IMPLEMENTING A ROLL STABILITY REQUIREMENT: ISSUES, PROBLEMS AND RESULTS

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ABSTRACT

In July, 2002 the Land Transport Safety Authority in New Zealand introduced a new Dimensions and Mass Rule which, in a world-first, imposed a minimum roll stability requirement of most large heavy vehicles. This innovation was made possible through the development of a low-cost easy-to-use method for calculating roll stability, which was described at the last symposium.

In this paper we outline how the stability requirement was implemented. This includes key issues such as phase-in time, certification requirements and procedures, certifier training and approval, exceptions and exemptions, documentation and enforcement. For each of these issues there was a planned approach and although, in some cases, minor adaptations were required to accommodate unforeseen situations, for the most part the approach was followed. The paper discusses where the problem areas were and how they were resolved.

The purpose of implementing a minimum stability requirement was to reduce the heavy vehicle rollover rate primarily by targeting the poorest performing vehicles. The paper undertakes a preliminary assessment of how successful the measure has been.

INTRODUCTION

In New Zealand on July 1, 2002, Vehicle Dimensions and Mass (VDM) Rule 41001 (LTSA, 2002) came into force. This Rule introduced for the first time anywhere in the world a minimum rollover stability requirement for most large heavy vehicles in the general fleet. Some other jurisdictions have minimum stability requirements for some categories of vehicles where the potential outcome from a rollover is very serious, for example, the United Kingdom requirements for buses and coaches (HMSO, 1972) and the ECE requirements for tank vehicles (ECE, 2001) but no other country has made stability a requirement for general heavy vehicles.

The stability requirement is New Zealand is that all heavy truck of class NC (greater than 12 tonnes GVM) and all heavy trailers of class TD (greater than 10 tonnes GVM) must achieve a minimum Static Roll Threshold (SRT) of 0.35g. There are some exceptions and these will be discussed later. The option to bring in this stability requirement was made possible through the development of the SRT Calculator which provides a simple low-cost and reasonable method for assessing SRT. The development and validation of the SRT Calculator was described at the last symposium (de Pont et al, 2002).

In this paper we describe:

- the process of developing the VDM Rule and the SRT requirements within the Rule
- what the implementation process was and how it proceeded
- modifications that had to be made to the original implementation process

SAFETY AT REASONABLE COST

The Land Transport Safety Authority (LTSA) is the New Zealand government agency charged with maintaining the safety of the land transport system including both road and rail transport. Underlying all their activities is a principle of "safety at reasonable cost", i.e. not safety at any cost. The primary way that this

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principle is applied is that the public is surveyed to determine a "social cost" for a road crash fatality, serious injury and minor injury. This "social cost" does not reflect the actual cost to society of these outcomes but rather reflects the amount the public is willing to spend to prevent these outcomes. Currently the "social cost" of life is a little over $3M. Thus this means that the public, on average, is prepared to spend $3M to prevent one road fatality. When evaluating a proposed road safety counter-measure, the LTSA estimates the reduction in fatalities, serious injuries and minor injuries that might be expected from the counter-measure and then calculates the associated reduction in social costs. If the cost of implementing the counter-measure is less than the social cost reduction it meets the reasonable cost criterion and can be implemented. If the implementation cost is greater than the social cost reduction the counter-measure is not justified.

Although the validity of this approach can be questioned it does have some obvious benefits. It provides an objective means of assessing the value of proposed counter-measures and gives a basis for comparing different alternatives. When funds are limited it allows proposals to be prioritized in a rational way. In terms of the implementation of the minimum SRT requirement in the VDM Rule, the principle of safety at reasonable cost was a driver for some of the decisions that were made and so it is necessary to understand how this principle is applied.

THE RULE DEVELOPMENT PROCESS

The transport regulations in New Zealand are being rewritten as a set of Rules. This is gradual process which is being undertaken over a number of years. As each Rule is developed the opportunity is taken to review and update the requirements.

Essentially the process proceeds as follows:
- LTSA staff review all the relevant regulations, consult with key stakeholders and prepare an overview and draft Rule, termed the "Red Draft"
- The "Red Draft" is then circulated to industry stakeholders for consultation and based on their responses the "Yellow Draft" is prepared.
- The "Yellow Draft" is circulated to the public and the industry for general consultation and a preliminary final draft, the "Green Draft" is prepared.
- The "Green Draft" is circulated for final comments before the final draft; the "White Draft" is prepared.
- The "White Draft" is taken to the government for ratification and formal acceptance and implementation.

If the "Yellow Draft" does not require significant changes to become the "Green Draft", the "Green Draft" stage may be omitted.

