Low Volume Vehicle Technical Association (inc)

INFORMATION SHEET
 # 09 - 2021 (October 2021)

Helping New Zealanders Build & Modify Safe Vehicles

RAISED VEHICLE STABILITY CALCULATION

Introduction

Questions from the wider off-road community about LVVTA's approach to raised vehicles have brought about the need to explain the rollover risk assessment process applied to raised off-road vehicles. LVVTA has taken a cautious approach toward raised vehicles, as modifications to increase a vehicle's ride height have the potential to adversely affect its stability.

It should be noted that the calculation applied isn't a new rule or change of legislation, just a more accurate way of implementing existing requirements.

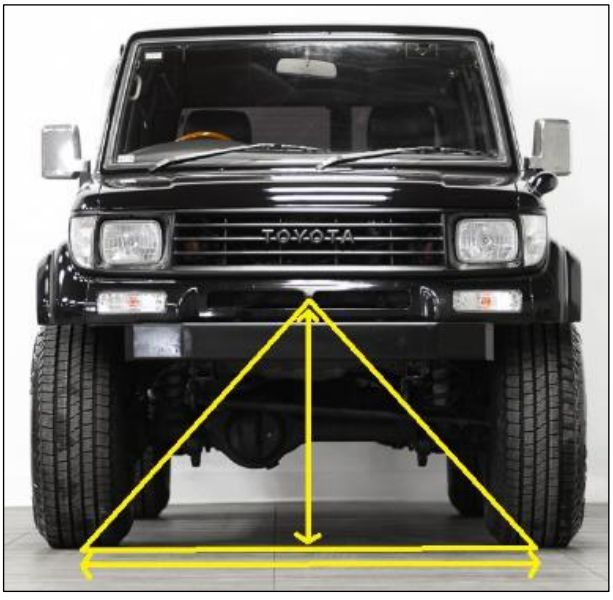
Background

Growing interest in off-road and 'lifestyle' vehicles has brought a lot of previously niche modifications into the mainstream that were designed to make a vehicle more capable off-road, but not usually intended for vehicles in daily use.

Because these vehicles are increasingly being used as everyday transport, their safety as road vehicles needs to be ensured, including making sure this type of modification has not reduced the vehicle's on-road safety below an acceptable tolerance from OE (as required by the over-arching NZTA Vehicle Standards Compliance Rule). Australian research [(1)] has found that four-wheel-drive vehicles (4WD) and sports utility vehicles (SUV) are more than twice as likely to roll over in a crash than a standard passenger vehicle, so safeguarding the stability of raised vehicles is vital.

Common modifications to raise a vehicle's ride height, such as fitting extended spring shackles, larger circumference all-terrain tyres, raised springs, lift blocks and coil spacers can all increase a vehicle's propensity to roll. Most of these modifications will require LVV certification, and as part of this the LVV Certifier will assess the vehicle's stability.

To help LVV Certifiers judge how stable a raised vehicle is, LVVTA has introduced a simple calculation to be applied to vehicles that are raised to an extent where LVV certification is required.



When a Vehicle needs a Stability Calculation

The need for an LVV Certifier to carry out a stability calculation is triggered by a vehicle with any one of these three criteria:

- a body lift over 50 mm; or
- a suspension lift over 50 mm; or
- an increase in tyre radius over OE of more than 50 mm.

If any one of these areas exceeds 50 mm, one of the following calculations to assess vehicle stability is required.

(1) https://www.monash.edu/__data/assets/pdf_file/0006/218364/racv-4wd-crash-involvement-patterns-summary.pdf

Static Stability Factor (SSF)

The first tool available as a quick indicator of a vehicle's tendency to roll is called a Static Stability Factor, which is a basic calculation to figure out the relationship between the vehicle's track width and its centre of gravity (CoG). This uses the equation ***SSF=t/2h***, where:

- **t** = track width measured between the tyre tread centres (*not the outside edges)*
- **h** = centre of gravity height

The crankshaft centreline is usually a good approximation of the centre of gravity height, so if the actual figure is not known, the measurement is taken from ground level to the centre of the crank pulley.

