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TITLE **Engineering approaches to reversing a worsening road accident trend in Malaysia**

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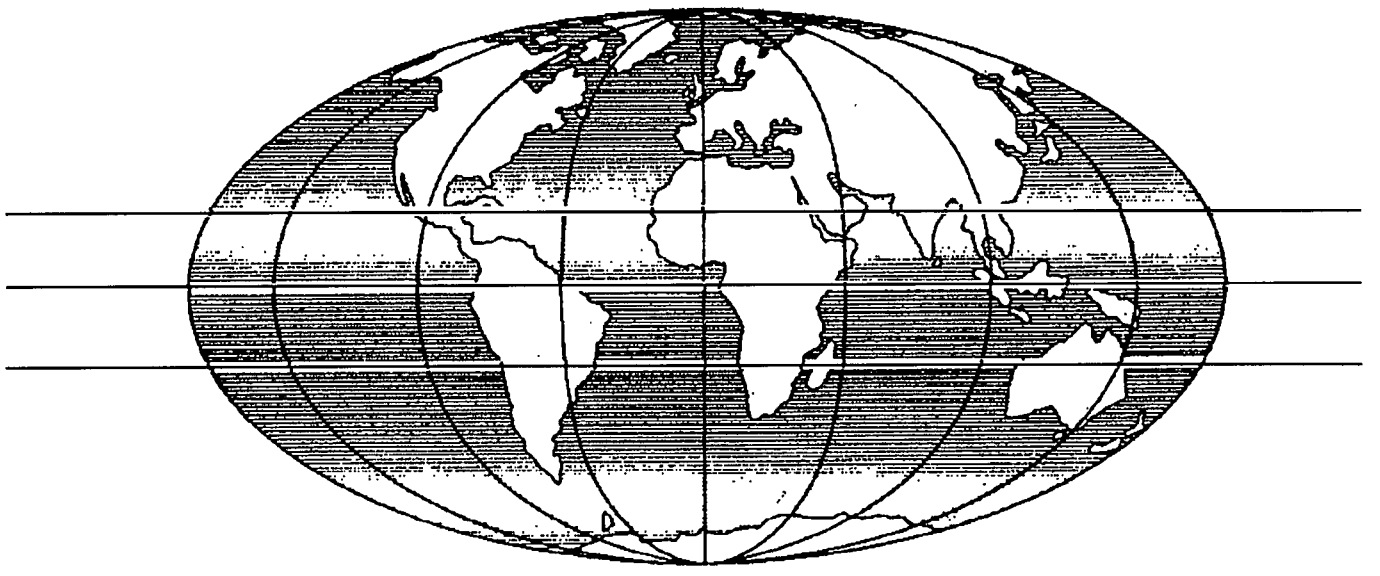

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Engineering Approaches to Reversing a Worsening Road Accident Trend in Malaysia

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ABSTRACT

Malaysia has, like several other countries in the Asia Region, enjoyed rapid economic development in recent years which has led to a substantial growth in its vehicle fleet. Unfortunately, this has in turn contributed to a steadily increasing annual road accident death toll which over the past 5 years has averaged a 6.5% increase each year with fatalities in 1994 alone now exceeding 5,000.

This worrying trend was causing great concern even five years ago such that, in 1990, a Cabinet Committee for Road Safety was formed. One of this Committees' first acts was to set an overall fatality reduction target of 30% to be achieved by the year 2000, and to draw up a national action plan which, it was hoped, would produce such a reduction. However, the current accident figures clearly indicate that this target is not being met gradually as it needs to be.

This paper reviews the efforts that have been made in the road engineering field within the Plan which includes an expenditure of US$35 million on a blackspot improvement programme. The schemes introduced have tended to be high cost and, despite some indications of overall accident savings, the measures have not produced enough impact on the national problem.

Proposals under consideration at present to attempt to bring the situation under control and back on track are discussed. These include the disaggregation of targets to each road authority and the setting up of Road Safety Units within the authorities. These Units would be allocated special budgets for engineering treatments and would have the prime responsibility for achieving their respective targets.

1. INTRODUCTION

Reputedly the worst single road accident that has occurred in Malaysia was a head-on vehicle collision on the Kuala Lumpur - Karak Highway in 1990 which claimed the lives of 17 people. This particular tragedy, however, created a general awareness of the road accident problem of the country and, in response, the Government formed a Cabinet Committee on Road Safety. Their first act in 1991 was to set a target for accident reduction by remedial action. This target is commonly expressed as a 30 per cent reduction in deaths by the turn of the century, and was actually stated in terms of a fatality rate reduction from 7.12 deaths per 10,000 registered vehicles (based on the 1989 figures) down to 3.14 deaths per 10,000 vehicles to be achieved by the year 2000.

Over three years have now elapsed since the national target was set, and this paper reviews briefly the attempt made to date towards its achievement. The recommended plan made in 1991 is summarised and the paper focuses on its engineering aspects and suggests new and necessary proposals to increase the efforts being made.

2. THE CASUALTY REDUCTION TARGET AND ITS ATTAINMENT

One of the basic objectives of government policy should be to improve the safety of travel for every category of road-user. The setting of targets is a well established management strategy which, when applied to accident reductions, has proved very effective in other countries. It has contributed greatly to the overall objective by focusing the minds of road authorities on their individual quantifiable goal. With limited budgets this has meant that they have had to be efficient in their efforts and have tended to target their most serious problems first, though with cost-effectiveness as a high priority.

Although many countries have stated a target in terms of overall casualty reductions, the Government of Malaysia chose to specify the reduction in terms of the most severe accidents. However, it was hoped that the efforts applied would also affect the other categories of injury accident to produce similar reductions.

Malaysia, like many developing countries, is experiencing a very rapid expansion of its vehicle fleet. The occurrence of road accidents appears to approximately mirror the pattern of this growth. This can be seen from the plot of accident fatalities and registered vehicles shown in Fig. 1

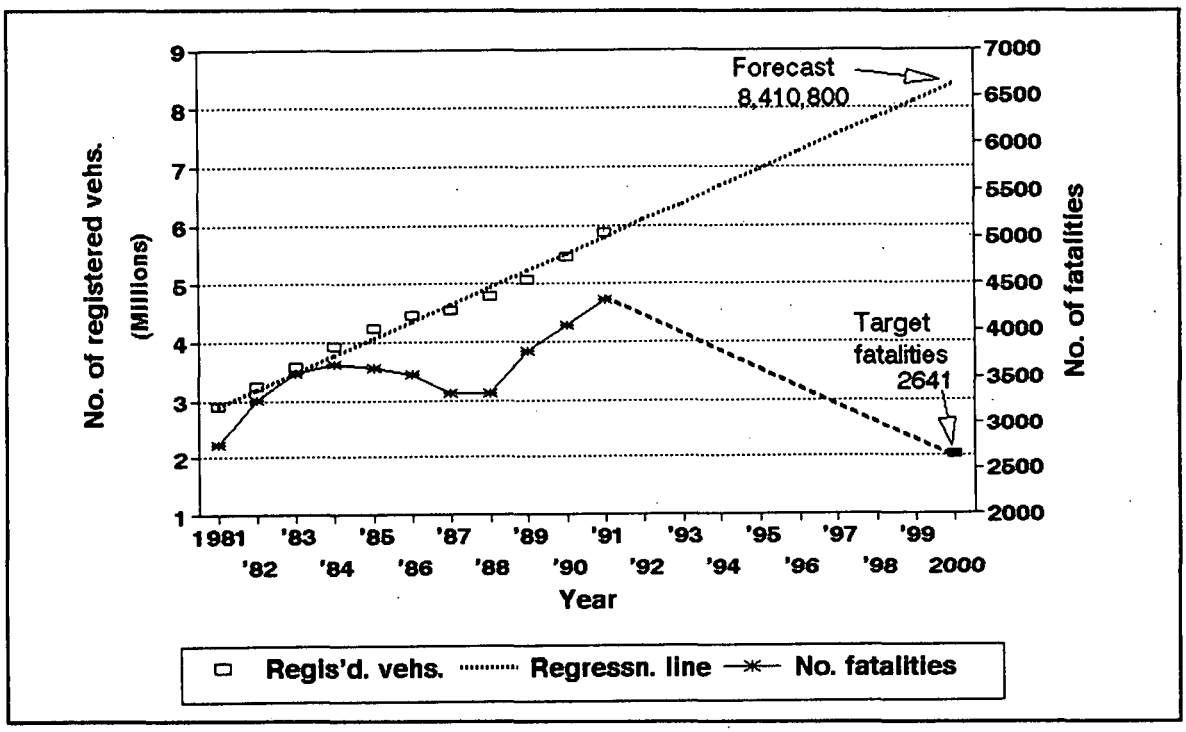

Fig. 1 Growth of registered vehicles and accident fatalities in Malaysia, 1981-1993

where a noticeable dip in the accident growth occurred in the mid to late 1980's, which itself

coincided with a minor national economic depression. The above fatality rate reduction target for Malaysia takes some account of the general increase of vehicular traffic by assuming a linearly increasing traffic growth pattern (see Fig. 1). Based on this prediction, the target reduction of some 56% in rate was set such that the actual number of fatalities should be decreased by **30 per cent** of the 1989 figure by the year **2000.** This means in numerical terms a reduction **from 3773 down to 2641 deaths per year in spite of the growth in traffic in the intervening years**.

