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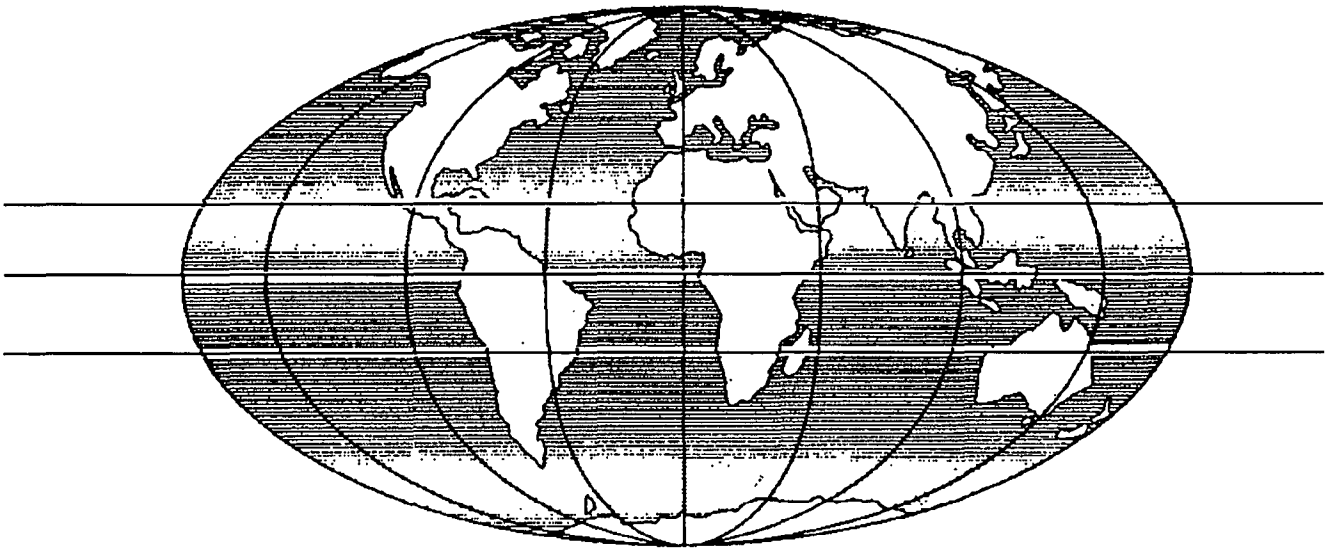
TITLE Seminar on road safety, Malaysia : Progress towards the national casualty reduction target since 1991

by C J Baguley



Overseas Centre
Transport Research Laboratory
Crowthorne Berkshire United Kingdom

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PROGRESS TOWARDS THE NATIONAL CASUALTY REDUCTION TARGET SINCE 1991

Chris J Baguley
Transport Research Laboratory
United Kingdom

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.

Three full years have now elapsed, and it is timely to review progress towards achieving the national target. This paper, therefore, summarises the recommended plan made in 1991 and focuses on its engineering aspects by attempting to report what has been achieved to date.

2. THE 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.

The above fatality rate reduction target for Malaysia takes some account of the relatively rapid expansion of vehicular traffic in recent years (see Fig. 1) by assuming a linearly increasing traffic growth pattern. 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.**

It was recognised that road accidents and, of course, casualties were increasing (see Fig. 2), partly as a direct result of the rapidly expanding vehicle fleet of the country; and so in 1991

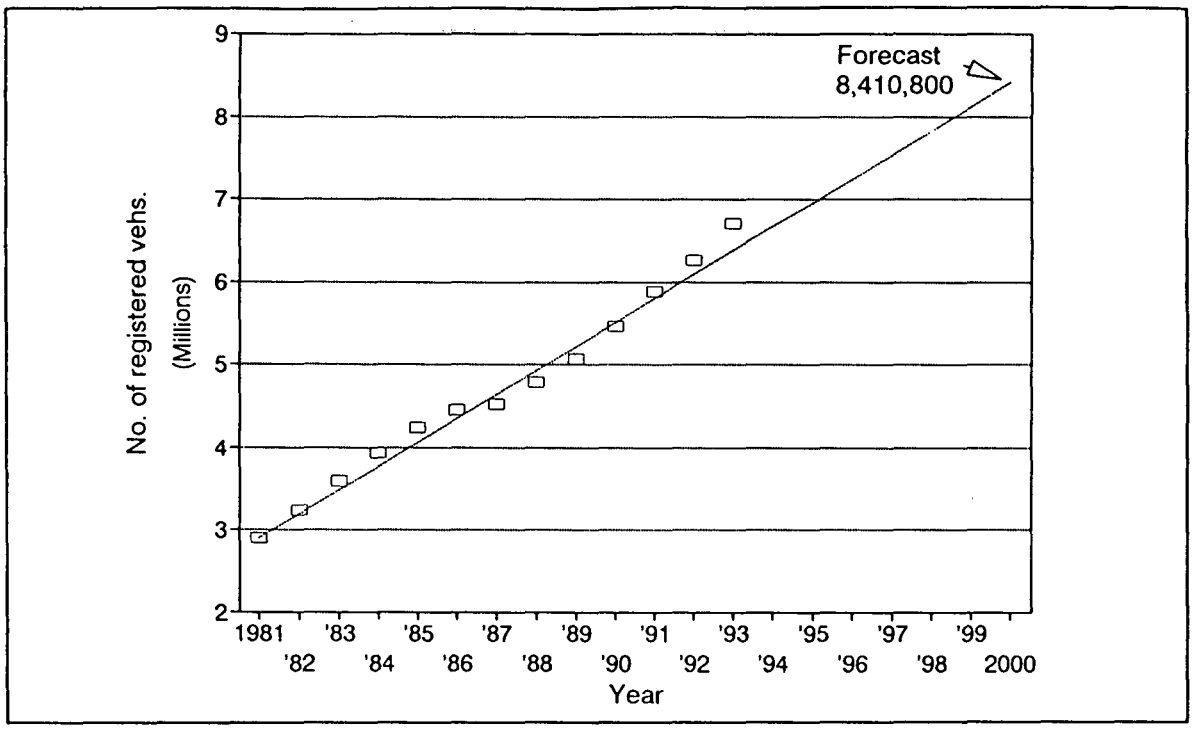


Fig. 1 Growth of registered vehicles in Malaysia, 1981-1993

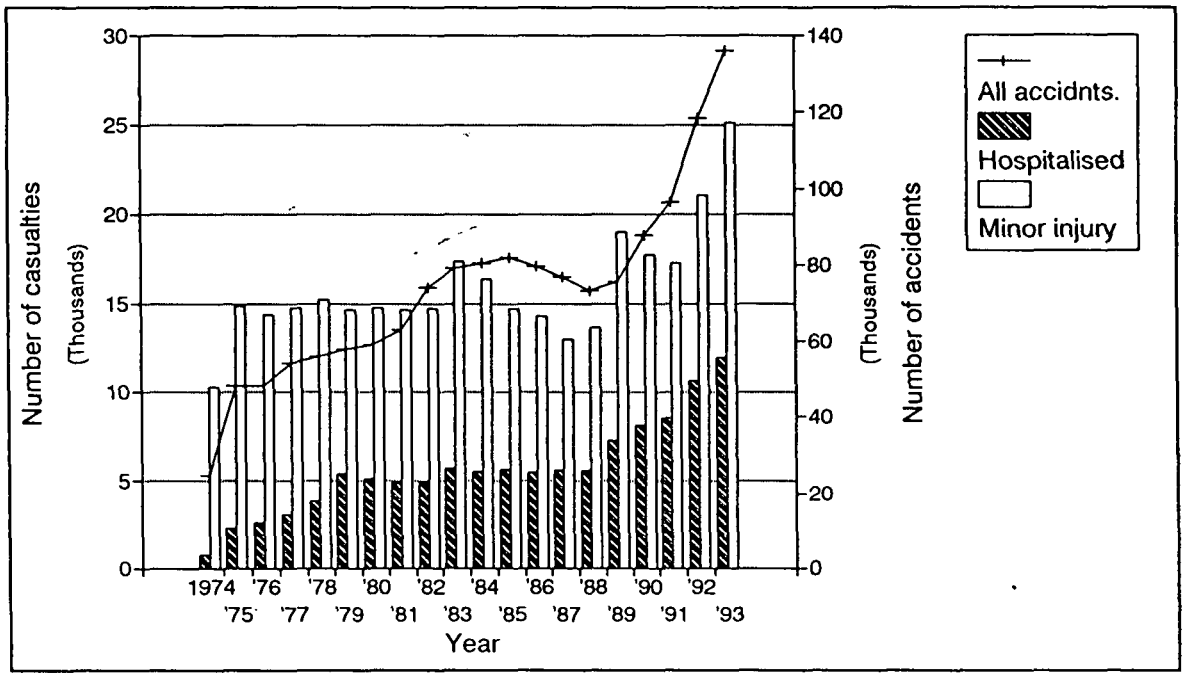


Fig. 2 Road accidents and injured persons in Malaysia, 1974-1993

the National Road safety Council (MKJR) organised a brainstorming meeting on Langkawi 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.

