STUDENT MANUAL

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Table of Contents

Introduction

This Learner Manual has been developed by Eureka 4WD Training to assist its students in knowing the fundamentals of four-wheel driving.

This Trainee Manual is not an exhaustive resource of information for every four-wheel drive situation you may find yourself in. Eureka 4WD Training may also offer additional learning materials as and where required. These materials may be in electronic format, printed or physical items used for demonstration or recovery purposes.

Eureka 4WD Training is willing to offer independent advice on equipment selection. We do not sell or receive commissions for any equipment we recommend; therefore, the advice is given in good faith.

Eureka 4WD Training's methods have been developed over more than 26 years, to satisfy the considerable needs of the "Industrial Sector" (Mining, Construction Industry sector), the Community and Government Service Agencies and many more. The courses also cover the knowledge and skills needed to plan work-related four-wheel drive activities and to ensure that principles of Eco-driving are followed and minimum environmental impact occurs.

You should always exercise care in your four-wheel drive activities. At some time after your training, you may find yourself in a situation where the use of this training manual is either insufficient or possibly inappropriate at the time. This training manual is produced by Eureka 4WD Training purely as a resource tool and an aid to your off-road driving.

Please remember that four-wheel drive vehicles differ greatly between makes and models. It is up to you to know the fundamental controls and workings of the vehicle you are driving, and to learn its individual handling characteristics. Our recommendation is that you thoroughly study the manufacturer's handbook before driving any vehicle for the first time.

How to Use This Student Manual

This Student Manual is an important resource tool and wherever possible it may be printed and kept in your vehicle.

It will become invaluable should you need to use it to get out of a sticky situation.

In the index pages you will find a particular subject numbered, simply go to the relevant page to resource the information.

About Your Trainers and Assessors

Eureka 4WD Training is a Registered Training Organisation (RTO #52488) regulated by the Australian Skills Quality Authority (ASQA).

All Eureka 4WD Training Trainers and Assessors are selected for their skills in both four-wheel drive training and communication. Each handpicked Trainers and Assessors has many years of four-wheel drive experience, both in four-wheel drive training and travelling through remote Australian locations.

All of our Trainers and Assessors are TAE40116 Certificate IV in Training and Assessment qualified and hold Senior First Aid Certificates.

Eureka 4WD Training is licensed (No. HQ67416) by the Department of Biodiversity, Conservation and Attractions (DBCA).

Our Trainers and Assessors are also responsible for many voluntary activities and are members of Track Care WA.

Our commitment is to preserve the environment for our children and our children's children. We need to look after the environment to maintain access for the future. Track Care needs your help.

Please ask your Trainer and Assessor for more information about becoming a Track Care WA Member or contact Track Care WA via their website: www.trackcare.com.au.

Glossary of Four-Wheel Driving Terms

Terms and Terminology

A knowledge and understanding of these terms will assist you in understanding parts of this Learner Manual.

Glossary of 4x4 terms

4x4 - This general term is used to describe a vehicle with four-wheel drive. The first figure is the number of wheels, and the second is the number of powered wheels.

4x2 - This term refers to a two-wheel drive vehicle with four wheels.

Approach Angle - This is the greatest angle or grade that a vehicle can approach or run off without grounding the chassis or body ahead of the front wheels. When viewed from the side, this is the angle between the ground and a line running from the tyre to the front bumper or other low-hanging component. This angle gives an indication of how steep a ramp a vehicle can negotiate without damage. It gives a good indication of a vehicle's ability to climb over rocks and logs without hitting and potentially damaging the front part of the vehicle's body or chassis.

Anti-Lock Braking System (ABS) - This braking system senses any significant difference between wheel and road speed under severe braking. When any of the wheels begin to lock up (completely stop rotating), ABS automatically reduces the braking forces to that wheel or wheels in order to keep all the wheels rolling in order to prevent brake- induced skidding. ABS can control all four wheels (cars and most 4x4s have this system) or any two. The system can group wheels together in "channels" of operation (i.e. a three-channel ABS system on a four wheeled vehicle) or have one channel for each wheel (four-channel ABS).

Anti-Sway Bar - This suspension element is a long torsion bar (essentially a rod that can twist) mounted across the vehicle from one wheel to the wheel on the opposite side. By transferring force from one side of the vehicle to the other, an anti-sway bar car restricts body lean (or roll) during cornering. Vehicles may have anti-sway bars in the front, rear or both.