2.1 The 1991 National Action Plan

In 1991 the National Road safety Council (MKJR) organised a brainstorming meeting which comprised all national experts and interested parties. Following this meeting a National Action Plan[1] was formulated and subsequently presented to the Cabinet.

It is generally agreed that improving road safety requires an integrated approach and the Plan identified nine separate methods of approach encompassing the much quoted "three E's", ie. Education, Engineering and Enforcement. The nine main areas specified where it was decided that action was required were as follows:-

1. Education
2. Engineering for environment and vehicles
3. Vehicle testing
4. Legislation enactment
5. Training and Testing Target Groups
6. Road Safety Administration - planning
7. Research - collecting information, identifying and solving problems
8. Law Enforcement
9. Medical Services - accident victims

The Plan summary is included as an Appendix and it can be seen that a list of recommended activities was given for each of the above. The agent responsible for the activity was identified along with other supporting agencies, where appropriate.

Although human error is involved in most accidents and, indeed, the Royal Malaysia Police (PDRM) have recorded this as the main cause in 97.5% of accidents[2], it is generally accepted that, in many cases, the road environment is an under-reported, major causal factor. In the UK, for example, it has been estimated from on-the-spot accident survey teams that the road environment is a contributory factor in 28% of all accident cases[3].

Policemen attending the scene of accidents are not generally trained in recognising road engineering factors that may have contributed to a particular accident, and tend to favour attributing blame solely to the road user(s) involved. The human error aspect is certainly an extremely important accident factor to tackle but, as Fig. 2 shows, the most common classification of error recorded by the Police in Malaysia for both male and female drivers or riders is that of "careless driving". This constitutes almost half of all errors recorded. Whilst it is recognised that better training, media campaigns and enforcement should have a positive effect on other driver errors such as "close following" or "speeding" or errors of judgement made when "overtaking" or making "turning" manoeuvres, they are likely to be less effective in changing this main accident group caused by "careless driving".

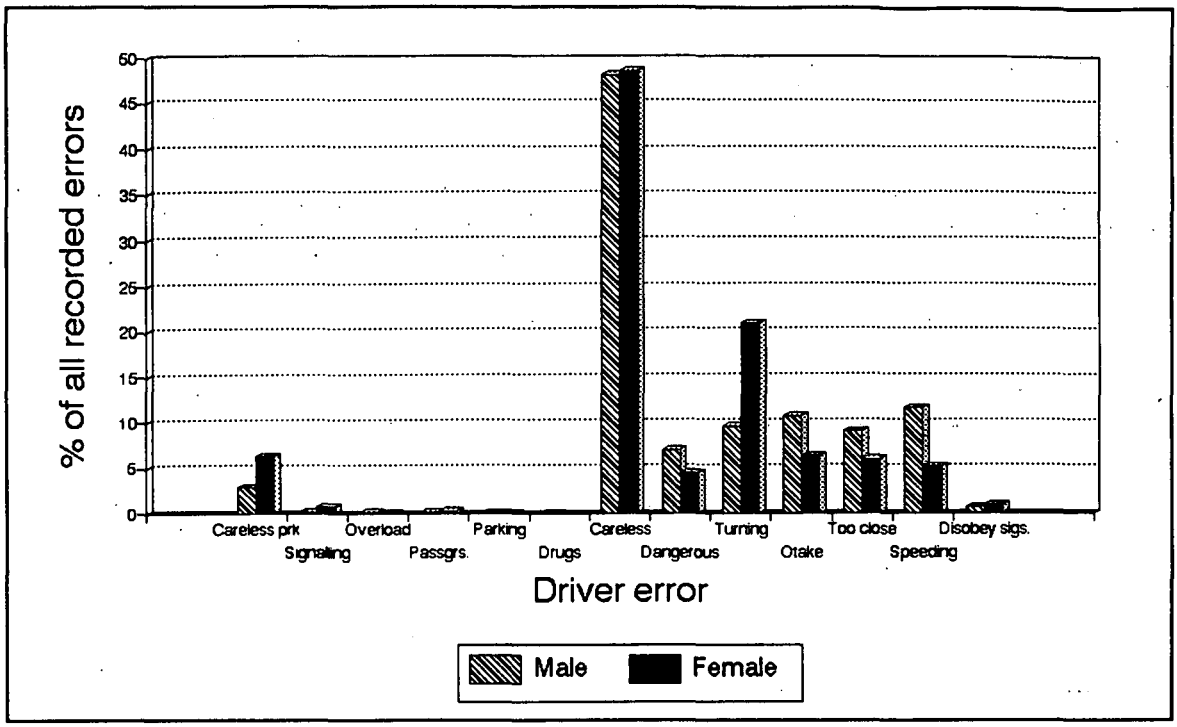

Fig. 2 Driver errors in all injury road accidents in 1992 and 1993

Experience in many developed countries has shown that road engineering has an important role to play here in making the road environment as "forgiving" as possible when such careless driving accidents occur. This is, of course, in addition to ensuring that the road geometry and surface condition minimise the chances for drivers to make mistakes and allow adequate space for effective evasive action when mistakes are made. UK and New Zealand experience suggest that engineering improvements could provide an overall reduction of about 15% of the total accident toll, provided that sufficient manpower and cash resources are put into systematic accident investigation procedures[4].

2.1.1 Blackspot improvement

As stated earlier, this paper focuses on the *engineering* approaches and within the Plan the main item in this category (section 2) was a blackspot improvement programme which had originally been specified within the national Sixth Malaysia Plan. The sites to be treated were all on Federal routes and the projects were part-funded by the World Bank. The Plan also specified the need to identify new blackspot sites and to draw up a second programme for the Seventh Malaysia Plan. The Highway Planning Unit (HPU) of the Ministry of Public Works has been given responsibility for the identification of sites and Rural Roads Department (Jabatan Kerja Raya, JKR) the responsibility for detailed design and implementation. An evaluation of the present countermeasures' effectiveness was specified. Both JKR and the town councils were required to make a road inventory of facilities and road equipment.

Still under the engineering category, it was recommended that the MKJR should create an accident investigation team and PDRM should improve the method and quality of accident data. Institut Kerja Raya Malaysia (IKRAM) were to look into factors affecting design parameters of roads, road geometry, low cost treatments, improved skid resistance and identifying common patterns of

accidents at blackspot locations. They were also required to produce and update Design Guidelines: traffic control and road signs being specified. A safety audit system was to be introduced by JKR for all new schemes.

Town Councils were also required to improve and increase their public transport.

2.1.2 Vehicle testing

The driver and vehicle licensing authority (Jabatan Pengangkutan Jalan, JPJ) were required to continue to carry out checks on vehicle condition and to reappraise their approval system. They were also to investigate the possibility of introducing tachographs in lorries and compulsory fitting of child restraints in cars. For heavy vehicles and buses, compulsory fitting of in-vehicle audible and cab-mounted lights were planned which were to warn the driver (and other drivers) when the vehicle was exceeding speed limits.

The main activity planned was for JPJ to expand their road worthiness testing from just heavy goods lorries and buses to all vehicles on the road.

2.1.3 Road safety administration

The main recommendation for improving administration was the formation of a Road Safety Department to be operational by 1994. However, this recommendation was rejected at an early stage by the Public Services Department as impractical and, instead, it was agreed that MKJR should be strengthened.

MKJR were to organise the creation of an accident investigation team in each State. Each Ministry was required to provide specialist safety training, particularly for maintenance engineers.

2.1.4 Research

The MKJR Research Sub-committees were required to organise all safety research. The subject areas listed included the identification of blackspots; accident investigation and treatment; studies of road-user attitudes/personality in relation to risk perception, overtaking and speeding; driver errors; conflict studies; line of sight studies; haze, nighttime driving. The Plan called for research on improving the accident database, evaluations of road signs, safety of State roads, and effectiveness of countermeasures. It also requires an efficient way of disseminating this information.

2.2 Meeting the Target?

It is abundantly clear from Fig. 3 that this overall target for fatality reductions is **not**, as it should be, gradually being attained. Indeed the hospitalised and minor injury cases have also been rising at an alarming rate since the beginning of 1989 (see Fig. 4).