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 also an under-reported, major causal factor. In the UK, for example, it has been estimated from on-the-spot independent accident survey teams that the road environment is a contributory factor in 28% of all accident cases[3]. 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].

This paper, therefore, focuses chiefly on the road engineering approach to improving safety though it is, of course, recognised that an integrated approach should really be adopted; ie. requiring much-needed efforts in the areas of education, enforcement and vehicle engineering, many of them being highlighted in the National Action Plan (see below).

3. THE NATIONAL MASTER PLAN

As stated in the previous Section, there were nine main areas specified where it was decided that action was required, and these were:-

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 Appendix I 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 supportive agencies, where appropriate.

3.1 Education

On *Education* the Plan divided responsibilities between the Ministry of Education and the Jabatan Penhangkutan Jalan (JPJ) of the Ministry of Transport for child and adult education improvement. For children it specified an increase in education material and expanding the curriculum on road safety taught in schools, as well as special training for teachers and school crossing wardens. The Ministry was assigned the responsibility for monitoring this safety education plan. The Plan noted the need for the complementary role of parent-teacher associations to organise talks, road safety events and act as pressure groups (eg. in campaigning for crossing facilities). The Plan also stipulated the need for a child accident database to be set up at a data and information centre.

For adults, the Plan concentrated on strengthening the specialised staff responsible for mass

media campaigns in order to coordinate teamwork between various interested parties, and to monitor and evaluate the effects of campaigns. It also noted the need for JPJ to increase adult education of engineering concepts in relation to both vehicles and the environment.

3.2 Engineering

For *Engineering* the Road Safety Plan focused chiefly on the blackspot improvement programmes specified in the 6th Malaysia Plan which were all on Federal routes and were part-funded by the World Bank. It also itemised the need to identify new blackspot sites and draw up a second programme for the 7th Malaysia Plan. The Highway Planning Unit has been given responsibility for the identification of sites and JKR the responsibility for detailed design and implementation. An evaluation of the present countermeasures' effectiveness was specified. Both JKR and the town councils are required to make a road inventory of facilities and road equipment.

Still under engineering, the MKJR were to create an accident investigation team and PDRM to 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.

3.3 Vehicle testing

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 vehicle and buses an in-vehicle audible and cab-mounted light warning of exceeding the speed limit were planned.

Perhaps 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.

3.4 Legislation enactment

A range of new legislation for introduction by 1993 was the objective in this area. This included the compulsory wearing of child restraints and helmets for motorcycles; changing the law to enable full-face motorcycle helmets; fitting of air bags; tax exemption for safety equipment; limiting the speed and numbers of powerful motorcycles (or 'superbikes'); and increasing penalties for traffic law offences related to safety. These changes in legislation required input from the Standards and Industrial Research Institute of Malaysia, SIRIM (child restraints and helmet design), Ministry of Finance (tax and insurance incentives) and JPJ (helmets, air bags and motor-cycle restrictions) .

3.5 Training and testing

It was stated that JPJ should introduce eye tests for drivers as a condition for a licence and

provide (re-)training for errant speeding motorcyclists and heavy vehicle drivers. JPJ officers were themselves to be trained in first aid treatment by the Ministry of Health and to arrange subsequent training for certain target groups (eg. ambulance staff, police and firemen).

3.6 Road safety administration

The main recommendation here was the formation of a Road Safety Department to be operational by 1994. However, this recomendation 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.

3.7 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; effects of health, alcohol, drugs and pressure; protective clothing for motorcyclists; conflict studies; line of sight studies; haze, nighttime driving. The Plan called for research on improving the accident database, evaluations of driver training, media campaigns, counselling for accident victims, road signs, safety of State roads, and effectiveness of countermeasures. It also requires an efficient way of disseminating this information.

3.8 Law enforcement

Due to pressure of work by the Police, the Ministry of Home Affairs was to review the need to make accident reports in all cases. PDRM were required to introduce a new computerised system for paying compound fines at all police stations, to improve the accident reporting system and to enforce a minimum speed limit when introduced.

3.9 Medical service

The Ministry of Health was required to increase the number of trauma centres for accident victims in all States and also to compile a database for crash injuries.

4. 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. 2).

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

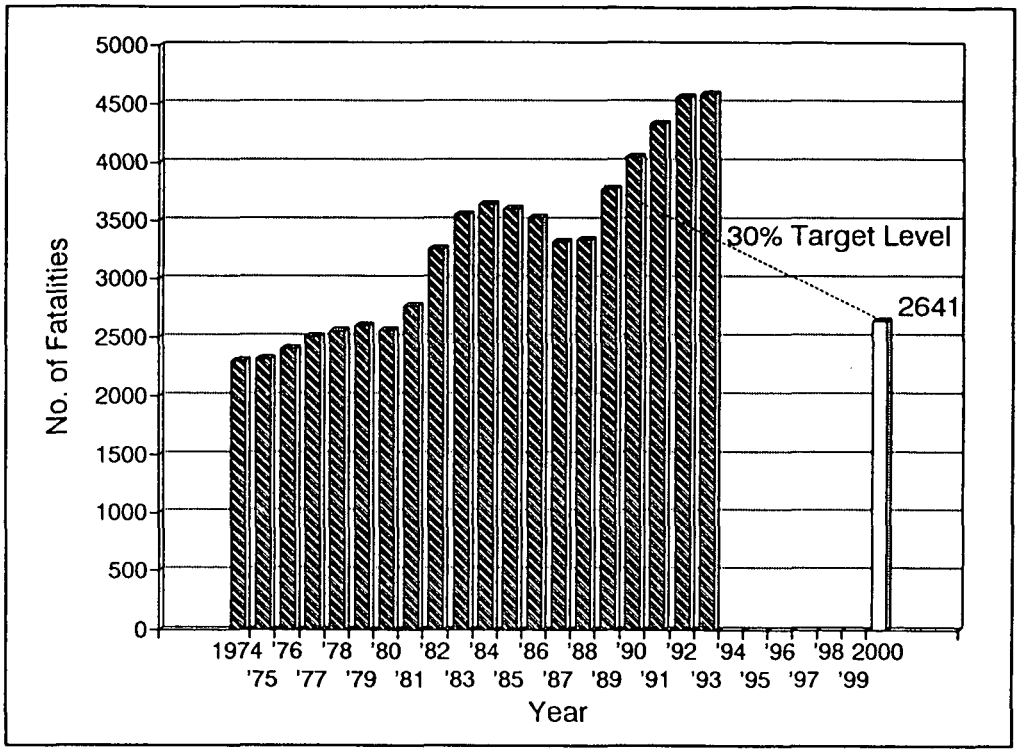


Fig. 3 Road accident fatalities and the reduction target

between accidents and volume with varying degrees of success and sometimes contradictory results. Perhaps the most famous and successful macroscopic model relating fatal accidents to population and vehicle registration was derived by Smeed[5] in 1949, which has been found to be still remarkably valid even in more recent years[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.

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, in reality 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*

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%)

be attributed to the increase in vehicles. Unfortunately, this also implies that *any safety improvements which have been introduced have failed to produce sufficient reductions in the nation's accident figures.*

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.

5. ENGINEERING PROGRESS WITHIN THE PLAN

It is beyond the scope of this paper to investigate how well all the actions mentioned in Section 3 have been implemented since it spans several Government ministries and departments. Hence this Section limits its investigation to the theme of this Seminar, namely, the road engineering aspects only. With reference to Appendix I, the following sections summarise and comment on each item in the order listed in the Engineering section (2).

5.1 Program I identify blackspots on Federal Routes.

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, PDRM, to 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 erroneous 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.

5.2 Programme II identify blackspot areas.

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.

5.3 Implement Program I.

World Bank funding was obtained for these sites which totalled approximately RM85.5 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 Cawangan Jalan involved realignment or road widening resulting in relatively high cost project values of between about RM1.8M and RM5.4M.

As of the author's last update in November 1994, 26 of the 42 sites had been completed with a further 9 under construction. Four of the remaining 7 were at the tender stage and it was hoped than the design and checking of the others would be completed soon in order to complete all works within the period of the 6th Malaysia Plan.

For the pedestrian bridge sites the cost ranged from RM309,000 to RM750,000. Twelve bridges have been completed and 7 are still under construction. Only 1 site is still under design with the rest at the tender stage.

Cawangan Jalan are relatively confident that all the sites listed will be completed by the end of June 1995.

5.4 Program II improve blackspot areas under 7th Malaysian Plan.

This was included in the schedule up to 1995 as it entailed drawing up a new list of blackspots, investigation of sites and designing new countermeasures for implementation within the next Malaysia Plan. The following paper in this Seminar will include a discussion of this item.

5.5 Safety improvements under the 6th Malaysia Plan.

This item is the improvement work to be carried out by the individual road authorities themselves, hopefully to include the blackspots of 5.2 in addition to supervising any projects of 5.1 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. The questionnaire is included for information as Appendix II.

A total of 135 questionnaires were sent out with a request for completion and return within 3 weeks. Unfortunately, a rather poor response was achieved with only 32 returned (24% response rate). 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 information, Figures 4(a),(b) & (c) summarise the main results obtained from the survey (excluding work on Program I) which is discussed in Section 5.6. It should be noted that the percentages given and following observations assume that the responses received were representative, and for such a small sample this may not be valid.

