



Overlanding with a 4x4

4x4 technology, accessories, driving technique and recovery

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Preface

This book is intended to shed light on the subject of "travelling in a 4x4 vehicle" in all its facets. It is not primarily aimed at hard-core off-road drivers who want to tackle extreme terrain with specialized and light-weight 4x4s. Rather, it is aimed at travellers who are planning to undertake a journey with an overlanding-capable, i.e. rather large and heavy vehicle, in which they would also like to travel off paved roads. There it is likely to get into difficult situations every now and then in which even a 4x4 vehicle can reach its limits.

Experience shows that many Overlander opt for a four-wheel-drive camping vehicle, but have hardly the opportunity to experience the use of the 4x4 off-road before the start of a trip. The reason can be that one can't even imagine what is behind it or because there are simply just too few opportunities in Europe to use the vehicle appropriately.

The intention of this book is to motivate you to think about this topic before the first "emergency" and to check if you are ready for the adventure. Once on the road, the only other option would be to learn from potentially expensive mistakes.

From the function and characterization of an off-roader, through accessories, equipment and up-grade possibilities of the vehicle, the individual facts of off-road driving are explained so that the reader can then assess what is used where and how and which equipment is less useful or important.

The whole theory of off-road driving presented here is of course only a basis for practice. It is therefore absolutely recommended to practice what you have learned here, ideally as part of a guided training course. It would be careless to venture into difficult terrain away from paved roads with just the theory in your backpack. Only in a practical training course can you push your own off-road vehicle to its limits largely without risks and thus get to know its behaviour. It's unbelievable what you can achieve off-road with a suitable vehicle, but it doesn't take much to push the limits.

Preface

The risks of off-road driving without the appropriate training and experience can be seen in the many accidents that tourists cause with rented 4x4's in Namibia and Australia. Most of the time, the cause is simply the fact that they are underestimating the limitations of themselves or the vehicle, or they don't take into account the special characteristics of an off-road vehicle.



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Characteristic of an Off-Road Vehicle

What mainly distinguishes an off-road vehicle from a normal car, by the way, this is also true on regular paved roads, is the higher weight, the larger dimensions and the much less agile driving behaviour. You not only have to be aware of this, but also adapt your driving technique accordingly.

Off-Road Vehicle or SUV?

There are some typical differences between an SUV and an off-road vehicle, although a formal definition does not exist as far as I know. "Sport utility vehicles" are often of a similar size and weight, but their driving behaviour is still more comparable to a car. They usually also have all-wheel drive, but in these vehicles it is primarily helpful for ice and snow on paved roads and not suitable in difficult terrain and off-road. The many electronic helpers are certainly useful when it comes to preventing the driven wheels from spinning or to facilitate control on a steep descent, but they usually do not help too much for prolonged use as it occurs on long sandy or washed-out tracks. The main reason for this is that these assistance systems are mostly based on braking the individual wheels on demand. This will quickly lead to overheating and consequently failure, or at least increased wear and tear, of the brakes.

Electronic systems such as stabilization programs and ABS can even be dangerous on tracks and gravel roads, namely if they prevent the wheels from locking and thus hardly allow any braking effect. Airbags can also be triggered if you overlook a pothole or crash into a steep dune, an expensive and also useless behaviour in this situation. In addition, these systems cannot always be switched off, and if so, only with great effort.

Low-range gears, which are very helpful in difficult terrain, are usually not available with SUVs.

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Picture 1: Example SUV

Source: By Keauto - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=69577272>

Another difference to an off-road vehicle is the often limited ground clearance and the plastic body parts which are damaged or even fall off at the slightest "enemy contact" or when driving on corrugated tracks. In addition, today SUVs mostly use low-profile tires on large aluminium rims. Such wheels are not suitable for off-road use and there are hardly any off-road tires on the market to fit these dimensions.

What is an Off-Road Vehicle?

The transition from an SUV to off-road vehicle is fluid. There are robust and suitable vehicles in the SUVs category, yet still have good off-road driving capabilities.



Picture 2 Toyota Land Cruiser HZJ75

There are fewer and fewer "real" off-roaders, which is due to the ever stricter environmental and safety standards. It should be said that fat tires, a roof rack with a few jerry cans on it and excessive body lifts are not necessarily the only and most important properties for characterizing an off-road vehicle.

The classic models that are assigned to this category and are usually well suitable for travels are:

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- The big Toyota Land Cruiser models, especially the older ones
- Land Rover Defender and older Discovery
- Mercedes G with long wheelbase
- Long wheelbase Nissan Patrol
- Jeep models with long wheelbase

In the meantime, even among these classics, variants have emerged that are not really suitable for travelling, less because they would not be suitable for off-road use, but more because leather upholstery and luxurious accessories would be too sensitive for the rough. In addition there are also some more exotic brands and models and certain trucks, but these are not explicitly dealt with here.

Pickups are a newer category of off-road vehicles in Europe, for example:

- Toyota Hilux
- Ford Ranger
- VW Amarok



Picture 3 **Pick-Up 4x4**

Source: By EurovisionNim - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=72307903>

On top of these very popular pick-up models, Mazda, Nissan, Mitsubishi, Mercedes, Fiat, Isuzu and other brands also offer similar models. However, they are all less suitable for travel vehicles, be it because they are not widely serviceable in the world or because the chassis are not robust enough for heavy off-road use when fully loaded.

Another group of basically suitable pick-up models are the large American models from Ford, Dodge and Chevrolet. These are quite robust, all-terrain capable and, above all, they have a large payload. For European standards, however, they are often too big, weighing more

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than 3.5 t and the usually high fuel consumption is reflected in the operating costs.



Picture 4 Iveco Daily 4x4

Source: By Carminelatronic - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=88827636>

But also some vans have what it takes to be off-road campers. Examples include the Iveco Daily and Mercedes Sprinter 4x4, but also exotic vehicles such as the Bucher Duro or the Pinzgauer. The latter are military vehicles and are therefore undisputed in terms of robustness and off-road capabilities.

Virtually all of the vehicles mentioned above are equipped with rigid axles and a ladder chassis. Even if they never achieve the driving comfort and spring travel of independent wheel suspensions, their simplicity and robustness make them more suitable for high loads. See also "[Axle constructions and suspension systems](#)"

Weight

Most off-road vehicles already weigh around 2 tons when empty. Converted to a camper and with all the equipment for a longer trip, 3 tons are usually exceeded quickly. Even if a model is robust enough to cope with the load on tracks without damage, the changed driving characteristics must be taken into account by the driver.

Three tons in motion are difficult to control at high speed, not only off paved roads. The braking distance increases disproportionately with increasing weight. And if such a vehicle slips on a steep descent, it becomes critical.

On snowy or generally on slippery roads, the high vehicle weight, in spite of all-wheel drive, is a decisive disadvantage when driving down. This can only be compensated with an adapted, careful driving style.

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Dimensions

Large off-road vehicles are often over two meters high, usually wider than a regular car and generally have a large body, often with blind spots restricting the overview of the surroundings. On the other hand, it is advantageous that the driver has a higher seating position, which offers a better view to the front.

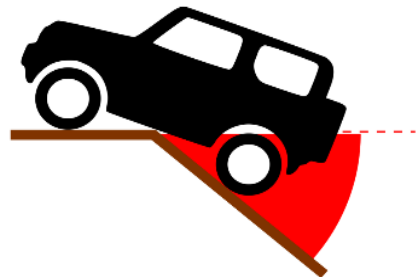
You have to get used to this size, because especially when driving on narrow tracks and off the road you have to be able to assess the dimensions well to avoid damage. You should also know exactly in which line the individual wheels are positioned. This is the only way to avoid obstacles and holes. This will protect the vehicle and reduce the risk of an accident.



Picture 6 Approach and departure angle

touch the ground when driving in and out of an incline and may cause expensive damage.

The ramp angle, on the other hand, defines how suitable an off-road vehicle is to drive over a hilltop without touching down. The shorter the wheelbase and the higher the ground clearance, the easier it is to drive over such obstacles.



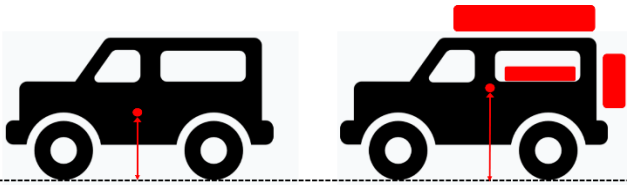
Picture 5 Ramp angle

Centre of Gravity

The usually greater ground clearance, the respectable height and the generally large weight will move up the centre of gravity of a 4x4. A

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heavily loaded roof rack and an unfavourable weight distribution due to incorrect loading add to the problem.



Picture 7 Higher centre of gravity due to incorrect loading

A high centre of gravity increases the risk of accidents when cornering at high speed. If the vehicle skids, there is

a risk that the off-road vehicle will roll over the side, which incidentally is one of the most common causes of accidents involving rental vehicles on gravel roads.

Also in difficult terrain, a high centre of gravity increases the risk of tipping over. This is most delicate when driving across inclined slopes or on steep ascents or descents.

Fortunately, if you approach difficult passages slowly, the "bum meter" usually sounds the alarm before it becomes critical, which means that the driver is afraid long before the car actually tips over.

The load distribution on the axles is also influenced by the payload. Most off-road vehicles are heavier at the front when empty, but when fully loaded, there is usually significantly more weight on the rear axle. This factor shouldn't be neglected, just think of the additional weight of fuel and water. In addition to the changed driving behaviour, the weight distribution also has an influence on the correct tire pressure and the permissible tire load should be sufficient for the situation.

The Peculiarity of the Driving Dynamics

As already mentioned, the usually high weight and the high centre of gravity lead to a driving behaviour that must be taken into account when choosing the speed. This is particularly important off paved roads, because once the 4x4 starts sliding, it becomes difficult to regain control of the vehicle. Any electronic helpers of the modern 4x4 also reach their

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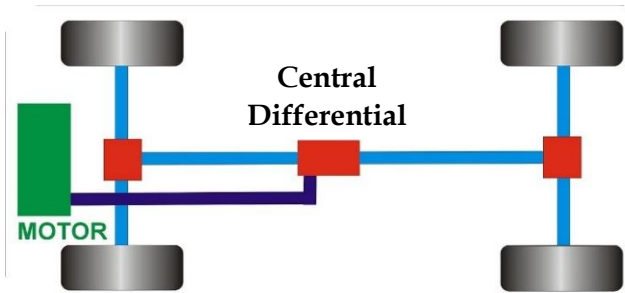
limit in such situations and you should not rely on them being able to prevent an accident.

Drive Variants

Modern 4x4 cars usually have permanent all-wheel drive installed, while the classic off-road vehicles have manually engaged 4x4 drive.

Permanent All-Wheel Drive

As the name suggests, this type of construction drives all four wheels

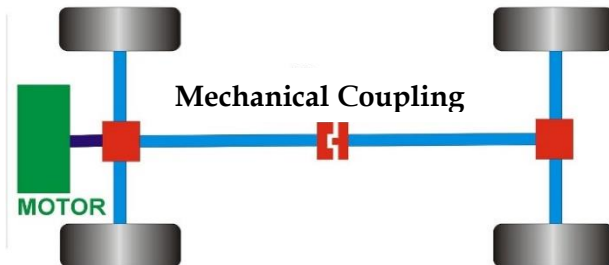


Picture 8 *Permanent all-wheel drive*; Source: CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=448153>

for the different wheel rotations between the front and rear axles (see chapter below for details)

permanently, even when the road conditions don't require it. This results in increased fuel consumption and the vehicle must be equipped with a central differential. This compensates

Manual Four-Wheel Drive



Picture 9 *Manual all-wheel drive*

Source: CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=448154>

is only engaged when the conditions require it.

In older off-road vehicles a selectable all-wheel drive is the rule. In normal conditions, i.e. on paved roads, the vehicle is operated only with rear-wheel drive. The front-axle drive

Cars with selectable all-wheel drive do NOT have a central differential and therefore the all-wheel drive may ONLY be engaged on loose or

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slippery surfaces. If the rotational differences between the front and rear axles are not compensated for with a central differential, this can lead to forces which can cause damage to the drive train. On loose ground, the individual wheels slip without great force, so that even without a differential, the differences are compensated without anything breaking.

HINT

It makes sense to engage the all-wheel drive briefly from time to time even if it isn't actually needed. This ensures that the differential oil is mixed and the entire transmission is freshly lubricated. The seals on the drive shafts can also be protected from aging damage.

Automatic- vs. Manual Transmission

For normal road conditions, driving with an automatic transmission is comfortable and sensible. In difficult terrain and especially in soft sand, however, an automatic transmission is very heavily burdened and can overheat or even fail completely. This can be reduced by installing an additional cooler or at least a temperature display for the transmission fluid. The problem mentioned only occurs when driving for a long time in soft sand or on extreme inclines in a gear that is too high. These problems can therefore be countered with a conservative driving style and manually shifted low gears.

A major disadvantage is the reduced engine braking effect of an automatic transmission. It can be reduced to a certain extent by manually selecting a lower gear or even low range gear if available. On steep descents you should avoid using the brake whenever possible and be able to use the engine braking force, which is only possible to a limited extent with automatic transmissions.

Low-Range Gears

An intermediate gear box, also known as a reduction gear, significantly reduces the wheel revolutions at the same engine speed and the same gear. In the drive train, a second gearbox is interposed after the normal transmission. This reduces the speed between the motor and the drive axles again noticeably.

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This has decisive advantages when driving off-road:

- There is significantly more power available at the wheels to cope with steep ascents or soft sand stretches.
- When driving downhill, the low gears offers a significantly increased engine braking force.
- In low-range gear you can drive through difficult passages much more sensitively and without using the clutch.
- The gradation between the individual speeds is much smaller.



Picture 10: Lever for 4x4 and low-range (right)

From these explanations it can be seen that the low-range gears are mainly used in difficult terrain. They should only be engaged when the vehicle is stationary or not faster than at walking pace. This means that you should drive with foresight in order to engage low-range gears BEFORE an obstacle that is difficult to negotiate. If you wait until you get stuck, it is very likely that you will not be able to continue driving without additional measures, even in low-range gears.

Differential

Differentials are used to compensate for the unequal rolling paths of the individual wheels. Axle differentials compensate for the different rota-

tions of the left and right wheels on an axle.



Each wheel follows its own track in a curve and covers a different distance. The result is that each wheel has a different speed when cornering. If

Picture 11: Different path for each wheel;
Source Toyota University (You Tube)

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the four wheels were rigidly connected to one another, the compulsion to adjust the identical wheel revolutions to the individually correct speed would lead to enormous frictional forces. Differential gears compensate for these differences and prevent the balancing forces. Each of the two driven axles has its own differential. Permanent 4x4 drives have in addition a central differential to compensate for the axle differences (see below)

Central Differential

As already mentioned above, a centre differential is only required for vehicles with permanent all-wheel drive. The task is to compensate for the different front and rear axle wheel rotations when driving on hard road surfaces in curves.

The functional principle is similar to the axle differential described below.

Axle Differential

What the central diff does between the two drive axles, the axle differential does between the two wheels of an axle. This is needed because when cornering, the inner wheel takes a shorter path than the outer one. This leads to a different rotations of the two wheels. Without a differential gear, the two wheels would have to compensate for the differences in revolutions by partially locking one wheel, which is quite a botch with good traction on asphalt. Without a differential, these forces would be so great that the drive train would be damaged sooner rather than later, apart from tire wear.

VIDEO

The function of a differential is illustrated in the linked [YouTube video](#).

Differential Locks

If one of the wheels loses traction, for example because it spins on slippery ground or gets up in the air on difficult terrain, the other will stop without power transmission because of the differential function. This means that the axle cannot contribute any force to the propulsion. In a

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vehicle with a central differential, spinning just one of the four wheels is enough to interrupt all propulsion.

In these cases, lockable differential gears are essential. As a rule, centre differentials can always be locked manually, which means that their normal function can be manually locked on slippery ground.

In the case of axle differentials, a locking mechanism is often only available as an option when buying a new 4x4 or as a retrofit. The reason is, because if one of the two axles loses its traction, the second is still available. But there are also situations where at least one wheel on each axle loses traction and then the vehicle will be at a standstill, even if it is equipped with four wheel drive.

Above all, there are cases where differential locks can fully exploit their advantages, namely when an incline with heavy washouts and / or steps have to be negotiated. It often happens that due to extreme twisting of the axles, one wheel on each axle goes into the air and the propulsion fails completely. With locks on both axles, there are always at least two wheels on the ground and can also transmit traction.