Development of the VDM Rule began late in 1999. For a number of reasons including terrain and roading conditions, New Zealand has a relatively high rollover crash rate. The VDM Rule was seen by LTSA an opportunity to not only rationalise size and weight regulations but also to improve safety by encouraging more stable vehicle configurations.

The "Red Draft" of the VDM Rule was issued in June 2000. It identified New Zealand's high rollover crash rate and noted that studies in both the USA and New Zealand had shown a correlation between rollover crash rate and poor SRT. It proposed that all new vehicles should be required to achieve a minimum SRT of 0.4g and that existing vehicles would be required to achieve a minimum SRT of 0.35g. It also presented an analysis of the reduction is "social cost" that would be expected to result from this measure.

Although SRT has long been considered a fundamental measure of vehicle rollover stability the traditional methods for assessing SRT are too expensive to meet the "reasonable cost" principle outlined above. However, in late 2000 TERNZ developed an analytical method for estimating SRT which had the potential to be sufficiently accurate and low-cost to be viable. The "Yellow Draft" of the Rule, which was released in July, 2001, presented a refinement on the proposed SRT requirements.

The key elements of this proposal were:
- large trucks and trailers would be required to have a minimum SRT of 0.35g
- trailers would be required to be certified for compliance while trucks would not

- trailers with a body height or load height less than or equal to 2.8m would not require certification but would still have to comply
- new vehicles first registered on or after the date of introduction of the Rule would be required to comply immediately, while existing vehicles would have a 6 month phase in period for compliance
- some specific categories of vehicles were exempted including tractor units, vehicles operating over-dimension or over-weight and some special purpose vehicles.
- four approved methods for determining SRT were defined. These were a tilt table test using the SAE procedure, a calculation using the analytical method developed by TERNZ, a calculation using the SRT Calculator which is a web-based software implementation of the analytical method, and lastly a test or methodology approved by the Director of LTSA.

The initial version of the SRT Calculator software was made available on the internet throughout the consultation period of the "Yellow Draft" so that anyone could evaluate it. Some validation work had been done to check its accuracy and reports on the validation tests were also available.

The SRT requirements in the "Yellow Draft" are more clearly defined and to some extent somewhat less demanding than the original "Red Draft" proposals. Specifically the minimum required SRT for new vehicles was lowered from 0.4g to 0.35g. Some vehicles are exempted from compliance and only the most at risk vehicles, the heavy trailers with a load height greater than 2.8m are required to be certified for compliance. These changes all result from applying the "reasonable cost" principle and keeping the cost of implementing the measure as low as possible while targeting the poorest performing vehicles which have the highest crash rates.

Based on the earlier crash risk study it was anticipated that 15-20% of vehicles would not meet the 0.35g SRT standard at their maximum weight and load height configuration. However, when a vehicle does not meet the SRT target at the weight and load height values entered, the SRT Calculator determines the reduction in weight or load height required to achieve the target. For vehicles requiring certification, the two pairs of height and weight results are printed on the Certificate of Loading. A failure to achieve a minimum SRT of 0.35g at the potential maximum height and load does not prevent the vehicle from operating although it will restrict its height and weight combinations. It was expected that some of these vehicles with poorer SRTs would be modified to improve their stability, some would continue to operate as is but with height or weight restrictions applying and a small number of poorer performing vehicles would be uneconomic to modify or to continue to operate as is and would be withdrawn from service.

The feedback from the "Yellow Draft" consultation resulted in only minor changes to the Rule and so the "Green Draft" stage was omitted. The Rule came into force on July 1, 2002. The only change to the SRT requirements as outlined above was that the phase-in period for implementation was extended by six months. The reason for this was industry concern about the availability of SRT certifiers and the workshop resources for vehicles needing modification.

SRT CERTIFIERS AND CERTIFICATION

As noted in the previous section under the Rule heavy trailers require certification for compliance with the minimum SRT requirement. Various other aspects of vehicle design in New Zealand, such as chassis modifications, load anchorages, drawbars and drawbeams, etc require certification before the vehicle can operate. The LTSA operates a system where manufacturers and engineers can sign up as approved certifiers for various categories. To be approved as a certifier, a person must have appropriate qualifications and experience and, for most categories, complete a training course and pass a test. In signing up the certifier undertakes to maintain standards and keep detailed records and to take responsibility for the certifications he or she issues. SRT certification constitutes a new category but existing certifiers could become SRT certifiers by attending a one day training course and passing the qualifying tests.