Although 19 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 during the past three years. From Fig. 4a, the single authority that sent a list of 23 blackspot sites unfortunately also returned the questionnaire blank, and so no further details of these sites or what the authority is doing to combat the problem are available.

Few authorities responded to the question about how often their blackspot list is revised but, of those that did, most claim to update this once per year.

There would appear to be some confusion and a general lack of clear definition of what constitutes a blackspot site. It would appear 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 condition of the road, though no further details were included.

Of those who had carried out accident remedial work since 1992, most appear to have treated junctions. This is reassuring since these are locations where conflicting manoeuvres are most

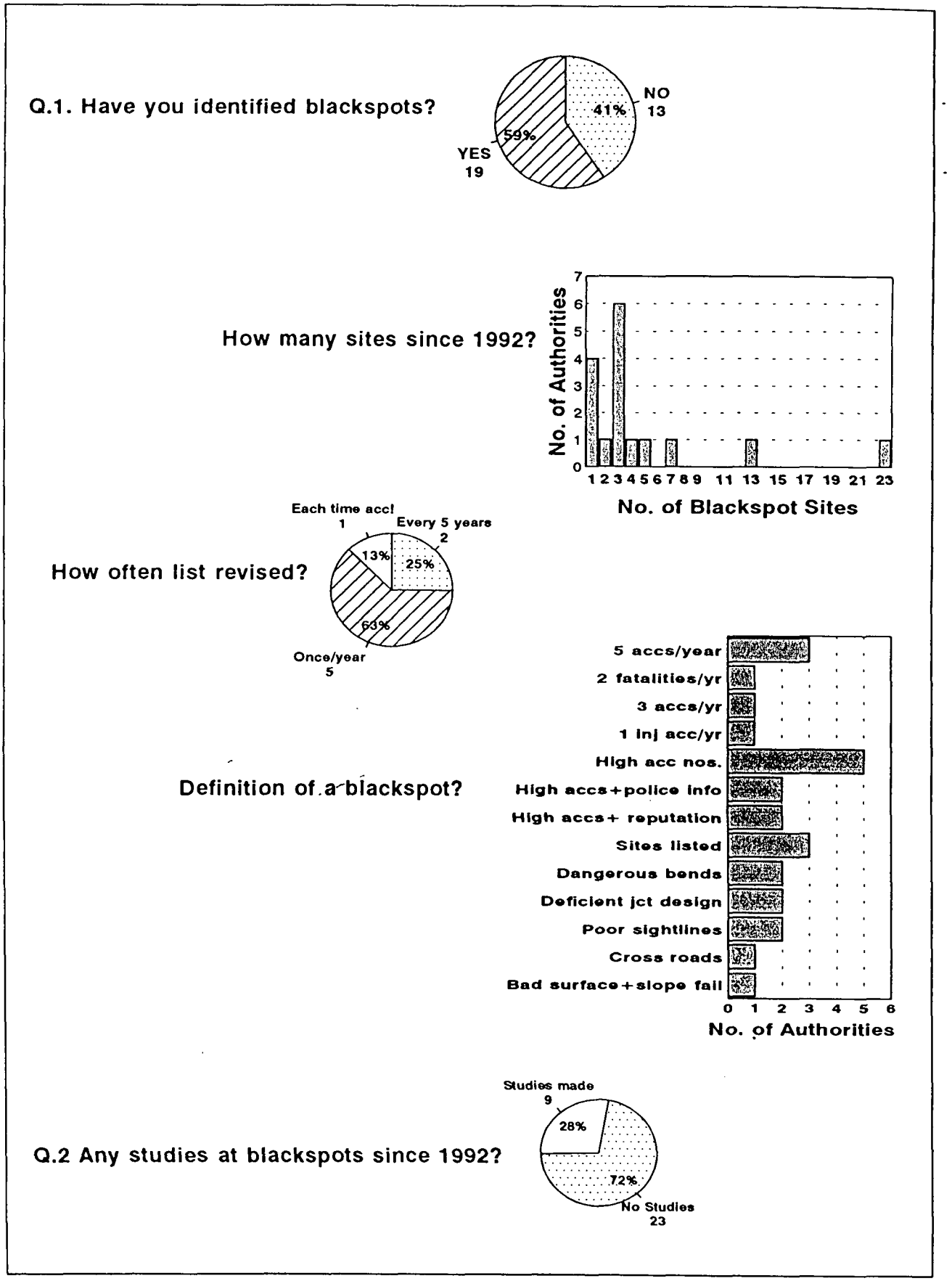


Fig. 4a Responses from road safety engineering questionnaire

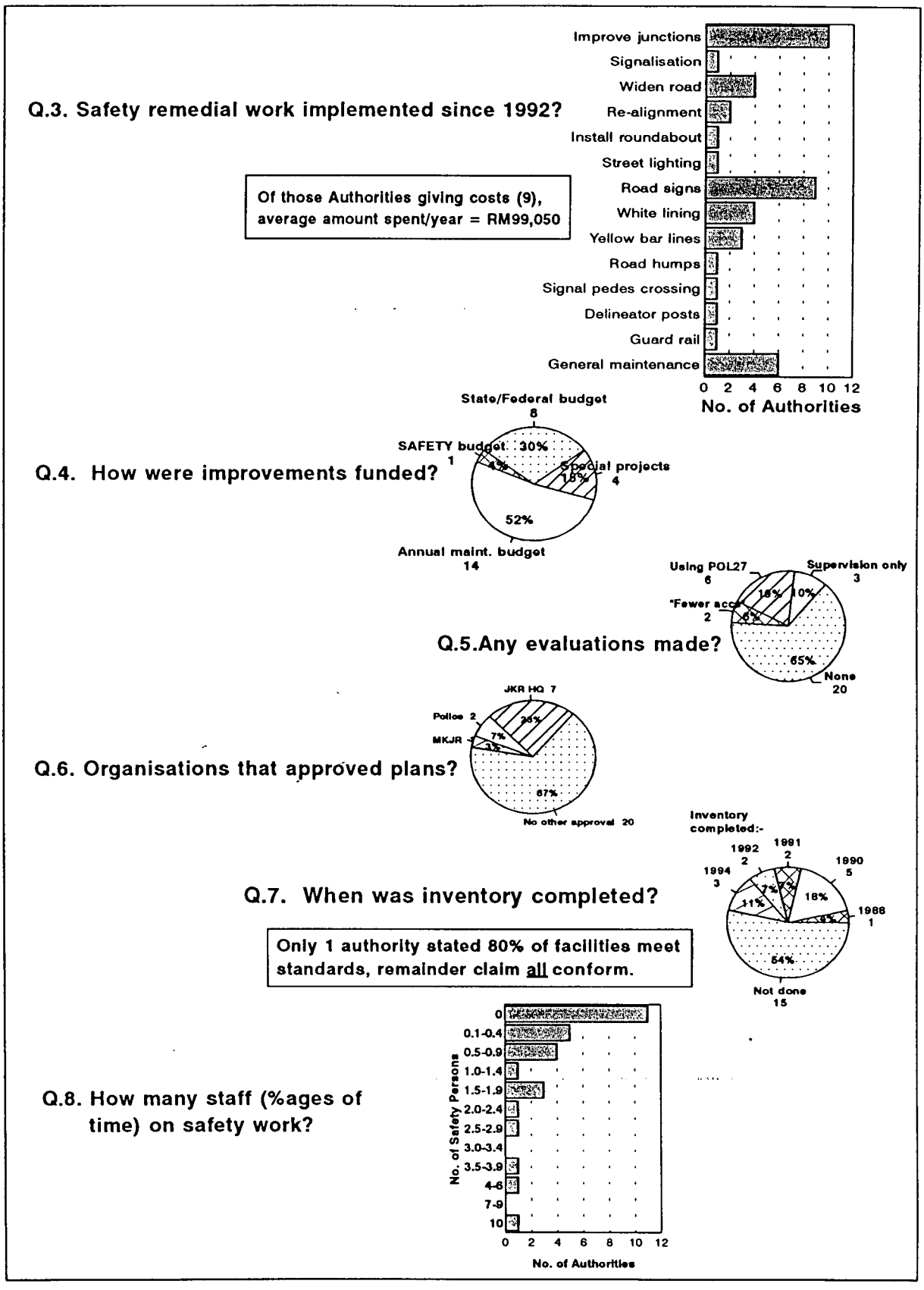
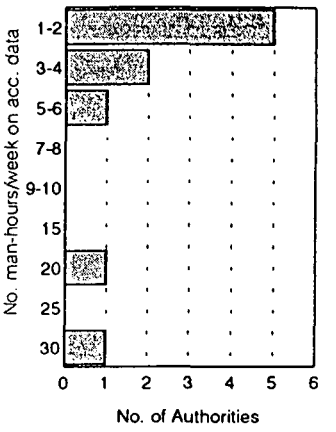


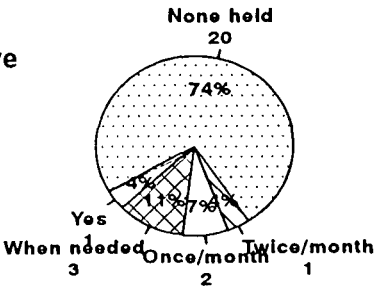
Fig. 4b Responses from road safety questionnaire (continued)

Q.8b How many man-hours/week on accident data checking?

