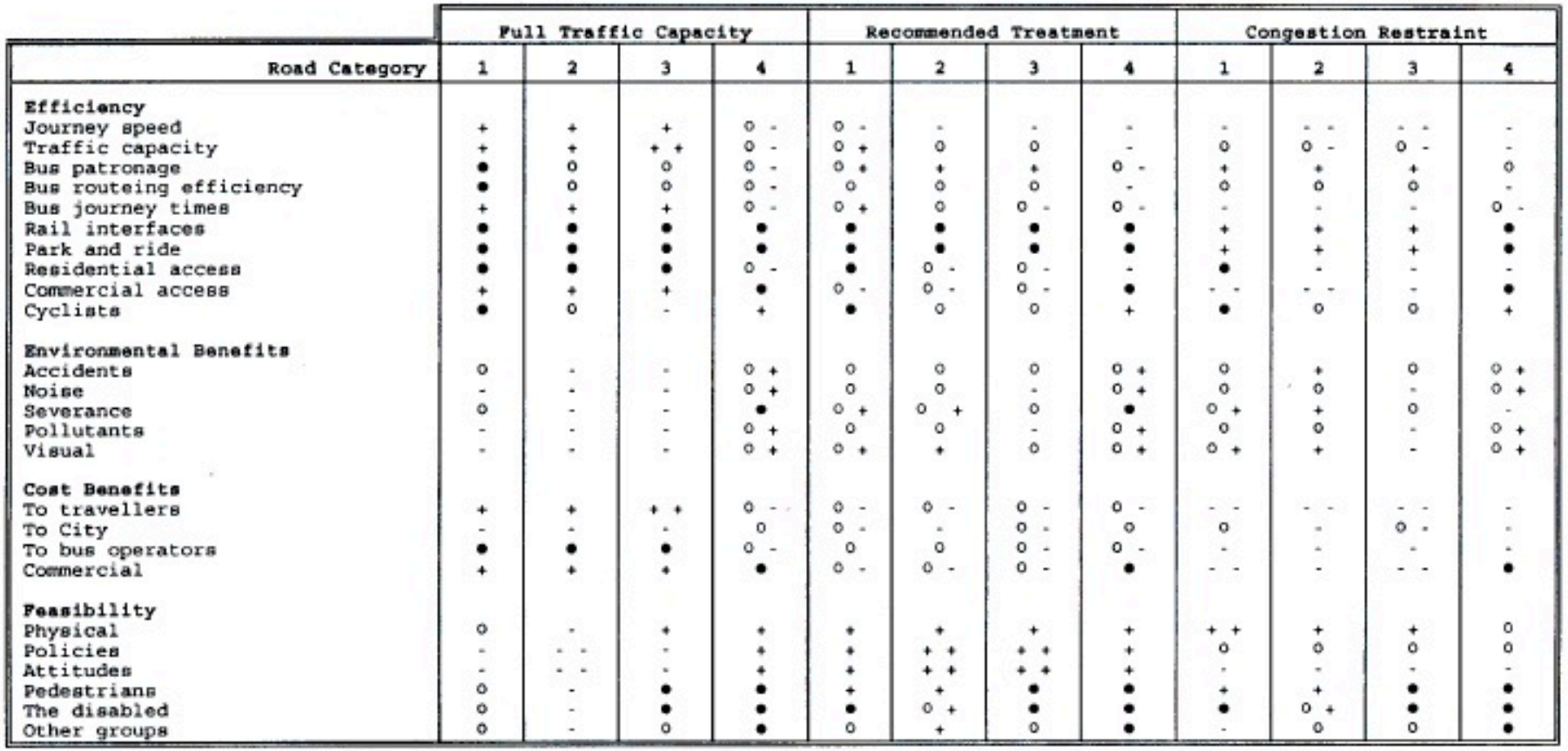
All three solutions were assessed against a range of criteria, the results being shown in Figure 5.1. It is necessary to separately assess each category of road within an option, since the options differ in the extent to which they transfer traffic between different categories of road. The assessment clearly demonstrates that the way forward must lie along the lines of the middle

treatment - providing as much traffic capacity as possible within the environmental constraints.

Providing full traffic capacity had to be rejected on the grounds of feasibility, firstly in terms of current public attitudes and secondly in terms of obtaining the land in such an urban area. It was not part of the strategic framework provided by BITS, and was specifically excluded by the study's terms of reference. Nevertheless, in a number of specific instances the accessibility benefits to industry and commerce were sufficient to justify continued safeguarding of land for road provision/widening (though overall the vast majority of inherited road improvement lines in the area have now been abandoned).

Congestion restraint had to be rejected because of the damage it would do to all forms of road movement in terms of journey speed, driver route choice and diversion of traffic onto unsuitable routes. This was explicitly on the basis that the postulated restraint would be obtained by traffic congestion, which would have to be supported by queue management on main and distributor roads, and by the creation of sealed residential cells to prevent through movement.