With the whole heavy vehicle fleet requiring certification in the first year of operation it was thought that there might be a shortage of certifiers. To address this issue, two levels of certifier were established. Within the SRT Calculator, the simpler input options require only information that is easily obtained by simple measurements. Using these options gives a more approximate estimate of SRT but the default parameter values have been chosen so that this estimate should be conservative. Level 1 certifiers are authorised to undertake certifications using only these options. The more complex input options may involve calculating the payload centre of gravity and or obtaining and interpreting suspension data. To use these options for certification requires a Level 2 certifier. The training course was structured so that the material related to Level 1 certification is covered in the morning session and the issues relating to Level 2 are covered in the afternoon session with qualifying tests at the end of each session.

Most of the vehicle testing stations, which carry out periodic inspections (6-monthly), have set up facilities to offer Level 1 certification by having their vehicle inspectors trained to this level. This provides a low cost (approx US$35) option for SRT certification for many vehicles. Where the vehicle does not achieve the target SRT with an operationally acceptable combination of height and weight, a Level 2 certification may give a more satisfactory outcome. Most Level 2 certifiers are professional engineers and the cost of these certifications is somewhat higher. If the vehicle does not achieve a satisfactory result at Level 2, the certifying engineer can usually also provide advice on the best way forward in terms of vehicle modifications etc.

The training of certifiers commenced shortly after the Rule came into force. Although there are only just over 40 engineers approved to do heavy vehicle chassis modifications, nearly 80 engineers have become approved as Level 2 SRT certifiers. There are a number of others who have passed the qualifying tests but have not bothered to become approved certifiers. In addition there are 10 certifiers qualified at Level 1 only and more than 120 vehicle inspectors who have passed the Level 1 qualification.

IMPLEMENTATION

As noted above the phase-in period was extended by six months following representations from the industry on resourcing issues. Thus all new trailers first registered after 1 January, 2003 were required to be certified on the first renewal of their periodic inspection certificate. Existing trailers were required to be certified on their first periodic inspection after 1 July, 2003. As periodic inspections are 6-monthly this means that all heavy trailers should be certified for SRT compliance by 31 December, 2003.

To facilitate the implementation the LTSA prepared and distributed a Factsheet (available on the internet) which explained the SRT requirements in plain language. They also prepared posters which were displayed in all vehicle testing stations and informed operators of the coming SRT requirements. A fully functional version of the SRT Calculator can be accessed on LTSA's web-site (www.ltsa.govt.nz/srt-calculator) and so anyone could check out the performance of their vehicles. This meant that operators could pre-screen their vehicles before approaching a certifier. It also means that vehicles, such as trucks, which must comply with the SRT requirement but which do not need certification could be checked by the operator personally at little cost.

Although the extension of the phase-in period theoretically more than doubled the time available for operators to have their vehicles certified, in practice, for most operators, it just delayed the start of the process by 6 months. Since the certification became mandatory, the process has proceeded on schedule. At as 6 Oct 03, 11534 (77%) of trailers had been certified. About 60% of these were undertaken at Level 1 by vehicle testing stations and other level 1 certifiers.

Most vehicles achieved the minimum SRT requirement at the weights and load heights that they normally operated at and so had no problems with the regime. In some sectors, particularly log transport and stock transport there were a significant number of vehicles that did not meet the minimum SRT requirement at their usual load weight and heights particularly when the more conservative Level 1 certification method was used. This was not surprising as these vehicles are recognised in the industry as having poorer stability and this is reflecting in their high rollover crash rates. For many of these vehicles applying a Level 2 certification using actual suspension data resulted in a sufficiently better SRT to be able to operate. For other vehicles suspension modifications were made to improve their SRT. In many cases, with steel leaf spring suspensions, sufficient gains in performance could be achieved through reducing the suspension lash which is a relatively low-cost modification.

ISSUES AND CHANGES

During the implementation a number of issues arose. A number of these have been addressed with a revision to the Factsheet, modifications to the SRT Calculator software and notification to the certifiers of policy changes. Others relate to the availability and quality of suspension data and these are being worked through.

Level 1 certification may use one of two standard load categories. In both of these options the calculator uses the load bed height and the load height to determine the payload centre of gravity height. This implicitly assumes that the load bed height and load height are constant along the length of the vehicle. However, for simple departures from this assumption such as sloping decks and step decks it is simple to calculate an equivalent load bed height and load height and to use these standard load categories. This then raised the question of whether sloping deck and step deck vehicles should be able to be certified by a level 1 certifier because although the load categories are suitable for level 1 some calculation is required. This has been clarified in the policy changes. The SRT Calculator software has been modified so that sloping deck and step body styles are an input option, the user is only required to input measured data and the Calculator determines the equivalent load bed and load heights. With the changes these vehicles are permitted to be certified by a level 1 certifier.

