MECHANICAL SAFETY OF HEAVY VEHICLES: PERIODIC INSPECTIONS VERSUS QUALITY ASSURANCE

Ron Allen

McINNES GROUP

NZ

Presented to the

Institute of Road Transport Engineers of New Zealand

FOURTH INTERNATIONAL HEAVY VEHICLE SEMINAR

AUCKLAND

3 - 5 March 1992

IRTE 4th International Heavy Vehicle Seminar, Auckland, March 1992

MECHANICAL SAFETY OF HEAVY VEHICLES
Periodic Inspection *vs* Quality Assurance

Ronald R Allan *

MSc*(Hons)* PhD FCIT FITE MRAeS MIRTNZ MIPENZ Reg Eng

McInnes Group
New Zealand

Abstract

Roadworthiness of heavy vehicles affects road safety. As evidence of roadworthiness, New Zealand's heavy vehicles must carry a Certificate of Fitness issued six-monthly after inspections at Ministry of Transport testing stations. In 1991 the New Zealand government commissioned a study to determine whether safety would be better served by Quality Assurance (QA) rather than by government inspections. # Under QA the government would take a step back, leaving operators and maintenance personnel to assume primary responsibility for roadworthiness. The government's role would be to set standards and undertake surveillance to ensure standards were being met.

QA is a proven system in other fields. Applied to roadworthiness, the study concluded that surveillance costs were likely to be much the same as at present, but compliance should cost less since vehicles would not have to take time out to visit testing stations. QA would oblige vehicles to be roadworthy at all times, rather than at six-monthly intervals. Safety benefits were identified, but the accident data were insufficiently dependable to estimate the safety benefits reliably.

New Zealand's road transport industry is opposed to QA because QA would mean taking greater personal responsibility and because the six-monthly check is a discipline on every operator, giving none a competitive advantage. It would be odd to argue against an industry united in favour of government checks for which they pay. Moreover, on the basis of the available data, it can plausibly be claimed that the present system is working— few crash-involved heavy vehicles are found to be defective.

In the absence of more dependable data it was concluded that Certificate of Fitness checks should continue. The checks should be twelve-monthly, rather than six-monthly, augmented by random checks at the roadside and in operators' depots.

---

* The important contribution of my colleague, Ian Brown, to the study being reported here is acknowledged. Appreciation is also due to Land Transport Division of the Ministry of Transport for permission to present this paper outlining the results of the investigation undertaken on their behalf.

McInnes Group; *Quality Assurance and Heavy Vehicle Fitness*; Land Transport Division, Ministry of Transport; November 1991

Conceiving safety without risk is like seeking love without courting the danger of rejection.
Aaron Wildavsky

This paper concerns roadworthiness of heavy vehicles and its interrelationship with safety or, more accurately, with the incidence and consequences of accidents. Safety cannot be absolute. When we say something is "safe" we mean it carries an acceptable level of risk—acceptable to us personally and to society as a whole.

Reason for Government Intervention

Road safety is part of a bigger picture. How much we spend on safety is related to what we are prepared to pay to reduce risk in everyday life. It is the role of the government to interpret and give effect to this "will of the people", through directives and safety legislation.

Where the general public is liable to be innocently involved in accidents the government cannot permit people to make safety decisions based solely on their own costs and benefits. Their decisions affect the welfare of other people too, these affects being termed "externalities". The question becomes: *how* should the government intervene? This was the issue addressed by the Swedavia-McGregor Report on aviation safety, which steered government safety policy towards an auditing role. Increasingly the role of government in the field of safety is being viewed as checking that:

1 enterprises themselves set adequate safety standards, and institute systems to achieve those standards, and

2 they abide by those systems.

This is the essence of "quality assurance", or "QA". It contrasts with the current system which requires vehicles to display a Certificate of Fitness (CoF) issued by government personnel who physically inspect vehicles and pass them as fit for another six months.

Forms of Government Intervention

To correct for externalities governments have the choice of two types of intervention. One corrects prices, leaving individuals freedom of action thereafter. The other stipulates, by regulation, how individuals should behave. Prices can correct for externalities by imposing legal liability in the case of an accident. This course is not available in New Zealand owing to the Accident Compensation Act, which has precisely the opposite effect.[1] This leaves regulation (which is imperfect) as the only means by which the New Zealand government can correct for safety externalities.

The Aviation Model

The Swedavia-McGregor Report, endorsed by the government, recommended there be a clear-cut division of responsibility for safety between the State regulatory authority and the participants, designed on the assumption that approved firms and licensed individuals will act in a responsible way. A plausible case can be made for taking the same approach to road transport but there are differences between the two forms of transport that caution against assuming automatically that what is good for aviation must be good for road transport.