Perhaps the next question to ask is whether the actual increase in fatalities might have been as expected owing to traffic growth during the period under consideration, 1989 to 1993 (the latest year of available statistics). It is certain that road accidents are related to traffic volume since the

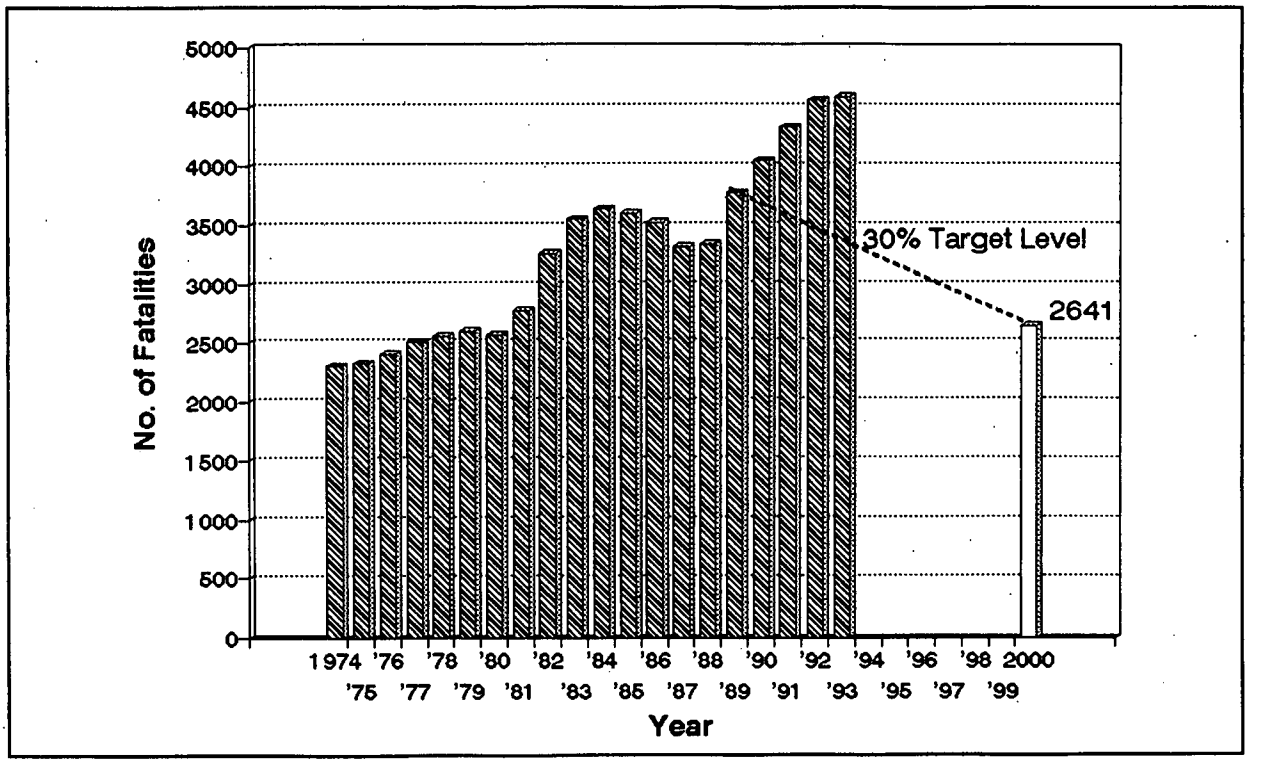

Fig. 3 Road accident fatalities and the reduction target, 1974-1993

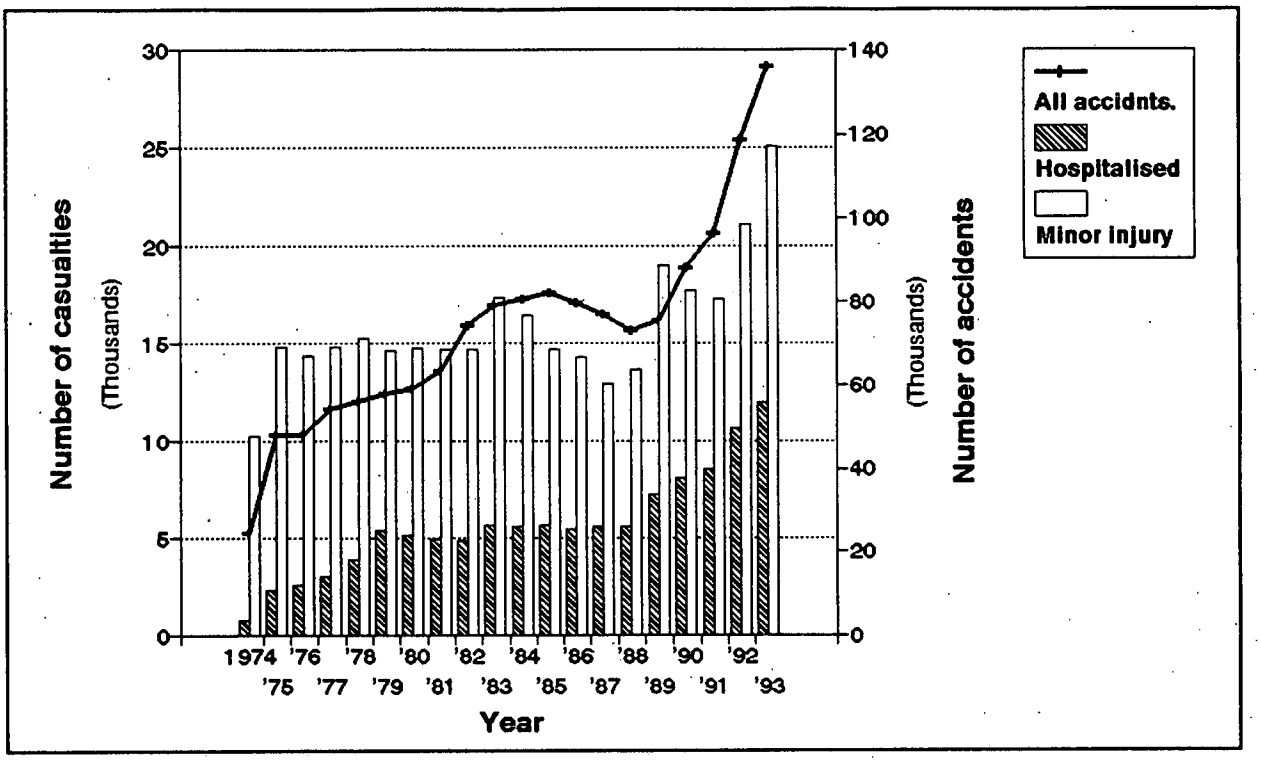

Fig. 4 Serious and slight casualties and all recorded road accidents 1974-1993.

number of opportunities for road users to come into conflict increases with the number of manoeuvres made. Many researchers have attempted to derive relationships between accidents and

volume with varying degrees of success and sometimes contradictory results. Perhaps the most well-known and successful macroscopic model relating fatal accidents to population and vehicle registration was derived by Smeed[5] in 1949 which, despite it being based chiefly on European data, has been found to be still remarkably valid even in more recent years and applied to other countries [6,7]. Smeed's formula, in full, was:-

$$D = 0.000099\ N^{0.3377}\ P^{0.7323}$$

where D = number of deaths,
N = number of registered vehicles, and
P = population

A more recent paper by Fieldwick and Brown[8] claimed to improve this model considerably by including an important speed factor term, namely the general urban and rural speed limits of the country. The predicted fatalities from these models are shown against the actual recorded values in Malaysia in Table 1.

Table 1 Actual and predicted road accident fatalities

Year	Population	Registered Vehicles	No. of Fatalities	Smeed formula (% diff. to actual)	Fieldwick & Brown formula (% diff. to actual)
1989	17,376,800	5,071786	3773	3646 (-3.4%)	3241 (-14.1%)
increase	9.6%	32.3%	23.7%	17.6%	9.8%
1993	19,050,000	6,712,479	4666	4287 (-8.1%)	3560 (-23.7%)

It can be seen that with the increase in population and much larger proportional increase in vehicles over this 4-year period, Smeed's formula, which predicts the 1989 number of fatalities relatively well, would indicate a rise of over 17% in fatalities. The Fieldwick and Brown formula (which may not be as reliable since it does not contain a registered vehicles term but effectively assumes an average {and lower} increase in the vehicle fleet corresponding to the population increase) predicts a more modest 10% increase in fatalities.

However, according to police records, fatalities have increased by almost ***24%*** in this period. This may thus *indicate a worsening road safety situation which cannot wholly be attributed to the increase in vehicles*. It should perhaps be stated that these models were based on countries where motorcyles, a very vulnerable road user group, do not comprise such a large proportion of the vehicle population as they do in Malaysia (approximately 58%). Nevertheless, the above statement implies that *any safety improvements which have been introduced have failed to have any impact on the nation's growing accident problem.*

In order to investigate reasons for the above statement let us now review how the various actions itemised within the Engineering section of the National Road safety Plan have in fact been applied.