The second issue that arose was the question of what values of weight and load height should be used for SRT certification. As noted above, if a vehicle does not achieve an SRT of 0.35g or more at the gross weight and load height values entered the SRT Calculator determine the reduction in load height or weight required to achieve 0.35g. Figure 1 shows the load height and weights to achieve a minimum SRT of 0.35g for a particular vehicle when the certification is attempted at 4m load height and 28 tonnes gross mass. This point is marked on the figure and as can be seen results in an SRT that is less than 0.35g. At 4m load height the gross mass to pass is approximately 19 tonnes while at 28 tonnes gross mass, the load height to pass is 3.31m. These two pairs of numbers (4m/19 tonnes and 28 tonnes/3.31m) appear on the loading certificate. This creates a difficulty in determining whether the vehicle complies with the SRT for height and weight combinations between these extremities such as 3.5m and 25 tonnes.

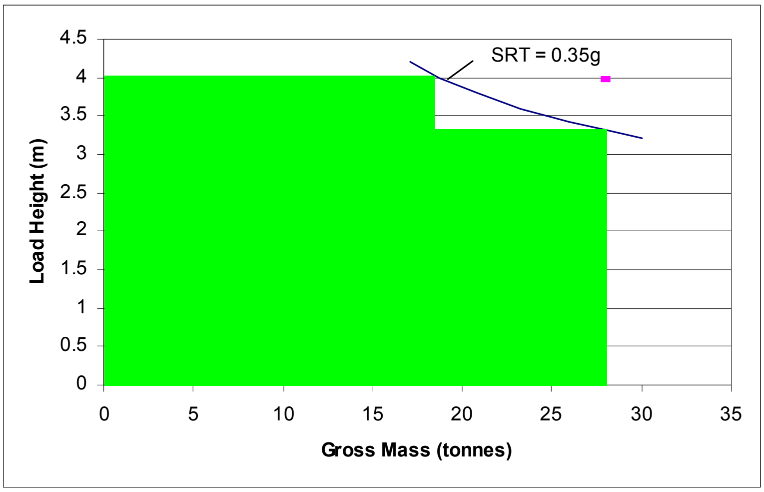

Figure 1. Reduced weight and height to meet 0.35g SRT.

If the vehicle certification is done at a height and weight combination (3.6m and 23 tonnes) where is passes as is shown in Figure 2, then this pair of numbers will appear in both positions on the loading certificate. Compliance with the SRT requirement is straightforward and unambiguous. For this reason certifiers used the operational maximum height and weight for the vehicle as the basis for certification rather than the legal maxima the vehicle was capable of.

A legal opinion from within the LTSA found that the wording in the VDM Rule implied that SRT certification should be done at the legal maximum height and weight of the vehicle rather than the operational values. The effect of this was that more vehicles would not achieve 0.35g at full height and weight (as shown in Figure 1) and so would have distinct pairs of height and weight combinations on their loading certificates. At a theoretical level this is not a problem but at a practical level, for height and weight combinations between the two extremes on the loading certificate the operator and the enforcement officer would have difficulty determining whether the vehicle complies. To resolve this the SRT Calculator was modified so that when a vehicle does not meet 0.35g at full height and weight, the calculator determines the reduced weight at full height and then calculates the load height for all weights between the maximum and reduced values in one tonne increments. The results of this calculation are presented in a table on the SRT Certificate. Thus the operator has a complete picture of the heights and weights at which the vehicle complies.

Figure 2. Height and weight to meet 0.35g SRT.

Some other minor operational issues were identified and the policy was clarified. These related to the exchange of data between different levels of certifier and options to approximate some types of load as a level 1 load category in a conservative way.

The other major issue that arose was the availability of suspension data. Level 1 certifications are undertaken using generic suspensions for which the parameters are embedded in the software. These parameters have been chosen to be at the more roll compliant end of the spectrum and so the resulting SRT is conservative. Level 2 certifiers have the option to input the suspension parameters which usually will result in a higher SRT. The certifiers are expected to obtain the suspension parameter data from the suspension supplier or manufacturer and keep documentary support.