There are different types of locks. The classic version connects the two drive shafts rigidly so that the two wheels are mechanically connected and therefore rotate synchronised in the same direction. Even if one wheel lifts off, the two keep running at the same speed and the wheel that touches the ground continues to contribute 100% of its traction.

There are also locks which, by means of spring pressure disks, can transmit the torque to the load-bearing wheel via a friction clutch. The "electronic" locks have the same effect. Instead of a mechanical coupling of the two wheels, the freely rotating one is braked by the brake system and the force can be transferred to the second wheel. The great advantage of these systems is their permanent availability, because they automatically take over the function when required, even during the drive, and do not have to be switched on first.

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VIDEO

The [You Tube video](#) shows the function of the limited slip differential with clutch

Both and other designs have a decisive disadvantage. The freely rotating wheel has to be braked and this creates frictional heat. With prolonged use, this leads to overheating and possibly damage to the system.

Full locks, on the other hand, do not have this disadvantage. But you have to make sure that the locks are only activated on lose ground. On the one hand to avoid the stress caused by uncompensated wheel revolutions (see above) and on the other hand because an activated lock on the front axle on firm surface means that the vehicle can only be forced into the curve with difficulty.

WARNING

Diff locks may only be switched on when the vehicle is stationary and must be switched off again on hard surface!!

Axle differential locks can be retrofitted to common off-road vehicle models with rigid axles. They are usually operated electrically or pneumatically. For the latter a compressor must therefore be installed. This can then also be used for tire inflation. The cost of this accessory is around USD 2000 per axle.

HINT

Because differential locks are rarely used, they should be switched on briefly a few times periodically in order to keep the mechanism moving smoothly and to check the function.

But be careful, if no gravel road is available, the lock may only be activated briefly and in a straight movement.

VIDEO

In this [You Tube video](#) you can see how the mechanical lock, for example the one from ARB, works.

An [instruction video](#) clearly shows when and how differential locks are used.

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Free Wheeling Hubs

Vehicles with manual all-wheel drive usually have so-called freewheel hubs installed. These ensure that the drive train of the front axle is not driven by the rolling wheels when the 4x4 is not engaged. If all-wheel drive is required, the mechanical coupling of the free wheeling hubs must first be engaged, otherwise the power from the drive train will not be transmitted to the wheels.

In situations where you have to expect the use of the 4x4 drive, it makes sense to preventively lock the hubs so that the all-wheel drive can be switched on if necessary without having to get out of the car. In the hectic pace of a surprising 4x4 demand, switching on the free wheeling hub is often forgotten.

Free wheeling hubs that are unnecessarily locked are not a fundamental problem, but the drive train of the front axle experiences unnecessary wear and tear and fuel consumption is increased.

Manual Free Wheeling Hubs

Manual hubs are engaged manually using a rotary knob. The mechanical connection between the drive shaft and the wheel is established via a toothed coupling system. But that means that you have to stop and get out. If you are on a muddy or sandy track or if water crossings are to be expected on the route, the free wheeling hubs should be locked as a preventive measure, so that if needed, you can engage the all-wheel drive without delay.



Picture 12: Manual Freewheel hub

By the way, with most vehicle models, in contrast to the reduction gear, this can also be done without any problems while driving

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Automatic freewheel hubs

The automatic freewheel hub basically works like the manual one. The difference is that it is automatically engaged when the drive train transfers power to the wheels with the 4x4 drive engaged. To disengage again, you have to back-up a short distance without the all-wheel drive being engaged. Since this is a smooth-moving mechanism, it can become stuck after a long period of non-use or if the lubrication is insufficient and thus impair its function. You should therefore move this mechanism from time to time and re-grease it and to keep it free moving.

Axle Constructions and Suspension Systems

Off-road vehicles that are used for heavy duty are often equipped with a suspension and axle design completely differently than SUVs. There are reasons for this, but all axle designs have certain advantages, but also limitations. The same applies of course to suspensions. The spring travel is one of the decisive factors for the off-road capabilities of an all-wheel drive vehicle. It is usually the combination of axle and spring design that is relevant for this factor. Long suspension travel is important for the traction with rigid axles, among other things, and the better this is, the better the ground contact of the individual wheels can be guaranteed.

The most common variants are compared below.

Rigid Axle

The most common axle design on off-road vehicles is a simple construction and at the same time very robust and resilient. However, the ride comfort is not outstanding due to the large unsprung mass and the mostly limited spring travel. The twisting of the axles is also limited, especially in combination with leaf springs. As a result, if the axle is heavily articulated, one wheel will increasingly lose contact with the ground and thereby lose traction. The traction of the other wheel can only be maintained with a differential locker. It is typical for rigid axles when one wheel compresses strongly, the opposite one tends to rebound, there is mutual interference.

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Picture 14: **Rigid axle with coil springs**

Quelle: By Johannes Overmann - Self-photographed, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=38111254>

Picture 14: **Rigid axle with leaf springs, articulated**

One advantage of the rigid axle is the constant ground clearance, even with increased payload and during compression. However, due to the differential housing protruding downwards, ground clearance is limited at this point. In addition, the motor and the gearbox are positioned well protected over the axles so that damage from contact with the ground can be largely avoided. However, the disadvantage here is that the space between the axle and the underbody must remain free in order to allow spring travel.

In order to achieve high axle loads, this construction is still popular with "Heavy Duty" vehicles. In newer models, and almost generally in pickups, for example, a rigid axle is still installed at the rear, while an independent suspension is often installed at the front.

Independent Suspension

As mentioned above, an independent wheel suspension is usually only used on the front axle in off-road vehicles, which increases driving comfort and at the same time enables a greater steering angle. Because there is no low-lying differential, generally better ground clearance is achieved in the area of the front axle. But if the weight increases or the springs compress, the ground clearance is reduced. In extreme cases, the underside of the vehicle can hit the ground and, because the oil sump is often the lowest point, can cause major damage. For this reason alone, a robust underbody protection should be installed for this axle construction. See chapter below. The biggest advantage, however, is that with

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Picture 15 Independent suspension with „double wish bones“ front and rear

Source: Rallye car Desert Warrior, Rally Raid UK

the independent suspension, the articulation is usually better. This means that the opposite wheel remains in contact with the ground even if one wheel has to deflect heavily. The spring travel is usually significantly greater than with a rigid axle, which further increases the advantage.

In principle, an independent suspension is structurally more complex and requires many more moving parts. This automatically increases the risk of a defect and wear. In addition, the swing arms, which are usually made of pressed sheet metal, are often less robust, so that they can be damaged in the event of a strong force and when touching an obstacle. The bearings of these suspension components also wear out under heavy use, and these are not easy to overhaul in all vehicle models.

Due to the design, the drive shafts require two universal joints, which can also wear or break. Since leaf springs cannot be used, either coil springs or torsion bars are used. The former are often one unit together with the shock absorber. If the shock absorber has to be replaced, the necessary tools to compress the spring must be available.

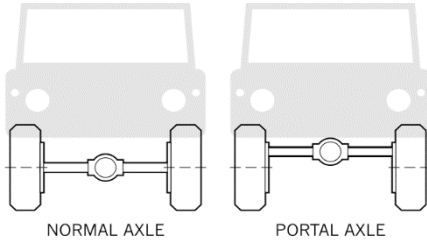
Torsion bars have the advantage that the preload and thus the ground clearance can be changed within a certain range. For higher loads, however, it must be replaced by a stronger one. Although legally permissible exchange options are not available on the market for all vehicles.

Design principles for independent suspensions are quite diverse. On off-road vehicles, however, an upper and a lower wishbone are usually used on the front axle. The suspension is supplemented by a shock absorber which is usually built into a coil spring.

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Portal Axle

The good of both worlds. Outstanding ground clearance, despite the use of the robust rigid axle, yet it is a more complex construction. The best-



Picture 16: *Portal Axle compared with a standard rigid axle*

Source: <https://commons.wikimedia.org/wiki/File:NormalVsPortal->

known vehicle models with portal axles installed as standard are the Unimog and the Pinzgauer. Otherwise, mainly military trucks are equipped with it as standard. Some of the well-known off-road vehicles can be retrofitted with it, but it is an expensive investment that is hardly worthwhile for travel vehicles, because you also buy a higher centre of gravity and components which can hardly be repaired in the event of damage on the way.

Leaf Springs

Leaf springs are a tried and tested design for rigid axle suspension. This is usually a package of pre-formed spring steel leaves to which the axle is attached directly. One end of the spring assembly is connected directly to the chassis while the other is attached to it via a movable shackle. The whole construction is therefore relatively simple and, above all, all components are “low-tech”, i.e. they can be repaired or replaced worldwide with little effort. The axle is guided lengthways and crossways by the spring assemblies without the need for additional components.

Furthermore, this construction offers a lot of freedom in design, so you can increase the load capacity and ground clearance with additional spring leaves. The main disadvantage is the high weight of strong spring assemblies and that, when they are mounted under the axle as usual, they significantly reduce the ground clearance right next to the wheels. See picture 14

The axle articulation is also restricted by leaf springs, which in turn means that a wheel likely loses contact with the ground when operated

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in difficult terrain. The friction between the spring leaves relieves the shock absorbers on the one hand, but on the other hand it prevents sensitive response in the case of small bumps, which is not adding to driving comfort. In general, a leaf spring suspension works best when it is loaded, i.e. a light vehicle without a certain load has a very hard ride.

The disadvantages mentioned can largely be avoided by using parabolic springs. This type of spring is often standard on trucks, while normal off-road vehicles are usually equipped with conventional leaf springs. In principle, however, these can be replaced with tailor-made parabolic springs. But that means you lose the simple interchangeability, because parabolic springs are not so easy to adapt or replicate.

Coil Springs

This type of spring is the most commonly used design for independent wheel suspensions but is increasingly used for rigid axles. The ride comfort and the suspension travel can be significantly improved.

In interaction with heavy rigid axles, however, shock absorbers are stressed much more than with a leaf spring chassis. There, the friction within the spring assembly creates a certain level of self-damping that is not given with the coil springs. In order to guide the axles, swing arms are also installed lengthways and crossways.

It is unlikely that a coil spring will break if it is correctly designed and used properly, but if it does, you will need a suitable spare part before you can continue. A defective shock absorber also has a greater impact on driving behaviour and must be replaced.

Wheels and Tires

The tires and their thread have a very decisive influence on the driving performance off-road. It is therefore of great importance to define the planned use of the vehicle before deciding on a type of tire to install.

Rim Types

Four more or less common designs are described below:

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Standard rims



Picture 17: Steel rim with off-road tire

There are no removable parts with this design. It is either cast aluminium or pressed and welded from sheet steel.

Split Rim

A split ring is inserted into the rim well. When the tire is depressurized, it can easily be removed, making it easier to pull the tire off the rim. In the past, this system

was the standard solution for off-road vehicles, today it is hardly used, especially because this rim is only suitable with restrictions for tubeless tires (with an additional sealing ring only).

Dealing with split rims involves the risk of injury if not handled properly and should therefore be practiced. The big advantage is that changing tires is much easier. Split rims have not been allowed for new car registrations in many countries for many years.

Function and application is explained in this [video](#).

Bolted Rims

This type of construction is especially common for trucks. Some of them are also used in racing and car posers love the cool look. They are not robust enough for long-term off-road use or, and if they are, they would be very expensive. To change the tire, the two-part rim can be unscrewed so that the tire can be removed and refitted without great effort.

Bead-Lock Rims

This rims are also screwed and offers the additional benefit of securing the tire so that it cannot rotate on the rim.

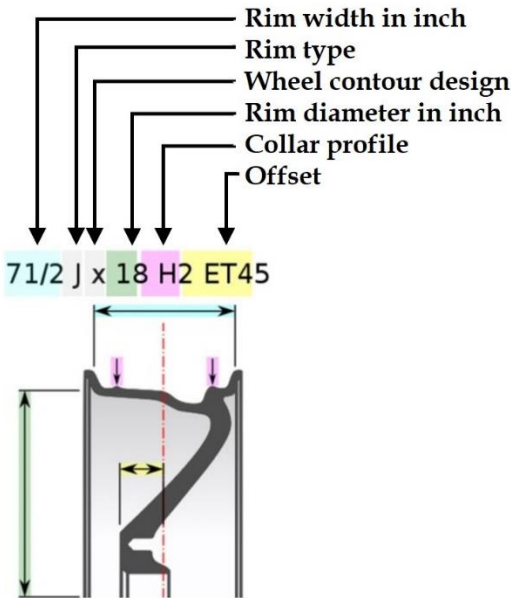
More common than the use of bead lock rims to fix the tire is the use of a retrofitted "bead lock system" on any original rim. The function is comparable, but less expensive, and robust standard rims can be used.

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See also chapter [„Bead-Lock“](#) .

Rim Material and Sizes

Rims for tough off-road use are usually pressed from sheet steel. They are robust and if a stone is overlooked on the track, the resulting damage to the rim can be fixed to some extent. Even a crack, should it occur at all, can be welded on the go if necessary. They are also inexpensive, but they do add weight.



Picture 18 Rim marking

often archaic working methods of tire workshops in third world countries.

Forged aluminium rims offer the weight advantage of aluminium and a similar robustness as steel rims. But they are usually more expensive and should damage occur, forged rims are hardly repairable either.

Modern 4x4s are increasingly being delivered ex works with cast aluminium rims, but retrofitting to aluminium rims is also popular, primarily because of their more attractive appearance. However, cast, inexpensive aluminium rims are nowhere near as robust and easy to care for as steel rims. When hitting an obstacle there is a risk that part of the rim flange will break off beyond repair. The aluminium rims are also often not up to the

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With regard to the rim size and tires, three dimensions are particularly relevant:

Rim Diameter

It must match the tire diameter. For a 16" tire, that is the inner diameter of the tire, the rim must of course also have a 16" diameter.

Rim Width

Here you have some leeway, because a permissible range for the tire width is defined for a certain rim width. For example, any tire with a width of 215 to 245 mm can be fitted to an 8 "(corresponds to approx. 200 mm) wide rim, whereby the recommendation is 225-235 mm. It should be noted that rim widths are usually specified in inches, while tire widths can be defined in both inches and millimetres.

Rim width [inch]	min. tire width [mm]	ideal tire width [mm]	max. tire width [mm]
5.0	155	165 - 175	185
5.5	165	175 - 185	195
6.0	175	185 - 195	205
6.5	185	195 - 205	215
7.0	195	205 - 215	225
7.5	205	215 - 225	235
8.0	215	225 - 235	245
8.5	225	235 - 245	255
9.0	235	245 - 255	265
9.5	245	255 - 265	275
10.0	255	265 - 275	285
10.5	265	275 - 285	295
11.0	275	285 - 295	305
11.5	285	295 - 305	315
12.0	295	305 - 315	325
12.5	305	315 - 325	335

Picture 19: Rim vs. tire sizes

If you have the choice, you should choose a rather narrow rim. Firstly, the tire has more lateral support at low air pressure and secondly, the rim flange is better protected against side injuries because the tire protrudes further.

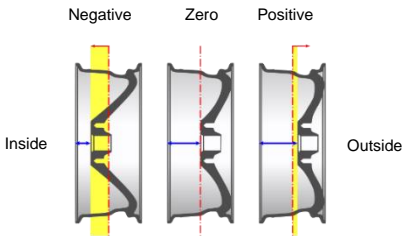
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Above all, however, it is important that both the rim and the tire comply with the regulations and the vehicle type certificate, as otherwise you are driving illegally or you risk the tire not being properly seated.

Rim Offset

The offset defines the axial measure between the contact surface of the rim on the wheel carrier and the centre of the tire.

This dimension is primarily determined by the vehicle model and requires special attention if you want to use a different tire dimension or rim. If the offset is not correct, there is a chance that the tire will touch the body on the inside during compression. Here, too, it is important to observe possible legal restrictions. By changing the offset, the track width of the vehicle and thus the lateral position of the wheel can be changed. However, this modification must also be permissible. In addition, widening the track puts additional strain on the wheel bearings.



Picture 20: Rim Off-set

Source: Matterhorny, CC BY-SA 3.0 <<https://creativecommons.org/licenses/by-sa/3.0/>>

With or Without Inner Tube?

Tubeless tires are largely the standard these days, including off-road tires. However, the topic was and is often discussed. One argument in favour of inner tubes is that driving with low tire pressure, for example in sand, increases the risk of the tire jumping off the rim. This can basically also happen with an inner tube, but by increasing the tire pressure the tire will jump back into the correct position. A tubeless tire, on the other hand, needs a powerful flow of air to be re-inflated. An air compressor that is usually carried on board isn't usually capable of this. Only if a large pressure vessel is available can the tire be sealed again without any trick. (See below)

If, on the other hand, a tire with inner tube is driven with low air pressure, the inner tube can be heated up by flexing the soft tire to such an

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extent that it is damaged or the valve is torn off by tire rotation on the rim.