2.3 Engineering progress within the Plan

It is beyond the scope of this paper to investigate how well all the actions mentioned in Appendix or even Section 2.1 have been implemented since they span several Government ministries and departments. Hence this Section limits its investigation to some of the main road engineering aspects only.

2.3.1 Program I: identify blackspots on Federal Routes and implement countermeasures.

The first item listed was carried out by the Highway Planning Unit (HPU) of the Ministry of Works and was to identify blackspots on the Federal route network to be named as Program I. This in fact dates back to 1981 when HPU requested the Royal Malaysia Police produce a list of the worst blackspots in Peninsula Malaysia. This list was updated in 1986 and comprised a total of 200 sites from which HPU selected 42 sites as a priority list for Program I.

There were, however, many inadequacies in the accident database at this time, notably on accident location coding. For example, a random sample of accidents along Federal Route 3 for approximately 20kms was retrieved in 1989 from the police accident database and studied with reference to the police station records. It was found that 61 per cent of records were given no section number and a further 6 per cent were obviously located by the distance to the nearest town rather than the corresponding section number; (both numbers appearing on kilometre posts). If the same level of poor location coding was as widespread as suspected, then the sites listed may not have been the worst accident blackspots in the country. However, it must be stated that due to this known deficiency in the data, the list was also based on local knowledge obtained from the opinions of the respective traffic police stations.

In the list of 42 sites there was no distinction made between spot sites (eg. at junctions) and those on sections of road. Indeed, the lengths of road varied from less than 1km to more than 10km, and so the sites could not easily be ranked since a site having more accidents than another may refer to a much longer length of road.

Within Programme I, and in addition to the 42 sites, there were also 27 pedestrian blackspots separately specified at which the construction of a pedestrian footbridge was proposed. Again, the local JKR staff and police were requested to submit locations where they considered there were significant pedestrian problems, and a list of sites was compiled.

World Bank funding was obtained for these sites which totalled approximately US$35 million to be spent during the 6th Malaysia Plan. Several of the blackspot sites were packaged together for treatment to be carried out under a single contract; the final requirement being for 27 separate contracts. Most of the improvement works designed by JKR Design Branch involved realignment or road widening resulting in relatively high cost project values of between about US$0.7M and US$2.2M. About 35 of the 42 sites were expected to be completed within the period of the 6th Malaysia Plan with a further 4 under construction.

For the pedestrian bridge sites the cost ranged from US$127,000 to US$308,000. About 19 of the 27 bridges are expected to be completed on schedule with contracts started on most of the remainder.

2.3.2 Programme II: identify blackspot areas and improve under the 6th Malaysia Plan

This included the remaining sites from the original 200 and responsibility for improving these was handed down to the JKR offices within the State authorities or municipal authorities. This work would be in addition to supervising any projects of Programme I located in their area.

In order to gather some information about the level of achievement of the road authorities around Malaysia in work towards the Master Plan, a questionnaire was sent out to all JKR District Authorities and to the larger local authorities, ie the Majlis Bandaraya of all cities and major towns.

A total of 135 questionnaires were sent out but, unfortunately, a rather poor response rate of 24% was achieved. One possible, though pessimistic, reason for this may be a lack of much safety work actually being carried out by many authorities (whether due to inadequacy of funds or staff) which would leave little to fill in on the questionnaire, thereby discouraging its return.

However, in the absence of other available information, and bearing in mind that due to the low response rate these may not be completely representative, the main results obtained from this survey are summarised below.

Although the majority of authorities claim to have identified blackspot sites in their network, there is still a large proportion (41%) who have not. These authorities are thus presumably not sure that they are tackling the worst problem locations. Although the networks of the road authorities' obviously vary in size and traffic volume appreciably, it is somewhat disappointing that of those who gave the number of sites they have identified, most have considered fewer than four sites during the past three years.

Of those authorities that did respond, most claim that their blackspot list is revised once per year. However, there would appear to be some confusion and a general lack of clear definition of what constitutes a blackspot site. It would seem that very few authorities have adopted a formal definition (many actually stating a type of site, eg. cross roads, or simply stating "high numbers of accidents"). Those authorities that did quote a definition in terms of a number of accidents per year did not stipulate a physical area; eg. within 50m of a junction, or per 200m road section.

Less than a quarter of the respondents claimed to have carried out any studies at accident blackspots and of those only 2 stated that they had studied traffic and road surface condition, though no further details were included. Most authorities have not carried out any evaluation of their actions although about 25% stated that accidents had reduced.

Of those who had carried out accident remedial work since 1992, most appear to have treated junctions. Although these are locations where conflicting manoeuvres are most frequent and so tend to exhibit the highest clustering of accidents, the most serious accidents often occur between junctions. The most common treatment listed (see Fig. 5) was new or improved signing and, together with road markings, these are some of the lowest cost countermeasures that can be applied.

Only one authority (a municipal council) stated that it had an annual budget specifically for safety improvements. Most other authorities (82%) used their annual maintenance budget or that of the

State or Federal authorities to fund remedial work, which will inevitably compete with general maintenance needs.

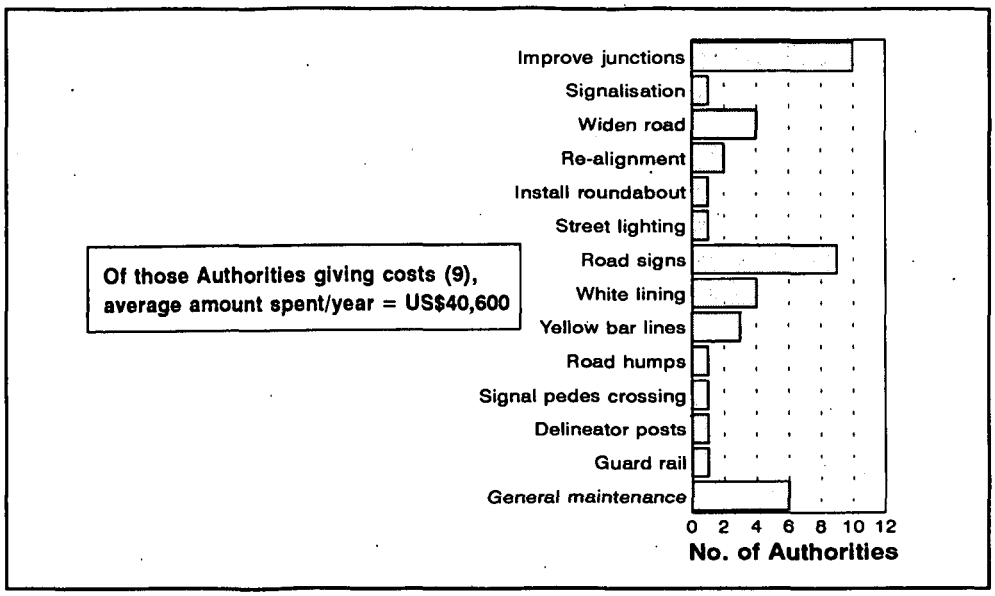

Fig. 5 Accident countermeasures applied by District JKR & local authority

Another disturbing finding is the level of manpower devoted to safety work. Many authorities stated that several people had differing percentages of their time devoted to safety and for comparison, the percentages within each authority have been summed (where given) and expressed as a number or fraction of full-time personnel in Fig. 6. Most have none or fewer than the equivalent of 1 person working towards the improvement of road safety. Also, half stated that they spent less than 2 man-hours per week in checking the police accident forms which they are now required to do. This may help to explain the rather poor quality of accident data, particularly with respect to accident location.