The SSF effectively creates a triangle between the CoG point and the wheel track, where the CoG height is at the top point and the vehicle's track at the two lower corners. This ratio should equal at least 1.1 or greater – the taller the triangle, the less stable the vehicle is, and the lower the SSF result will be.

For example, the calculation for a vehicle with a 1200 mm track and crank height of 500 mm would be as follows:

- Track width: 1200 mm
- CoG height (taken from centre of crank pulley): 500 mm

  SSF = 1200 ÷ (500x2)

  = 1.2

As 1.2 is greater than 1.1, this vehicle has passed the SSF calculation.

As an alternative to the SSF calculation, here is a handy chart to check if the 1.1 SSF target is met:

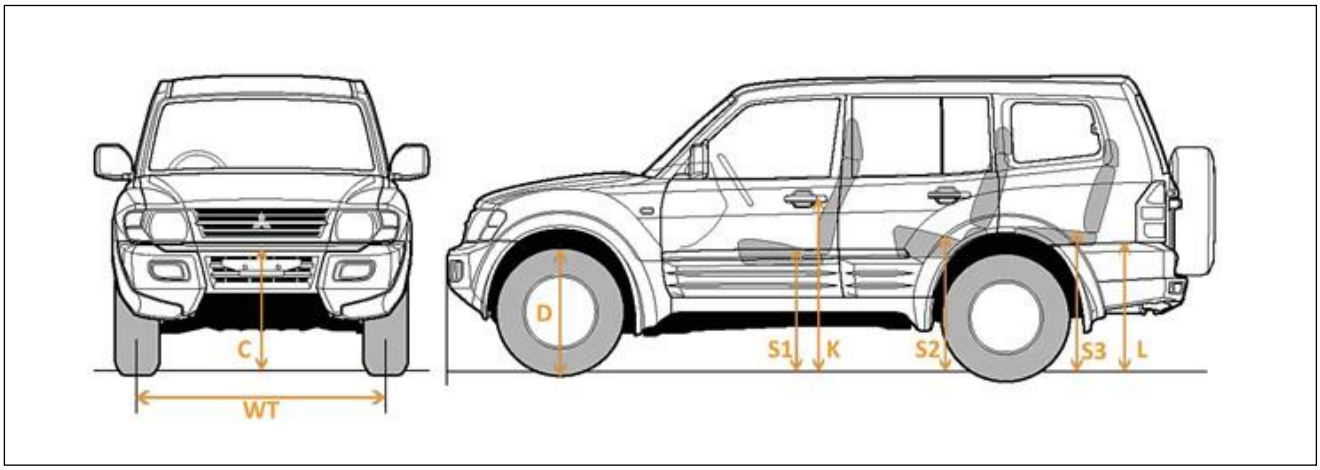
Track	1100	1120	1140	1160	1180	1200	1220	1240	1260	1280	1300	1320	1340	1360	1380	1400
Minimum CoG to meet SSF of 1.1	500	509	518	527	536	545	555	564	573	582	591	600	609	618	627	636

The calculation does not take into account vehicle weight or seat and load heights, which can be problematic when confronted with a raised flat deck ute with large toolboxes or a Hiab crane on the tray. If a vehicle has an SSF of less than 1.1, the LVV Certifier will refer the vehicle to the LVVTA office for a full Static Roll Threshold calculation.

What is a Static Roll Threshold?

A Static Roll Threshold (SRT) is a calculation of a vehicle's height and weight at various points divided by its maximum weight, to give an indication of the likelihood that it will tip over.

The minimum acceptable figure that LVVTA employs for a raised 4WD SRT is a ratio of **0.9** or **95% of the unmodified OE vehicle ratio**.



How the Static Roll Threshold is Calculated

The LVVTA model takes factors like the vehicle's weight, centre of gravity height, number of seats and their mid-point height, the load height, and divides this by the vehicle's rated Gross Vehicle Mass (GVM - which is the maximum rated all-up weight of the vehicle, including cargo). This gives a more accurate idea of how stable a vehicle is than the SSF calculation, as dynamic considerations such as vehicle weight and load placement are factored into the equation.