Figure 5.1 Initial assessment



	Full Traffic Capacity				Recommended Treatment				Congestion Restraint			
Road Category	1	2	3	4	1	2	3	4	1	2	3	4
Efficiency												
Journey speed	+	+	+	o -	o -	-	-	-	-	- -	- -	-
Traffic capacity	+	+	+ +	o -	o +	o	o	-	o	o -	o -	-
Bus patronage	●	o	o	o -	o +	+	+	o -	+	+	+	o
Bus routeing efficiency	●	o	o	o -	o	o	o	-	o	o	o	-
Bus journey times	+	+	+	o -	o +	o	o -	o -	-	-	-	o -
Rail interfaces	●	●	●	●	●	●	●	●	+	+	+	●
Park and ride	●	●	●	●	●	●	●	●	+	+	+	●
Residential access	●	●	●	o -	●	o -	o -	-	●	-	-	-
Commercial access	+	+	+	●	o -	o -	o -	●	- -	- -	-	●
Cyclists	●	o	-	+	●	o	o	+	●	o	o	+
Environmental Benefits												
Accidents	o	-	-	o +	o	o	o	o +	o	+	o	o +
Noise	-	-	-	o +	o	o	-	o +	o	o	-	o +
Severance	o	-	-	●	o +	o +	o	●	o +	+	o	-
Pollutants	-	-	-	o +	o	o	-	o +	o	o	-	o +
Visual	-	-	-	o +	o +	+	o	o +	o +	+	-	o +
Cost Benefits												
To travellers	+	+	+ +	o -	o -	o -	o -	o -	- -	- -	- -	-
To City	-	-	-	o	o -	-	o -	o	o	-	o -	-
To bus operators	●	●	●	o -	o	o	o -	o -	-	-	-	-
Commercial	+	+	+	●	o -	o -	o -	●	- -	-	- -	●
Feasibility												
Physical	o	-	+	+	+	+	+	+	+ +	+	+	o
Policies	-	- -	-	+	+	+ +	+ +	+	o	o	o	o
Attitudes	-	- -	-	+	+	+ +	+ +	+	-	-	-	-
Pedestrians	o	-	●	●	+	+	●	●	+	+	●	●
The disabled	o	-	●	●	●	o +	●	●	●	o +	●	●
Other groups	o	-	o	●	o	+	o	●	-	o	o	●

Code: + beneficial - unwelcome o neutral ● irrelevant

Figure 5.1 Initial Assessment

5.2 Specific Recommended Treatments

The treatments, by road category, are thus as given below. A tool kit for achieving these results is given in Figure 5.2.

- Category 1 (SHN with Traffic Priority)

  - Existing lane widths retained but redistributed
  - Surface level pedestrian crossings introduced in addition to retaining subways
  - Tree planting in central reservation/kerbside to indicate reduced width to motorists
  - Car parking provided off-street

- Category 2 (SHN with Mixed Priority)

  - In sensitive sections, the "2+ turns" approach to be introduced
  - Ensure traffic capacity at key junctions is maintained (2 unrestricted traffic lanes for at least 60m before junction)
  - Provision of with-flow bus lane to overtake traffic queues at junctions
  - Beyond key junctions road width used for controlled kerbside uses e.g. bus stops, loading laybys, short-term parking, kerb build-outs used to prevent occupancy by free flowing traffic
  - Tapers adjacent to bus laybys to enable buses to enter traffic stream
  - Planting on kerb build-outs including gateway treatment to provide impression of narrow road and to reduce speed
  - Extensive surface pedestrian crossings using alternative surface material
  - Some kerb space devoted to short term off-peak parking

- Category 3 (Distributors with Mixed Priority)

  - Entry controls/planting to reduce speed (as above)
  - Selective use of road humps to control speed and traffic levels
  - With such treatments, some distributors could take more traffic than at present consistently with their environmental status

- Category 4 (Cells with Living Priority)

  - Cells treated from centre of Birmingham reflecting accident and traffic problems
  - Accident problem areas treated with road humps, 2Omph zones, entry treatment and signage
  - Circulation pattern amended by appropriate closures to discourage rat running

The treatments (Figure 5.2 below) are allocated numerically to the 4 categories of road; the letters "F" and "R" indicate that they are particularly suitable for, or restricted to, provision of Full traffic capacity or traffic Restraint.