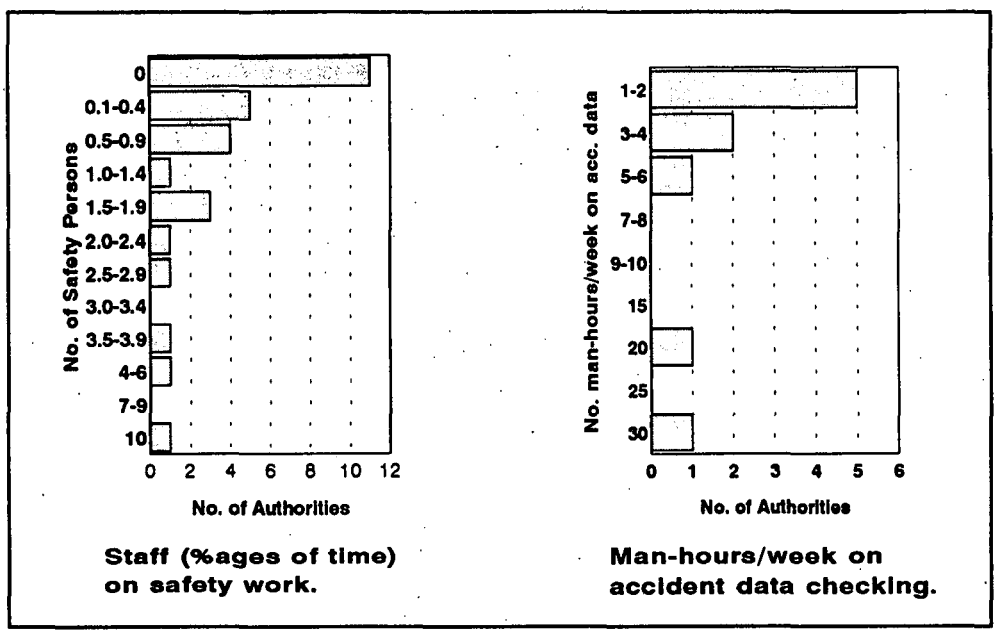

Fig. 6 Staff allocation on road safety in District JKR & local authorities

In summary, it is not known how many of the original 131 (200-42-27) blackspot sites have been treated by the road authorities. However, as such a large proportion of authorities have not actually identified blackspot sites (which is likely to be even higher than 41% given the numbers of unreturned questionnaires), it would thus appear that inadequate efforts are being made. Proper detailed studies to assist in targeting problems specifically do not tend to be carried out nor, it is suspected, are evaluations being made and reported.

2.3.3 Evaluation of effectiveness of Safety Programme I.

World Bank officials made annual visits to monitor progress of their blackspot improvement works as part of their standard monitoring procedure for the full loan. However, IKRAM were requested to provide an evaluation of the actual effectiveness of the treatments with respect to safety.

As installation at most sites had been completed or was under construction by 1993, it was agreed that only the effect upon accidents could be investigated, and indeed this was a conclusion of an earlier visit by TRL officers in 1991[9].

Initially, ten sites were identified at which accident histories were to be investigated. These are listed in Table 2 and were selected simply on the basis of being those where the countermeasures had been installed longest (completion between 1989 and 1991) so that as long an 'after' period as possible would be available. Accident data retrieval therefore aimed to provide 3 years 'before' data and as long a post-installation as possible. This entailed extensive time spent at all relevant local police stations covering the area around each of the ten blackspot sites. This was because full and accurate accident data were not available on computer, certainly in the 'before' period.

Table 2 World Bank blackspot sites for accident data evaluation

Site No.	Route No.	Listed Km/MS	Location
1) 1 Pinang	F0001	MS13-14	Bumbong Lima, Butterworth - A.Setar, P.
2) 2	F0001	MS6¼-7	Bukit Tengah, Butterworth - Ipoh, P. Pinang
3) 3	F0001	MS17-18	Sg. Bakap, Butterworth - Ipoh, P. Pinang
4) 4	F0001	Km37-38	Nebong Tebal, Butterworth - Ipoh, P. Pinang
5) 5	F0001	Km 66	Kelumpang, Selangor
6) 6	F0001	Km72-73	Kg. Baru Kelumpang, Selangor
7) 7	F0005	MS14-14½	Kg Jenjarom, Jalan Klang-Banting, Selangor
8) 9	F0005	MS20-20½	Klang-Kuala Selangor, Banting, Selangor
9) 10	F0005	MS28½-29	Kuala Selangor, Selangor
10) 12	F0005	Km 114	Jalan Pontian - Batu Pahat, Johor

As accidents are not catalogued by location, this was not a simple task for the investigating team. Data were also collected for lengths of road each side of the treatment site (for a total of 2 to 4kms) to act as 'control' data, ie. carrying the same type of traffic during both 'before' and 'after' periods but the road environment itself hopefully being unchanged. The installation period at each site has been kept separate in the analysis, and excluded from the final 'before' and 'after' evaluation.

Unfortunately, the first site had to be abandoned from the study owing to the discovery of accident location discrepancies (linked with telegraph post numbers, which had been used for accident location, being changed during the study period and also found to be non-unique).

When the accident data were retrieved insufficient time had elapsed after countermeasure installation when to be able to collect a full 3-year 'after' period, which is the widely accepted time normally required for statistically valid comparisons of 'before' and 'after' accident histories. However, careful note was made of the precise start and end of each remedial works and the longer 'before' period was averaged by month to obtain a 'normalised' accident frequency matching the length of 'after' period at each site. Only accidents involving personal injury were considered in this comparison due to their assumed more reliable reporting. A full list of injury accident changes before, during and after installation for various accident types, taking account of changes at the 'control' sites, is given in ref. [10].

A summary of the calculated total injury accident changes after the installations and types of treatment at each site is given in Table 3 and shown graphically in Fig. 7. In this sample it is apparent that there was considerable variation in the accident rates at the sites identified as blackspots, with two sites having 2 or less injury accidents per year.

It must be noted that, probably owing to the relatively shorter 'after' periods, most of the accident changes are not statistically significant. Nevertheless the results at least give an indication that on the whole there has been some improvement in accidents at six of the nine sites. The unweighted overall reduction at these nine sites is about 24% (or a total of 26.7 injury accidents per year). Caution needs to be exercised in interpreting this overall success since, although the general increasing accident trend is accounted for by consideration of appropriate control sites, no account has been taken of the possible regression-to-mean effect. This is the statistical effect which exists when only the highest accident sites are considered such that accident numbers will appear to go down in subsequent years even if no action is taken. Only about two years of 'after' data was available at most sites, and for this period it has been reported elsewhere[11] that the regression-to-mean effect could be between 7 to 15% of the benefit. However, as several of the sites have experienced relatively low accident rates in the 'before' period this effect may not be so large.

At two of these (sites 04 and 06) there has been more than an 80% reduction in injury accidents and this is statistically significant at the 1 percent level. At site 04 the junction improvements appear to have had the most significant effect on sideswipe accidents and those involving motorcyclists. This is also true of site 06 with perhaps the addition of overtaking accidents which may well have been improved by the new chevron signs.

Assuming an average injury accident cost of RM33,000 (US$13,525), the first year rate of return for these two sites is 31% and 190% respectively. The higher return at the latter site, 06, is largely due to the remedial work costing only about a third of the price of the other site. Generally,

Table 3 Overall summary of injury accident changes following remedial work at blackspot sites and first year rate of return.

Site No.	Brief description of remedial work {Cost}	Expected accs from before period per year	After accs per year	Increase in accs per year. -ve indicates decrease	% increase -ve indicates decrease	FYRR % -ve is a loss
02	Sealed shoulders; widening; realignment; bus bays; double white lines. {US$437,330}	17.9	24.0	**6.1**	**34**	**-19**
03	Removal of ~100m of central median; marked right turn bay; reduced width by road marking. {US$178,710}	31.5	26.1	-5.4	-17	41
04	Cross roads made into left-right stagger; right-turning lane; raised splitter islands on minor arms; signs and bus bay. {US$391,920}	10.8	1.8	-9.0	-83*	31
05	Guard rail on bend; double white lines; bend signs; chevron boards. {US$139,060}	8.7	4.3	-4.4	-51	43
06	Superelevation on bend; bus stops moved; small junction improvements; guard rail; chevron boards; warning signs. {US$139,069}	23.0	3.4	-22.8	-85*	190
07	Junction widening and traffic signals {US$339,130}	12.4	19.0	**6.6**	**53**	**-26**
09	Minor T-junction arm moved slightly; guard rail and chevron boards. {US$126,480}	6.3	2.9	-3.4	-54	36
10	Roundabout removed; initially uncontrolled, now traffic signals; central median; right turn lane. {US$86,995}	1.7	5.2	**3.5**	**202**	**-54**
12	Minor road entry shifted to other side of bend; guard rail; signs. {US$13,115}	2.0	0.9	-1.1	-55	113

Notes: * = Change statistically significant at at least 5% level
FYRR = First Year Rate of Return assuming average injury accident cost = RM33,000 (US$13,525)

however, the FYRR at most of the sites is rather low which probably reflects the fact that the treatments could chiefly be classed as high cost (with the exception of site 12, although new realignment work is also planned here which is being combined with work at another site in a

contract valued at approximately US$1.68M). It would appear that in several cases work in addition to that which might address the particular safety problems at a site (such as extensive roadside drainage where wet road accidents were negligible) had also been included.

