Over-taking Distance (Detailed Version)

Car & Caravan over-taking another vehicle

Safety is by far the *most* important consideration when towing a caravan. You *must* have sufficient power available to accelerate the car-caravan combination at a reasonable rate, and to maintain a reasonable speed when climbing hills.

It is vital that you are able to *accelerate* quickly to get *out* of trouble, and especially to avoid getting *into* trouble, for example when *over-taking* another vehicle.

It is also vital that you are able to *stop* at a reasonable rate… safely, and in a straight line.

With so many significant variables involved, it is *not* possible to provide a definitive procedure to determine the overall distance required for over-taking, for *every* tow-vehicle - caravan situation.

Risking *your* life - and that of your passengers and other road-users - to save a few seconds can come with enormous risks… are you prepared to pay this horrendous price???

The *most* important aspect is that the driver *must* have good eye-sight… especially for the perception of *distance* on the road. The No: 1 Rule is that if you are *not* 100%-confident that you can over-take a slower vehicle safely, in the prevailing atmospheric and road conditions… do *not* attempt to over-take.

The *second* most important aspect is that the driver *must* have a good appreciation of the *acceleration* performance of their tow-vehicle, when towing a loaded caravan.

The *third* most important aspect is that the driver *must* have a good appreciation of the *handling / stability* performance of their tow-vehicle and caravan combination… when a *lane-change* manoeuvre is under-taken.

A while back, a gentleman named Mr Newton derived a formula, stating that:

Force = Mass multiplied by Acceleration [$F = m \times a$]

In reverse, Acceleration = Force divided by Mass [$a = F / m$]

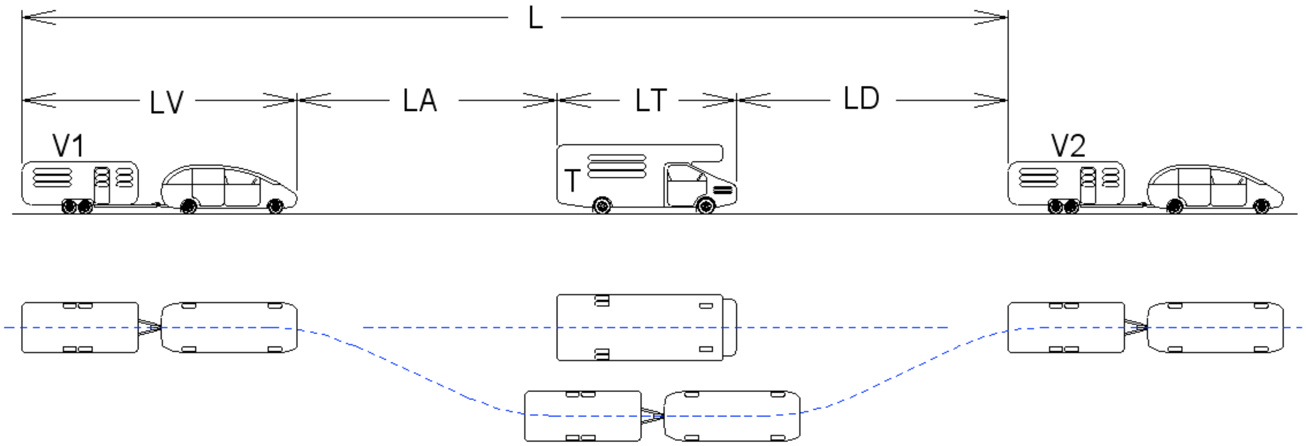
"Acceleration" is what we *need* to increase speed, in order to over-take a slower vehicle.
"Mass" is the *total* mass of the car-caravan *combination*.
"Force" is the forward thrust - "tractive effort" - supplied by the car tyres' traction on the road surface.

It is vital to realize that the "Mass" of the car-caravan *combination* is *much* greater than the "Mass" of the car alone… hence the "Acceleration" performance will be *considerably* reduced.