Picture 21: "TUBELESS" tire

Probably the best solution is to use tubeless tires as a rule, but keep inner tubes in reserve. This makes it possible to continue driving if, for example, the tire or the rim is damaged in such a way that you can no longer seal them. In this case you insert the tube and can continue driving. But pay attention, the valve hole on the tubeless rim is probably

too small for regular inner tubes, but there are special inner tubes available (in Europe) with a suitable valve stem diameter. When travelling in other countries, you can only get around by drilling a larger valve hole on the rim to fit a regular, local tube. In this case, the rim would no longer be usable for normal tubeless valves, but again, there are suitable diameters as an alternative on the market and it makes sense to have some of them with you as spares.

If you only have a compressor with a small volume flow available, you can use one of the following two tricks when re-fitting tubeless tires:

The Ratchet Strap Trick

After the tire is mounted and rests neatly on the rim shoulder, a ratchet strap is attached to the outer diameter of the tire and tightened so that the tire seals properly on the rim shoulder. Now you can try whether the air pressure can be built up. The whole thing only works if you can position the tire correctly so that it lies neatly in the rim bed on both sides.

The Explosion Trick

With this trick, the tire is mounted in such a way that it is already in good contact with the rim shoulder on one side, but a gap remains open on the opposite side. Now you inject a flammable gas or a volatile, flammable liquid (e.g. brake cleaner) into the tire and ignite it immediately.

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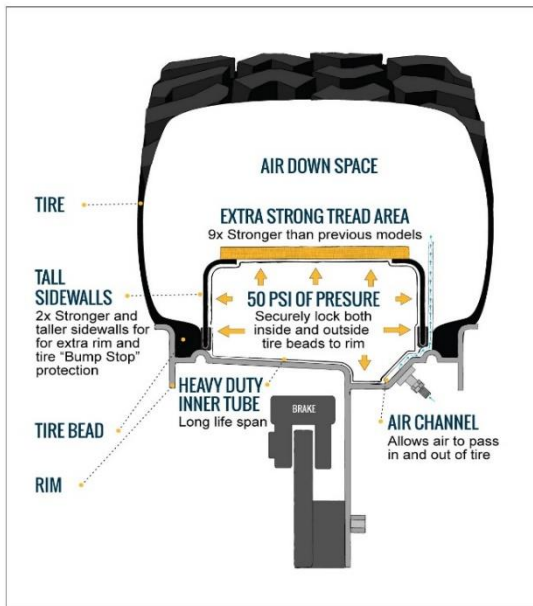
This leads to a sudden build-up of pressure which pushes the tire into position on both sides and seals it.

Here is an explanation [>VIDEO<](#)

WARNING

This procedure is not without risk, because the dosage and ignition of the fuel gas are difficult to control. In any case, the gas must be sprayed INSIDE the tire and then ignited as quickly as possible and in any case with a safe distance.

Bead-Lock



Picture 22: *Bead-Lock System, retrofittable*

Quelle: <https://www.coyoteents.com/beadlocks/>

is the optimal solution for off-road vehicles, but as always, every solution has its disadvantages. In the case of bead locks, this is primarily the purchase price (> 200 USD per wheel, rims are even more expensive) and approx. 3 kg weight per wheel add up.

In order to be able to mount the bead-lock system, an additional valve hole must be drilled in the rim. A bellows located in the rim bed is inflated via this valve so that it presses the tire into the rim shoulders on

With such a device, the tire is pressed to the inside and fixed against the rim shoulders by a separate, inflatable bellow. This prevents the tire from jumping off the rim when the pressure is low. It also enables the installation of tubeless tires without special measures (see above). It should also be mentioned that bead lock systems are only available for tubeless tires.

You might think that this

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both sides. This prevents the tire from rotating on the rim when the tire pressure is low and from jumping off the rim.

Bead lock rims or the retrofitted bead-lock systems are normally only used in competitions, where extremely low tire pressure is used at low speeds and over short distances (trophies, rock-crawls). In daily traffic, on trips and on paved roads in general, the systems have hardly any practical use.

In any case, there are two further advantages. Bead-Lock systems with their additional "bellows" support the airless tire somewhat in the event of air loss of the tire and can thus prevent loss of control of the vehicle. But you shouldn't drive long and fast like this, tires and bead lock would be damaged by the extreme flexing movement.

The risk of tire damage at low pressure is also reduced, as the bead lock balloon serves as additional puncture protection.

It should be ensured with these accessories, that they can be legally approved.

Influence of the Tire Dimensions

It is widely believed that wide tires only have advantages in off-road use. But that is not fundamentally correct, on the contrary, they also have disadvantages. They do reduce the specific weight per surface area, which is actually advantageous in soft sand, but at the same time the rolling resistance increases proportionally due to the wide profile, which resists propulsion. In addition, wide tires are exposed to a greater risk of punctures and are also heavier and more expensive.

A larger tire diameter offers the greater advantage off-road, because it has a flatter roll-off angle and therefore less rolling resistance and also creates a longer thus bigger contact surface.

A greater height of the tire, this is the dimension between the rim and tire diameter, is really advantageous. On the one hand, such a tire is more elastic, which increases driving comfort, on the other hand, by

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lowering the air pressure, the contact surface can be significantly extended without the tire contact width of the tire being significantly increased. The narrow wheel "cuts" through the soft sand and nevertheless offers an advantageous surface load, which reduces sinking in and improves traction. A disadvantage is the "spongier" driving behaviour, which can be noticeable in heavy vehicles on paved roads.

In any case of larger tires, it should be noted that they put additional stress on the wheel bearings due to the additional weight and wider track, and there is a considerable risk of wear, or even defects, in a heavily loaded touring vehicles.

Comprehensive information about driving in sand can be found in the chapter ["Driving in soft sand"](#)

Modern SUVs, but increasingly also off-road vehicles, are supplied with ever larger rim diameters, not least because the brake discs are getting bigger and bigger. This means that the original rim dimension for off-road vehicles, the 16 "size, is being used less and less. In less developed countries, however, "old-fashioned" vehicles are still in use, which is reflected in the sold range of tire sizes. Therefore, especially if a longer trip outside of Europe is planned, it is important to carefully research which tire sizes can be easily obtained in which region.

Tire Types and Properties

Radial tires are now standard in almost all areas of application including off-road tires.

When choosing tires, you may have to pay attention to their suitability for snow, especially if the vehicle is to be driven in winter and in countries with corresponding winter tire regulations. A rough tread alone does not make a winter tire.

Off-road tires differ from normal car tires primarily in terms of their dimensions and the robust construction of the tread and sidewall. Profiles are also offered for different purposes (see following chapter)

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If you want to drive on tracks and away from paved roads regularly, you should definitely invest in off-road tires. Commercially available regular car tires are usually simply not robust enough, which is exacerbated by the usually high vehicle weights.

A basic distinction is made between tires with and without tubes (tube type and tubeless). In both cases the rim must be suitable. Rims for tubeless tires have an additional hump in the rim bed for lateral fixing of the tire. In an emergency, however, tire and rim types can be combined as desired, but that would not be legal, at least in Europe.

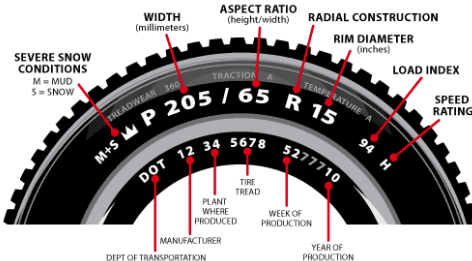
The profile and the tire dimensions influence the permissible speed and the maximum load capacity and should therefore be taken into account when choosing a tire. The speed is less relevant for touring vehicles, but these are usually heavy, if not overloaded, which leads to a high load on the tire. If the vehicle is also driven at reduced pressure, the risk of tire blowouts and carcass detachment increases, especially if the tires do not have sufficient load-bearing capacity.

In addition, it must be taken into account that the desired tire also meets the legal requirements. If necessary, clarify with the appropriate authorities what is permissible.

Load Index

As already mentioned, the most important thing is to observe the load index in relation to the maximum weight of the vehicle. It should be noted that the rear axle of touring vehicles generally has a significantly

higher axle load. The load index in kg is defined per wheel, while when determining the vehicle weight, the individual axle is usually weighed. The load on the front and rear axles should be determined at least once when the vehicle is fully loaded, and not just for the selection of the correct tire. It should be noted that the load index always



Picture 23 Tire markings

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determines the permissible weight at maximum tire pressure and maximum speed.

If the pressure is reduced off-road, the permissible load is also reduced, but you will not be travelling at top speed. Nevertheless, it is advisable to buy the tire with the highest possible load index, because it is generally more robust and offers additional reserves.

So-called "LT" (Light Truck) tires generally have a higher load capacity and some are also available with an off-road thread.

Tire Tread

Which tire profile you choose, should primarily depend on the intended use. "Mudterrain" tires are often fitted because of their cool look. However, they are less suitable for travelling unless you plan to cross the Amazon or Africa in the rainy season. In addition to the loud driving noise, they often feel spongy on paved roads and wear out quickly, especially when new. A mud tire with tread of just a few millimetres left will not perform as expected in the mud. Due to the greater tread depth, the tires are also markedly heavier, calculated for five or six tires, a significant disadvantage.

"All Terrain" profiles are the most common for touring vehicles. They are nowhere excellent but, as the name suggests, they can be used in any terrain. Some of these tires are also snow-approved, which makes them a true all-season tire.

Sand tires are hard to find on the market and they don't make much sense unless you live in a desert region and spend your free time in the dunes. An "A/T" tire with reduced air pressure is only little inferior to a sand tire in terms of traction and sand suitability.

Sidewall of the Tire

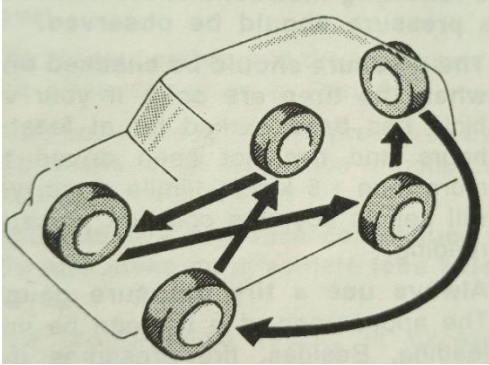
The sidewalls of the tires are heavily exposed on stony tracks and when the tire pressure is low, and they can be irreparably ripped by sharp-edged rocks. Therefore, it makes sense to choose a tire with a reinforced

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sidewall. This can be recognized by the “ply rating” (layers) of the carcass, it should have 8 layers or more. "LT" tires generally have more robust sidewalls, e.g. the KO2 All-terrain from BF Goodrich with 10 layers.

Tire Maintenance

A good off-road tire has a mileage expectation of 40,000 to 60,000 km. If you can't travel a lot, it may take a few years to unwind the kilometres. In general, tires should not be more than 8-10 years old as the rubber



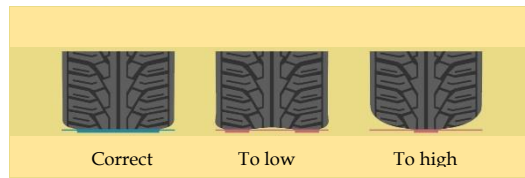
Picture 24: *Tire rotation*

Source: *Toyota Land Cruiser Handbook*

will become brittle over time. This increases the risk of damage and also decreases grip on asphalt. The year of manufacture of a tire can be seen on the sidewall. The 4-digit number in an oval provides information, the first two digits indicate the calendar week, the other two the year of manufacture.

If you rotate the wheels, including the spare wheel, about every 10,000 km, you can achieve the best possible mileage and the spare wheel will wear out together with the other wheels.

It is also worthwhile to maintain the optimal tire pressure. This is the only way to ensure that the tread wears evenly and that the tire can remain in use longer. Too much pressure reduces rolling resistance and thereby fuel consumption, but driving comfort suffers and the tread wears excessively in the middle. If there is too little pressure, the edges wear in excess and the tread blocks are worn unevenly.



Picture 25: *Correct tire pressure*

Source: <https://dein.reifen-in.de/wie-ist-der-richtige-reifendruck/>

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Spare Wheel

A popular discussion is whether one or two spare tires should be carried on a trip. However, it is very unlikely that a puncture occur so quickly after the other, that the first defective one cannot be repaired before the second failure. But if you drive in a region where the fitted (exotic?) tire dimension is not available, it can make sense to have a second spare tire with you. It doesn't have to be a heavy complete wheel, a tire is sufficient, provided you can install it yourself if necessary.

However, it does not make sense to carry along an expired or inferior spare tire, in order to save costs. In general, it is worth purchasing high-quality off-road tires too.

4x4 Accessories and Gear

The range of accessories to spice up your 4x4 is huge. Just, what makes sense? Actually, you should first determine the need and then procure what offers an additional benefit for the intended vehicle use. But that is difficult if you have little experience yourself. Here is an attempt to illuminate and classify some of the available equipment.

Recovery Gear

Sooner or later, even with a 4x4, you will get stuck somewhere don't get any further forward. There is a wide range of recovery gear to help getting unstuck from such situations.

Well-fitting recovery equipment means, the individual components are optimally matched to one another and adapted to the vehicle weight and use. It therefore makes sense to select the gear to match the vehicle and intended use.

Here are the most important points to consider when choosing:

- Maximum vehicle weight
- If it has a winch, its pulling force and rope type
- Type of recovery points at the rear and front of the vehicle
- Use of equipment: hard-core, travel, only occasional use, etc.

By the way, there are two principles when it comes to recovery:

1.

To recover a vehicle, always the gear that the vehicle to be rescued has on board is used! That means, if I get stuck and get help from outside, my material is used. If I help someone out of their troubles, their recovery material is used.

2.

By the way, the cheapest and most effective recovery gear sits between the driver's ears!! Most recovery actions can be avoided by careful and foresighted driving.

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When travelling, in particular, you will probably not want to take too great risks. After all, your own home and all the equipment stowed in it are at stake, so extremely difficult routes will be the big exception.

The [practical recovery](#) technique itself is dealt with in a separate chapter.

Where to Stow the Gear

It is very important that recovery gear carried on board must be within reach. Usually you are in an uncomfortable, if not dangerous, situation when recovery gear is to be used. Maybe it is no longer possible to get to the equipment that is at the bottom of a box. Often you don't have much time to carry out a recovery task, think of a situation where you get stuck in a raging river crossing.

So, the most commonly used gear should definitely be at hand. Ideally in the driver's cab or in an outside compartment that is always easily accessible. The gear includes at least one recovery belt and, if required, the winch control and the shackles required.

Winch and its Accessories

A winch can be very useful, especially for self-recovery. But you have to be aware that their use has its limits. On an overlanding trip you will hardly ever have to use a winch, but if you do, it can make all the difference. With all accessories and the necessary, robust bumper, you can easily add 100 kg of additional weight and the costs for procurement and installation are considerable.

A distinction is made between how a winch works:

Power Take-Off Winch

The winch drive is connected to the engine of the vehicle and this drives the winch.

Advantage: Very powerful and reliable, often standard on ex-military trucks.

Disadvantage: only works when the engine is still running, only available as an option for very few 4x4 models. This equipment is also quite expensive.

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Electric Winch

This is the most common design in 4x4 vehicles. The pulling force is limited to approx. 4-6 t. Since a winch is rarely used, it is not uncommon for it not to work in an emergency, so it should be used briefly every now and then and the electrical contacts should remain well maintained.

Advantages: Retrofitting on many vehicles is possible, cheaper than engine-driven winches.

Disadvantages: Requires a lot of battery power (a 2nd battery is an advantage), limited pulling power, overheats quickly.

In modern off-road vehicles and SUVs, it is becoming increasingly difficult to attach a winch, mainly because the body is made of plastic parts, which makes it difficult to attach a robust bumper. With a good old ladder frame, that's less of an issue.

Hydraulic Winch

A very powerful and robust construction driven by a hydraulic motor. The whole machinery is heavy and requires a lot of space. In addition, these winches are also very expensive and are therefore mainly used in commercial operations, such as forestry machines.