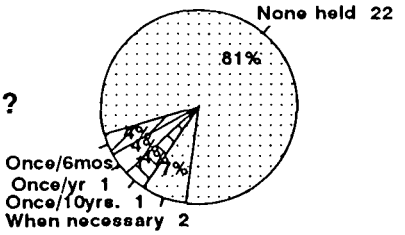


Q.9. Does your authority have regular meetings with:-

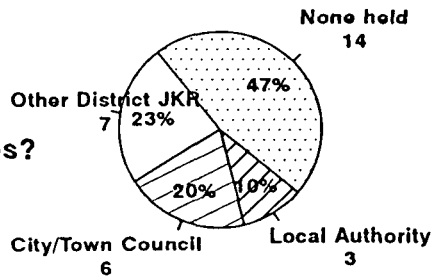
a) Police?



b) Local schools?



c) Other authorities?



Q.10. Regular meetings at which safety fixed item on agenda?

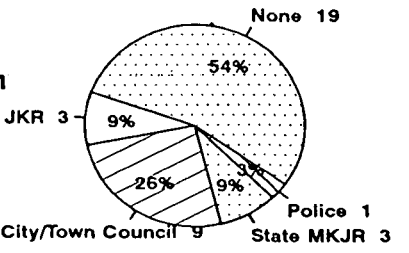


Fig. 4c Responses from road safety questionnaire (continued)

frequent and so tend to exhibit the highest clustering of accidents. The most common treatment listed was new or improved signing and, together with road markings, these are some of the lowest cost countermeasures that can be applied. New yellow bar markings are still being installed and, although this has been proved elsewhere to be an extremely cost-effective accident countermeasure, it is likely that over-use will diminish their effectiveness: they become less likely to capture driver attention. Road widening was listed by at least three authorities which should be welcomed by the vulnerable road user groups (pedestrians and 2-wheelers) since it gives other vehicles more space to overtake or take evasive action. However this safety benefit may be counteracted somewhat by vehicle speeds increasing following the perceived more open, and generally 'faster', appearance of the roads and the fact that pedestrians now have wider roads to cross.

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.

Most authorities have not carried out any evaluation of their actions and, although about 25% stated that either accidents had reduced or that they had at least looked at POL27 records, no figures were included as requested on the questionnaire.

All JKR road authorities were instructed to compile road inventories since about 1990, and it would appear that this is gradually being completed. According to the responses received, all road facilities comply with the appropriate standards, with only one authority estimating that about 20% of its facilities did not meet the standards in some way.

In response to the query regarding the number of people employed in road safety work, many stated that several people in their authority had differing percentages of their time devoted to safety. 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. 4b. It is again disappointing to note that most have none or fewer than the equivalent of 1 person working towards the improvement of road safety. Also, of the respondents to the accident data part of this question, half stated that they spent less than 2 man-hours per week in checking the police POL27 accident records. This may help to explain the rather poor quality of accident location data (discussed in a later paper of this Seminar[9] and see ref.[10]). It is also possible that several respondents misunderstood this question; for example, one authority claimed that they had ten people devoting *all* of their time to road safety, and yet failed to supply details of the number of blackspot sites or work carried out at specified sites.

With regard to communication as part of the integration of safety work, it would appear that the majority of authorities do *not* meet regularly with the local police and schools (74 and 81% respectively). There does, however, seem to be slightly better communication between different road authorities with only 47% stating that they do not meet regularly with any other road authority.

Just under half of the respondents reported that road safety was at least a fixed item on the agenda of any regular meeting, though information about the regularity of such meetings was rather scant.

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.

5.6 Evaluation of effectiveness of RM6 safety programme.

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[11].

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	F0001	MS13-14	Bumbong Lima, Butterworth - A.Setar, P. Pinang
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, the investigating team therefore had to initially scan all entries of accident location description in the relevant 24-hour report books for a period of at least three years before the schemes were implemented. The reference numbers of relevant accidents were noted so that the accident investigation files could be subsequently extracted. These files contain a collection of papers used in the court cases and include witness statements which needed to be read and checked for the location and other details of each accident. This information was then recorded on coding sheets and eventually entered onto MAAP.

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.

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).

Unfortunately, insufficient time had elapsed after countermeasure installation when the accident data were retrieved 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. Due to their assumed more reliable reporting, only accidents involving personal injury were considered in this comparison. 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 Appendix III.

The period of time for each installation, of course, varied. However, from the tables in Appendix III it can be seen that, with the exception of site 09, safety at the roadworks sites does not appear to have been a problem as overall accident rate tended to decrease during this period. This may have been as a result of lower traffic speeds being adopted through the chiefly major roadworks sections, though the change is not generally statistically significant.

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. 5.

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.

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; realignment; bus bays; double white lines. {RM1,067,079}	17.9	24.0	**6.1**	**34**	**-19**
03	Removal of ~100m of central median; marked right turn bay; reduced width by road marking. {RM436.053}	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. {RM956,293}	10.8	1.8	-9.0	-83*	31
05	Guard rail on bend; double white lines; bend signs; chevron boards. {RM339,309}	8.7	4.3	-4.4	-51	43
06	Superelevation on bend; bus stops moved; small junction improvements; guard rail; chevron boards; warning signs. {RM339,309}	23.0	3.4	-22.8	-85*	190
07	Junction widening and traffic signals {RM827,484}	12.4	19.0	**6.6**	**53**	**-26**
09	Minor T-junction arm moved slightly; guard rail and chevron boards. {RM308,614}	6.3	2.9	-3.4	-54	36
10	Roundabout removed; initially uncontrolled, now traffic signals; central median; right turn lane. {RM212,266}	1.7	5.2	**3.5**	**202**	**-54**
12	Minor road entry shifted to other side of bend; guard rail; signs. {RM32,000}	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

This is the statistical effect which exits 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[12] 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 high.

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

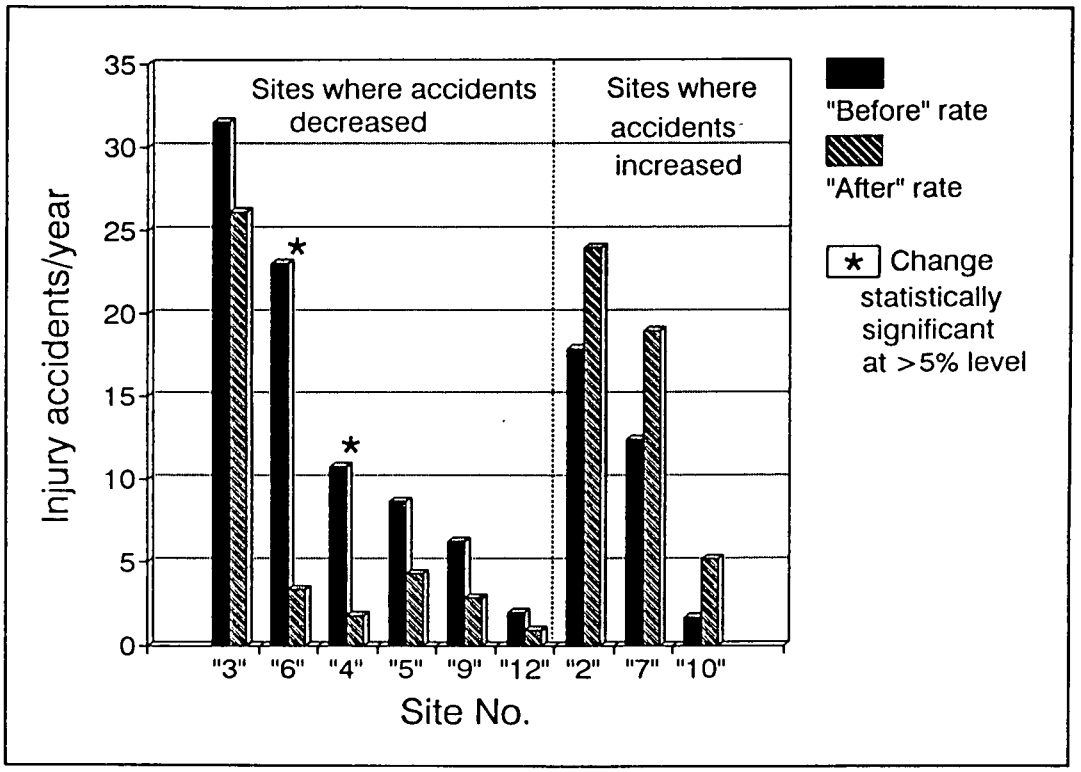


Fig. 5 Changes in injury accident rates at blackspot sites after remedial work complete

accidents which may well have been improved by the new chevron signs.