The "Force" is the *horizontal* force available, hence it will be *considerably* reduced on an *incline*.
The "Force" available depends on the friction between the *driven* tyres and the road surface, hence it will be *considerably* reduced on wet roads and dirt roads.

The critical factor in over-taking, is to spend as *little time* as possible in the "wrong lane" (on 2-lane roads), hence it is prudent to start accelerating close to the required over-taking speed, while still in the *left* lane, behind the vehicle that you are over-taking.

However, caution is needed, just in case the vehicle ahead of you suddenly slows down, or some other situation requires you to stop the planned manoeuvre, and you need to brake heavily.



The drawing depicts a car-caravan combination [V1 & V2] over-taking another vehicle [T] (in side & plan views). The drawing is *not* to scale, as LA and LD are relatively *much* longer than LV and LT.

- V1 and V2 show the car-caravan combination, before and after the over-taking manoeuvre.
- T shows the vehicle being over-taken.
- LV is the length of the car-caravan combination.
- LT is the length of the vehicle being over-taken.
- LA is the “acceleration” distance.
- LD is the “deceleration” distance.
- L is the total distance needed for a *safe* over-taking manoeuvre.

The most influential factor in determining “L” is the speed of “T” - hence the required *increased* acceleration and speed of “V” - in order to over-take safely, and move back into the left lane.

The *relative* speed between “V” and “T” is also instrumental in determining the over-taking *distance* required… along with the *time* spent in the “wrong” lane.

Of course, the “LA” and “LD” distances and times are *much* longer than these “just to clear” figures… and the two (“before and after” over-taking) “*Safety Factors*” must be added.

Relative Speed:

Distance just to *clear* a 5m-long vehicle (with a 15m-long combination)… allowing a *total* [LA + LD] “Safety Factor” of 8 times the length of the combination, which in this example equals 120 m:

30 km/h (9 m/sec)	20 + 120 metres	Time Taken:	16 seconds
20 km/h (6 m/sec)	20 + 120 metres	Time Taken:	23 seconds
10 km/h (3 m/sec)	20 + 120 metres	Time Taken:	46 seconds

As the speed of “T” increases, the manoeuvre… the required “L” - and the danger - increase at an *exponential* rate.

The “air-drag” increases with the *square* of the speed, hence the acceleration rate is reduced.

The "inertia" (momentum) of the combination also increases with the *square* of the speed.

The engine "power" required increases with the *cube* of the speed.

Total Resistance = Rolling Resistance (which does *not* vary with speed) **+ Air-Drag Resistance**

$$= \{M \times Cr\} + \{0.5 \times D \times A \times Cd \times v^2\}$$

M = Mass of car-caravan combination
D = Density of air (1.202 kg/m^3 & 0.0024 lb/ft^3)
A = Area… *effective* frontal area of car-caravan combination
A *typical* Rolling Coefficient - Cr - for a car-caravan combination on bitumen is 0.03
A *typical* Air-Drag Coefficient - Cd - for a car-caravan combination is 0.8

It is *well* appreciated that some (most?) "mature-age" drivers still prefer to use, and are much more comfortable with, *Imperial* - rather than *Metric* - units and calculations. That is fine… providing the correct units are used, so that each side of any equation precisely "compares apples with apples"!

Power Required = Total Resistance x *Relative* Air Speed

Determining *Actual* Acceleration Performance of the Combination:

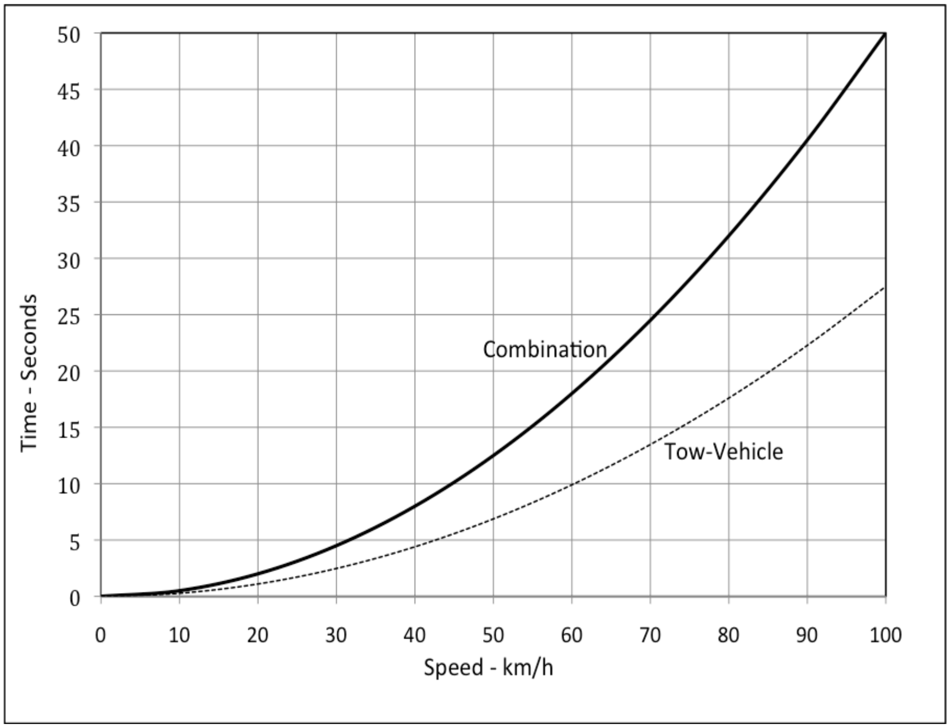
Advertised powers and torques may be quite different to those actually achieved in the "real world"; while they may be "honest" figures, they *may* have been measured at the flywheel on a blue-printed engine (without accessories), under perfect conditions on a dyno in a professional controlled-atmosphere laboratory. These figures will inevitably reduce as the engine becomes worn, as the distance travelled increases.

Hopefully you will *never* be caught in a "tight spot" (read, "dangerous situation") when over-taking. However, it is best to be well-prepared… and know "what the ol' girl will do" when you push the "loud pedal" to the floor.

Safety First:

- Ensure that both the tow-vehicle and the caravan are in good mechanical condition.
- Ensure that all tyres are correctly inflated to the prescribed pressures.
- Ensure the caravan brakes are operating efficiently and evenly.
- Load the tow-vehicle as you normally would for a trip.
- *Just for this test*… Load the caravan to its *legal* limit… in a "reasonable and typical manner".
- Use a *certified* weigh-bridge to measure the: (a) All-up load; (b) Axle(s) load; and (c) Ball-load.
- (Ensure that *none* of the vehicles' *Ratings* are exceeded.)
- With a passenger to record the readings, locate a suitable safe flat road… ideally the middle of a level, deserted, 3-lane (in each direction) freeway.
- Check the accuracy of the speedometer using a good GPS unit.
- With the aid of a stop-watch, carefully and safely, conduct a *series* of wide-open-throttle acceleration runs, recording the *times* taken to go from 40 - 50 km/h, 50 - 60 km/h, 60 - 70 km/h, 70 - 80 km/h, 80 - 90 km/h and 90 - 100 km/h. Be alert if the caravan should start to sway at the higher speeds.
- Record - or calculate - the *distance* travelled between each 10 km/h segment.

This will enable you to appreciate how long - time and distance - it will take to over-take another vehicle, when you wish, or need, to.



The graph shows a *typical* “Acceleration Curve” for an *average* (power and mass) car and caravan combination. The broken line shows a *typical* “Acceleration Curve” for just the tow-vehicle on its own.