The Nissan Safari is a good case study as it has some of the widest range of aftermarket parts available in terms of suspension and body modifications, and is therefore one of the most commonly modified 4WD vehicles.

When it left the factory, a standard long-wheelbase GQ Safari had a loaded SRT of 1.01 (according to LVVTA figures). With a 75 mm (3") suspension lift, 35" tyres and a 50 mm (2") body lift, depending on how wide the vehicle's track has become this can put the vehicle below the 0.9 or 95% threshold for a satisfactory SRT calculation.

An LN65 Hilux is another good comparison – from OE this has a loaded SRT of 0.84, which is already well below what is acceptable for a modified vehicle SRT result. For this reason, the LVVTA calculation incorporates a tolerance value (95% of OE), but with an already poor SRT figure from standard there is limited scope for lifting the vehicle without drastically increasing the track to compensate.

Another thing to consider is, because the Hilux is a utility vehicle, the load height may be higher than a station-wagon type SUV due to the height of the load bed in the tray, which contributes to the high centre of gravity. Therefore, an SRT calculated on a cut-down station wagon (like a Safari or Land Cruiser) will not be the same as a passenger vehicle that has not been cut down.

Left: *Nissan Safari/Patrol GQ* ***Right:*** *Toyota Hilux LN65*

LVVTA is currently compiling a database of OE figures for the SRT calculator, with figures available for more than 30 different models at the time of writing.

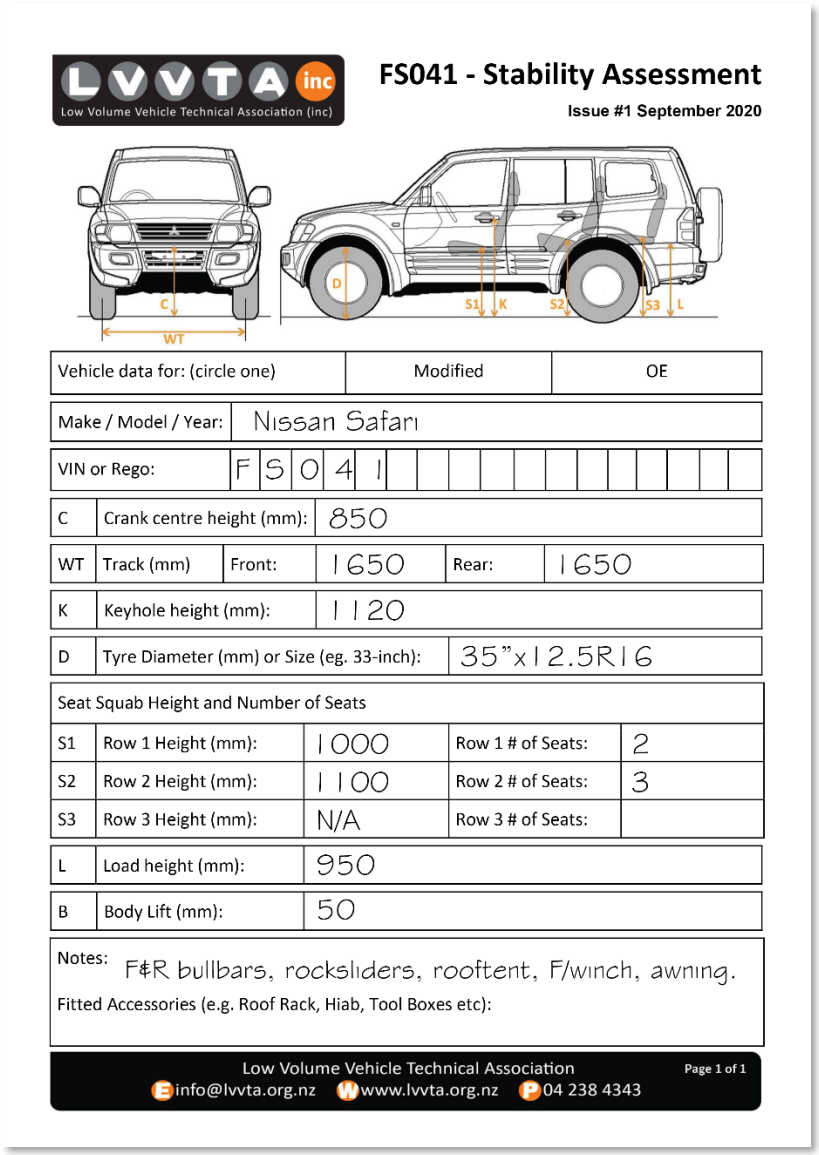
Here are some of the most common models for SRT calculation, and their results as OE vehicles:

- Ford Ranger/Mazda BT50 – 0.94
- Nissan Safari/Patrol GQ (Y60) – 1.01
- Toyota Land Cruiser HDJ80/81 – 1.04
- Toyota Hilux KUN26 – 0.91
- Toyota Land Cruiser LC70 – 0.83
- Toyota Hilux Surf KZN130 – 0.98
- Jeep Wrangler – 1.05

As mentioned previously, this is a more accurate way of implementing the existing requirement. Whereas in the past LVV Certifiers had to rely solely on their judgement as to whether a vehicle was raised too high, this tool provides a way of comparing it to its OE specification and achieving consistent outcomes in terms of stability for every vehicle. The LVV Certifier must still road test the vehicle, and there are other factors (such as suspension setup) that may result in a vehicle with an acceptable SRT figure still failing the road test assessment.

If a vehicle fails the SRT calculation, this can be remedied by increasing the wheel track or reducing the ride height. One thing to note when increasing a vehicle's wheel track is that the tyre tread must be covered; LVVTA Information Sheet 05-2020 – *Tyre Track and Protrusion of Tyres Beyond Mudguards* details WoF requirements that must be met when increasing wheel track.

Fitting larger diameter tyres will also alter the vehicle's speedometer reading, and in order to meet LVV requirements it must remain accurate, however mechanical and electronic methods are available to correct the speedometer reading. Note that increasing wheel diameter can also adversely affect braking performance.



LVVTA inc
Low Volume Vehicle Technical Association (inc)

FS041 - Stability Assessment

Issue #1 September 2020

Vehicle data for: (circle one)			Modified		OE
Make / Model / Year:	Nissan Safari				
VIN or Rego:	FS041				
C	Crank centre height (mm):	850			
WT	Track (mm)	Front:	1650	Rear:	1650
K	Keyhole height (mm):	1120			
D	Tyre Diameter (mm) or Size (eg. 33-inch):	35"x12.5R16			
Seat Squab Height and Number of Seats					
S1	Row 1 Height (mm):	1000	Row 1 # of Seats:	2	
S2	Row 2 Height (mm):	1100	Row 2 # of Seats:	3	
S3	Row 3 Height (mm):	N/A	Row 3 # of Seats:		
L	Load height (mm):	950			
B	Body Lift (mm):	50			

Notes: F&R bullbars, rocksliders, rooftent, F/winch, awning.
Fitted Accessories (e.g. Roof Rack, Hiab, Tool Boxes etc):

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This is the form that an LVV Certifier submits when a full SRT calculation is required.

The measurements on this form are what is used to calculate a vehicle's loaded CoG, which is in turn used to work out its SRT. This is calculated on the vehicle's recorded GVM and kerb weight, both of which can make a sizeable difference to the result of the CoG calculation.

The Keyhole Height figure is a useful point of reference to gauge the total increase in ride height of a raised vehicle – this is something that only normally changes because of a difference in ride height.

Note: The 'Keyhole Height figure' is the distance between the driver's door lock barrel [which is usually in approximately the same place relative to the rest of the vehicle] and the ground.

Summary

Ensuring that a vehicle's stability has not been unduly compromised is an important factor in assessing the safety of a modified vehicle. The LVVTA stability calculations provide another tool for LVV Certifiers to determine how prone a vehicle may be to rolling over, and help ensure a modified vehicle is still within a safe tolerance of OE.

The deciding factor in any case is still the LVV Certifier's assessment of the vehicle, including when road tested.

FOR FURTHER INFORMATION PLEASE CONTACT YOUR LVV CERTIFIER, OR LVVTA.