Assuming an average injury accident cost of RM33,000, 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, 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 RM4.11M). 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 carried out at these sites , 03, 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 03 the road has been widened: this may well have encouraged higher speed and indeed motor cycle accidents seem to have increased (see Appendix III). 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

(Appendix III).

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. These 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.

5.7 Road inventory: facilities and street furniture

As reported in Section 5.5 both the JKR and local authorities were required to compile an inventory of road facilities and street furniture in the Plan. According to completed questionnaires, although this is gradually being done, there would appear to be more than 50% of authorities who do not yet have such an inventory. It has not been possible to review in detail in this paper the level and quality of facilities installed since 1991. However, it is hoped that with the introduction of road safety audit procedures, then street furniture and the inclusion of safety features will be more likely to be assured for future installations.

5.8 Engineering research

Safety research funded by MKJR since 1991 include projects at three universities. Those which could be classed as related to engineering were at Universiti Pertanian Malaysia (UPM) and Universiti Malaya (UM) with Universiti Kebangsaan Malaysia carrying out a project on medical health (of bus and taxi drivers). UPM research included the pilot project in Seremban, Shah Alam and Petaling Jaya to improve the accident data form, POL27, to be used with TRL's software package, MAAP; and also a project to evaluate the impact of the "ride bright" campaign for motorcyclists. At UM research projects included a driver behaviour study on close following, and also a study of the suitability of special boxes and motorcycle lanes in town centres. Unfortunately, this latter project has now been terminated.

Research at IKRAM has been somewhat limited by a lack of qualified research staff. Rather than produce new Design Guidelines on traffic control or road signs, effort has been concentrated on producing a general accident investigation Guide as this was considered a higher priority. In order to attempt to standardise the methods used by all engineers in Malaysia with responsibility for managing part of the road network, guidance on identifying and treating hazardous locations is much needed, and the Guide will be discussed later in this Seminar.

Other work has included the monitoring of the World Bank blackspot sites described above and also trials of low-cost road surface devices such as the use of Vibralines as double centrelines to discourage overtaking on hazardous two-way undivided roads, raised pavement markers and flexipost edge delineators. IKRAM has also been working with Kajang District JKR as a pilot area where landmark mapping is being tried as a means of improving the recording of location of road traffic accidents.

6. DISCUSSION AND CONCLUSIONS

(1) It appears from the records that road traffic accidents in Malaysia are increasing dramatically with annual fatalities rising at about the same rate that they should be decreasing if the Government's casualty reduction targets are to be met.

(2) Fatality rates have increased by 24 per cent since the target base year of 1989 and, according to well-known macro models, this is higher than would be expected from the large growth in traffic over this period.

(3) With regard to the road engineering aspects of the Road Safety Master Plan of 1991, it would appear that many road authorities are not allocating enough staff time to checking police accident data (about half the questionnaire respondents spend less than 2-hours per week on this task).

(4) Road safety on the local road networks does not appear to be being managed adequately. Very few authorities claim to have full-time safety staff, with percentages of staff time totalling less than 1 person in most cases. There is a lack of consensus of what constitutes a blackspot site and a large proportion of authorities stated that none had been identified. Those authorities that had identified blackspots tend to have considered only a few over the past three years. Studies of specific problems at individual sites are not generally made.

(5) Almost all road authorities reported that they do not have separate safety budgets and so all spending on accident countermeasures has to compete with general maintenance needs.

(6) The questionnaire survey also indicates that integration of safety work is probably lacking judging by the relatively low proportion of authorities who have regular meetings with the local police, education and other authorities. This is unfortunate since some individual authorities are obviously keen to further the cause of improving safety and cooperate with others, such as the Police Headquarters of Pahang who even maintain their own up-to-date accident database on computer.

(7) 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, there would appear to have been an overall saving in injury accidents of about 24% at these sites. Although this figure takes into account the generally increasing accident trends by considering groups of control sites, the possible regression-to-mean effect has not been included. It is thought that this could range from 7% to 15% if the sites were indeed some of the worst blackspots, and if so, this should strictly be subtracted from the quoted benefit of the countermeasures. At three of the nine sites investigated injury accidents may have actually increased by an average of about 5 per year.

(8) The remedial work at the so-called World Bank accident blackspots all tended to be high cost and the estimated 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.

(9) The overall conclusion remains that the engineering and, indeed, all other efforts made from 1991 to date have failed to have sufficient impact on the growing numbers of road accident casualties. Much more needs to be done otherwise the casualty reduction target will almost certainly not be achieved and a far more hazardous situation than that in 1989 will prevail.

7. ACKNOWLEDGEMENTS

The author wishes to thank the relevant Royal Malaysia Police stations at the World Bank blackspot sites for making road accident data available; all JKR District and State offices and local authorities who responded to the questionnaire; IKRAM for facilitating this cooperative safety research programme between JKR and Transport Research Laboratory, United Kingdom, and to the many staff of IKRAM for their help and support throughout this project.

The views expressed in this report are those of the author and not necessarily those of the Institute Kerja Raya Malaysia, JKR or the Transport Research Laboratory, U.K.

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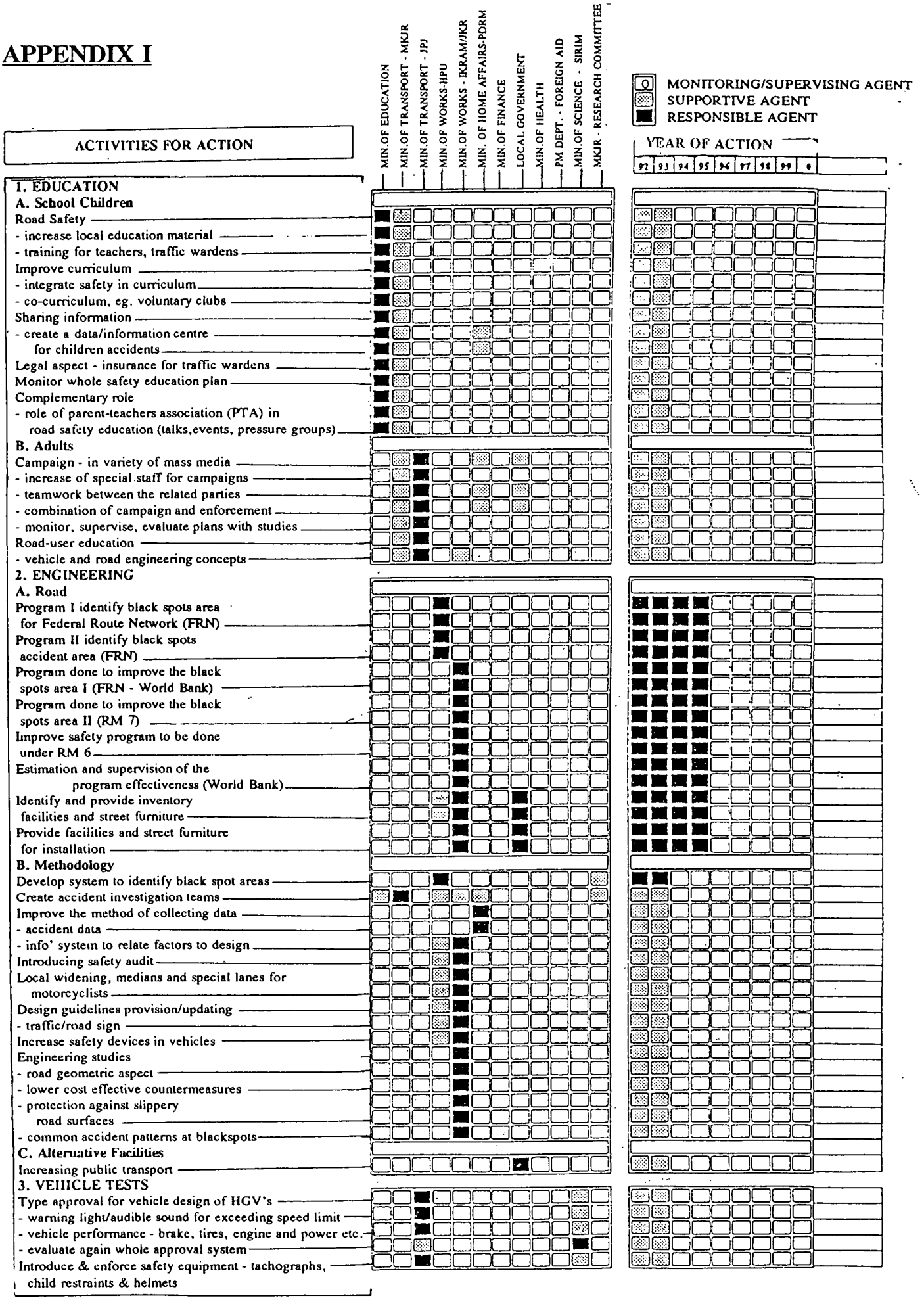
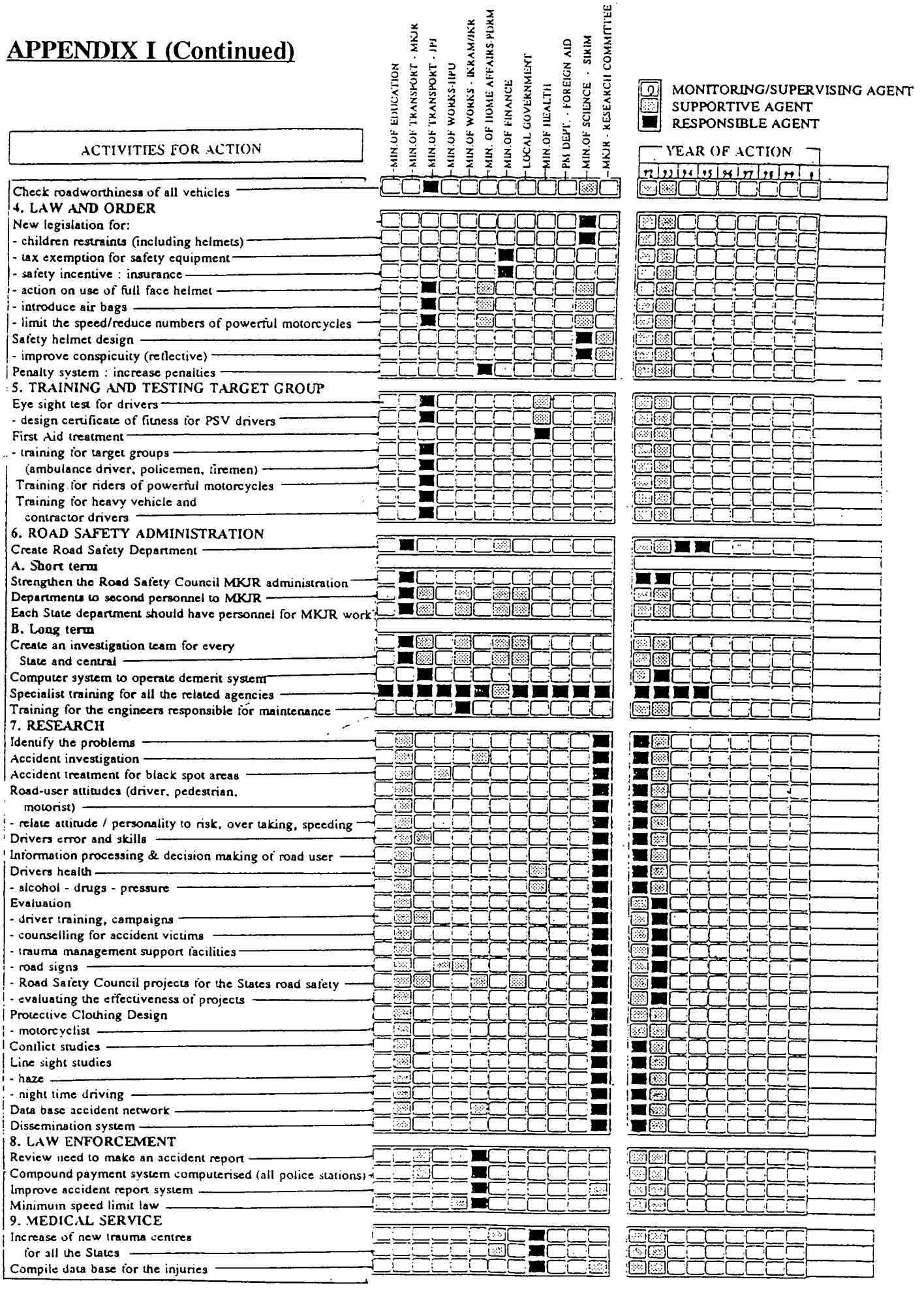
NATIONAL MASTER PLAN FOR ROAD SAFETY IN MALAYSIA