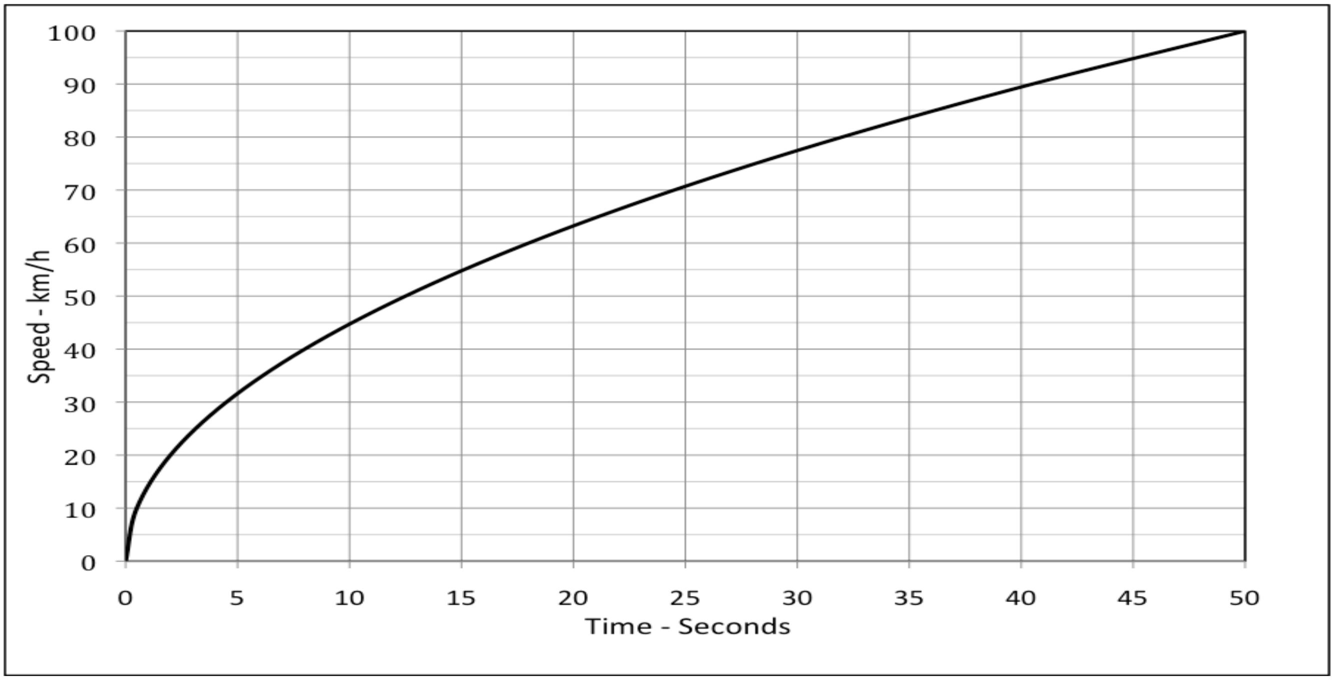
“Average” is taken as the (full-size) ‘van mass being around 2/3 of the mass of the tow-vehicle, and the non-turbo diesel engine of a popular 4WD tow-vehicle being around 4.0 litre capacity.

The available acceleration rate is *reduced* as the:

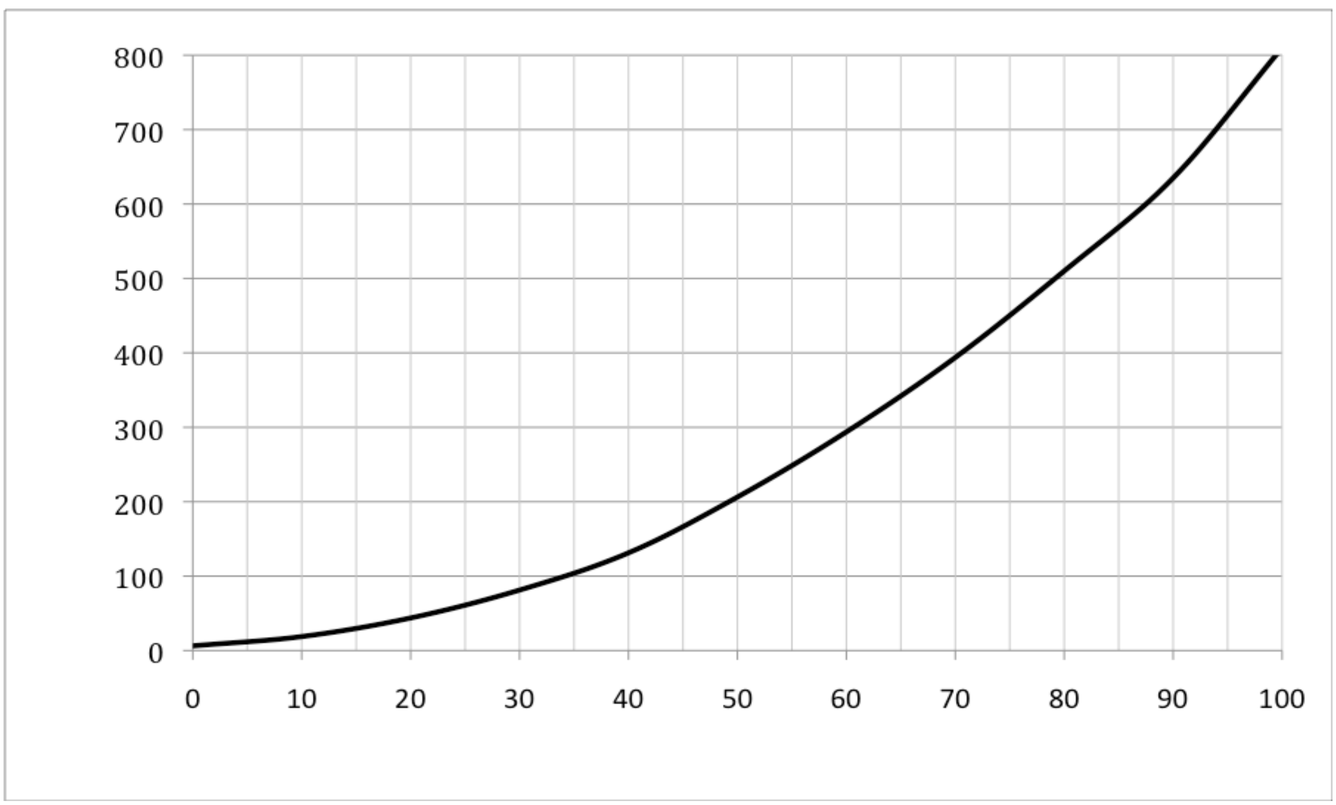
- Mass of the ‘van increases
- Mass of the tow-vehicle increases
- *Effective* frontal area - *actual* area and the aerodynamic *co-efficient* - of the *combination* increases
- *Head-wind (if present) increases*… i.e. as the *relative speed* increases
- Tyre (especially under-inflated), brake and wheel-bearing (not adjusted) drag increases
- Available engine power decreases (with wear, and poor tuning)

www.caravancouncil.com.au has under “Technical Articles” on the home-page, an independent doc on “Selecting a Suitable Tow-Vehicle”, high-lighting the important issues to be considered (without mentioning any vehicle Makes and Models).

While a *heavier* tow-vehicle will have a lower acceleration ability, compared to a lighter tow-vehicle with the same engine power, it is *essential* to have a tow-vehicle with sufficient mass - compared to the caravan that it is towing - in order to prevent the dangerous situation of “the tail wagging the dog”, should the caravan start to sway or snake.



The graph shows the *inverted* typical “Acceleration Curve” for a combination.



The graph illustrates a *typical* curve of “Distance covered V Speed” for an acceleration run, from a standing-start.