Hand Winch or Cable Pull



Picture 26: Recovery with cable pull

Source: https://www.landypedia.de/index.php/Datei:LP_Handgreifzug_02.jpg#filelinks

In order to develop the necessary pulling force, one must have a suitably strong device available. The maximum pulling force for manual operation using a lever is a little over 3 t. To use it, you need at least 20 m of special steel cable and possibly additional accessories such as shackles and winch block. All together then weighs around 50 kg, apart from the space required. For travellers in a normal 4x4, this equipment is probably too

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heavy and bulky and for trucks you could generate too little pulling force, so it is hardly useful.

Winch rope or cable

The winch rope should be at least 30m long so that a reasonable pulling distance can be achieved even with a winch block. The winch rope can usually be extended 6-12 m with a tow strap. Whether steel cable or one made of synthetic material is a question of price and durability.

Synthetic ropes are now common and also perform well. In any case, they are much lighter and easier to use with the same nominal load capacity. The rope is guided by a simple, rounded aluminium gate (fairlead). However, this type of rope is significantly more sensitive to damage from sharp-edged obstacles and must therefore be treated with care. In addition, heavy stain from mud or sand shortens the service life. If the rope breaks, it can be repaired in the field with the appropriate splicing tool (but it must be carried along and the handling must be skilful).

Steel cables are usually cheaper and often installed as standard. When using them, you should always work with leather gloves, because there is always the risk of injuring yourself on loose wire fibres. Steel cables must be carefully rolled up onto the pulley to prevent kinking and jamming. The fairlead consists of a frame comprised of four rollers.

Certain accessories belong to the winch application in order to be able to work safely and gently:

Tree protector

The extra-wide, usually short belt is placed around the anchor tree to prevent damage to the trunk and to ensure that the winch rope is securely fastened. Alternatively, a static tow belt with sufficient load capacity can be used.



Picture 27: Winch recovery with tree protector
Source: <https://www.supercheapauto.co.nz/p/ridge-ryder-ridge-ryder-tree-trunk-protector-5m-10000kg/347356.html>

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WARNING

If the winch is used with a pulley (winch block), the pulling force doubles, which ultimately also acts on the harness. This means that this must either have a correspondingly high load limit, or you put the tree belt in double loops but for this the length must be sufficient.

Shackles

These are often necessary to connect the winch rope to the tree harness or a vehicle anchor point. "Soft shackles" are safer and, above all, lighter.



Picture 28: Soft shackle

Source: www.liros.com

Due to the high load, the soft shackle should have a protective sleeve to prevent damage to the rope. In any case, it must be ensured that the "SWL" (Safe Working Load) is sufficient. A corresponding designation should not be missing on the shackle. Soft shackles only have a small safety margin up to the breaking load and even small damage can significantly reduce the load-bearing capacity. Therefore one should tend towards stronger models. But also with soft shackles, it must be ensured that they fit through the holes of existing recovery points.



Picture 29: Steel shackle

source: www.hornertools.com

Steel shackles should only be used if the recovery point on the vehicle is sharp edged, in all other cases the soft shackle is preferred. When purchasing, you should make sure that the bolt is not too big for existing recovery points on the car, but still has a working load of at least 4 t. The breaking load of a steel shackle is many times greater and will therefore withstand the load safely.

Even if chrome steel shackles look very elegant, they are less suitable for recovery tasks. With the same load limits, they are significantly heavier and also much more expensive

4x4 Accessories and Gear

Heavily loaded steel shackles can be deformed. As a result, the bolt is often blocked so severely that it can only be loosened again with difficulties.

HINT

If you unscrew the bolt half a turn after tightening it, blocking can be avoided without reducing the safety or the permissible load.

Winch (or Snatch) Block

Even a strong winch will soon reach its limits when it comes to pulling out a vehicle stuck in mud. The pulling force can be doubled with a pulley.



Picture 31: Pulley for synthetic ropes
Source: factor55.com

The conventional design (right) is quite heavy and bulky but the correct design for steel cables that require a large deflection radius.



Picture30: Traditional winch block for steel cables
Source: www.arb.com.au

Synthetic winch ropes may also be deflected with smaller roller radii. There is a very recommendable alternative for this application, namely a simple pulley that is held in place with a soft shackle. The parts are significantly lighter and smaller, but unfortunately (still) cost a lot.

The appropriate working load must also be considered when purchasing these components. During use, it must be ensured that the rope cannot jump off the pulley under tension. This can cause the rope to jam, or worse, a split block might fail and break apart. It is therefore essential to work carefully when aligning the pulley and tensioning the rope.

Kinetic rope / strap (Snatch-Strap)

A recovery strap or rope uses the kinetic energy that builds up during recovery. The force is increased with momentum when it is stretched and then released again relatively gently in order to free the stuck vehicle. In addition to the classic straps, there are also ropes. These are easier

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Picture 32: Recovery strap and rope

Source: <https://overlandingsurvival.com/overlanding-question-snatch-strap-or-snatch-rope/>

to handle and have a longer usability because they allow more load cycles. But they are heavier, more voluminous and, above all, more expensive. The method using kinetic straps is very efficient for recovering a stuck vehicle with the help of a second vehicle, but it involves considerable dangers. It is therefore essential that the user is skilful to use it. A length of 9 m or more is advantageous, as otherwise you would have to drive up too close to the vehicle to be recovered. Extra-long straps can easily be shortened when doubled.

If a vehicle is stuck in the sand or deep mud, “snatching” is usually the only method that is successful without major efforts.

HINT

A kinetic recovery rope should only be used when all other methods have been exhausted, simply because the risk of an accident is significantly higher. This is due to the fact that the forces generated are large and, above all, cannot be calculated. In addition, the energy stored in the strap is suddenly discharged in the event of a component failure, which has sometimes led to fatal accidents and major property damage.

How to use see chapter: [„Recovery of others“](#)

Rope Dampers

Using a recovery strap or even a winch cable requires the use of rope dampers. These help reduce the force of the tearing strap / rope in the event of failure. There are special dampers which are placed over the tensioned rope or winch cable. In principle, the function of a damper can also be improvised by attaching a soft, but approximately 5 kg heavy, large object to the cable / rope. In contrast to earlier recommendations to use only one damper in the middle, the experience now suggests to attach a damper approx. 1 to 2 m from both ends. This procedure is also

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logical, as straps / ropes rarely tear in the middle, but rather at the attachment points.



Picture 33: Rope damper at work

Source: www.bushranger.com.au

The kinetic forces of a tearing belt are immense. A rope damper that is not made very robust will be torn to pieces. It is ideal to fill the damper, which is designed as a bag, with sand or wet soil, this is the only way to achieve the full effect by forcing the belt / rope to the ground as quickly as possible. But as the video below shows, the forces are often too high to be tamed at all.

That means people in the danger zone and the two drivers are at great risk if something goes really wrong!

This [video](#) is intended to illustrate the dangers of a breaking rope!

Tow Rope or Static Recovery Strap

In contrast to the dynamic recovery rope, a tow belt or rope is not elastic. As the name suggests, this is intended for towing a vehicle. However, it can also be used to recover a vehicle, but under no circumstances should this be done with momentum, as the jerky forces generated by this can lead to damage to the vehicle or the strap. As a result, the use for recovery only makes sense if the required pulling force is not too big and the nature of the ground provides the towing vehicle with good traction.

With this piece of equipment, too, it is important to ensure that it has sufficient load-bearing capacity. In contrast to towing on paved roads, the tensile load on soft ground can be significantly higher, so the permissible load for towing a loaded 4x4 should be at least 3-4 t, better more.

In contrast to kinetic belts, static tow ropes are also permitted to extend a winch cable, but should NEVER be connected with steel shackles! The strap can also be used as a tree protector during winch recovery.

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Recovery Tracks

Recovery tracks are indispensable, especially in the desert and off-road.



Picture 34: *MaxTrax* recovery tracks

Source: www.maxtrax.com.au

If you get stuck in the soft sand without another vehicle being able to pull you out, they are the only sensible way to free yourself.

Today, plastic tracks such as those from [Maxtrax](#) are particularly popular. They are light and the risk of injury and damage to the vehicle is lower. However, they are not suitable for bridging washouts or trenches, since they only have a small load-bearing capacity and therefore have to lie flat when in use.

Spinning the wheels during recovery should be avoided as they can damage the tracks or the knobs on it. Cheap alternatives usually don't keep what they promise.

The classic sand ladders were made from air landing tracks. The perforated tracks were used by the military to build improvised runways in wartimes. They were made of steel, very heavy, or aluminium, still quite heavy, and were 3 m long and about 40 cm wide.

In the meantime, however, these have largely disappeared from the market and are mainly used by truck drivers, because the strength of them is great and the weight of the sand ladders plays less of a role in a truck.



Picture 35: *Alu* sand ladders

Source: www.sandladder.net

As a substitute, however, lightweight and nevertheless quite resilient sand ladders are offered today. If they are bent in use, which is not uncommon, they have to be straightened again with great effort, which is not always easy. If the sand tracks are attached to the vehicle using special brackets, it is important to consider whether they can still be fitted if they are slightly bent. In addition,

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they can cause damage to the underside of the car body during use if they rear up in the sand during recovery. But they can be used for bridging small trenches without any problems, especially if they are doubled in pairs. They can also be used as a base when jacking up the car on soft ground.

If there is enough space for transport, the length of the sand sheets should be as large as possible, but at least 1.2 m

Jacks

If a jack is not only to be used for changing wheels on solid ground, a generous lift must be guaranteed. The manufacturer's original jack can usually not offer that. This applies even more to lifting a stuck vehicle. In any case, the model used must match the weight of the vehicle and its ground clearance.

There are basically three designs that are suitable for this task:

Hydraulic Bottlejack



Picture 36: *Hydraulic jack*

Because it is cheap and compact, this design is very popular. Since an off-road vehicle with its large tires sags a lot when one runs flat, both the minimum and the maximum height of the jack must be suitable for the vehicle. With many models, however, the lifting height of the original jack is not sufficient in every situation. If you have two of them on board, you can lift the vehicle in steps using wooden blocks, but this can only be done safely on solid ground and with the help of wooden blocks.

Hi-Lift-Jack

This archaic but also powerful lifting tool is very popular and available in different lengths.

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If you choose it, you should pay attention to quality, because there are many copycat products. Depending on the design, you can use it to lift the vehicle up to over a meter.



Picture 37: *Hi-Lift Jack*

Source: www.hi-lift.com



Picture 38: *Hi-Lift Jack in use*

The Hi-Lift Jack can also be used for winching, a laborious but possible way of recovering the vehicle. With the help of a pulley, a pulling force of several tons can be achieved. However, a single stroke is only about one meter. Then the vehicle must be secured and the jack must be returned to its starting position. One can imagine how much time and equipment it takes to move an all-wheel drive vehicle 20 m!

But the gear also has some decisive disadvantages and limitations:

- The jack is heavy and bulky and therefore not easy to stow away. If it is exposed to the weather and is not cared for, the mechanism can rust and block.
- Using it, especially lowering the vehicle, is dangerous if you do not proceed properly.
- Many of the modern vehicles do not even have any appropriate places to put this type of jack on. The rim hooks available as accessories, can only be used to lift the vehicle, but this does not help when changing wheels unless you can set the vehicle on blocks after it has been lifted.

Air Jacks

An air jack is placed under the car and inflated with exhaust gas. That works quite well but has its pitfalls. First, the exhaust system has to be tight in order to be able to build up the necessary pressure. In addition,

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you have to ensure that the balloon is not damaged, be it by sharp-edged or hot vehicle parts or pointed objects on the ground. Thirdly, you must never be under the vehicle while only the air jack serves as a support, which actually applies to all types of jacks.



Picture 39: Air jack
Source: www.bushranger.com.au

With this type of jack, a robust construction is essential, so you should examine the product before buying. It also makes sense to carry a repair kit and protective blankets for the floor and possibly also against the vehicle underbody. Of course, the exhaust system must have no significant leak, otherwise the pressure cannot be built up in the first place. With enough patience and an appropriate adapter, you can also inflate the balloon with the compressor, but be careful, its high pressure can lead to destruction.

Shovel



Picture 40: Digger Shovel
Source: www.bushranger.com.au

A sturdy shovel with a long handle should not only be on board for recovery tasks. Be it working around the campfire or burying your private business in the bush, a shovel is a must.

If the car is stuck in mud or sand up to the axle, you will appreciate a long shovel handle. The blade should be made of sturdy sheet steel, otherwise it will hardly survive long use in hard ground. However, a long-handled shovel is difficult to accommodate in a vehicle with limited space. The “Digger” model from “Bushranger” offers a clever variant. The Australian product is robust, the long handle comes in two parts and the whole thing is stowed in a transport bag to save space.

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Safety

All equipment that is used for a recovery with the use of ropes / straps must be in perfect condition and have sufficient reserve in terms of load capacity. Basically, the strap or the rope should be the weakest link in the chain, since failure can cause the smallest possible damage.

A recovery chain usually consists of the following components:

- **Anchor point:**
Anchor, harness, recovery point on a vehicle, etc.
- **Connecting parts:**
Shackles, hooks (only use if absolutely necessary)
- **Rope / strap:**
Winch rope, recovery strap or towing rope

In order to achieve optimal safety and function, these components must be of good quality and the load capacity must be matching each other.

Damage, especially to a strap and rope, significantly reduces the load-bearing capacity and cannot be assessed properly. Therefore, such equipment should be sorted out whenever possible. Frequent use can also reduce the load limits.

Air Compressor

Adjusting the tire pressure when driving off-road is important and necessary. Pressure can be reduced without tools, but a powerful compressor is required to raise it again. The same applies, of course, to fix a flat tire. A repair kit is of little use if you cannot pump up the tire again afterwards.

Inexpensive supermarket compressors are not suitable for regular use and will probably not even be able to bring four tires back up to road pressure. If they don't fail, they will most likely overheat, if you have that much patience at all. A suitable compressor is sure to cost more than USD 100. Cheaper models are hardly suitable and prices for top models can be rather steep. By the way, if a compressor is offered with a cigarette plug, good performance is excluded, because it cannot perform to expectations with only max. 10 A.

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This results in the most important properties that a compressor must have:

- High delivery rate even with high tire pressure > 50 l / min at 2 bar
- Should remain operational even after 30 minutes of use
- Watertight and dustproof design, especially if the compressor is installed in the engine compartment

Since a powerful compressor draws a lot of current (> 20 A), it is best to install it permanently and wire it directly to the battery with a fuse. Even if the assembly in the engine compartment put a lot of stress on it, it is advantageous to keep it close to the battery, because the cables must have a large cross-section. However, it must then be ensured that there is an air hose of sufficient length to be able to reach each wheel. If there is space for a pressure vessel, the compressed air can also be used to clean parts. However, the pressure vessel should have a volume of a few litres, otherwise this application is only possible to a very limited extent. A compressed air gun with a small nozzle improves the application possibilities.



Picture 41: Fixed and mobile ARB compressor

Source: www.arb.com.au

the compressor is not installed in a protective case, it should at least be mounted on a base plate and not operated in sand or on a dusty surface.

Electrical contacts and switches, but also the hose coupling, should be protected from dust and moisture if installed in the engine bay. If the compressor is not used regularly, corrosion and dirt will sooner or later impair its function.

Mobile compressors are also a good solution, but they require additional storage space.

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Which model you choose should depend on the delivery rate and robustness, space requirements and budget. You should try to gain experience from other users before you purchase.

Additional Equipment

The range of 4x4 accessories is extremely large and it is difficult to keep track of. It is not always easy to determine what is useful and worth the money. Some pieces of equipment that are popular, from the author's point of view, are presented below. It is important, however, that the user is clear about the costs / benefits as well as the possible uses before he puts additional loads on his vehicle and stuffs it up.

Lightning

Any type of work lights, "light bars" and high beam headlights are popular. Apart from the fact that most of them are not street legal, the practical value is not always given beyond doubt. When travelling in foreign countries, it is better avoided driving at night whenever possible. Good headlights are only of crucial importance if you are forced to do so anyway. Older vehicles with simple H4 halogen lights in particular tend to emit dim light.

When driving at night on narrow, winding roads, it is less important to have a long distance illumination, but rather that the edges of the road are well illuminated for 50-100 m. That should be a priority when selecting the headlights.



Picture 42: Mobile work light
Source: <https://www.steffen.ch/de/products/19-95195>

"Work lights", i.e. lights that can illuminate the immediate vicinity of the 4x4, are quite useful. They are very helpful, for example, if you have to set up camp in the dark or, something you don't wish to anyone, to be recovering until late at night.