What is perhaps of greatest concern is that at three of the sites which have had extensive remedial work implemented, the accident rate has increased. Looking at the type of remedial work which was

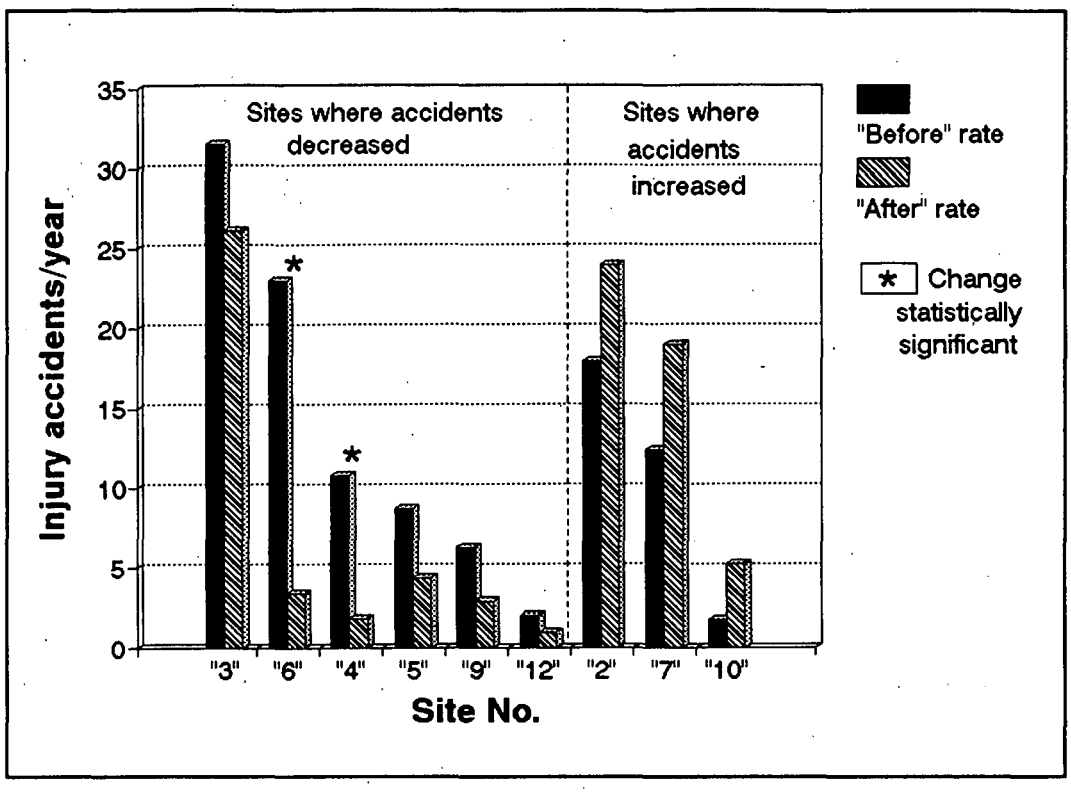

Fig. 7 Changes in injury accident rates at blackspot sites after remedial work complete

carried out at these sites 02, 07, & 10, even without a thorough knowledge of the accident history, it is not difficult to envisage reasons why accidents appear to have increased. At site 02 the road has been widened: this may well have encouraged higher speed and indeed motor cycle accidents seem to have increased. At site 07 a junction was widened and traffic signals installed: again this may have encouraged higher approach speeds and the greater temptation to 'run the red' light. At site 10 a roundabout was removed and the junction left uncontrolled initially (though traffic signals have now been installed). Previously approach speeds on all arms of the roundabout would have been relatively slow, whereas now overtaking, rear-end and motorcycle accidents have all increased.

A more cost-effective use of the capital spent on at least the nine projects investigated here, could probably have been achieved by prior and thorough site investigations. This assumes, of course, that relevant personnel had been trained in accident investigation techniques. Applying such techniques should have identified common safety problems at the sites, thereby assisting the design of appropriate countermeasures which specifically addressed those problems.

If we assume the same level of accident saving over all the 69 sites (inclusive of pedestrian bridges) which will have been treated during the 6th Malaysia Plan, then the very approximate injury accident saving would be 205 per year. Assuming an average of 1.35 injured persons per injury accident (from 1993 figures) then this investment represents only about 0.7% of the current road accident casualties of the nation.

3. PROPOSALS FOR GETTING BACK ON TRACK

From the previous sections it has hopefully been established that much more effort is necessary in trying to reduce the road accident casualty toll by as many different groups as possible (the integrated approach). However, this paper is focusing on the road engineering approach which, as stated earlier, should ensure that the road geometry and surface condition minimise the chances for drivers to make mistakes; allow adequate space for effective evasive action when mistakes are made; and also make the road environment as "forgiving" as possible when collisions do occur.

3.1 Disaggregation of targets

The previous section has discussed general areas for safety improvement based on a simple analysis of the national accident database. However, for the Government of Malaysia's casualty reduction target to be effective - leaving aside for the present whether it is indeed achievable - there is a need for all road engineers throughout the country to relate this to the particular road system for which they have responsibility. That is, each authority should be given gradual achievable goals which they should review on an annual basis.

As no research has been carried out in Malaysia to determine the overall influence of environmental factors in accidents, it is suggested that the UK's Institute of Highways' (IHT) recommendation[4] be adopted. This states that an overall accident reduction target by highway engineering of the order of 15 per cent should be feasible. That is, the overall engineering contribution to the Government's target should be about **one half** of the 30 per cent reduction total.

In order to calculate exactly how many casualties need to be saved by the end of 1999 to achieve the Government target, it will be necessary to calculate the expected number of accidents during that year with no action taken. This is because the general upward trend due to increasing levels of traffic and other factors will also have to be part of the target. Fitting a simple regression to the annual fatality numbers since 1974 (the start date of published accident data), this predicts nationally an increase of approximately 36% of the base 1989 year by the year 2000. The recommended formula, therefore, for an individual road authority target is:-

$$n_t = \frac{1}{2} \times \frac{(0.30 + 0.36) \times N_{1989}}{y} \qquad \text{.....(1)}$$

where n_t = Target no. of injury accidents/year to be reduced
N_{1989} = Total no. of casualties in 1989
y = No. of years from now until end of 1999

It will be noticed that total casualties rather than fatalities have been used in the above, since it is unlikely that there will be many sites with more than one fatality per year, and these do not tend to occur regularly in consecutive years. It is assumed that if all road authorities concentrate on improving their most hazardous sites and can produce the above reductions in all injury accidents then this should also achieve the required reduction in fatalities. It should be stated that this is not an easy target to achieve, and will require the immediate allocation of much greater resources and widespread dedication of all those involved in the task.

3.2 Accident Investigation Units

It is strongly recommended that accident investigation teams be set up as a Unit in each road authority with the prime objective of meeting these targets. The relevant accident database and tool for analysing it will, of course, need to be made available to all road authorities, and this can easily be facilitated by distribution of TRL's software analysis package MAAP[12]. The national database is already stored on MAAP and being used by Police Headquarters and other central government departments. The Units could have the following main functions or objectives:

i) check and code location and other details on accident report forms, and send to HPU

ii) carry out investigations to determine appropriate areas for action as well as detailed studies at individual high-accident sites

iii) apply cost-effective countermeasures to reduce accidents

iv) produce an annual Road Safety Plan with details of how they will achieve their target

v) carry out independent safety audits of new schemes and maintenance/rehabilitation of existing roads to help prevent accidents

In the U.K. a similar casualty reduction target of 30% by the year 2000 was set in 1984, though this is, of course, a much less ambitious target than that set in Malaysia since it covers a longer period in which there has been a lower traffic growth rate. However, the most serious casualties have already (by 1992) been reduced by 24.5% and 33.0% for fatal and seriously injured respectively[13]. It has been argued that much of this success was due to the setting up of Accident Investigation Units, which was in itself due to a legal requirement of the Road Traffic Act of 1988 to "carry out studies into accidents arising ...on roads...within their area...and to make measures appropriate to prevent such accidents".

It is therefore suggested that, in order to ensure that action in setting up such Units is begun swiftly, a similar mandatory requirement of road authorities should be made in Malaysia.

3.2.1 Staffing

It is considered most important that the staff for these Units work full-time on safety and are not simply staff in existing posts with road safety occupying only a proportion of their time. The responsibility of achieving the targets will require them to concentrate fully on the accident reduction goal and not be diverted by other tasks.

The IHT[4] recommend staffing levels of one engineer or technician for every 400-1000 reported injury accidents. With the additional work of accident location coding and safety audits and the currently increasing casualty trend, it is suggested that one per 300 injury accidents may be a more appropriate level to aim for in Malaysia.

Formal training for specialised staff in these Units will be required and it is suggested that the new

Guide[14] discussed later (Section 3.2.5) could be used as a basis for setting up regular courses. Much of the skill of recognising potential safety problems and designing appropriate countermeasures will, however, probably be gained "on-the-job" within the specialist Unit.

3.2.2 Road Safety Plans

In order that a gradual programme of safety improvement is managed efficiently it is strongly recommended that all road authorities are required to produce an annual Road Safety Plan document which is published.