The SRT Calculator requires three fundamental quantities as suspension parameters, the total or composite roll stiffness, the vertical stiffness of the springs, and the roll centre height. The availability and quality of suspension data has varied tremendously. Some suspension manufacturers have had good data and have been very forthcoming in providing it. Others have been unwilling to provide data, citing "commercial sensitivity", while a third group have been willing to provide the data but have not had good data and in some cases do not appear to have had a good understanding of the behaviour of their suspensions. The main area where there is a lack of understanding is in the contribution of auxiliary roll stiffness. With mechanical suspensions a number of the manufacturers assume that there is no auxiliary roll stiffness and so they calculate the composite roll stiffness from the measured vertical spring stiffness on this basis. For trailer and drive axle suspensions, the auxiliary roll stiffness is usually relatively small (5%-10% of the total) and so this assumption is conservative and does not affect the SRT result very much. In some instances it can cause a minor problem for the SRT Calculator when the original data are in imperial units. When the data are converted to metric units as required for input to the Calculator, numerical rounding can create the situation where the implied auxiliary roll stiffness is negative. The Calculator checks this value and will give an error message in this case. More serious problems arise for truck steer axles where the auxiliary roll stiffness may be 50% or more of the total roll stiffness. Ignoring this contribution substantially under-estimates the total roll stiffness and the resulting SRT. To overcome this problem a test rig has been constructed and some 11 steer axles on different trucks have been tested to determine their suspension parameters.

COMPLIANCE ISSUES FROM A REGULATORY PERSPECTIVE

Prior to the Rule, the transport regulations required that, in essence, operators must load their vehicles safely. The key benefit of the new requirement is that a measurable benchmark (0.35g) has been set. Note however, the more general clause still remains. From a regulatory perspective, the implementation of SRT has been extremely useful in showing how a performance based approach can be used to provide safe and efficient vehicles.

Although the SRT regime is a performance based standard, on-road compliance is delivered by prescriptive requirements, the allowable weight and height combinations. The key benefit of controlling the performance outcome via two relatively simple measurables is that both the operator and the enforcement officer have a transparent way of checking and maintaining compliance. However, it does create the possibility that a vehicle might violate its height and weight restrictions but still meet the performance standard or vice-versa. This can occur if the centre of gravity height of the actual load is different from that used in the SRT Calculation. Although this introduces the risk that a vehicle may meet its prescriptive requirements but not achieve the performance standard it does not follow that the vehicle will then be unsafe. Prior to the Rule the same vehicle would have been limited only by the general height and weight limits and could have been configured to be less stable.

CONCLUSIONS

New Zealand introduced a minimum SRT requirement for most large heavy vehicles as part of the VDM Rule in July 2002. Underpinning this requirement is the SRT Calculator which provides an easy-to-use low cost method for assessing SRT. The intention to introduce a stability requirement was signalled two years prior in the "Red Draft" document and spelled out in detail in the "Yellow Draft" one year later. These drafts are consultation documents and in conjunction with the "Yellow Draft", the first release of the SRT Calculator software was made freely available to all. The consultation process resulted in some minor modifications to the SRT Calculator and an extension of 6 months on the phase-in period. One year after the implementation of the VDM Rule, which is midway through the phase-in period, a review identified some issues. Addressing these meant some policy clarifications and a revision of the SRT Calculator software which added additional features.

The ultimate goal of this measure is a reduction in the rollover and loss-of-control crash rate for heavy vehicles. Because the measure is still in the phase-in stage it is not possible to determine the extent to which this has been achieved. However, anecdotal feedback from various operators does indicate that the measure is effective.

The engineer for a large fleet of container trucks in Auckland when asked how he was finding the SRT requirements said that most of his vehicles passed comfortably apart from two or three older vehicles which he already knew were not very good and which he was now going to scrap.

Another engineer from a large Rotorua-based fleet compared the calculated SRT values for his trailers with their rollover history and found a very direct correlation between poor SRT and rollovers.

One of the factors affecting SRT is the amount of lash in the suspensions and so one of the easiest modifications to improve SRT is to reduce the lash. A certifying engineer reported that after reducing the lash on a log trailer the driver reported that he had noticed, in his mirrors, the trailer wheels lifting while cornering and was aware that he was travelling too fast for the stability of the vehicle. Prior to the modification he would have been travelling just as fast but was not aware he was so close to disaster.

Some sectors in the transport industry, particularly logging and stock have had some difficulties achieving satisfactory SRT ratings, although in both sectors the better performing vehicles have no problem. This is not surprising because these two sectors also have the highest rollover crash rates. The difficulties are caused to some degree by the nature of the payload and the associated operational requirements which result in relatively high centre-of-gravity vehicles but with innovative design these difficulties are by no means insurmountable and there are good examples of stable vehicles in both sectors. The SRT requirement effectively eliminates the poorer designs.

The implementation of a minimum stability requirement for the general fleet is a world-first and is attracting considerable interest from other jurisdictions where rollovers are a problem. There is anecdotal evidence that the introduction of the minimum SRT requirement is leading to improved stability performance in the New Zealand heavy vehicle fleet and this should be reflected in a reduction in rollover crash rate.

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