Since the direction in which these headlights should shine is not clear from the start, wide-angle light at least to the front and back make the most sense. Another, much more flexible option is a rechargeable

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handheld searchlight. However, ideally it should be chargeable or operated with 12 V on-board voltage. A suction cup or a magnetic base allow secure attachment to the body.

Additional Fuel Storage

Wherever your journey is taking you, sufficient fuel autonomy must be ensured. With a few exceptions, the standard capacities rarely offer a



Picture 43: Jerry cans on the roof rack

Source: www.weltrekordreise.ch

range of more than 600-800 km.

This is usually not enough on remote routes in the Australian desert or in the Sahara. However, in order to increase the necessary range to 1500 km or more, several 20 l jerry cans would be required, depending on the vehicle. The picture shows the Swiss couple Schmid who have been travelling the world in their Landcruiser for over thirty years. They started at a

time when auxiliary tanks were still largely unknown and they were therefore dependent on jerry cans.

Jerry cans are inexpensive but have some disadvantages:

- Leak-proof: Even though they are robust and also well sealed, there is a certain risk of leakage. Inside the vehicle that would be a safety issue and, with diesel, at least a lasting mess.
- Handling: Filling and refuelling is time-consuming, full jerry cans are heavy and they need a well-sealed spout.
- Space requirements: You should not transport them inside the vehicle and they lift the centre of gravity if carried on the roof rack and are difficult to load and unload. If attached outside, it may be illegal and there is a risk of theft (should be lockable).

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Border crossings: At most borders you can bring a maximum of 20 L spare fuel with you. This means that it is not possible to bring cheap fuel from one country to another in jerry cans.

Jerry cans are therefore more useful as an emergency solution for certain, long distance legs. But whether you should carry one or more empty canisters with you all the time is questionable. If needed get some cheap plastic canisters on site and fill them into the tank immediately when fuel is used up. Sell again after the stage.

If you decide to buy jerry cans anyway, it is worth buying good quality and you shouldn't forget to get a matching spout.



Picture 44: 180 l replacement tank

As an alternative, permanently installed additional or larger replacement tanks are more advantageous, but they are a more expensive investment. In addition to greater convenience and volume of fuel, this solution also offers greater safety and a lower

centre of gravity. Some of the costs can be repaid over time, as you can benefit from low fuel prices, not only in cross-border traffic. The Dalton Highway to Dead Horse in Alaska may serve as an example. The length of the route there and back from Fairbanks is approximately 1,600 km. If you have to refuel in Dead Horse for the way back, you pay almost twice as much as in Fairbanks. The extra tank volume can quickly save 100 USD. Over time this amortizes the procurement costs on a long journey. But also in countries where fuel procurement is complicated or availability is not guaranteed, you benefit from a large tank volume. One of the large Land Cruisers can easily transport 270 litres of fuel, which corresponds to a range of up to 2000 km.

It is ideal if the additional tank works completely independently of the main tank with two filler nozzles, separate level indicator and switchable from one to the other on demand. If the two are hydraulically con-

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nected, you lose all of the fuel in the event of a leak and you cannot continue driving before repair is carried out. Pumping into the main tank also carries a risk, because if the pump fails, you can no longer easily get to the fuel.

If you decide to go for an extra tank make sure the manufacturer is experienced fabricating tanks. Many of the prototype models tend to crack and baffles should be included to minimize movement of large volumes inside the vessel.

Roof Rack

Roof racks are a popular topic mentioned in campfire stories, but mostly not for good. On the one hand, roof racks are often too heavily loaded, which not only increases the centre of gravity, but many inexpensive racks or models for regular cars are simply not up to the harsh conditions. In addition to breaking the rack supports, excessive loads can also damage the vehicle's gutter.



Picture 45: ARB roof rack with 6 supports

Therefore you should make sure that the roof rack has as many supports as possible to distribute the load. The whole construction shouldn't be too

heavy, because the rack weight is also added to the approved roof load.

The vehicle must of course be approved for a corresponding roof load and if the vehicle has no gutter, that is quite usual with modern vehicles, robust roof rack systems, which do not fail on corrugated gravel roads, are few and far between.

It is better if you can do without a roof rack entirely. This can be achieved if either less equipment is carried or a larger vehicle is procured

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Tire Pressure Monitoring System

If a tire pressure monitoring is not available ex works, it is worth retrofitting. It is often difficult to realize when the tire is slowly losing pressure, especially off-road. This is in particularly true for the rear wheels. The spongy driving behaviour on a track is superimposed on the influence of a deflating tire. The result is then often a completely destroyed, irreparable tire.

A good pressure monitoring system can be fully configured, i.e. the low pressure limit values, that trigger an alarm if the pressure falls below, can be set individually. The reason for this is, that if you drive in the sand with reduced tire pressure, it would already be classified as flat by the factory system.

The cheapest models come with sensors that are screwed onto the valves. The main disadvantage of these is that they can be torn off, e.g. in mud, and this would lead to a sudden loss of pressure. They can also leak if the sensors get loose. Otherwise, however, they have some significant advantages, such as the easy relocation when rotating the wheels. With sensors that are installed inside the tire, the new position must be reprogrammed



*Picture 46: Short metallic valve
Source: www.reifenmontagezubehoer.de*

every time the wheels are rotated. In order to reduce protrusion of the sensors, it can be considered to install metallic and short valve stems. However, these are less flexible and therefore also more likely to be damaged.

It makes sense to get a system with a good display of all four wheels and to mount this on the steering column. So the pressure always stays in the driver's field of vision. In addition, it should be ensured that the display unit can be connected to the on-board power supply, this saves the regular battery change. The sensors should have replaceable batteries.

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Picture 47: Pressure monitoring with external sensors

Source: www.elv.com

The system can also offer valuable assistance in finding the optimal tire pressure on paved roads. A tire heats up during operation, as is well known, and therefore the tire pressure increases. Depending on the tire type and load, this should be 5 to 8 PSI and this is exactly what can be checked with the tire monitor. If the pressure on both axles increases roughly equally and within this range, the pressure for paved roads is optimal. In addition, the behaviour can also be observed via the temperature, because many systems measure the temperature at the valve as well. The measurement is not very precise and depends on external factors, but if you notice a striking difference between left and right, for example, something is wrong. The temperature should also be roughly the same between the two axles. A noticeably higher temperature of an individual tire indicates that the pressure is too low. A temperature display which is generally significantly higher than the ambient temperature should be examined.

HINT

A pressure monitoring system should offer the following functions:

- *Pressure and temperature display of each individual wheel*
- *Freely adjustable alarm limit set points*
- *Alert if the pressure is too low and if there is a sudden pressure drop*
- *Easily audible acoustic alarms and possibly additional visual alarms*

Upgrades

Off-road vehicles that are built for heavy duty only need a few adjustments to be suitable for travel and off-road use, but certain improvements can still be worthwhile.

Suspension

Since touring 4x4s are often loaded to the limit or even more, a reinforced suspension with more robust shock absorbers is often useful. Usually this goes hand in hand with an increase in ground clearance as

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an appreciated side effect. An increase of a few centimetres is usually also legally permissible, but in any case you should ensure that the gear can be legalized.

On off-road vehicles with rigid axles, the leaf or coil springs are exchanged. Other suspension designs, for example, torsion bars must be reinforced or if possible, re-adjusted.

If a reinforced suspension is installed, usually better shock absorbers are part of it. Since the springs have a more travel, the shock absorbers often have to be longer than the original ones as well, on a trip they may not be as easy to replace if they fail. It is therefore important that the quality and robustness are high so that failures should not occur at all. In particular, suspensions with screw springs instead of leaf springs place a significantly higher load on the dampers. A leaf spring suspension can still be driven quite safely if necessary, even if shock absorbers fail. A



Picture 48: Protector for the shock absorber at the rear axle

car with coil spring suspension is difficult to control at higher speeds without a damper.

Depending on the type of vehicle, the shock absorbers are mounted exposed and can be damaged by flying rocks. The dampers on the rear axle are particularly at risk, as they are often in the trajectory of thrown up rocks. If a protection is not supplied as standard, you should consider building a suitable protection sleeve yourself.

[Custom-made dampers](#) like those used in rally raid sport would be ideal. Not only can they be optimally adapted to the vehicle weight, but they can also be rebuilt if it ever becomes necessary. However, such dampers cost several times more than standard products.

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Under Body Protection

Especially with models with independent suspension on the front axle, there is a risk of damaging the oil pan or the gearbox off-road. The reason for this is that the body with the engine dips between the wheels during compression and thus comes closer to the ground. This problem is less common with rigid axles, as the motor is always placed above the axle and the differential always has the same ground clearance and represents the lowest point of the vehicle. For vehicles with rigid axles, also at the front, a under vehicle protector is not of great use for "normal" driving.



Picture 49: Skid plate Toyota Hilux

Source: www.arb.com.au

In vehicles with independent suspension, an under vehicle protection makes much more sense because it can prevent damage when touching down. However, if you drive carefully, the risk is low, even without protection.

Countless products for protecting the underbody are available in the accessories trade. However, many are more of a visual appeasement

than robust protection. If you want to invest in additional protection, the following criteria should be decisive:

- **Robust material** - Made from >6mm high-strength aluminium sheet, steel is even more robust, but also heavy
- **Simple design** - If you bend the sheet metal, it can hardly be bent back into shape if it has a complex shape and therefore can no longer be re-fitted
- **No exposed screws** - These will otherwise be sheared off or be damaged when they touch ground
- **No large panels** - Too large parts tend to bend in use and can no longer be re-installed

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Engine Tuning

By means of chip tuning, the performance most modern motors can be increased with adapted motor control software. It should be noted that many of these interventions are not legally permitted. With older engines, especially old naturally aspirated diesels, a turbocharger can at best be retrofitted; the issue of approval remains there too.

For trips to regions where very bad diesel and gasoline may be encountered or countries where driving at over 3500 meters above sea level is likely, it's worth considering appropriate measures. It's not primarily about more power, but about adapting the complicated and sometimes sensitive engine management so that it can cope with these conditions. Most of the time, it is also about removing exhaust systems such as catalytic converters and particle filters and adapting the software accordingly, otherwise there is a risk of engine malfunctions or even damage that cannot be easily repaired on the way.

Old naturally aspirated diesel engines run poorly at altitude and produce more smoke than power. A turbocharger with moderate boost pressure improves the situation considerably.

In any case, it is important to get information about the vehicle model in advance in the relevant specialist forums before undertaking an extensive conversion or simply driving off. Be aware that any of above measures will likely void the legality of the vehicle in the home country! It will therefore also be impossible to pass technical inspection after returning home.

When travelling, however, reliability and durability are more important than high performance, and that should be given priority when making decisions.

Improving Filter Performance

Be it air, fuel or oil filters, when travelling, especially the former are heavily used. If the vehicle model is not appropriately equipped ex works, it is worth making improvements here.

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Air Filter

If available, you can consider replacing the standard filter with a washable one. This means that there is no need to carry replacement filters, which can be quite voluminous. See also the "snorkel" chapter below.

Fuel Filter

In third world countries, clean fuel is not always guaranteed. Should you ever refuel with dirty fuel, the normal filter is quickly clogged and the flow is blocked. If the vehicle has a pre-filter, usually an inexpensive paper filter, only this filter has to be replaced or can simply be removed temporarily. The main filter is thus protected from excessive contamination. Only a few off-road vehicles are factory-fitted with a pre-filter, but retrofitting is possible and makes sense if you go on a big tour.

Oil Filter

In the case of the oil filter, there is also the option of installing a fine filter from "[Frantz](#)" or "[Trabold](#)". Such a filter is installed parallel to the normal oil circuit and fine filters the oil. The advantage is that the regular oil and oil filter change is largely eliminated. It is sufficient to change the fine filter (approx. 12 USD / pc.) periodically and top up engine oil if necessary.

Both products have a good reputation and appear to be working well. The initial costs are paid back after a short time with large quantities of oil (e.g. Landcruiser up to 11 l) and expensive oil filters and the engine always has clean oil in the circuit. In addition, you don't have to worry about where you can change oil on the way.

Snorkel

A snorkel has two advantages: First, the air is drawn in much higher up and the air filter is therefore less polluted on dusty tracks. Some of the snorkel models even have a cyclone insert that separates coarse particles or even a pre-filter. Secondly, a snorkel prevents sucking in of water when crossing deep water, which would probably lead to major engine

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*Picture 50: Original snorkel
Toyota Land Cruiser*

damage with diesel engines and at least major problems with petrol engines.

Retrofitting snorkels is no longer easy due to the latest safety laws (Europe), but there are models that are approved. Check before installation.

It is important to ensure that the connections along the air inlet are and will remain water-tight.

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Tools and Repair Material

On a longer tour, away from civilization, you will have to carry a minimum of tools, repair material and spare parts. However, it is also an advantage to have the skills to use it properly. But even untalented mechanics are well advised to carry this equipment because in less developed regions, one often meets good mechanics who are, however, inadequately equipped. It is astonishing how little such people need, to perform miracles, but if you can provide them with your own tools and other material, the results are certainly even more impressive.

With four universally applicable tools or repair materials, most of the little things, and fortunately, they usually make up the greatest proportion of problems, can be fixed in a few minutes. It is all the more important that this material is stowed within reach:

- Screwdriver with exchangeable bits
- Good quality multi-tool
- Small socket wrench set with bit sockets if possible
- An assortment of zip ties and a roll of duct tape



Picture 52:
Multitool, eg. Leatherman



Picture 52:
Screw driver with a bit set

Tool Kit

A general tool kit with good quality material and a socket wrench set will get you quite a long way. In addition to the usual ½" socket wrench set, it makes sense to have a smaller one, because many bolts and nuts on the vehicle are 13 mm wrench size and smaller. A bit set with a universal screwdriver handle extends the range of applications without investing a lot in money and space.

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In principle, the tool kit should be optimized for your own vehicle. However, later added components and accessories, may require additional wrench sizes or inserts, this must also be considered. Especially with smaller, already heavily loaded vehicles, you should put some effort into defining the optimal equipment.

In order to save space and avoid rattling, tool roll bags have proven themselves. In addition, the tools are clearly arranged and should something get lost in the hustle and bustle, you will discover it when you pack it up and not only when you want to use it next time.

To save weight / space, the spanner sets can be reduced to the sizes that are used on the vehicle, although you may have to procure additional special sizes separately.



Picture 54: Tool roll bags



Picture 54: Roll bags closed

Whether power tools, such as a cordless drill, should also be included is not least a question of space and weight, it can make sense, but only if you like to work on the car yourself.

Here are some tools that are not always considered to be "standard":

Mechanical Tools

- **Vise Grip pliers** - Help to clamp parts, loosen damaged screws or generally as a temporary lever.

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- **Torque wrench** - Some bolt tightening torques are critical, but many garages in third world countries work without the appropriate tools. Wheel nuts require up to 200 Nm, which should be the achievable.
- **Pop rivet kit** - Consisting of the pliers and various high quality rivets.

Electric Tools

Defects and basic work on the electrical system of a touring vehicle occur regularly. Therefore, the most important utensils for such work should be carried on board.

- **Gas-powered soldering iron**- For minor work on the on-board electrics, but also for heating, burning off, shrinking.
- **Multimeter** - Ideally with a [clamp ampere meter](#), for measuring circuits and the charging and consumer currents.
- **Crimping pliers** - With a set of different connectors.

Tire Repair Kit

Even though tire repair shops can be found almost everywhere in less developed countries, you should be able to repair a tire yourself in an emergency.

A distinction must be made between a small hole, which is often caused by nails or the like, and a larger damage to the carcass.

With tubeless tires the former can be patched without even having to take off the wheel or tire. The hole is drilled out with the appropriate tool and then a rubber worm is vulcanized in. With tube type tires, you will have to pull off the tire at least on one side in order to repair the defective inner tube with a patch.

In the case of greater damage, for example a cut in the side wall, the effort is significantly greater. The tire must be completely removed in order to glue a suitable patch on the inside.

In both cases you must be able to inflate the tire again afterwards. A powerful compressor should therefore be on board.

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The off-road tires can often not be pulled off the rim easily, therefore you need the appropriate tools. The Australian company [Tire Pliers](#) offers comprehensive and recognized good repair material. To push the tire

off the rim, you can alternatively put the removed wheel on the ground and drive the front wheel of the vehicle on it, preferably with the help of a board. This should work with the necessary caution and some skill. You can also try it with a jack clamped between the bumper and the tire.



Picture 55: *Comprehensive tire repair set*

Source: <http://www2.tyrepliers.com.au/>

Even if they seem a little heavy, you are better off with robust and long tools.