APPENDIX I



APPENDIX I (Continued)



APPENDIX II

INSTITUT KERJA RAYA MALAYSIA
Jabatan Kerja Raya
Unit Pavemen
Jalan Serdang
43000 Kajang
Selangor Darul Ehsan

IKRAM

SOALSELIDIK MENGENAI KAEDAH KEJURUTERAAN KESELAMATAN JALANRAYA
ROAD SAFETY ENGINEERING MEASURES QUESTIONNAIRE

Institut Kerja Raya Malaysia (IKRAM) telah diminta untuk membuat satu kajian mendalam tentang pencapaian pengurangan kemalangan jalanraya sebagaimana yang telah ditetapkan oleh Kerajaan. Maklumat ini diperlu untuk pertimbangan samaada sumber ataupun polisi perlu ditambah. Oleh yang demikian, adalah diminta anda menjawab borang soalselidik ini secepat mungkin dan kembalikan ke IKRAM sebelum 10 November 1994. Sila gunakan kertas tambahan jika ruang jawapan tidak mencukupi.

Institut Kerja Raya Malaysia has been requested to carry out an internal review for the Government of Malaysia on progress towards the Government's stated road accident casualty reduction target. Information is required on which to base decisions on whether any additional resources or policy changes are necessary. We would therefore request that you complete the following questionnaire as quickly as possible, and return this to IKRAM at the latest by 10th November 1994. Please attach separate sheets of paper if insufficient space.

Nama dan alamat penguasa jalanraya
Name and address of road authority: . . . . . .
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1. Sudahkah dikenalpastikan kawasan titik hitam atau merbahaya di dalam rangkaian jalanraya? Sila nyatakan bilangan tapak yang telah dikenalpastikan; berapa kerap senarai ini diperbaharui, dan definasi sesuatu kawasan titikhitam.
[Sebagai contoh "5 kemalangan/tahun/simpang atau jarak km" atau " keterangan yang diambil dari Polis". Jika tiada jawapan, sila tulis "Tiada"].

Have you identified the accident blackspots or hazardous areas on your road network? Please state how many sites, how often this list is revised, and how you define your "blackspots'. [E.g. "5 injury accidents/year/junction or x km length" or "Police verbally inform". If not done, please write "NO"].

ADA/TIADA
YES/NO . . . . . .

Bilangan tapak?
How many sites? . . . . . .

Kekerapan senarai diperbaharui?
How often list revised? . . . . . .
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Definasi kawasan titikhitam
Definition of "blackspot" . . . . . .
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APPENDIX II (Continued)

2. Semenjak 1992, nyatakan sebarang kajian yang telah dibuat di kawasan titik hitam atau merbahaya dalam rangkaian jalanraya. [Jika tiada, sila tulis "TIADA"].

Since the beginning of 1992 please list any studies you have made at accident blackspots or hazardous areas on your road network. [If none please write "NONE"]

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3. Semenjak 1992, nyatakan kerja-kerja membaikpulih yang dibuat oleh pihak tuan. Sila beri keterangan ringkas tentang kerja atau tindakan yang telah diambil, tempat dan kos. Sila masukan pembaikan kecil [contoh: pembaikan tanda jalan, papantanda baru dll. Jika TIADA, sila beri sebab/keterangan].

Since 1992, please list the accident remedial work implemented by your authority. Please write a brief summary of the type of work done or action taken and its location(s) and approximate cost. Please include all small improvements [eg. reinstatement of roads markings, new signs etc. If NONE, please state reasons/resources needed to rectify].

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4. Bagaimana pembaikan itu di bayar? Adakah ia termasuk di dalam peruntukan <u>tahunan</u> yang dibelanjakan untuk pembaikan keselamatan setiap tahun?

How were the above improvements funded? Do you have in your budget an <u>annual</u> amount to be spent on safety improvements solely each year?

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APPENDIX II (Continued)

5. Adakah tindakan diambil untuk menilai keselamatan, dan jika ya, sila catitkan jenis pengukuran yang digunakan? Nyatakan sebarang perubahan kemalangan disebabkan kerja pembaikan. YA/TIADA

Has any attempt been made to evaluate the safety action taken, and if so, please state what measurements were used? List any known changes or accident savings due to your remedial work. *YES/NO*

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6. Sila nyatakan samaada organisasi lain meluluskan cadangan tersebut [contoh: JKR Ibupejabat, MKJR], and catitkan samaada odit keselamatan telah dijalankan?

Please specify whether any other organisation(s) approved your plans (eg. JKR HQ, MKJR), and state whether any form of safety audit was carried out?

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7. Sudahkah anda siapkan inventori kemudahan jalan dan tepi jalan? Sila catitkan tarikh siap dan jika ada, tarikh perubahan. YA/TIADA

Have you completed an inventory of road and roadside facilities? Please state date of completion and date(s) of any subsequent updates. *YES/NO*

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Adakah semua kemudahan telah diperiksa untuk pengesahan dengan Arahan
Have all facilities been checked to conform to the relevant Arahan Teknik? YA/TIADA
YES/NO

Butir-butir kemudahan yang tidak mengikut piawaian yang ditetapkan
Details of those which do not meet standard . . . . . .

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APPENDIX II (Continued)

8. Berapa jumlah kakitangan di dalam pengawasan tuan yang diberi tanggungjawab terhadap keselamatan jalanraya? Nyatakan bilangan kakitangan dan masa yang diperuntukan untuk kerja keselamatan. [Contoh 2 (60%), 1 (10%), 2 part-time (100%). Tulis "TIADA", jika tiada kerja keselamatan dijalankan].