The “derivative” (gradient) of the curve at any point reveals the instantaneous acceleration rate, while the “integral” (area under the curve) reveals the distance covered.

Cautions:

If you *must* over-take another vehicle, ensure that you do it safely, and without having to exceed the speed limit… or such a high speed that the 'van becomes dangerously unstable.

It is highly preferable that the driver of the vehicle being over-taken realizes that you wish to over-take them, and hopefully reduces their speed to assist you.

If their vehicle - a truck or caravan - has a CB radio call-sign on its rear, and you also have a CB radio, it is advisable to alert them of your intention.

Be *extremely* careful, and double-check the road ahead to ensure you have sufficient distance of clear road to safely over-take another vehicle. Check that there are no *dips* in the road ahead, and that there are no intersecting roads, from where a vehicle could suddenly emerge. Check that the road is wide enough, and does *not* have very rough edges.

Check that the vehicle that you are about to over-take, is *not* preparing to over-take another vehicle, or make a right turn. If that driver is *not* aware of your over-taking them, be cautious of their possible increase in speed. Check your mirror carefully to ensure that *you* are not about to be over-taken.

Use your turn-signals appropriately, in plenty of time, to indicate your intention to over-take. However, do *not* rely on the turn-signals of the vehicle being over-taken, as a "safe to over-take" signal.

Do *not* swerve *sharply* into the right lane, or *sharply* back into the left lane, as this may well induce a hazardous sway… possibly ending in a dangerous "jack-knife".

On the *other* side of Over-taking:

When *being* over-taken, you must consider the *other* party, and realize that speeding up in such a situation will not only risk *lives*, but may very well lead the other party to extreme frustration and an even *more-dangerous* effort to pass you.

As a courtesy, you should *gently* slow down, to make the over-taking safer. Of course, if the over-taking driver has made a serious error of judgment, and is in a hazardous situation, it is imperative to brake *heavily*, to better-allow the driver to quickly cut back in front of you, so as to avoid a lethal head-on collision.

It is important - *before* you set off on a trip - to ensure that the 'van brakes are operating efficiently… and evenly.

Caravan Council of Australia

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Additional Information for "Tech Buffs"!

For *constant* acceleration:

$V = U + (a \times t)$	$S = 0.5 \times a \times t^2$	$V^2 = U^2 + (2 \times a \times S)$

Metric Units:

V = Final speed {m/sec}	U= Initial speed {m/sec}	S = Distance {m}
a = Acceleration {m/sec/sec}	t = Time {sec}	

Imperial Units:

V = Final speed {ft/sec}	U= Initial speed {ft/sec}	S = Distance {ft}
a = Acceleration {ft/sec/sec}	t = Time {sec}	

Some relevant conversion formulae:

1 km = 0.621 mile	1 mile = 1.609 km
1 km/h = 0.278 m/sec	1 m/sec = 3.597 km/h
1 mph = 1.466 ft/sec	1 ft/sec = 0.682 mph
1 kg = 2.203 lb	1 lb = 0.454 kg
1 m = 3.281 ft	1 ft = 0.305 m
1 m^2 = 10.763 ft^2	1 ft^2 = 0.093 m^2
1 m^3 = 35.314 ft^3	1 ft^3 = 0.028 m^3
1 kW = 1.341 HP	1 HP = 0.746 kW
1 Nm = 0.738 lb.ft	1 lb.ft = 1.356 Nm
1 HP = 550 lb.ft/sec	1 lb.ft/sec = 0.0018 HP
I kW = 101.97 kg.m/sec	1kg.m/sec = 0.0098 kW

Metric: **Power (kW) = Torque (Nm) x RPM / 9,549**

Imperial: **Power (HP) = Torque (lb.ft) x RPM / 5,252**

Tractive Effort = Engine Torque x Transmission Ratio x Differential Ratio / Tyre Rolling Radius

Speed = Engine RPM x 60 / Transmission Ratio / Differential Ratio x Tyre Rolling Circumference