HINT

The following tools and materials are at least required for tire repairs:

- *Jack and wheel nut spanner!*
- *At least two long, sturdy tire levers*
- *Compressor, permanently installed (then with a long hose) or portable*
- *Repair kit for tubeless tires (drill, pick-up awl, glue, rubber worms)*
- *Repair kit for tires and tubes (various tube and tire patches, glue, file)*
- *A bead breaker if you want to avoid the "drive on" method*
- *Valve key*
- *Pressure gauge*

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Special Tools

Depending on the vehicle model, special tools might be required even for maintenance work. If you are planning a longer trip in areas with limited supplies, you should inquire in the relevant travel and / or vehicle forums which special tools would be required to carry out common maintenance and repair work. In particular, it must be ensured that spare parts brought along can actually be exchanged with the tools on board.

Repair Material

To be able to carry out general repair work on the car, the following (not exhaustive) tools are useful:

- Ratchet straps
- Cable ties, different sizes
- Adhesives and sealants for various applications (metal, plastic, hard and elastic, etc.)
- Electrical tape
- Teflon tape
- High-strength fabric adhesive tape (race tape, duct tape)
- Velcro, different sizes and strengths
- Wire for securing and fixing, different gauges
- Screws and bolts (various threaded rods, screws, nuts, washers, also sheet metal screws, including special threads used on the vehicle and spare wheel nuts)
- Possibly some rivet nuts of different sizes
- Brake cleaner
- Universal spray (WD40)
- Contactspray
- Replacement fuses, of all types that are installed, especially "exotic" types.
- Sheet metal and flat material remnants
- Various hoses, whatever is installed (engine, gas, water) possibly also [elastic sealing tape](#) for repairing hoses and pipes

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- Electric cables in various gauges
- Shrink tubing material

Bush Welding

It is quite possible that damage occurs on the trip that would require welding. However, most of such damage is not serious enough, that you would not make it to the next workshop or the broken parts are anyway too heavy and thick-walled for the welding method described below to be used.

The following equipment is useful for small weld jobs, provided you already have experience in welding:

- Jump starting cables as thick as possible, as large currents will flow
- 2-4 car batteries in good condition connected in series (+ - + - + - + -) to increase the voltage (thick connecting cable required)
- Thin welding electrodes (approx. 1.6 mm)
- Well prepared components and good ground contact
- An experienced welder
- If the terminals of the jump start cable are not sufficient, you may need to carry an electrode holder with a suitable cable connection

The [linked video](#) shows how the whole thing works, but before you have to use the technology in an emergency in the bush, you should practice using it at home. You have to consider that welding puts an extreme load on the battery and they can even be destroyed. It doesn't help if the vehicle can be welded together, but the engine can no longer be started!

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Picture 56: African welding

HINT

Having a few different welding electrodes with you can also help if you find a bush mechanic with welding equipment, but who does not have suitable electrodes available.

Spare Parts

Which spare parts you should carry with you for the off-road vehicle depends on various factors. If you are travelling for a long time in a region where maintenance and wear parts are not easy to obtain, they should be on board. This certainly includes oil, fuel and air filters that need to be replaced regularly. A set of these should always be available in reserve.

V-belts, wheel bearings and brake pads require little space and can sometimes wear out or fail surprisingly. If weak points of the vehicle model are known and the required parts are small and easy to replace, these spare parts can also be carried.

In order to get to know the weak points of your own vehicle better, you should consult the relevant brand forums or your mechanic of trust. Errors that often occur, should be revealed and the need for spare parts can be determined based on this. Additional special tools may be necessary to replace them.

Often, however, parts no one has thought of fail or parts are too big or too expensive to have with you as a preventative measure. Basically, the focus should be placed on parts which, if they fail, inevitably prevent further travel, but can also be carried on board. As an example, it is not important whether an air conditioning system can be repaired immediately, but if the brake fails, it is hardly possible to continue. Much damage can also be temporarily repaired or at least mitigated through improvisation.

Driving Off-Road

Driving Off-Road

Driving off-road can be a lot of fun, but it carries some risks, some of them are fatal. It is sometimes amazing what an off-road vehicle is capable of, but if the limit is exceeded, serious accidents can result. If you want to wander off from good roads, it is important to gain experience step by step and to complete solid basic training. But even if you don't plan on such "adventures", it is possible to get into situations that require good control over the 4x4. Heavy rain can lead to almost impassable tracks and harmless streams turn into rapid rivers. Or it turns out that roads that are declared as main roads on a road map, can only be tackled with an all-wheel drive vehicle with a good ground clearance.

This chapter is intended to convey at least the theoretical basics. In addition, it makes sense to attend a practical off-road driving course with your own 4x4. Even after that, you are by no means an expert, but you can build on it and then it should be possible to avoid gross mistakes. In addition, you get to know the limits of your own vehicle in a controlled environment.

General Advice

When driving in difficult terrain, there are some basic rules to be observed:

- Get up-to-date information on the track condition before driving the planned route.
- In the case of very difficult, remote and lonely stretches, authorities or confidants should be informed about the plans so that a search and rescue action can be organized in an emergency.
- Make sure the vehicle and equipment are suitable and in good working order.
- Away from good roads and tracks, it is advisable to travel with at least two off-road vehicles so that one can help each other in case of difficulties. However, more than three vehicles per group should be avoided, or several independent sub-groups should then be formed.

Driving Off-Road

- If you are driving in a group, you must always keep enough distance to the vehicle in front that you can still stop in a safe place if the driver in front gets into difficulties.
- Stop before any difficult stretch of route (river crossing, steep ascent or descent, etc.), get off and examine the terrain, make a plan, prepare and only then start. In front of serious obstacles, have the recovery gear ready.
- In difficult terrain with steps and ditches, you should get into the habit of not putting your thumbs on the inside of the steering wheel. If a front wheel unexpectedly hits an obstacle, this can cause a strong rotational momentum on the steering wheel, which can lead to painful injuries and even broken thumbs. The problem is less serious with power steered cars, but you should still stick to this rule.
- The windows should either be completely closed or completely open. The reason is that if the vehicle is unexpected to move violently, the edge of a half-open window can lead to serious injuries if you hit it with your head.

The most important rules for off-road driving are:

1.

When in doubt: stop, get out and examine the situation

2.

Then: consider, assess and act

Driving Off-Road

Driving Technique

When driving off paved roads, one encounters certain conditions over and over again. The most common are covered below.

Tire Pressure

In general, the air pressure in the tires should be reduced and the four-wheel drive should be engaged as soon as you leave paved roads for a long time. This not only makes driving more comfortable, but also gives you more traction and better braking power. In addition, the gravel roads are significantly protected from excessive erosion.

Unfortunately, general rules for tire pressure cannot be given because it depends on several factors:

- Tire type and size
- Axle load
- Surface condition

The following rule can be used as a guideline:

Paved road	100%	As per specs
Gravel road	80%	Not over 80 km / h
Rough tracks, hard packed	60%	If necessary, less
Sandy tracks, solid dunes, mud	30%	Not below 1.2 bar, must steer gently
Soft sand, driving straight	Below 1 bar	(for a short time)
Stuck in the sand	0.5-0.8 bar	Start very gently!!

By the way, too high tire pressure on stony tracks increases the risk of tire damage because sharp stones can pierce the tread, while a "soft" tire will flex way better.

With very little pressure, the tire can jump off the rim due to a sharp steering movement. At high speed it can overheat and be damaged.

Driving Off-Road



Picture 57: *Adjusting the tire pressure*

A powerful compressor is required to increase the air pressure. You should take the time to adjust the tire pressure. There are special valve caps for dropping the pressure, allowing automatic drop to a pre-set value when you put them on. Since only one valve can be preselected anyway, the advantage is actually only a few minutes of time saving, when dropping the pressure.

Further information on the subject in the chapter "[Driving in soft sand](#)"

Steep ascend

Steep ascends are often washed out, which significantly increases the risk of getting stuck. If the four-wheel drive is equipped with differential locks, this is a situation in which they should be engaged before the obstacle.

A straight slope that is not furrowed by ditches and without steps can be taken with momentum, in the 2nd or 3rd low-range gear at 50-75% of the maximum rpm. But be careful, if you are too fast, you will catapult the vehicle over the edge, which can have serious consequences.

If, on the other hand, the track is washed out or has steps, you choose a low gear and climb up slowly. You should drive with the most constant engine speed possible (2000-3000 rpm) and the clutch must not be touched, and sudden gas changes also should be avoided.

If you notice that you cannot manage the incline, you have to react quickly and not try for long. The safest way to master the situation is to step on the brake without using the clutch, stalling the engine and securing the car. Now the brake must not be released for the moment.

BREATHE DEEPLY AND COLLECT YOURSELF!

Driving Off-Road



Picture 58: Steep ascent with steps

Getting back down backwards is very tricky and has already caused many 4x4s to overturn. The great danger is that the vehicle will come sideways when reversing and roll over to the side or that you will lose control and shoot down the hill at high speed.

The following procedure largely reduces the risk:

Initial situation: You are stuck in the incline, the wheels are blocked by the brakes, the engine is stalled and the gear is still engaged.

- Step 1:** Keeping the brake on, disengage the clutch, put in reverse gear (low gear!) and engage clutch again
- Step 2:** Slowly take foot off the brakes, the car should still be secured by the drive train
- Step 3:** Make sure that the front wheels are exactly in the direction of travel
- Step 4:** Take your feet off the pedals and start the engine **WITHOUT** the clutch. The vehicle starts moving backwards very slowly

In this situation, the brake should not be applied or only in an extreme emergency, as otherwise there is a risk that a wheel will lock and the car will break out and roll over.

HINT

This routine should be exercised on a harmless slope until it becomes an automatism.

Driving Off-Road

Once you have reached the bottom safely, you can try again with a little more momentum or, if available, use the winch or a second vehicle to assist you. The safest option is to avoid the obstacle.

Steep Descends



*Picture 59:
Steep descent in a vertical line*

Steep descents can always be negotiated, everyone will get down, but if you lose control, that can also be fatal. Here, too, a distinction must be made between straight and smooth tracks and tracks with trenches or steps. In the first case, you drive the front axle over the edge in the first low-range gear and roll down without touching any of the pedals. The air conditioning must be switched off, that the idle gas remains low during the downhill. In many vehicle models, the AC automatically increases the idling speed when the compressor kicks in, which results in an undesirable increase in speed when descending.

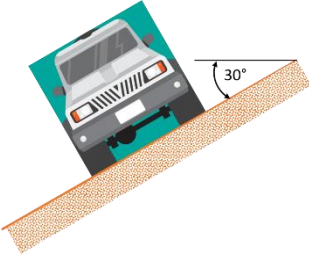
Even if the 4x4 picks up a bit of speed on the descent due to the steepness, you should avoid using the brakes, because this can lead to the car going off the vertical line and overturning sideways or over the top. Should that happen, only a heartfelt burst of gas will help to regain the vertical line. The risk of a rollover is significantly lower than if you try to brake.

Driving across inclined slopes

Driving on inclined slopes is critical above a certain tilt angle. Fortunately, however, the built-in “bum meter” ensures, that the driver has concerns before a critical condition occurs.

In this situation in particular, a high a centre of gravity plays a crucial role. It is all the more important when loading to stow the heavy equipment as far down as possible in the car and keep no heavy items on the roof rack.

Driving Off-Road



Picture 60: *Driving a slope*

Slope angles of up to 30 ° can be driven without difficulty in most vehicles. However, it is tricky when the upper front wheel hits an obstacle or the lower front wheel drops into a hole. If you are too fast, the resulting kick can cause the vehicle to tip sideways downhill or even roll.

It is therefore advisable to drive through such a passage in the first low-range gear at the lowest speed and to ensure that the individual wheels do not run into additional obstacles. Brusque manoeuvres should definitely be avoided. If possible, someone should get out to direct the driver with agreed hand signals. The situation can also be better assessed from the outside.

If, despite all precautionary measures, the car threatens to tip over, the only thing left, is to bring the vehicle into the direct downhill line as quickly as possible. Of course, this hint doesn't really help if you steer into an abyss, on the other hand, should the 4x4 roll down sideways, the situation isn't really a better option. In order to actually be able to initiate this reaction in an emergency, the driver has to mentally prepare himself to this exceptional situation before start driving.

Sand Driving

The very basic rule of sand driving is to apply the correct air pressure!! In order to make the physics behind it a little more understandable, the following chapter should explain the relevant factors in detail.

Sand Suitability of Off-Road Vehicles

If the vehicle is fundamentally unsuitable for driving in soft sand, ultimately releasing air only helps to a limited extent. In order to better understand the relations and to determine the sand suitability of a vehicle, the "sand formula" was developed as early as the 1970s.

Vehicles are all the more suitable for driving in soft sand,

- the larger the wheel diameter

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- the wider the tire
- the more driven wheels there are
- the lower the weight

When driving in soft sand, ruts are created. The off-road vehicle sinks in depending on the nature of the ground, vehicle weight, etc. When driving through pristine sand, the wheels have to constantly climb up a sand hill because they sink into the soft sand. However, repeatedly driving on the same track can solidify the sand, which can improve the load-bearing capacity.

But the larger the tire diameter, the less steep the sand hill in front of the wheels and therefore the lower the rolling resistance. But the depth of the ruts also plays a role. The higher the surface pressure, the more the tires sink in.

The surface pressure in turn depends on the vehicle weight and the contact area of the tires. The contact area is influenced by the tire width and diameter. If you reduce the air pressure, the contact surface becomes primarily longer and just a little wider. With a large wheel diameter and a large tire height, this effect is significantly greater, i.e. the surface pressure and thus sinking in are significantly reduced.

To avoid the rear wheel from sinking even deeper and thus further increase the rolling resistance, it must be ensured that the surface pressure is the same or less. Since the rear axle usually has a higher axle load, this can practically only be achieved by lowering the tire pressure at the rear even more, contrary to the usual rule, more weight = higher tire pressure.

To understand the physical relationships mathematically, the formula below can be used. If that's too much theory or details for you, skip to the end of the chapter. In order to check how well your own vehicle is suitable, you should make the calculation for both the empty weight and fully loaded:

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Rolling resistance (RR)

The following factors play an important role in the calculation:

n = Number of wheels

d = Wheel Diameter in meter

w = Tire width in meter

W = Vehicle gross weight in metric tons

The influence of the individual factors is related to the following:

$$RR = (n * d * d * w) / W$$

It reveals that sinking in is reduced by a larger contact area, which in turn is the product of increasing diameter and width of the tire, and by reducing the weight. It is important to understand that the increase in the tire diameter has a positive quadratic influence.

The engine power per ton of weight and the number of driven and load-bearing wheels must also be taken into account.

Power to weight ratio (c)

P = Engine power in kW

W = Vehicle gross weight in metric tons

$$c = P / W$$

Driven wheels ratio (z)

nd = Number of driven wheels

n = Total number of wheels

$$z = nd / n$$

The three components RR, c and z multiplied together results in the formula for calculating the sand suitability (SS), which takes into account all the above influences combined:

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Sand suitability = rolling resistance times power-to-weight ratio times driven wheels ratio

$$SS = (z * d * d * w * P) / (W * W)$$

What does the SS value mean in practice?

1 - 4: Not very suitable for sand driving

4 - 15: Common range for off-road vehicles (heavy to empty)

> 15: Very good properties for sand driving

Sample calculations

Landcruiser 4x4 expedition camper

Empty weight 2.7 t, max. gross weight 3.6 t

235/85 R16 tires ($w = 0.235$ m, $d = 0.8$ m)

Power 100 kw

$$SS_{\text{empty}} = (4 * 0.8 * 0.8 * 0.235 * 100) / (2.7 * 2.7) = \underline{8.25}$$

What does it look like when the vehicle is fully loaded?

$$SS_{\text{loaded}} = (4 * 0.8 * 0.8 * 0.235 * 100) / (3.6 * 3.6) = \underline{4.64}$$

Conclusion:

The sand suitability is reduced by the payload to almost half!

Can the situation be improved with wide tires?

$$SS_{\text{wide tire}} = (4 * 0.8 * 0.8 * 0.285 * 100) / (3.6 * 3.6) = \underline{5.63}$$

Conclusion:

A wide tire (285) only improves the situation by about 20%

But be careful:

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Pressure reduction is not taken into account in these calculations. And that makes a big difference. As can be seen below, by lowering the pressure, the contact surface can be increased by around 40% and the rolling resistance can be reduced accordingly.