The Road Safety System

The road safety system addresses vehicles and roads together with rules for their provision and use.

- Vehicles are required to be licensed, be roadworthy and pass the CoF test every six months.
- Drivers of vehicles must be licensed. Applicants are given a practical driving test and are examined on their knowledge of the relevant regulations. Licences are graduated according to the vehicle to be driven.
- Transport operators have to demonstrate the service will be carried out in a safe and reliable manner.
- Roads are the responsibility of the territorial local authority in which they are located, apart from the designated State Highways, which are controlled by a State agency, Transit New Zealand.
- The Ministry of Transport (MoT) has overall responsibility for:
  - developing safety policy and standards for drivers, vehicles and facilities;
  - education and safety promotion;
  - monitoring road traffic safety; and
  - enforcing road traffic rules.

---

[1] New Zealand has a "no fault" compensation scheme for accidental injury and loss of life. Rather than legal processes determining compensation, and who should pay it, the Accident Compensation Commission pays compensation for personal injury and loss of life— irrespective of who, if anyone, was at fault.

Apart from policy matters, expenditure on roads and road safety is controlled through the Land Transport Programme which allocates funds from the Land Transport Fund.

Road Safety Performance

Safety needs to be considered in two dimensions:

1 the *probability* of an accident, and

2 the *consequence* of an accident.

Halving the number of accidents is of no merit if at the same time their severity is more than doubled.

There is no unique measure of road safety performance. Accidents per million people per year, deaths per million vehicle-km, *etc*, are helpful and have their place, but none can encapsulate all the factors that need to be considered.

During the five years 1986-90, the average number of crashes involving heavy vehicles was 1026 per annum, of which 10% were fatal. Very few heavy vehicles involved in crashes appear to have defects. "CoF defects" were absent (or at least undetected) in 96% of the heavy vehicles involved in fatal accidents—95% when injury-only accidents are included. This creditable result could be a reflection of the rigorous CoF inspections to which vehicles submit every six months. On the other hand, it might reflect data collection deficiencies.

Legal Obligations of Operators

The law places responsibility for operating safe vehicles on the operator. The Transport Services Licensing Act 1989 states:

> **31. Requirements as to vehicles**—(1) every holder of a transport service licence shall ensure that—
>
> (a) Every vehicle to be used in connection with the service is maintained in a fit and proper condition and that the requirements of any Act or regulation made for this purpose are met...

In law, the responsibility for operating a safe vehicle rests with the operator, not the government. Yet this is not the attitude of the industry whose keenness to keep the system of CoF checks at government testing stations is, in part, based on an unwillingness to assume greater personal responsibility.

Vehicle Testing

Nowhere in the statutes is there a definition of what precisely a CoF must check, so CoF checks are subject to administrative edicts which result in non-safety matters, such as the validity of goods service licences, being checked where appropriate. In practice the rigour of the check depends on the person doing the checking. It may also depend on the characteristics of the vehicle. The main reasons for rejecting vehicles are brakes and lights. Inspectors concentrate on brakes and steering.

Although vehicle inspectors have the authority to stop vehicles at random and inspect them at the roadside, this type of inspection is rare.

To keep track of those vehicles subject to CoFs the MoT has introduced a computer system known as TASS, all testing stations having access *via* terminals. Information entered into the system includes: information on each vehicle inspected, reminders of matters to be followed up at subsequent CoF checks, tabs on vehicles that have been in crashes, crack tests after accidents. TASS also facilitates better control of entry to and exit from the system. TASS enables a vehicle to go to any testing station for a check or recheck. TASS is a valuable tool under the existing system of periodic testing. Its ability to monitor and track vehicles would make it even more valuable under a QA system.

Participants' Views of Present System

> "Safety is paramount for us. Our existing expenditure on safety is economic. Satisfied the present level of expenditure is optimal. Happy to have another organisation verifying safety of our vehicles. We like to have that comfort."

Extensive interviews of operators uncovered strong support for the existing system of CoF checks by MoT vehicle inspectors, but largely for the wrong reasons. Operators do not wish to lose a system under which the government takes the responsibility for safety off their shoulders.