Road Safety Plans are now produced annually by most road authorities in the United Kingdom regardless of the current success or failure of each in achieving its target. They provide the public and higher authorities with a valuable record of the efforts the authority is making on their behalf towards improving the safety of the road network.

Within the Plan the local casualty reduction target should be clearly stated and a strategy for achieving the target developed. The authority will need to review existing highways and transportation policy and investigate accident trends for various road user groups in the authority's geographical area.

The Plan should contain background to the road accident situation in the authority area (accident trends with respect to road user groups, road features etc) and a summary of proposals planned (including major capital schemes, smaller remedial engineering work, safety audit, maintenance, costs, relationships with other agencies, and could also include safety publicity and traffic law enforcement). It should also describe the methods used for monitoring and evaluation and should include a summary of the previous year's work and effect on accidents.

3.2.4 Financial allocation

Adequate budget provision is essential to cover the cost of running the proposed Road Safety Units and, of course, of funding the remedial works they recommend.

Using the amount spent nationally on the World Bank-funded blackspot improvement programme, Malaysia has been spending an average of US$6.8M per year on safety engineering works. This is the equivalent of US$1480 per year per fatal accident or 37 cents per head of population per year.

For comparison, the UK's estimated annual spend on pure safety engineering works is £70M (or US$112M). This means that they are spending over 5 times more per head of population and almost 10 times more per fatal accident than Malaysia.

It is not suggested that Malaysia spend equal amounts as the UK owing to differences in development and GDP, but the above figures are simply quoted to suggest that a greater capital expenditure be allocated than at present. As an approximate guide to the overall budget required to achieve the above injury accident targets, the IHT suggest the amount should be :-

$$\frac{C \times n_t}{R} \quad \ldots\ldots\ldots (2)$$

where C = Average cost of an injury accident
n_t = Target no. of injury accidents/year to be reduced
R = Average benefit to cost ratio for treatment

For Malaysia as a whole from now until the year 2000:

From eqn. (1):-

$$C = \text{US\$13,525}$$

$$n_t = \frac{1}{2} \times \frac{(0.30 + 0.36) \times 30037}{5} = 1982$$

$$R = 2 \quad \ldots\ldots \text{(a conservative estimate)}$$

which gives an annual overall budget requirement = **US$13.4M**. This should be updated when a more recent accident costing becomes available or new trend in accidents is apparent. The estimates for each individual road authority can be made in a similar manner.

3.2.5 Guidelines

It was recognised by IKRAM that due to the lack of formalised accident reduction work currently being carried out in many road authorities, there is likely to be a lack of experience in this field, and thus a great need for a basic reference guide. This has now been produced and is entitled "Interim Guide for identifying, prioritising and treating hazardous locations on roads in Malaysia"[14].

This Guide which has been produced jointly by TRL and IKRAM contains much of the proposals described above. Although based on the UK RoSPA Road Safety Engineering Manual[15], it has been substantially modified for its intended for users, that is, traffic engineers and road safety officers in all road authorities of Malaysia and, indeed, copies have now been widely distributed.

An attempt has been made to make the 140-page Guide as comprehensive as possible covering the complete range of accident reduction work which it is suggested that road authorities should carry out; that is, from identifying hazardous locations and investigating individual problem sites through to producing and implementing an effective strategy plan.

The Guide comprises seven main chapters, of which the first two include an introduction to the accident problem of Malaysia, managing a strategy and the accident data. In order to be able to plan the most efficient expenditure of public money on engineering improvements, a reliable accident database is essential. The Guide therefore has made the assumption that such data on the MAAP software system is available to the road authority, as stated in Section 3.2. Indeed the role of the various public bodies now involved (or recommended) in compiling the database is clearly specified. Much greater improvement is required in the recording of accident location and this inevitably involves close cooperation between the road authority and the local Royal Malaysia Police. Unless the database can be trusted to give accident frequencies at their true location, then engineers cannot be certain they are treating the actual problems at the appropriate places, nor will they be able to judge how effective they have been in the action taken. The Guide therefore recommends methods the various authorities should employ in implementing this responsibility.

The remaining five chapters include a step-by-step approach to tackling the problems efficiently. These cover the subject areas of Investigation, Diagnosis of problems, Selection of appropriate

treatments, Implementation of schemes, and Evaluation of their effect. Fig. 8 illustrates the ten steps which are described fully in the Guide.

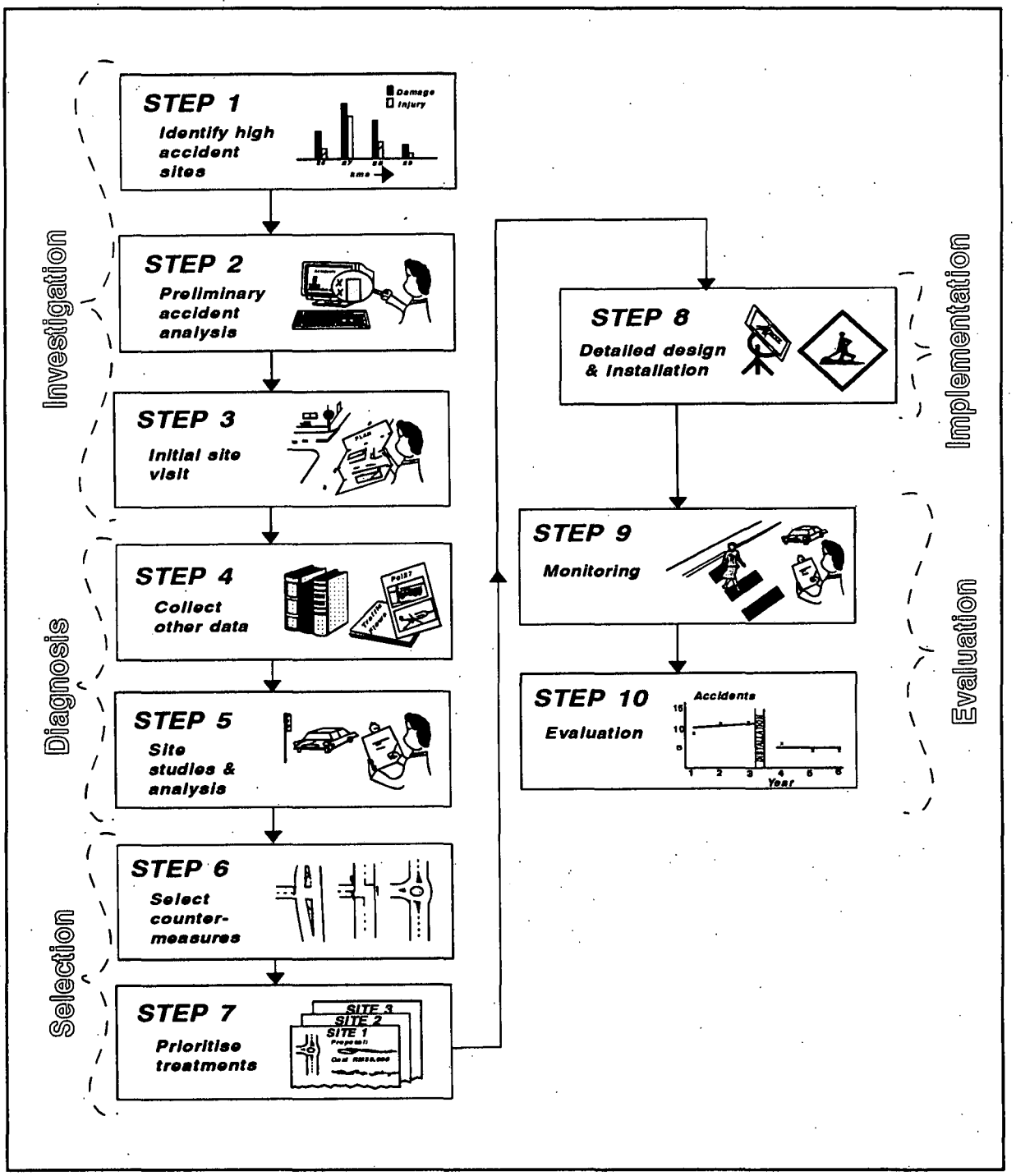

Fig. 8 The ten steps to reducing accidents included in the Guide

4. CONCLUSIONS

(1) It appears from the records that road traffic accidents in Malaysia are increasing dramatically when fatalities should really be decreasing sharpely each year if the Government's casualty reduction target is to be met. Fatality rates have increased by 24 per cent since the target base year of 1989 and, according to well-known macro models, this is even higher than might be expected from the large growth in traffic over this period.

(2) With regard to the road engineering aspects of the Road Safety Master Plan of 1991, it would appear that many road authorities are not managing road safety on their networks adequately. Very few authorities claim to have full-time safety staff, with percentages of staff time totalling less than 1 person in most cases. Insufficient staff time is currently allocated to checking police accident data (about half the questionnaire respondents spend less than 2-hours per week on this task). Few authorities had identified blackspots and of those that had, only a few had been considered over the past three years. Spending on accident countermeasures in almost all cases has to compete with general maintenance needs, and studies of specific problems at individual sites are not generally being made.