The following calculator is available to calculate the various tire dimensions :> [LINK](#) < (German only)

Pressure Reduction

How far you have to reduce the pressure in order to drive on sand without problems depends on several factors:

- Sand properties
- Topography, e.g. large dunes that are driven with momentum or soft sand fields
- Tire size, especially tire diameter and height
- Weight of the four-wheel drive vehicle

The following procedure can be used as a rule of thumb:







1. Measure the tire height on a hard surface (from the ground to the outer diameter of the rim)
2. Reduce the pressure until down to 75% of the previously measured tire height
3. This pressure should be noted for driving in sand and adjusted to if necessary.

If the reduction is not sufficient, the pressure can be further reduced to below 1 bar. However, then you have to drive very carefully to prevent the tire from turning on or jumping off the rim. The permissible load of a tire also decreases markedly as the pressure is dropped. Under such conditions you should only drive slowly and increase the pressure again as soon as the situation allows. Bead-Lock systems allow a pressure reduction of down to 0.5 bar!

The following graphic shows clearly what the effect of reducing tire pressure is.

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Assumption: vehicle weight approx. 1.7 t, tire size 235/80 x 16

						
Pressure (bar)	1,0	1.3	1.7	2.0	2.3	2.7
Width (cm)	23.5	23.5	23.5	23.5	23.5	23.5
Length (cm)	33	29	25	23	21	19
Area (cm ²)	775	681	588	541	494	447
Better by...	42%	34%	24%	17%	10%	0%

Picture 61 Pressure vs. area table

General Sand Driving Rules

In cool temperatures, the sand usually is usually a bit firmer and is therefore easier to drive on. In addition, there is less risk of the engine overheating.

Especially in the dunes you should avoid driving around noon, as the shapes of the dunes are hardly visible and it is therefore difficult to identify the ideal line to drive. In addition, the temperatures are high, which puts additional strain on the cooling system.

Driving Soft Sand

The greatest risk of getting stuck is that you will be surprised by the soft sand, because it requires enormous engine power and if you are caught in the wrong gear, there is no time to downshift. The same applies, of course, if you are not already driving with four-wheel drive. So if you are surprised, see chapter ["Stuck in the sand"](#)

The risk of being bogged can be reduced by driving in 4x4 mode whenever you have to expect soft sand. As soon as you see the slightest sign of soft sand, shift down a gear. The engine should run at about 2/3 of the maximum engine speed. If you get on soft sand you have to push

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full throttle immediately to try to keep the engine speed and momentum. You definitely will not have time to downshift, if you press the clutch you will be thrown to the windshield!

If you notice that the power is not sufficient and you are in danger of getting stuck, immediately stop the accelerator and disengage the clutch. After that, under no circumstances try to drive forward, but try to free



Picture 62 *Driving on soft sand*

yourself backwards in low-range gear. If that doesn't work right away, stop and keep dropping the pressure. If you are on firmer ground again, you can try again with reduced air pressure, of the order of 1 bar, and more momentum.

Does that not work or you have already buried yourself too deeply: See ["Stuck in the sand"](#)

Driving in Dunes



Picture 63 *Descending a dune on the lee side*

Driving in the dunes belongs to the master class of off-roading. How well this works depends on the vehicle on the one hand, but also very much on the skills of the driver on the other. Above all, "reading" the dunes and setting the line is largely a matter of experience. This also means that you should make your first attempts in a rather easy environment and not choose to cross the "Grand Erg Oriental" as your first tour.

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In an area where there is still solid ground between the dunes, you should take advantage of it. But don't forget to stick to the planned course. Since keeping the course is definitely not easy, you should stop from time to time and reassess or check the situation. The best way to do this is by stopping on the descent of a dune, as you can start again from there without problems and gain momentum. A co-driver who keeps an eye on the GPS and can give directions is a great help.

If you have to cross the dunes, it is advantageous to drive in less steep places and to use existing humps, because depressions are in most cases, but not always, softer. If you are forced to drive on dunes from the leeward side, which is the steep and soft side, the task is significantly more difficult, if not impossible.



Picture 64 Going to fast over a dune edge...

With larger dunes there is always the risk of shooting over the edge with too much momentum, so you might land on the roof. So better not making it up and try again with more momentum.

It is very unfortunate when you finally park the car on the summit of the dune with all four wheels in the air. Either a lot of shovelling is needed or a friend who can pull you back down again.

When driving down high dunes you have to drive in the fall line, otherwise you risk the car rolling sideways. If that doesn't work, a courageous push on the gas and counter-steer helps.

If you cannot see how it continues when you drive over the edge of the dune, you risk ending up in a funnel from which it is difficult to get out. If you recognize this risk on the descent, all that might help, is full throttle and hope that the momentum is enough to get up on the other side. If you react quickly when the momentum is insufficient, you might be

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able to spiral up the funnel to keep the momentum until you can exit, a very difficult manoeuvre! Since the funnel bottoms are usually very soft sand, you can hardly get any momentum from there, so it is better to stop on the slope, even if it is not possible to escape from this position right away.

In the dunes, it is highly recommended to travel with two vehicles. The lighter vehicle or the most experienced driver should lead and lay the tracks, the second can learn and offer help from behind if the first gets stuck. Long or multiple recovery straps are helpful, because you often cannot get close enough to the vehicle to be recovered without getting stuck yourself.

Water Crossings



Picture 65: Long water passage in the „Pantanal“

Crossing water is always associated with a certain risk, especially if the depth and nature of the ground cannot be determined. It is therefore important to assess the situation in any case, including water holes on the

tracks. In the case of wide rivers that are crossed by few vehicles or just out of caution, one person should examine the ford on foot. This is the only way to check the depth and any underwater obstacles in the track.

No special measures are necessary for water depths up to hub height, unless the current is very strong that one would not dare to cross on foot.

At wheel height you should first examine the ford and then drive in the 1st-2nd low-range gear at a constant 2/3 maximum engine rpm. You have the ideal speed when you produce a light bow wave in front because then the waterline along the side of the vehicle is significantly lower. With strong currents, the risk of being drifted increases sharply as soon

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Picture 66: Watercrossing with a bow wave

as the body is also exposed to the lateral water pressure. As a precautionary measure, you can preventively fasten a recovery belt at the back and take the belt through the window into the car. If you get stuck, it can be thrown back ashore, where a second car is ready to attach and retrieve you. If possible, you can cross at an angle with the current and thus reduce the lateral water pressure.

Some precautionary measures must be taken at greater water depths. A big risk is that the air intake gets submerged and the engine draws water. If the four-wheel drive is equipped with a snorkel, this risk can be avoided.

If the expected water depth is higher than the permissible fording depth of the vehicle, which is usually <0.8 m, additional measures are required.



Picture 67: Critical ford with strong current

Then a tarpaulin should be pulled over the front and engine compartment of the 4x4. To do this, you open the hood and put a suitable tarpaulin over the engine bay and pull it down over the entire width at the front. The tarpaulin is secured to the body by closing the hood and using rubber straps

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or the like. This measure is a must, especially for vehicles without a viscous fan, because if large amounts of water shoot into the running propeller, it is very likely to be destroyed.

In the case of gasoline engines, it makes sense to spray the ignition components with a contact spray (e.g. WD40) as a preventive measure to avoid ignition failure in the water.

Then proceed as above, whereby a second vehicle should be available as a backup because there is a risk of losing your vehicle! With strong currents you shouldn't risk such a crossing. Even if everything goes well, you will not be able to avoid that the vehicle interior will be at least partially flooded.

If you get stuck in the middle of the river you have to make sure that the engine does not stop, otherwise water threatens to enter through the exhaust into the combustion chambers of the engine. This can be prevented, for example, by increasing the idle speed to around 2000 revs before crossing, either with hand throttle, for example the 70s and 80s Land Cruisers have this feature, or by adjusting the idle speed in the engine compartment before the crossing.

After legs with many deep water crossings, you should check the wheel bearings and the differential oil for water ingress to avoid consequential damage. Differential oil becomes yellowish, milky when water has penetrated and must be replaced as soon as possible. Wheel bearings have to be re-greased after water ingress. If the water is very muddy, the alternator can also be damaged, often because the brushes wear out more quickly due to sand or even become so badly clogged that they give up. Thorough cleaning after dismantling should ensure functionality again. However, you may need replacement brushes. .

HINT

If you cannot cross the water on foot, the risk with a vehicle is very high and should be avoided.

Driving Off-Road

Driving in Mud

When driving muddy tracks wear and tear of the brake system can increase dramatically. Pads and discs, but also drums, are literally sanded down on long exposure. This is especially true if the mud contains sand.



Picture 68: Mud passages always carry a certain risk

You can't do much about it, but if you want to drive a route in the rainy season that is known for these conditions, you should at least have spare brake pads with you. If the muddy stretch is behind you, it is worthwhile inspecting the condition of the

brakes in order to replace the pads as a preventative measure, before the discs and drums are damaged.

As in the sand, it helps reducing tire pressure. Not only do you increase the tire contact area to reduce sinking in, but this is also beneficial for traction and the self-cleaning of the tire tread.



Picture 69: Tricky mud hole?

On tracks you will always come across mud holes in the middle of the road. For supposedly logical reasons, one tends to avoid the deep hole by driving along the edge. This is often deceptive, because while the underground is mostly firm in the middle of the main track, this often does not apply to the edge zones

where you will sink in. One exception is if there is a clear, frequently travelled bypass lane, then this is likely the safer option.

Driving Off-Road

You should always be careful, because if a vehicle got stuck in the mud hole before, it may well be that branches and rocks from other people's recovery are still left in the murky water. If your speed is too high, these represent a considerable risk of damage.

Driving on Gravel Roads

Driving on well-maintained gravel roads is not much different from driving on paved roads, but you have to be aware that the braking distance will be considerably longer. In addition, the tire grip is of course generally lower and should you underestimate a curve and then brake, there is a good chance of “flying off” the road or a vehicle roll over.



Picture 70: Risk of curves on fast gravel roads

Even if four-wheel drive does not appear to be absolutely necessary on such roads, it helps to avoid the formation of corrugation and it stabilizes the vehicle if you drive too fast into a curve.

On less well-developed gravel roads and rough tracks, you will generally have to reduce speed, no question about it. That's a necessity, because you always have to expect unpleasant surprises on tracks like this.

In any case, the 4x4 drive must be engaged in order to have the necessary traction in the case of an obstacle, river crossing, wash-outs, soft sand field, and much more. On such stretches you always have to reckon with trenches and washouts and should then have time to react. Trenches across the track should be approached at an angle if there is enough space, this protects the suspension and is also more comfortable.

In both cases you should adjust the tire pressure and don't forget to engage the freewheel hubs.

Driving Off-Road



Picture 71: Track with grass in the centre

Driving on routes with grass between the tracks harbours a particular danger. If the grass is tall and dry on low-traffic routes, seeds can clog the radiator and lead to an overheated engine. In Australia in particular, this is a known problem at the beginning of the travel season in the Outback. A fine wire mesh mounted in front of the radiator grille can help.



Picture 72: Burned out wreck on the Canning Stockroute

However, dry grass can also collect under the vehicle and ignite on the hot exhaust pipe or catalytic converter, especially in gasoline-powered cars. This is particularly dangerous because the situation occurs primarily in the desert, where there is hardly any water to kill the fire. Extinguishing with a powder fire extinguisher is also not efficient in such a

fire. It is therefore important to stop briefly every now and then and, if necessary, free the undercarriage from the grass.

Driving Off-Road

Driving in difficult terrain



Picture 73: *Even an easy gravel road can become dangerous with rain*

Really difficult terrain will usually only be encountered if you aim at it. Main roads, also in third world countries, are often used by buses and trucks and are therefore not a big problem for an off-road vehicle. However, this can change quickly if the weather conditions change. These can turn a small stream into a torrent, and a good laterite road into a slide.

Washed-Out Slopes

Steep tracks are always more demanding. Rainwater washes out the



Picture 74: *Steep and rocky track*

road and causes longitudinal and transverse trenches, which are often very difficult to navigate. These are situations in which a differential lock offers advantages.

push a heavily loaded off-road vehicle to its limits.

Routes that have been cut into the rock often have steps that must be overcome, which can

Obstacles on the Track

There are often obstacles such as boulders or tree trunks on the track. Then it is important to correctly assess the ground clearance of your own vehicle in order to avoid hitting a rock or getting stuck. If you know exactly where the individual wheels are rolling, you can largely mitigate the danger with an ideal line. The following should be considered:

4x4 with Rigid Axles

With this construction, the ground clearance is always the same and the lowest point is the differential housing. This is often asymmetrical,

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meaning not arranged in the middle. With the appropriate experience, one can estimate which line the differential will follow and can therefore avoid the obstacle. You can achieve even more distance if you deliberately and slowly drive over the obstacle, because you usually have more ground clearance between the axles under the body. If possible, it makes sense to have someone outside to guide you.

4x4 with Independent Suspension

Off-road vehicles with this design often have more ground clearance between the front wheels. However, this is lost during compression. This means that if the car compresses exactly when the obstacle is under the front axle, there is a chance of getting stuck or of damage occurring if it hits.

Can I Retrace if Needed?

If you are travelling lonely routes, you should think at every steep descent or before a difficult obstacle whether you could come back in an emergency, because on such routes it can happen that you cannot go any further you have to turn around. The steep sandy slope that you just surfed down so wonderfully can become an insurmountable obstacle.

Recovery Techniques

Recovery Techniques

In this chapter we address the cases where things did not go as planned. A 4x4 is by no means a guarantee that you can get through everywhere. A good driver with a suitable vehicle can cope with difficult situations without losing fun, but he, too, can get into a situation where things will come to a halt and a major recovery effort is required. In the following, the most common cases are presented, considering both self and third-party recovery.

In general, on routes that are so demanding that a recovery might be necessary, it is better to travel with two vehicles, even more so if you have little experience yourself. A recovery with the help of a second vehicle is much faster and easier to accomplish.

Recovery Hierarchy

Recovery actions are ALWAYS associated with an accident risk. All the various techniques described below carry the risk of causing personal injury or material damage. To minimize this, you should follow the method below.

And it is of course even more important, with an appropriate driving style and the necessary care, to avoid the need for recovery as much as possible!

An applied recovery hierarchy is a systematic approach to minimize the dangers of recovery. Only when a safer method is not sufficient, you move on to the next step, etc.

Phase 1

- Check if the car is in 4x4 and the freewheel hubs are engaged
- Can I further reduce the air pressure?
- Shovel the wheels free in the direction of travel
- If available, underlay stones and branches
- If available, use recovery boards

Phase 2

- Use your own winch if available or that of a second vehicle

Recovery Techniques

- Use of a second vehicle with a STATIC recovery belt (towing belt)

Phase 2

- Use of a KINEMATIC rope or strap (snatch-strap)

Link to video with warning and possible dangers when recovering:

<https://youtu.be/2rHvQykNt2M>

Self-Recovery

Stuck in Sand

Getting stuck in the sand usually happens faster than you think. The best recipe to avoid this is:

Adjust air pressure, drive in the right gear and always have enough momentum when it gets soft.

However, if it happens anyway, rule number 1 is:

Do not try to keep moving any longer, this only works in the rarest of cases, most of the time the vehicle only digs in more and more and the liberation only costs more sweat and time.

What you can try before pulling out the shovel and sand ladders:

Lower the tire pressure to 1 bar or even a little less, free the wheels a little towards the rear from sand and CAREFULLY try to get back onto firmer ground.

If this doesn't work on the first attempt, the recovery boards will have to be used.

To do this, the rear wheels are jacked up one after the other and the boards are placed under the tires. Then an attempt is made to drive back out again. The track should also be smoothed behind the front wheels to reduce resistance.

If you don't have a suitable jack available, the tracks behind all four wheels are shovelled clear and smoothed out so that the sand plates can be laid flat underneath. You should push the sand plates as far as possible under the rear wheels.

Recovery Techniques

You should only try to escape forward if there is a good chance that it will work safely, otherwise you may have to repeat this action multiple times before you get rolling again.

If you enjoy the luxury of four sand boards, the chance of freeing the car is greater, but you will have to carry them with you the whole time. You can think about that on an extended desert tour, but on a world tour it is probably too much ballast. If you drive in company, but cannot be recovered by the second vehicle, it will certainly have more recovery boards (and shovels) on board.



Picture 75: Recovery with 4 recovery boards

If you have tried too often to free yourself, you will most likely "sink" the vehicle up to the axles. Any attempt to recover while the axles are still in the sand are doomed to failure and will only make the situation worse. So in this case you have to shovel away the sand from under the whole car, so that the underbody and axles are free. This is the moment

when the shovel with the LONG handle shows its value. Incidentally, you usually encounter this situation when you get stuck on a dune ridge and sit the car on its "belly". Then you have to be prepared for a massive shovel action.