Operators are concerned about their competitive position and have no argument with the charges for CoF checks and their own costs of compliance, provided the same costs are faced by all. Virtually all the operators interviewed expressed strong support for the present system, although many drew attention to a geographic variability in the standards applied by testing stations and vehicle inspectors. Operators considered all vehicles over 10 tonne gross, and

vehicles in combination, should be subject to CoF testing; the remainder could be covered by the Warrant of Fitness (WoF) requirements for light vehicles. At present all vehicles over 3.5 tonnes are required to get CoFs, not WoFs.

The "Ideal" Road Safety System

In an "ideal" road safety system all participants accept the concept of personal responsibility. Indeed the notion that the *government* can be responsible for safety on New Zealand roads is obviously illogical when most accidents are attributed to "bad" driving. It is more sensible to assign to government the responsibility for the umbrella of standards, regulations and surveillance governing the driving environment. The government should also be responsible for ensuring that the level of surveillance is sufficient to achieve the safety objective. Regulations and surveillance go hand in hand. Surveillance need not necessarily be undertaken by government agencies alone. The government can set the level of surveillance it requires, and delegate the task to the industry.

In the ideal system operators would accept responsibility for their actions and be held accountable. Competent people would be designated and held personally accountable for their enterprises meeting the standards.

Regulations and specifications would set the safety standards for vehicles entering the road system. That a vehicle's CoF is still current is no guarantee that the vehicle meets the safety regulations. So, ideally, vehicles would be in the hands of maintenance facilities that ensured vehicles were kept up to scratch at all times.

It is thought that a large proportion of accidents would not occur but for driver error. Drivers appear to be the most important single factor in the road safety system. Drivers of heavy vehicles should:

- be properly trained in driving skills and matters of safety;
- be responsible for checking that equipment meets safety standards; and
- play a responsible part in the maintenance of the vehicle.

A pivotal ingredient is attitudinal change, the development of positive attitudes in drivers and those with whom they interrelate. This is often absent— the mechanic thinks "What would the driver know!" and the driver thinks "If he's so smart, let *him* find the fault!".

Vehicle Fitness— QA Scenario

QA is a system that gives confidence that a product or service meets established quality criteria, without checking each and every item.

The government cannot be held wholly accountable for safety on the roads. The government can set the framework, assign responsibilities, establish surveillance systems and punish transgressors. But it is the participants— operators, drivers, mechanics— who, by their actions, determine the level of safety actually attained. Acceptance of personal responsibility by all participants maximises road safety.

This is the essence of QA. The QA system aims to ensure vehicles meet the required standard at all times, not just once every six months. Whilst in practice it is unrealistic to expect all vehicles to meet the standard at all times, QA, successfully implemented, minimises the number of defective vehicles on the roads.

QA Applied to Heavy Vehicle Maintenance

The features characterising a QA maintenance system are as follows.

- Standards vary according to the type of vehicle and operation.
- Vehicle entry to the system involves a "type certificate" confirming the vehicle to be of satisfactory design and manufacture.
- Vehicles are maintained at an Approved Maintenance Facility (AMF) that would be required to demonstrate it had the staff, premises, equipment and systems necessary to maintain heavy vehicles;
- Maintenance programmes and manuals of instruction ensure proper maintenance. Not all vehicle components require periodic inspection and maintenance at the same time. Some should be inspected daily, others on longer cycles. Some inspections should be distance-related. The manuals should therefore divide total maintenance of the vehicle into its constituent parts, detailing inspection/maintenance intervals according to time or mileage.
- Quality control provides an audit trail of work done, showing who did what and when.

- Work carried out by AMFs is subject to internal and external audits. External audits are carried out by inspectors making unannounced visits to AMFs' premises and operators' yards. By making auditing a task to be performed by the industry, the safety system would be insulated from arbitrary government budget cuts.
- AMFs employ licensed personnel and have a designated person personally responsible for the AMF meeting its obligations.
- Approved vehicle operators accept that operating heavy vehicles on public roads carries a solemn responsibility.
- Penalties for transgression are sufficient to deter infringements of safety rules.
- There is provision for exit from the safety system when vehicles, licensed personnel, operators, maintenance facilities, mechanics and drivers fail to meet the regulatory authority's standards.

In the QA context the role and duties of the road safety authority are:

- to define goals and objectives;
- to develop and maintain national rules, regulations and standards;
- to ensure no person, organisation, facility, equipment or procedure is allowed into the system without complying with the relevant requirements;
- to ensure licensed persons and approved organisations maintain competence and to initiate corrective action and/or enforcement if a deficiency is found;
- to support persons and organisations in the system;
- to analyse information to identify potential hazards and adverse safety trends; and
- to investigate accidents and incidents.