How many staff in your authority have road safety responsibilities? Please state number of personnel and estimate percentage of their time devoted to safety work. [E.g. 2 (60%), 1 (10%), 2 part-time (100%). Write "NONE", if no safety work done].

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Jumlah tenaga kerja seminggu yang diperuntukan untuk menyemak data kemalangan:
No. of man-hours per week spent on accident data checking: . . . . . .

9. Adakah kakitangan di bawah pengawasan tuan mengadakan mesyuarat mingguan dengan
Do any of the staff in your authority have regular meetings about safety matters with

Polis tempatan? ADA/TIADA Kekerapan?
the local Police? YES/NO ***How often?*** . . . . . .

Pihak sekolah tempatan? ADA/TIADA Kekerapan?
the local schools? YES/NO ***How often?*** . . . . . .
Nama sekolah
Name schools . . . . . .
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Lain-lain Penguasa tempatan? ADA/TIADA Nama
other authorities? ***YES/NO*** ***Name*** . . . . . .
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10. Pada mesyuarat yang diadakan, adakah keselamatan jalanraya dijadikan agenda tetap? Jika ya, sila catitkan nama mesyuarat dan kekerapan ianya diadakan. YA/TIADA

At any of your authority's regular meetings, is road safety a fixed item on the agenda? If yes, please state name of meeting and how often it is held. ***YES/NO***

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Slia kebalikan kepada IKRAM selawat lewatnya 10 Nov 1994
Please post back to IKRAM before 10 November 1994

TERIMA KASIH DI ATAS KERJASAMA PIHAK TUAN
THANK YOU FOR YOUR TIME AND COOPERATION

APPENDIX III. WORLD BANK SITES: BEFORE & AFTER FREQUENCY OF INJURY ACCIDENTS

KEY: Bef adj = Before period accidents averaged and expressed over same period as after (or implementation) period
Impl exp/ After exp = Expected no. accs in implementation (or after) period from change at control sites
% increase = per cent increase(+) or decrease(-) in study period over expected no. ; CONTROL x = Accidents at control sites for site x
Chi-sq = 2 x 2 chi-squared value for change in accidents at site (compared with control sites)
Cost inst. = Total cost of installation; FYRR = First Year Rate of Return.

SITE 02

Av acc cost = 33000 (RM)
Cost inst. = 1067079 (RM)
Annual increase = 6.1 (accidents)
FYRR = -19.0 (%)

Injury accident numbers

Acc type	Before	IMPLEMENTATION PERIOD Bef adj	Impl exp	Impl.	acc increase	% increase	Chi-sq	AFTER PERIOD Bef adj	After exp	After	acc increase	% increase	Chi-sq
Period: (months)	*40*	*7*	*7*	*7*	*7*	*7*		*17*	*17*	*17*	*17*	*17*	
All	53	9.3	12.53	10	-2.5	-20.2	0.05	22.5	25.30	34	8.7	34.4	0.78
Sideswipe	27	4.7	6.38	4	-2.4	-37.3	0.11	11.5	12.89	15	2.1	16.4	0.03
Rear end	15	2.6	3.55	3	-0.5	-15.4	0.06	6.4	7.16	8	0.8	11.7	0.00
O'take	17	3.0	4.02	1	-3.0	-75.1	0.60	7.2	8.11	6	-2.1	-26.1	0.07
Head-on	4	0.7	0.95	2	1.1	111.5	0.01	1.7	1.91	3	1.1	57.1	0.00
Out cntrl	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	5	5.0	>100	2.71
Pedes.	3	0.5	0.71	1	0.3	41.0	0.39	1.3	1.43	1	-0.4	-30.2	0.16
M/c	47	8.2	11.11	9	-2.1	-19.0	0.03	20.0	22.43	30	7.6	33.7	0.64
Wet rd	4	0.7	0.95	0	-0.9	-100.0	0.06	1.7	1.91	0	-1.9	-100.0	0.37
CONTROL 02	440	77.0	104.00	104		35.1		187.0	210.00	210		12.3	

SITE 03

Av acc cost = 33000 (RM)
Cost inst. = 436053 (RM)
Annual increase = -5.4 (accidents)
FYRR = 40.8 (%)

Acc type	Before	Bef adj	Impl exp	Impl.	acc increase	% increase	Chi-sq	Bef adj	After exp	After	acc increase	% increase	Chi-sq
Period: (months)	*40*	*3*	*3*	*3*	*3*	*3*		*17*	*17*	*17*	*17*	*17*	
All	53	4.0	5.29	5	-0.3	-5.4	0.08	22.5	44.64	37	-7.6	-17.1	0.27
Sideswipe	27	2.0	2.69	1	-1.7	-62.9	0.06	11.5	22.74	18	-4.7	-20.8	0.16
Rear end	9	0.7	0.90	2	1.1	122.7	0.00	3.8	7.58	5	-2.6	-34.0	0.06
O'take	16	1.2	1.60	1	-0.6	-37.4	0.12	6.8	13.48	11	-2.5	-18.4	0.02
Head-on	6	0.5	0.60	0	-0.6	-100.0	0.55	2.6	5.05	8	2.9	58.3	0.10
Out cntrl	2	0.2	0.20	0	-0.2	-100.0	4.68	0.9	1.68	1	-0.7	-40.6	0.18
Pedes.	7	0.5	0.70	5	4.3	615.9	1.20	3.0	5.90	1	-4.9	-83.0	1.45
M/c	48	3.6	4.79	0	-4.8	-100.0	2.51	20.4	40.43	34	-6.4	-15.9	0.19
Wet rd	2	0.2	0.20		-0.2	-100.0	4.68	0.9	1.68	0	-1.7	-100.0	0.02
CONTROL 03	431	32.3	43.00	43		33.0		183.2	363.00	363		98.2	

APPENDIX III (Continued)

SITE 04 Injury accident numbers

Av acc cost = 33000 (RM)
Cost inst. = 956293 (RM)
Annual increase = -9.0 (accidents)
FYRR = 31.1 (%)

Acc type	Injury accs Before	IMPLEMENTATION PERIOD Bef adj	Impl exp	Impl.	acc increase	% increase	Chi-sq	AFTER PERIOD Bef adj	After exp	After	acc increase	% increase	Chi-sq
Period : (months)	*36*	*9*	*9*	*9*	*9*	*9*		*20*	*20*	*20*	*20*	*20*	
All	24	6.0	9.69	3	-6.7	-69.0	1.87	13.3	18.03	3	-15.0	-83.4	8.30
Sideswipe	14	3.5	5.65	2	-3.7	-64.6	0.59	7.8	10.52	0	-10.5	-100.0	8.09
Rear end	3	0.8	1.21	0	-1.2	-100.0	0.01	1.7	2.25	1	-1.3	-55.6	0.00
O'take	8	2.0	3.23	1	-2.2	-69.0	0.17	4.4	6.01	1	-5.0	-83.4	1.96
Head-on	4	1.0	1.61	1	-0.6	-38.1	0.15	2.2	3.01	1	-2.0	-66.7	0.15
Out cntrl	4	1.0	1.61	0	-1.6	-100.0	0.06	2.2	3.01	0	-3.0	-100.0	1.10
Pedes.	1	0.3	0.40	1	0.6	147.7	0.25	0.6	0.75	1	0.2	33.1	0.41
M/c	16	4.0	6.46	2	-4.5	-69.0	0.97	8.9	12.02	2	-10.0	-83.4	5.14
Wet rd	1	0.3	0.40	0	-0.4	-100.0	2.03	0.6	0.75	0	-0.8	-100.0	0.24
CONTROL 04	374	93.5	151.00	151		61.5		207.8	281.00	281		35.2	

SITE 05

Av acc cost = 33000 (RM)
Cost inst. = 339309 (RM)
Annual increase = -4.4 (accidents)
FYRR = 43.2 (%)

Acc type	Injury accs Before	Bef adj	Impl exp	Impl.	acc increase	% increase	Chi-sq	Bef adj	After exp	After	acc increase	% increase	Chi-sq
Period : (months)	*32*	*13*	*13*	*13*	*13*	*13*		*14*	*14*	*14*	*14*	*14*	
All	11	4.5	8.98	5	-4.0	-44.3	0.30	4.8	10.18	5	-5.2	-50.9	0.60
Sideswipe	2	0.8	1.63	0	-1.6	-100.0	0.01	0.9	1.85	0	-1.9	-100.0	0.05
Rear end	0	0.0	0.00	1	1.0	>100	0.13	0.0	0.00	1	1.0	>100	0.15
O'take	3	1.2	2.45	3	0.6	22.5	0.11	1.3	2.78	2	-0.8	-27.9	0.09
Head-on	3	1.2	2.45	4	1.6	63.3	0.00	1.3	2.78	3	0.2	8.1	0.20
Out cntrl	4	1.6	3.27	0	-3.3	-100.0	0.93	1.8	3.70	1	-2.7	-73.0	0.22
Pedes.	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	0	0.0	0.0	0.00
M/c	2	0.8	1.63	1	-0.6	-38.8	0.21	0.9	1.85	2	0.1	8.1	0.33
Wet rd	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	0	0.0	0.0	0.00
CONTROL 05	294	119.4	240.00	240		100.9		128.6	272.00	272		111.5	