HINT:

If you try to drive away to the front, you place the sand plates in front of the front wheels and fasten the plates to the rear of the vehicle with a sturdy rope. This way the sand boards are dragged along after the liberation until you can stop on solid ground. This saves you having to search for and dig up the boards you have left behind.

Recovery Techniques

In general, well visible ropes or belts that are attached to the boards help to find the sand boards again, because they are often pushed deep into the sand during recovery and are difficult to locate.

Bogged in Mud

Liberation from a mud hole is very similar to that in sand, only the working conditions are significantly more uncomfortable. But there is a better chance that you can use the winch, since a tree is more likely available as an anchor point.

If the vehicle is stuck in the mud, the forces necessary to free it are significantly higher than in any other situation. Especially when the vehicle rests up to the chassis in mud, it becomes almost impossible to free the vehicle by simply pulling.



Picture 76: Winch recovery in mud

The most successful, albeit labour-intensive, method is to lift the wheels individually and stabilize the tracks with load-bearing material such as branches, stones, dry earth, etc. But it is a Herculean task in knee-deep water or mud. The use of recovery boards is possible, but the traction on them is much worse than in sand and the chance of

losing the boards is high. It is therefore important to secure each board with a rope.

Sliding sideways off the track

On a slippery and steep track, it can happen that you lose control of the car and slide off the track. If at least two wheels are still on the road, you're in luck. For this reason alone, one should not try to continue any further when sliding, but stop early when still on the track.

Recovery Techniques

Depending on the situation, the first thing is to avoid further adversity by securing the four-wheel drive against further slipping or even overturning.

Without a winch or outside help it will be difficult to get out of this situation on your own, but what is important is that nothing worse can happen. If a winch is available, the rear is first secured against further sideways sliding with a rope and then the front is pulled back onto the slope laterally with the winch. If necessary, the front is now secured and the rear is pulled up using a winch block.

It is ideal if you can use your own winch and additionally the winch of a second vehicle. This makes it possible to pull the front and rear up to the side in a well-controlled manner.

Use of the Winch

Recovering yourself with a winch is an effective and, above all, the safest method in many situations, but not always.

Anchor Points

An anchor point is a prerequisite for even considering the use of the winch.

This must basically meet two conditions:

- 1. It must be stable enough to withstand several tons of pulling force**
- 2. It must lie somewhat in the direction of pull**



Picture 77: Self recovery with the winch

on your own vehicle!

If you choose a tree or some other vertical structure, the fastening must be as close to the ground as possible. If the anchor gives way under load, the action must be stopped immediately. It has happened before that a tree has been knocked down and where does it fall? Yes, exactly

Recovery Techniques

If the winch has to be used on a steep slope, it is likely that, if the rope is low at the anchor point, the rope will drag across the ground. If the anchor point is stable enough, you can attach the rope higher up to avoid this and thus benefit from a better pulling angle.

You can also do without a stable anchor point, but only with considerable effort or material engagement.

On the one hand, there is the trick of burying a spare wheel deep enough that you can pull yourself out. A lot of work but... ..> [VIDEO](#) <.

The video also shows a hi-lift jack and a special "dead-man" device as an aid.



Picture78: Ground anchor in sand with a wheel

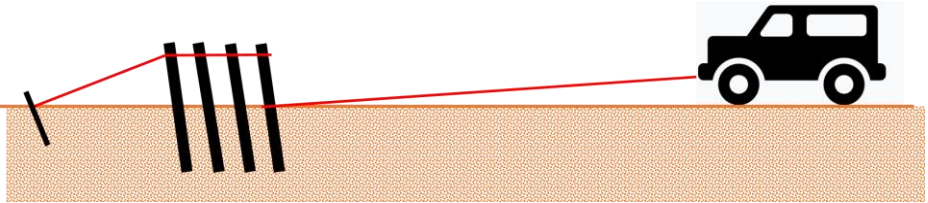
If you decide to bury a wheel or other object, you should proceed as shown in the sketch in the left. The wheel must be dug deep

enough and the pulling force should act as centrally as possible. In addition, you can lay the pull rope in a slot, difficult to achieve in the sand, so that the wheel is less easily torn out of the ground. In order to avoid bending the rim contact surface, the rope should not be fed through the central hole only, but rather through 2, better 4, holes near the tire.

On the other hand, there are ground anchors that work similarly to boat anchors, but also with these, the load-bearing capacity is very dependent on the nature of the ground. In addition, the parts are heavy and bulky, so hardly a suitable solution when travelling.

Recovery Techniques

A trick that has a better chance is to punch several poles, made of steel or wood, as deep as possible in a row, with a little distance in between, into the ground. At the top they are connected with a strong rope and anchored to the last post with a strong peg. The winch cable can then be attached to the first post close to the ground. Whether the whole construction can withstand the pulling force and whether the required material is available is another matter. This trick works primarily in solid ground, in the sand you would have to drive long stakes deep.



Picture 79: *Improvised ground anchor*

Winching Technique

So, a suitable anchor point has been found and now the action can start:

1. The tree strap is attached low to the anchor point
2. The winch cable is now pulled out with the winch motor clutch freed and ideally connected to the tree belt without using a shackle.
3. All uninvolved people leave the danger zone in a spacious manner and only the driver and possibly the operator of the winch remain in the area of the recovery action. The most dangerous area in the event of a rope failure is along the longitudinal axis of the recovery action, i.e. in front of and behind the vehicle.
4. The winch clutch is re-engaged, the winch rope is tensioned and a rope damper, or even better two, is placed over the winch rope.
5. With the support of your own traction, 1st low-range gear and low speed, you now pull yourself out. It must be ensured that the winch rope winds evenly on the drum. If necessary, the vehicle must be stopped and secured in between. The rope is then rolled out and then pulled in again properly. Then the action can continue.

Recovery Techniques

6. After the recovery has been completed, the rope should be fully rolled out again and then rewound correctly.

When using the winch you have to let the engine run if possible so that the battery is relieved a little by the charging current. If the action takes a long time, you have to let the winch motor cool down and recharge the battery with the motor running. Rule of thumb: pull for 30 seconds, pause for 3 minutes. Not only the winch motor itself can overheat if used for too long, but also the rope drum. This can damage a synthetic winch rope.

If the pulling force of the winch is insufficient, which can quickly become the case, especially with vehicles stuck in the mud, a winch block is used, which almost doubles the pulling force.

If it turns out that the winch rope is too short, it can be extended with a tow strap, for example. Especially when using the pulley you may have to proceed in this way because if doubling the winch rope extra length is required.

Ideally, NO metallic components should be used when working with the winch, i.e. no hooks and shackles made of metal. This reduces damage and injury should a part break.

In an emergency you can also try to [free yourself backwards](#) using the winch. To do this, some conditions must be met:

- The winch cable can be laid backwards under the vehicle WITHOUT the tensioned cable being damaged on a sharp edge and without damaging any parts of the vehicle under load. The whole thing works best with a vehicle with two rigid axles, because these have no sharp edges at the bottom and guide the rope under the chassis.
- And of course there must be an anchor point behind the 4x4 which is roughly in line. If the winch cable is extended for a correspondingly long distance, the off-set of the pulling angle is also relatively small, for example when the tree is off the track.

Recovery Techniques

IMPORTANT:

It must be noted that the winch rope must NEVER be completely unwound. There must always be at least 5 wraps left on the drum. It is best to mark this position in advance by marking the rope with a visible colour mark or tape when it is fully extended, if there is no marking from the factory.

A recommendable video shows the technique of winch recovery and the material used. [>LINK<](#) (EN)

Recovery with a HiLift Jack

The video shows the use of a specific accessory, which above all facilitates the relocation after the pull. This is done by means of chains that add a lot of weight.

<https://youtu.be/YAc2OwZUW5k>

There is also the possibility to use the Jack WITHOUT long chains and a lot of additional equipment. However, the vehicle must then be secured after each pull in order to relieve and move the Jack.

<https://youtu.be/xldBPnzohI>

Either way, this method, like everything, has advantages and disadvantages:

- +Cost-effective equipment, which can also be useful in other ways
- +Well-controllable forces serve safety
- Very complex and time-consuming method
- Only one short stroke possible at a time
- Limited tractive force and even slower with deflection

Recovering Others

If you are travelling on rather difficult routes, it is advisable, for safety reasons, to be on the road in pairs, but no more than four. The most experienced driver should lead the group in order to reach potential obstacles first. The following vehicles can thus better assess how the obstacle should be approached.

Recovery Techniques

Safety

If a vehicle recovery is necessary, the safety of the scene must first be established. It is best to first assess the situation in detail and then create a recovery plan under the guidance of an experienced person.

Uninvolved people in the rescue operation must leave the danger zone with sufficient distance during the entire operation. Every recovery involves potential dangers for people and / or equipment.

All equipment used must be in good condition and suitable for the expected load. This includes:

- Recovery points on both vehicles - Most of the existing attachment points are not specified, which means that the load limit is not even known. Since the load can hardly be estimated in advance, there is a considerable risk that they could fail.
- Straps, shackles and all other parts used - Every component of the recovery system has a permissible, maximum load limit and a defined breaking load. The theoretically weakest link in the recovery chain should be a strap / rope or a soft shackle if possible. This largely prevents metal parts from being catapulted through the air as projectiles if a component fails.

Since the forces involved in a recovery are immense, there is always a residual risk that an element will fail. In particular, hooks and metal shackles that fly through the area like projectiles when the rope breaks have caused a lot of damage, injuries and even death.

Recovery Techniques

Recovery Points

The attachment and connection points are of the greatest risks of failure.



Picture80:
Original recovery point of a Land Cruiser

In case of doubt, it is therefore advisable to replace the fastening points on the vehicle with accessories that can withstand loads. This includes high-strength bolts for fastening the recovery points. If you want to use the much safer soft shackles, you must ensure that the recovery eyelets are not sharp-edged.

Open hooks on the vehicle would generally be advantageous, because you can simply attach loops without having to use shackles. To prevent the slack rope from falling off, the hook must have a safety clip. The disadvantage of the hooks, however, is that they allow a lot less load for the same size. Therefore, closed eyelets are commonly used.

Especially in vehicles without a ladder frame, it is difficult to find sufficiently robust attachment points for recovery points.

In no case should you choose the following elements as attachment points:

- The bullbar or bumper, unless there is an integrated recovery point with a correspondingly defined tensile load limit
- The ball of a trailer hook. This is not designed for such high axial forces and must never be used for recovery
- The axle or on suspension parts of the vehicle
- Eyelets on the vehicle that are only intended for fastening during sea transport

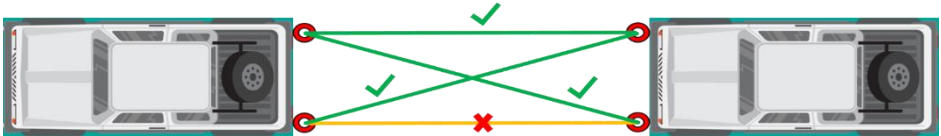
The fact that steel shackles fly around as projectiles is mostly due to the fact that the fastening point on the vehicle breaks, because if shackles

Recovery Techniques

with a SWW of > 4 t are used correctly, they will never be the weakest link.

HINT

In order to further minimize the risk of injury to the drivers in the event of a rope or strap failure, the fastening points on the two vehicles should, if possible, be chosen that the breaking rope is not in line with the driver. In left-hand drive vehicles, attach to the right-hand side or at an angle, i.e. once on the left and once on the right. Attaching crosswise has the additional advantage that jerky loads are dampened somewhat, but it can happen that the lighter vehicle is kicked out sideways when it is pulled. In any case, it must be taken into account that no spectators are in the extension of the rope!

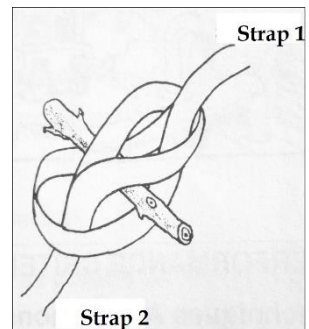


Picture 81: Attaching straps for recovery (left hand drive vehicles) Source: www.freepik.com

Connecting or Extending Straps

Sometimes it is necessary to extend a strap. This is best done with the following method:

1. Put the loop of strap 1 through the loop of strap 2
2. Then put the end of strap 2 on the vehicle side through the loop of strap 1
3. A robust stick or branch with a diameter of at least 30 mm is placed between the two connected loops



Picture 82 Extending straps safely

This prevents the two straps from becoming knotted un-detachable due to the tensile load. The use of a steel shackle to connect is not permitted as this is extremely dangerous should a belt break!!

„Snatching“

A recovery method especially popular in Australia is "snatching". The vehicle to be recovered is freed from its misery with an elastic strap or

Recovery Techniques

rope with momentum. The strap builds up kinetic energy, which ultimately becomes large enough to catapult even a heavy 4x4 vehicle out of its misery.



Picture 83: Recovery with Snatch strap

Source: <https://www.unsealed4x4.com.au/how-to-use-a-snatch-strap-safely/>

It should be noted, however, that the forces that occur, even if they do not occur suddenly, cannot be calculated. It is all the more important that the equipment used is sufficiently rated and in top condition.

This method should only be used if others cannot be implemented successfully!

Uninvolved people MUST leave the danger zone!

The two drivers are ideally connected by radio communication so that they can manage the recovery between them. The process and the commands must be clarified in advance.

The driver in the vehicle to be recovered has the command or he delegates this to a third person standing well off the scene.

And this is how it works:

1. The recovery vehicle moves backwards to about 2/3 of the strap length of the one to be recovered
2. The strap is attached to both vehicles and laid out in a snake shape to avoid knots
3. One, better two, rope dampers are attached in the middle or 1-2 m from each vehicle
4. In response to an agreed command, the vehicle in front pulls into the 2nd low-range gear, the second supports the rescue in the 1st low-range gear
5. As soon as the car to be recovered is free, the driver signals that to the pulling vehicle and follows it to solid ground

Recovery Techniques

If you cannot get close enough to the stuck vehicle, the strap has to be extended, see above. This can be done with a static strap / rope or a second dynamic one.

The towing vehicle should have roughly the same weight as the one that is stuck. Differences that are too large can lead to damage.

Unwanted Knot in the Strap or Rope?

If a knot is accidentally made in the rope or strap while handling, it seems impossible to undo it at first.

An Australian 4x4 guru shows a trick how to solve the problem in the [following video](#).

Maintenance Before & After Off-Roading

Maintenance Before & After Off-Roading

Off-road driving is usually a great burden for the vehicle. You should therefore sacrifice a few minutes to the well-being of the vehicle both before and especially after a major off-road trip.

Before Starting

Depending on the track conditions to be expected, four-wheel drive vehicles and equipment should be checked before-hand. This way an avoidable defect can be prevented and the operational readiness of the recovery equipment can be ensured.

In particular, the equipment, which is normally rarely used, must be checked for completeness and, if possible, for function. What could be more stupid than if you are up to your axles in a mud hole, to find out that the remote control of the winch cannot be found?

Recovery gear should be stowed easily accessible by now at the latest.

There are also a few points to consider when it comes to the car itself. If it makes sense, the air pressure should be adjusted to the expected conditions before the start. It is also important to check the spare wheel. The general condition of the tires should also be checked on this occasion.

Basically, the vehicle should always be in good technical condition. All fluid levels should be correct, the battery contacts should be firm and free of corrosion for winch use!

Particular attention should be paid to vehicle loading. No loose objects are allowed to lie around in the car and heavy equipment should be stowed as low as possible.

Weight can be reduced by minimizing the level of the water and fuel tanks. Especially in sand, 100 kg can make a decisive difference.

After the Trip

As already mentioned, off-road driving is a heavy burden on the vehicle. The risk of increased wear and tear and defects is correspondingly high.

Maintenance Before & After Off-Roading

After a tour you should check the vehicle again. The focus is on the chassis and the tires. The following points should be checked:

- Check the tires for visible damage and air loss
- Check the wheel bearings by trying to move the wheels sideways one by one when jacked up. Noticeable play has to be readjusted
- Check under the car whether any branches have jammed and whether parts are loose
- After long journeys through water, the wheel bearings and the differential oil should be checked for water ingress
- Check the air filter after dusty stretches and blow it out if necessary
- If recovery gear has been used, it must be checked for damage and cleaned before being stowed away.
- After using the winch, the rope must be checked, cleaned and rewound properly.