Cost-Benefit Analysis of QA

To look at the relative merits of QA *vs* CoFs, we need examine only the *change* in costs and benefits if CoFs were replaced by QA.

Running a safe system involves three costs:

- surveillance
- compliance
- accidents.

QA is almost neutral in its effect on the cost of surveillance but compliance costs are lowered significantly, due to operators no longer having to make special trips to testing stations. Without this saving, QA would be the more costly system— ignoring for the time being its effect on safety.

Surveillance

The cost of linking every AMF to the TASS network is estimated to cost $4M/y. AMFs would also need to be better endowed, adding $1.5M/y for equipment and $1M/y for personnel training.

Surveillance of AMFs would cost about $1.6M/y.

Random checking (mainly roadside checking of paperwork) is added to the list of costs because it is needed to catch vehicles not in the system, or not abiding by the system. There would also be some random checking of vehicles' roadworthiness to provide current data on the roadworthiness of the average vehicle travelling on the roads.

Compliance

Making sensible assumptions as to the average distance travelled to testing stations, the checking of trailers, numbers of rechecks, *etc*, it was concluded that operators' costs of presenting vehicles for inspection were currently $12M/y.

To belong to the QA system imposes some administrative requirements and compliance costs on the AMFs, estimated to cost them $4M/y.

Lastly, it is variously claimed, on one hand, that AMFs will tend to requires that repair work be done too soon and, on the other hand, that AMFs will be dominated by customers who will threaten to take their business away if the AMF is too strict. Though these effects are opposing, they do not cancel out since two wrongs do not make a right. On the basis of some plausible assumptions, each effect is estimated to result in an annual loss of $1.4M.

The results may be summarised thus:

Estimated Change in Surveillance and Compliance Costs from a switch to QA
($millions/year)

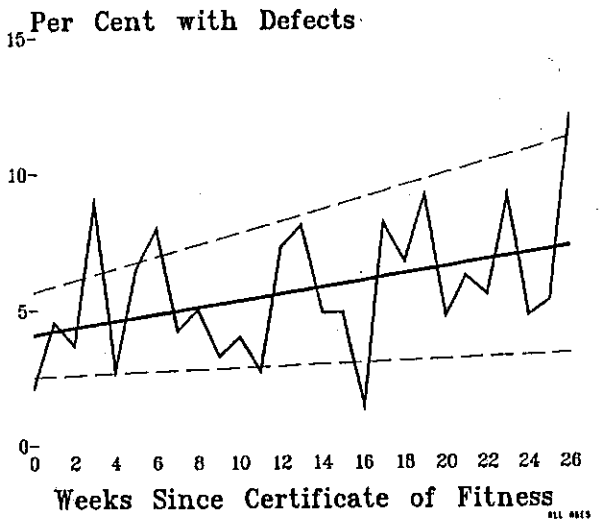
	Cost Savings	Added Costs
Surveillance		
CoF Inspections	10.0	
TASS Network		4.0
Extra Equipment		1.5
Personnel Training		1.0
Surveillance of AMFs		1.6
Random Checking		1.0
Cost Saving Due to QA	*0.9*	
Compliance		
Operators' Presentation Costs	12.0	
AMFs' Administration		4.0
Make-work Repairs		1.4
Domination by Customers		1.4
Cost Saving Due to QA	*5.2*	
Net Saving in Surveillance & Compliance	**$6.1** million/y	

Since the MoT places a value of $2.4M on saving a fatal accident, these $6.1M savings are equivalent to 2½ fatal accidents a year.

It is time to consider the effect on accidents of a switch from CoFs to QA.

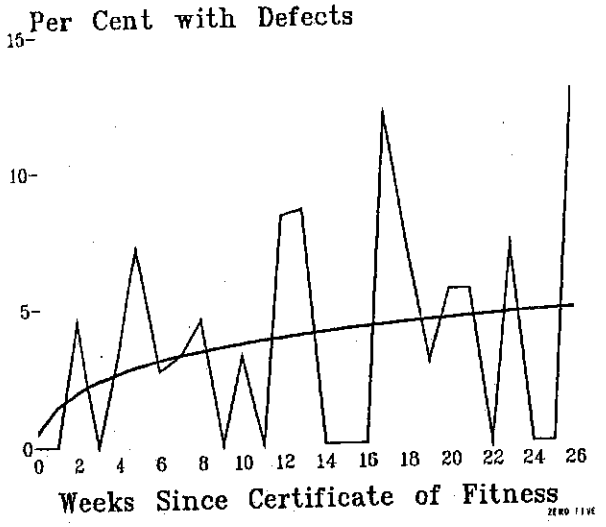
We start by analysing the incidence of defects found in crash-involved heavy vehicles. The graphs display data for the five years 1986-90 plotted against the number of weeks since the vehicle's last CoF check.