Build new bypasses	1F	Bus stop clearways	2,3
Build road improvements	1F,2F	Light Rapid Transit on-street sections	2R,3R
Safeguard road improvements	1,2	Bus exemptions to movement controls	2,3,4
Full grade separation (pedestrian areas maintained)	1F,2F	Distinctively surfaced areas of road	2,3,4
Provide or maintain subways and footbridges	1,2F	Shared cycling on the pavement	3
Increase junction capacities (extra lanes at signals)	1F,2F	Junction narrowing to control traffic levels	3
Development control to contain conflicting movements	1,2	Junction signalling to control traffic levels	3R
Cycle tracks alongside roads	1,2	Remove surplus dual carriageway operation	3
Tree planting to change vertical/horizontal scale	1,2	Remove unnecesarily wide roads	3,4
Limited good through lanes plus turns, bus lanes		Speed tables and raised junctions	3R,4
and parking	2	Gateways to reduce through traffic	3,4
Correct direction signing for through traffic	1,2,3	Road closures against through traffic	3R,4
Provide and sign access to Park and Ride	1,2,3	Diagonal road closures at junctions	3R,4
Surface pedestrian crossings	1(not F),2,3R	Movement controls (one-way roads) against through	
Manage kerbside lane use and parking	1,2,4	traffic	3R,4
Marked cycle lanes	2,3	Cycle routes using minor roads	3,4
With flow bus lanes (normally with setback)	2,3	Development control to discourage through movements	3,4
Occasional strips alongside car lanes	2,3	Chicanes by kerb alignment, parking and planting	4
Queue relocation to provide bus lanes	2,3R	20mph zones	4
Half height road humps	2,3	Full height road humps	4
Gateways showing mixed priority on main roads	2,3		

Figure 5.2 Toolkit for Environmentally Sensitive Highway Improvement

6 CONCLUSIONS AND POST-SCRIPT

The study has concluded that, in such an inner area of a major city, it is possible to provide neither for full traffic demand, nor to restrain traffic to its current levels.

Traffic can be provided for at somewhat enhanced levels, dictated by the environmental traffic capacity of mixed priority areas.

The mixed priority areas where major roads conflict with living priority, should use near-continental management techniques; in particular "2 lanes plus turns" (for 2-way traffic) rather than allowing the present 4 lanes, even if these are somewhat narrowed. These management techniques allow for increased pedestrian areas, access for cyclists and bus priority.

Increased public transport facilities should include careful design of restraint on distributor roads to preserve bus penetration.

Whilst SOBETMA recommended that road widening lines should in many cases be retained as an insurance against future traffic pressures and changes of policy, the City Council's acceptance of a degree of future traffic restraint has led it to abandon most of them.

The recommendations of the study are being implemented both in terms of plans being presented (in association with neighbouring authorities) to government and by providing bus priority on two major radial roads. These schemes were already being explored when SBS started, but through SBS they can be seen as the first steps in a larger vision.

The most significant contribution of SOBETMA to SBS as a whole has been the resolution of the conflict over inner area shopping centre sections of the SHN. The mixed priority designation and the '2-plus-turns' treatment allows

traffic capacity to be retained (at lower speeds): the lower speeds and narrower carriageway provide a better context for the community and shopping functions. This has greatly assisted healing of the rift between local community and the City Council's exercise of its city-wide strategic powers.

In terms of future increases in traffic pressure (discussed earlier in the context of BITS), the position implied by SBS and SOBETMA is

- To counter the pressures of dispersion (the main source of transport demand) by making inner areas more attractive;

- To accept a lower level of service to roads users in terms of speed, while retaining reliable access to inner area functions.

We are convinced that this provides a pragmatic and practical programme.

7 REFERENCES

May, A.D. 1990, "Integrated Transport Strategies: a new initiative, or a return to the 1960s?" Rees-Jeffreys Road Fund, Discussion Paper 21, Leeds Institute for Transport Studies.

Bundesministers fur Raumordnung, Bauwesen und Stadtebau, 1984, "Stadtebauliche Integration von innerortlichen HauptverkehrsstraBen".

Bundesminister fur Verkehr, 1992, Forschung Stadtverkehr Heft 45; "Flachenhafte Verkehrsberuhigung: Auswirkungen auf den Verkehr"

As above but 1986, Heft 37, "Mitteilungen uber Forschungen zur Verbesserung der Verkehrsverhéltnisse der Gemeinden"

Devon County Council, 1991, "Traffic Calming Guidelines"

Gemeente Eindhoven, 1985, "Technische uitwerking van het project in Eindhoven"

Pharoah, T. 1992, "Bus friendly traffic calming", Urban Transport International, March/April 1992

Pharoah, T. 1992 "Less traffic, better towns", Friends of the Earth July 1992

Topp, H. 1991 "Traffic safety, usability and streetscape effects of new design principles for urban arterial roads", paper to "Living and moving in cities congress", CETUR, Paris

Jones D, A.D. May and A. Wenban-smith (1990), "Integrated transport studies: lessons from the Birmingham study", Traffic Engineering and Control, November