APPENDIX III (Continued)

SITE 06 Injury accident numbers

Av acc cost = 33000 (RM)
Cost inst. = 339309 (RM)
Annual increase = -19.6 (accidents)
FYRR = 190.3 (%)

Acc type	Injury accs Before	IMPLEMENTATION PERIOD Bef adj	Impl exp	Impl.	acc increase	% increase	Chi-sq	AFTER PERIOD Bef adj	After exp	After	acc increase	% increase	Chi-sq
Period : (months)	*32*	*13*	*13*	*13*	*13*	*13*		*14*	*14*	*14*	*14*	*14*	
All	29	11.8	23.67	4	-19.7	-83.1	9.66	12.7	26.83	4	-22.8	-85.1	11.91
Sideswipe	14	5.7	11.43	3	-8.4	-73.8	2.62	6.1	12.95	3	-10.0	-76.8	3.50
Rear end	5	2.0	4.08	0	-4.1	-100.0	1.60	2.2	4.63	1	-3.6	-78.4	0.62
O'take	9	3.7	7.35	1	-6.3	-86.4	2.43	3.9	8.33	1	-7.3	-88.0	3.10
Head-on	4	1.6	3.27	0	-3.3	-100.0	0.93	1.8	3.70	0	-3.7	-100.0	1.22
Out cntrl	1	0.4	0.82	1	0.2	22.5	0.62	0.4	0.93	0	-0.9	-100.0	0.43
Pedes.	5	2.0	4.08	0	-4.1	-100.0	1.60	2.2	4.63	0	-4.6	-100.0	2.00
M/c	25	10.2	20.41	4	-16.4	-80.4	7.30	10.9	23.13	4	-19.1	-82.7	9.15
Wet rd	1	0.4	0.82	0	-0.8	-100.0	0.58	0.4	0.93	0	-0.9	-100.0	0.43
CONTROL 06	294	119.4	240.00	240		100.9		128.6	272.00	272		111.5	

SITE 07

Av acc cost = 33000 (RM)
Cost inst. = 827484 (RM)
Annual increase = 6.6 (accidents)
FYRR = -26.3 (%)

Acc type	Injury accs Before	Bef adj	Impl exp	Impl.	acc increase	% increase	Chi-sq	Bef adj	After exp	After	acc increase	% increase	Chi-sq
Period : (months)	*32*	*14*	*14*	*14*	*14*	*14*		*24*	*24*	*24*	*24*	*24*	
All	27	11.8	21.93	21	-0.9	-4.2	0.01	20.3	24.83	38	13.2	53.1	1.79
Sideswipe	14	6.1	11.37	14	2.6	23.1	0.03	10.5	12.87	22	9.1	70.9	1.49
Rear end	8	3.5	6.50	4	-2.5	-38.4	0.08	6.0	7.36	7	-0.4	-4.8	0.04
O'take	5	2.2	4.06	10	5.9	146.3	0.86	3.8	4.60	10	5.4	117.5	1.05
Head-on	1	0.4	0.81	2	1.2	146.3	0.01	0.8	0.92	1	0.1	8.8	0.50
Out cntrl	1	0.4	0.81	0	-0.8	-100.0	0.47	0.8	0.92	5	4.1	443.8	1.23
Pedes.	3	1.3	2.44	0	-2.4	-100.0	0.41	2.3	2.76	2	-0.8	-27.5	0.03
M/c	22	9.6	17.87	18	0.1	0.8	0.04	16.5	20.23	31	10.8	53.3	1.44
Wet rd	0	0.0	0.00	1	1.0	>100	0.10	0.0	0.00	0	0.0	0.0	0.00
					0.0								
CONTROL 07	298	130.4	242.00	242		85.6		223.5	274.00	274		22.6	

APPENDIX III (Continued)

SITE 09 Injury accident numbers

Av acc cost = 33000 (RM)
Cost inst. = 308614 (RM)
Annual increase = -3.4 (accidents)
FYRR = 36.3 (%)

Acc type	Injury accs Before	IMPLEMENTATION PERIOD Bef adj	Impl exp	Impl.	acc increase	% increase	Chi-sq	AFTER PERIOD Bef adj	After exp	After	acc increase	% increase	Chi-sq
Period : (months)	*29*	*5*	*5*	*5*	*5*	*5*		*25*	*25*	*25*	*25*	*25*	
All	22	3.8	3.65	8	4.3	119.1	0.89	19.0	13.07	6	-7.1	-54.1	2.16
Sideswipe	11	1.9	1.83	3	1.2	64.4	0.01	9.5	6.53	4	-2.5	-38.8	0.30
Rear end	2	0.3	0.33	1	0.7	201.3	0.08	1.7	1.19	0	-1.2	-100.0	0.10
O'take	7	1.2	1.16	1	-0.2	-13.9	0.32	6.0	4.16	0	-4.2	-100.0	2.61
Head-on	2	0.3	0.33	0	-0.3	-100.0	1.28	1.7	1.19	0	-1.2	-100.0	0.10
Out cntrl	3	0.5	0.50	1	0.5	100.9	0.16	2.6	1.78	0	-1.8	-100.0	0.49
Pedes.	3	0.5	0.50	3	2.5	502.6	0.65	2.6	1.78	0	-1.8	-100.0	0.49
M/c	16	2.8	2.66	6	3.3	126.0	0.60	13.8	9.50	0	-9.5	-100.0	7.75
Wet rd	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	0	0.0	0.0	0.00
CONTROL 09	458	79.0	76.00	76		-3.8		394.8	272.00	272		-31.1	

SITE 10

Av acc cost = 33000 (RM)
Cost inst. = 212266 (RM)
Annual increase = 3.5 (accidents)
FYRR = -54.2 (%)

Acc type	Injury accs Before	Bef adj	Impl exp	Impl.	acc increase	% increase	Chi-sq	Bef adj	After exp	After	acc increase	% increase	Chi-sq
Period : (months)	*41*	*6*	*6*	*6*	*6*	*6*		*23*	*23*	*23*	*23*	*23*	
All	6	0.9	1.24	0	-1.2	-100.0	0.00	3.4	3.31	10	6.7	201.7	2.38
Sideswipe	4	0.6	0.83	0	-0.8	-100.0	0.18	2.2	2.21	4	1.8	81.0	0.10
Rear end	1	0.1	0.21	0	-0.2	-100.0	4.84	0.6	0.55	4	3.4	624.1	1.32
O'take	1	0.1	0.21	0	-0.2	-100.0	4.84	0.6	0.55	5	4.4	805.1	2.14
Head-on	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	0	0.0	0.0	0.00
Out cntrl	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	1	1.0	>100	0.00
Pedes.	1	0.1	0.21	0	-0.2	-100.0	4.84	0.6	0.55	0	-0.6	-100.0	0.35
M/c	3	0.4	0.62	0	-0.6	-100.0	0.56	1.7	1.66	8	6.3	382.7	2.93
Wet rd	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	0	0.0	0.0	0.00
CONTROL 10	458	67.0	95.00	95		41.7		256.9	253.00	253		-1.5	

APPENDIX III (Continued)

SITE 12 Injury accident numbers

Av acc cost = 33000 (RM)
Cost inst. = 32000 (RM)
Annual increase = -1.1 (accidents)
FYRR = 113.1 (%)

Acc type	Injury accs Before	IMPLEMENTATION PERIOD						AFTER PERIOD					
Period: (months)	*41*	Bef adj *3*	Impl exp *3*	Impl. *3*	acc increase *3*	% increase *3*	Chi-sq	Bef adj *40*	After exp *40*	After *40*	acc increase *40*	% increase *40*	Chi-sq
All	5	0.4	0.47	0	-0.5	-100.0	0.96	4.9	6.66	3	-3.7	-54.9	0.57
Sideswipe	1	0.1	0.09	0	-0.1	-100.0	11.69	1.0	1.33	0	-1.3	-100.0	0.00
Rear end	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	0	0.0	0.0	0.00
O'take	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	0	0.0	0.0	0.00
Head-on	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	2	2.0	>100	0.25
Out cntrl	1	0.1	0.09	0	-0.1	-100.0	11.69	1.0	1.33	1	-0.3	-24.9	0.27
Pedes.	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	0	0.0	0.0	0.00
M/c	1	0.1	0.09	0	-0.1	-100.0	11.69	1.0	1.33	1	-0.3	-24.9	0.27
Wet rd	0	0.0	0.00	0	0.0	0.0	0.00	0.0	0.00	0	0.0	0.0	0.00
CONTROL 12	79777	5837.3	7509.00	7509		28.6		77831.2	106195	106195		36.4	

KEY: Bef adj = Before period accidents averaged and expressed over same period as after (or implementation) period
Impl exp/ After exp = Expected no. accs in implementation (or after) period from change at control sites
% increase = per cent increase(+) or decrease(-) in study period over expected no. ; CONTROL x = Accidents at control sites for site x
Chi-sq = 2 x 2 chi-squared value for change in accidents at site (compared with control sites)
Cost inst. = Total cost of installation; FYRR = First Year Rate of Return.