All Heavy Vehicles
(Dotted lines are the 90% confidence interval.)



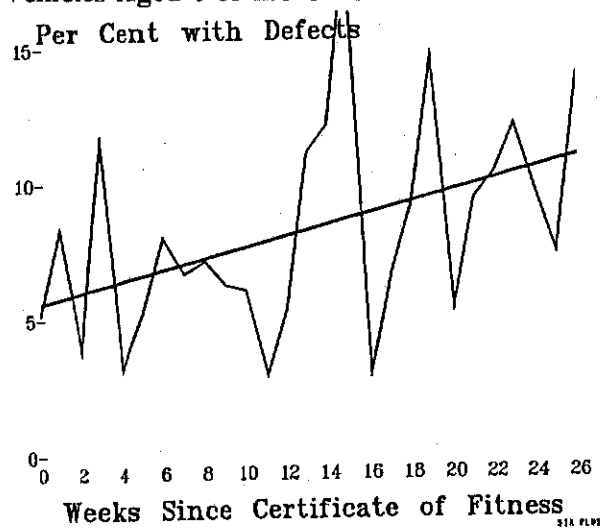
The next two graphs split the data into two groups, "new" vehicles and "old" vehicles.

Heavy Vehicles Aged 0 - 5 Years



For "new" vehicles the line of best fit shows a curious turn near the origin, probably an artifact of a log-linear relationship which gave a slightly better fit than a strictly linear relationship. The main point is that the defect rate is almost flat, at least after the first month. For heavy vehicles up to five years old the likelihood a crashed vehicle carries a defect hardly changes with age of the CoF sticker. This strongly suggests annual CoF checks would be ample for "new" vehicles.

Vehicles Aged 6 or more Years



For "old" vehicles the picture is different. The line of best fit shows that, over the six month interval between CoF checks, there is a 5% increase in the likelihood a crashed vehicle carried a defect. The average defect rate over the period between CoF checks is 7½% to 8%. Halving the period between checks would reduce this by 2½%. (Whether this reduction would be worthwhile is another matter.)

The first graph's regression line shows that the defect rate increases from 4% immediately after a CoF check to 7½% just prior to the next check, averaging 5.75% over the six months. Weekly CoF checks would be expected to achieve about 4.25%, an improvement of 1½%. Since we are not contemplating different pass/fail thresholds for QA vehicles, the 1½% reduction can be taken as an upper bound for safety improvements brought about by a switch to QA. Since 1½% as a proportion of 5.75% is ¼, we conclude that QA might avert *up to* one-quarter of accidents involving heavy vehicles with defects, or *up to* $3M/y in round figures.

Expressed another way, we estimate that QA would save about one fatal accident a year, on average. There is a significant margin for error in this figure, the greatest uncertainty surrounding the accident data. Under-reporting is not the concern since the overwhelming cost is from fatal accidents, thought to be 100% reported. Our doubt relates to the judgments of traffic officers and police as to what constitutes a vehicle defect. Vehicle inspectors prepare reports on fatal accidents and these ought to be fed into the accident statistics. Strictly, the 100 fatal crashes pa involving heavy vehicles deserve reports from persons of higher expertise, *eg* road transport engineers.

The estimated total saving is equivalent to 3½ fatal accidents a year. Against a backdrop of many hundreds of fatal accidents annually, this is too small figure on which to base a decision on mandatory QA. QA should be optional for operators meeting a sufficiently high standard; and they should be encouraged to adopt QA. Coupled with better accident data, concrete experience with QA may yet prove compulsory QA to be justified.

Possible Changes to Existing System

Given that the CoF system will be retained, at least for a time, we make some observations as to how the CoF system might be improved.

A mathematical analysis of roadworthiness and periodic vehicle inspections, which categorised operators as "good", "fairly good" and "bad", concluded that:

- the foremost benefit of the CoF system is "policing" bad operators;
- there is no point focusing the fixed resource available for CoF checks on vehicles travelling long distances unless this catches "bad" operators more often;
- there is no point subjecting "good" operators to CoF tests;
- the benefits of CoF checks for "fairly good" operators, perhaps representing the majority, are:
  - nil for failures occurring at random;
  - small for time- or distance-related failures; and
- empirically it appears that newer vehicles are prone mainly to random failures and are more likely to be well maintained. Older vehicles appear deserving a more frequent surveillance.