(3) Results from an accident analysis at nine of the Phase I identified blackspot sites on Federal roads have demonstrated some success with the remedial work implemented. Although not yet statistically significant and future monitoring is necessary, there would appear to have been an overall saving in injury accidents of about 24% at these sites (or between 9% and 17% if allowance is be made for the possible regression-to-mean effect). At three of the nine sites investigated injury accidents may have actually increased by an average of about 5 per year.

(4) The remedial work at the so-called World Bank accident blackspots all tended to be high cost and the estimated overall saving from these is only about 0.7% of the current injury accidents in Malaysia. It is therefore suggested that this money could have been spent more effectively by finding cheaper solutions to properly investigated safety problems over a much greater number of sites. This should in turn have yielded a much better casualty reduction.

(5) It is strongly recommended that the national target be disaggregated to realistic local targets to be achieved annually by each road authority in Malaysia.

(6) To achieve these targets much greater investment will be required and it is further recommended that Accident Investigation Units be set up in each authority with a full-time, trained staff (with sole responsibility for road safety and meeting the local target). Training courses for such permanent staff will need to be provided and these could be based on a relatively new IKRAM/TRL Guide[14].

(7) There will be a need to allocate adequate budgets to the Accident Investigation Units to enable them to carry out proper studies and implement large numbers of preferably low-cost accident countermeasures each year.

(8) Maintenance of the local accident database would be an important job function of these Accident Investigation Units. Further improvement is certainly required in order for this database to accurately determine where the main problems are located and to reveal

appropriate treatments.

(9) To help manage safety in their area and increase accountability, the Units should produce and publish an annual Road Safety Plan in which the main problems of the area are analysed, a priority list of sites given, forthcoming site work outlined, previous work reported and evaluated, and the overall progress towards the target clearly displayed.

(10) Much more needs to be done and it is suggested that only by introducing such a new institutional change can the process of regular monitoring and treatment of safety problems be implemented on the scale required. Indeed, if these changes are not introduced it is believed that the country stands little chance at all of achieving the Government's accident reduction target, and a far more hazardous situation than that which existed in 1989 will prevail.

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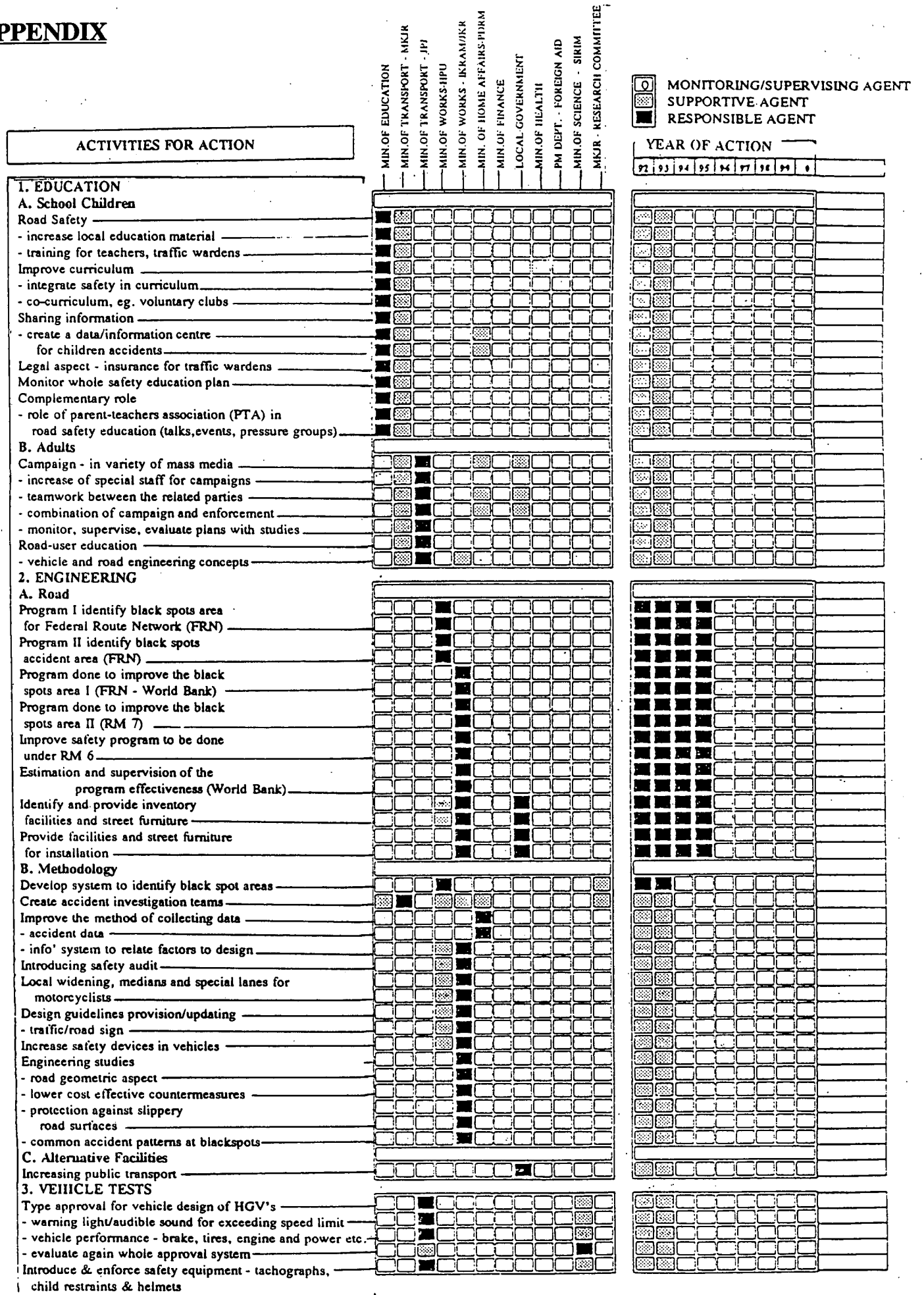
APPENDIX


MIN.OF EDUCATION
MIN.OF TRANSPORT - MKJR
MIN.OF TRANSPORT - JPJ
MIN.OF WORKS-JPU
MIN.OF WORKS - IKRAM/JKR
MIN. OF HOME AFFAIRS-PDRM
MIN.OF FINANCE
LOCAL GOVERNMENT
MIN.OF HEALTH
PM DEPT. - FOREIGN AID
MIN.OF SCIENCE - SIRIM
MKJR - RESEARCH COMMITTEE
MONITORING/SUPERVISING AGENT
SUPPORTIVE AGENT
RESPONSIBLE AGENT
YEAR OF ACTION
92 93 94 95 96 97 98 99 0
ACTIVITIES FOR ACTION
1. EDUCATION
A. School Children
Road Safety
- increase local education material
- training for teachers, traffic wardens
Improve curriculum
- integrate safety in curriculum
- co-curriculum, eg. voluntary clubs
Sharing information
- create a data/information centre for children accidents
Legal aspect - insurance for traffic wardens
Monitor whole safety education plan
Complementary role
- role of parent-teachers association (PTA) in road safety education (talks,events, pressure groups)
B. Adults
Campaign - in variety of mass media
- increase of special staff for campaigns
- teamwork between the related parties
- combination of campaign and enforcement
- monitor, supervise, evaluate plans with studies
Road-user education
- vehicle and road engineering concepts
2. ENGINEERING
A. Road
Program I identify black spots area for Federal Route Network (FRN)
Program II identify black spots accident area (FRN)
Program done to improve the black spots area I (FRN - World Bank)
Program done to improve the black spots area II (RM 7)
Improve safety program to be done under RM 6
Estimation and supervision of the program effectiveness (World Bank)
Identify and provide inventory facilities and street furniture
Provide facilities and street furniture for installation
B. Methodology
Develop system to identify black spot areas
Create accident investigation teams
Improve the method of collecting data
- accident data
- info' system to relate factors to design
Introducing safety audit
Local widening, medians and special lanes for motorcyclists
Design guidelines provision/updating
- traffic/road sign
Increase safety devices in vehicles
Engineering studies
- road geometric aspect
- lower cost effective countermeasures
- protection against slippery road surfaces
- common accident patterns at blackspots
C. Alternative Facilities
Increasing public transport
3. VEHICLE TESTS
Type approval for vehicle design of HGV's
- warning light/audible sound for exceeding speed limit
- vehicle performance - brake, tires, engine and power etc.
- evaluate again whole approval system
Introduce & enforce safety equipment - tachographs, child restraints & helmets

APPENDIX (Continued)