Standardisation

It may sound fair to impose the same standard on all, but a vehicle travelling on public roads used by only a few hundred vehicles a day poses much less of a threat to the general public than if it travelled on highly-trafficked urban roads and motorways. The more traffic with which a vehicle mixes, or the more passengers it carries, the better should be its quality of maintenance. Large vehicles should bear a greater onus of safety because of their destructive potential in accidents. Passenger service vehicles should achieve higher levels of safety than goods service vehicles, in keeping with their passenger capacities.

Annual Checks

Another issue is whether to keep the same *frequency* of check for all vehicles, old and new. The average "older" heavy vehicle (over five years old) is twice as likely to carry a defect than the average "newer" heavy vehicle (less than five years old). There is merit in annual checks for newer vehicles. For older vehicles the defect rate depends on the period between checks. It would require much more numerical figuring to pin point the optimum check frequencies, but there may be no need. A practical suggestion, which is hard to knock down, is to retain six monthly CoF checks for older vehicles and introduce yearly checks for newer vehicles. Indeed, if the checks of older vehicles were made more stringent, they too might be checked annually, in which case checks of roadworthiness could be associated with annual relicensing of the vehicle.

Random Checks

Maintenance by "bad" operators tends to be governed by the imperative, "keep the wheels turning". We deduce that a minority of "bad" operators probably contribute a large proportion of vehicle defects. Random checking would be a way of making up for the reduction in check frequency that annual checking would entail. Vehicle inspectors could spend much more of their time outside the testing stations inspecting vehicles at random.

Roadside checks at random would tend to intercept vehicles travelling long distances on busy roads, these being the vehicles most likely to impose externality costs on the general public. It would be wise to redeploy part of the present testing station effort on random checking on roads where the need for vehicle safety is greatest, *ie* roads carrying the most traffic.

Random inspections would single out the "bad" operators — unlike the present system which penalises "good" and "bad" alike since all must front-up every six months. Random checks would provide information that currently does not exist, *viz* the roadworthiness of typical vehicles using the roads. Without this information it is difficult to reach conclusions about the role of vehicle defects in accident causation. As well, more crash-involved vehicles should be subject to reports by vehicle inspectors. The defect classification system needs revision, and records should note the level of thoroughness/technical expertise of the inspection.

Vehicles Covered by CoFs

Too many vehicles are obliged to get CoFs rather than Warrants of Fitness (WoFs), to which cars and vans are subject.

Rental cars are technically no different from passenger cars, so they should be checked at WoF garages. The modern paradigm is that consumer preference should be left to determine service quality. The hirer should be free to "rent a wreck", provided the "wreck" meets WoF roadworthiness standards. Parallel arguments apply to taxis.

The experience of the testing stations is that problems start with large two-axled trucks, and three-axled vehicles. This suggests treating vehicles with only four tyres on the road differently from the rest or possibly treating all two-axled vehicles differently, irrespective of single- or twin-tyres. This would save surveillance and compliance costs for vehicles that are less at risk.

A conservative option would be to adopt the following.

> Apply the CoF test to any vehicle over 3.5 tonnes and
> *either* has more than four tyres
> *or* will be used in combination with another vehicle.

The 3.5 tonne threshold is severe and might well be doubled.

Main Recommendations of the Study

- That the heavy road transport industry be encouraged to substitute, on a voluntary basis, QA for periodic inspection.
- That the decision on mandatory QA be reviewed as soon as there is sufficient reliable accident data concerning heavy vehicles involved in crashes.
- That data on defect rates of crash-involved heavy vehicles be improved by:
  - vehicle inspectors' reports being fed into the accident statistics,
  - road transport engineers assisting vehicle inspectors to examine heavy vehicles involved in fatal accidents,
  - engineers and inspectors together conducting random checks to determine the typical roadworthiness of vehicles using the roads,
  - sampling according to statistical "experimental designs" that maximise the utility of the data collected, and
  - recording defects according to a more useful classification system, also noting the level of thoroughness/technical expertise of the inspection.
- That, if and when it is decided QA will be mandatory, buses be made to join the system first.
- That, in the expectation QA will eventually be mandatory, investment expenditure on CoF testing facilities be minimised.

Whilst periodic CoF inspections remain, it was also recommended that:

- That TASS be employed to automate charging for CoF tests according to the time taken for inspection, and that re-checks be charged.

- That random checking be instituted, at the roadside and at operators' depots *etc*, targeting vehicles more likely to impose accident costs on the general public.
- That buses be subject to higher standards of roadworthiness than other heavy vehicles.
- That the CoF test be applied to every vehicle that is (1) over 3.5 tonnes and (2) *either* has more than four tyres *or* is used in combination with another vehicle.

BIBLIOGRAPHY

— ; *A Guide for Operators; Department of Transport, UK*; 1988

— ; *A Hard Road*; Truck and Bus Transportation; November 1988

— ; *A National Car Safety Scandal*; Consumer Magazine; November 1990

— ; *A Testing Time - Monitoring Truck Safety*; Lifting and Transportation International; November-December 1988

— ; *Big Trucks and Highway Safety*; Truck Australia; September 1989

— ; *Brake Defects*; Insurance Institute for Highway Safety, United States; 1985

— ; *Evaluation of Motor Vehicle Safety Standards*; National Highway Traffic Safety Administration; December 1973

— ; *"Fit for a Bullock Cart" - Imported Second-hand Tyres are a Menace*; Consumer Magazine; April 1991

— ; *Heavy Vehicle Safety on Major NSW Highways: A Study of Crashes and Countermeasures*; Roads and Traffic Authority of New South Wales; 1990

— ; *Report of the Independent Committee of Inquiry*; Road Haulage Operators' Licensing; 1978

— ; *Random Inspections to Increase: VicRoads*; Australian Bus and Coach; May 16, 1991

— ; *Report of Inquiry; National Road Freight Industry* (Australia); 1984

— ; *Researchers Analyze 25,000 Fatal Crashes Involving Big Trucks*; Status Report, **23** (12); Insurance Institute for Highway Safety, United States; 1988

— ; *Safety Legislation*; Heavy Duty Trucking; August 1989

— ; *Safety Inspection*; Heavy Duty Trucking; August 1989

— ; *Streamlined Inspection Criteria*; Heavy Duty Trucking; August 1988

— ; *The Auditors Are Coming*; Heavy Duty Trucking; June 1988

— ; *The Effect of Truck Size and Weight on Accident Experience and Traffic Operations, Volume 3: Accident Experience of Large Trucks*; Federal Highway Administration, United States; 1981

Ashenhurst, B; *The DMT Gets Hi-Tech Help*; Truck and Bus Transportation; 1986

Atkins, AS; *The Economic Costs of Road Accidents in Australia: Some Issues in Estimation, Concept, and Application*; ARRB Proceedings Vol 11, Part 5; 1982

Baas, PH and DM White; *Improved Vehicles Will Improve Safety*; Road Traffic Safety Research Council of New Zealand, Paper presented to the Road Traffic Safety Seminar, 14-16 September 1988; 1988

Bellinger, DQ; *Component Degradation Braking Systems Performance*; TRW Systems Group; 1969

Buxbaum, RC and T Colton; *Relationship of Motor Vehicle Inspection to Accident Mortality*; Journal of the American Medical Association; 1966

Calspan Corporation; *Light Truck Safety - A Literature Review and Research Outline*; Motor Vehicle Manufacturers Association, United States; 1985

Corben, CW; *Truck Design, The Shortfalls*; Traffic Authority of New South Wales; August 1982

Ergun G; *Condition of Vehicles in Saudi Arabia*; Accident Analysis and Prevention; 1987

Fancher, PS and A Mathew; *Safety Implications of Various Truck Configurations*; Federal Highway Administration, United States; 1990

Fosser, S; *Periodic Inspections Have No Effect On Safety*; Nordic Road & Transport Research, No2; 1991

Fuchs, VR and I Leveson; *Motor Accident Mortality and Compulsory Inspection of Vehicles*; Journal of the American Medical Association; 1967

Garbacz, C and JG Kelly; *Automobile Safety Inspection: New Econometric and Benefit/Cost Estimates*; Applied Economics; 1987

Gardeski, RM; *Roadside Inspection: A Needed Upgrade*; ITE Journal; April 1987

Golob, TF, WW Recker and JD Leonard; *An Analysis of the Severity and Incident Duration of Truck-Involved Freeway Accidents*; Institute of Transportation Studies and Department of Civil Engineering; University of California Irvine, California; reprinted in Accident Analysis and Prevention; 1987

Guria, JC; *Estimates of Social Costs of Accidents and Injuries*; (draft) January 1991

Guria, JC; *Estimation of Social Costs of Traffic Accidents and Injuries in New Zealand*; Papers of the Australasian Transport Research Forum Volume 15 Part 2; 1990

Guria, JC; *Length of Hospitalization - An Indicator of Social Costs of Disabilities from Traffic Injuries*; Accident Analysis and Prevention; 1990

Joscelyn, KB and JR Treat; *A Study to Determine the Relationship Between Vehicle Defects and Failures, and Vehicle Crashes*; US Department of Transportation; 1973

Jones, IS and HS Stein; *Defective Equipment and Tractor-Trailer Crash Involvement*; Accident Analysis and Prevention; 1989

Khasnabis, S and SH Lyoo; *Use of Time Series Analysis to Forecast Truck Accidents*; Transportation Research Record 1249 ; 1989

Loeb, PD and B Gilad; *The Efficacy and Cost-Effectiveness of Vehicle Inspection - A State Specific Analysis Using Time Series Data*; Journal of Transport Economics and Policy; May 1984

McDowell, GJ; *Commission of Enquiry into the New South Wales Road Freight Industry*; 1980

McInnes Group; *Quality Assurance and Heavy Vehicle Fitness*; Land Transport Division, Ministry of Transport; November 1991

Mundey, B; *Truck Safety - who's in charge*; Truck Australia; September 1989

Oluwoye, JO; *Heavy Truck Safety*; Australasian Transport Research Forum; 1990

Pearson-Kirk, D; *Safety and Environmental Problems Associated with the Operations of the Road Freight Industry, Part 1: Safety Aspects*; prepared for the Commission of Enquiry into the New South Wales Road Freight Industry; 1980

Sacks, WL; *Vehicle Factors and Traffic Accident Causation: an Interim Report*; Traffic Quarterly; 1973

Saffron, DG; *Quality Licensing as a Traffic Safety Measure: The U.K. Evidence*; Traffic Authority of New South Wales, August 1981

Scott, GB and WT White; *The Economic Worth of the New Zealand Periodic Motor Vehicle Inspection Scheme*; NZ Ministry of Transport; 1988

Slovic, P, D MacGregor and NN Kraus; *Perception of Risk from Automobile Safety Defects*; Accident Analysis and Prevention; 1987

Stein, HS and Jones, IS; *Crash Involvement of Large Trucks By Configuration: A Case-Control Study*; American Journal of Public Health; 1988

Strotton, C and F Schnerring; *The Mount Ousley In-Depth Study of Heavy Vehicle Crashes August 1979 to September 1980*; Traffic Authority of New South Wales; February 1983

Symonds, MJ and DW Reinfurt; *A Model for Evaluating the Effectiveness of Motor Vehicle Inspection Programs*; Accident Analysis and Prevention; 1975

Tan, HW and KW Ogden; *Truck Involvement in Fatal Road Accidents in Australia*; 14th ARRB Conference; 1988

Taylor, MC; *The Cost of Vehicle Damage Resulting from Road Accidents*; Digest 256; 1990

Teal, RF; *Estimating the Full Economic Costs of Truck Incidents on Urban Freeways*; AAA Foundation for Traffic Safety, Washington DC; 1988

US Department of Transportation; *Period Motor Vehicle Inspection Report*; January 1974

US Department of Transportation; *Motor Vehicle Inspection Project Report No. 24*; 1974

US Department of Transportation, National Highway Traffic Safety Administration; *1975 Societal Costs of Motor Vehicle Accidents*; 1975

Vaughan, RG; *Random Inspections - Cost Effective?*; Department of Motor Transport, New South Wales, Australia; 1988

White, WT; *Defects in New Zealand Vehicles: Implications for the Annual Testing of New Cars*; Ministry of Transport Traffic Research Report No 32; April 1984

White, WT; *Does Periodic Vehicle Inspection Prevent Accidents*; Accident Analysis and Prevention; 1986

White, WT; *Determinants of Car Failure Rates at Inspection*; Ministry of Transport, NZ; 1988

White, WT; *A Theory of How the Period of Vehicle Inspection Affects the Evolution of Defects and the Probability of Accidents*; Road Traffic Safety Research Council, Wellington, NZ; 1988

White, WT; *Should Mandatory Periodic Inspection of Cars be Less Frequent?*; Road Traffic Safety Research Council, Wellington, NZ; 1988

Wildavsky, A; *Searching for Safety*; transaction Publishers; 1988

Williams, AF; *US Motor Vehicle Injuries*; Paper presented to Road Traffic Safety Seminar, Wellington NZ; 1988

Wolkowicz, M; *On-the-Scene Study of Commercial Vehicle Accidents*; International Symposium on Heavy Vehicle Weights and Dimensions, Kelowna, British Columbia; 1986