Arms, Links, Rods, Wishbones - These terms describe a variety of suspension components that "locate" the wheels or axles and restrict their movements for optimum handling and traction. The complex relationship among suspension components as they move is called suspension geometry.

Ball Joint - A ball joint is a flexible joint consisting of a ball in a socket. It is most often used in suspensions because it accommodates a wide range of motion in two directions.

Beam Axle - A beam axle is a rigid axle.

Brake Fade - The tendency for a braking system's performance to deteriorate under hard or repeated use.

Brake Lockup - In braking, lockup describes the point at which a tyre starts to skid in an emergency stopping situation. A tyre's maximum braking force is developed when it is on the verge of lockup, so a car's shortest stopping distances are produced when its front and rear tyres are held just short of lockup. Anti-lock brakes (ABS) prevent wheel lockup, giving the advantage of simultaneous steering and braking ability (a locked wheel cannot be steered). On extremely loose surfaces, locking the brakes may shorten stopping distances by clearing the loose material from under the tyres.

Bridle - A short recovery strap (Tree Trunk Protector) that's used between two recovery points to half the load applied to the points.

Bush - A suspension bush is a type of bearing for suspension components. Typically made of rubber or a synthetic material, a bush can be "tuned" to affect ride quality and handling and minimise the transmission of vibrations to the passenger cabin.

Cadence Braking - A method of manual braking with the foot brake to simulate the action of ABS brakes. (See Anti-Lock Braking System above).

Camber - When viewed from the front of the vehicle, camber is the angle of the tyre/wheel compared with true vertical. When the tops of the front wheels are tilted inward, a vehicle's camber is negative; when tilted outward, camber is positive. Camber influences lateral control.

Castor - This angle describes the inclination of the front wheels, when viewed from the side, as the wheels "travel" from the suspension's lowest to its highest points - in effect, the angle between a vertical line and the vehicle's steering axis. Just as an office chair or shopping trolley uses castors to roll forward more easily, a high degree of castor in a vehicle makes the wheels "self-center" more readily.

Chassis - This term can describe a vehicle's structural elements or the collection of mechanical components attached to its frame. In vehicles with monocoque or "unibody" construction, the chassis comprises everything including the bolted-on body panels of the car, possibly even the window glass. In vehicles with a separate frame, chassis usually refers to the frame.

Coil Spring - Used in a suspension system, a coil spring consists of a rod of resilient metal (usually a steel alloy) wound into a spiral form. It can be compressed repeatedly or extended without permanent deformation. Their function is to support the weight of the vehicle.

Constant-Velocity Joint - A "CV" joint is a type of universal joint, usually used between the front half-shafts and front spindles/wheels in a front-wheel-drive or four-wheel-drive vehicle. CV joints are engineered to transmit power more smoothly (compared with universal joints) as they move through two planes. They are also less prone to driveline vibrations.

Cross-member - This component of a chassis (or sub-frame), placed transversely, connects to, and strengthens, longitudinal chassis members.

Departure Angle - Is the greatest angle of the grade as per approach that a vehicle can emerge from a deep rut, or to a level off after a steep slope, without the underside rear body touching the ground. In side view, this is the angle between the ground and a line running from the rear tyre to the rear bumper or other low-hanging bodywork. Similar to the approach angle, the departure angle indicates a vehicle's ability to drive off a ramp or obstacle without damaging the rear.

Differential - A differential transmits power from the transmission, or transfer gearbox to the wheels, and allows the wheels to turn at different speeds (so the vehicle can turn corners without drive-train wind-up - a situation in which the wheels on the outside of a curve turn faster and travel a greater distance than the inside wheels). While most differentials are mechanical gear-driven devices, sometimes a multi-plate clutch pack (MPT) can act in place of a differential.

Differential Lock - The main disadvantage of an "open" differential is that it will send power to the wheel (or axle) with the least traction. A differential lock literally locks out the differential action and forces power to be split equally between each wheel (or each axle) for maximum traction. In a rear-wheel-drive vehicle for instance, locking the rear differential locks the left and right rear wheels together so that both receive equal power. In a full-time or permanent 4x4 vehicle, locking the center differential locks the front and rear drive-shafts together sending equal power to the front and rear axles. Whilst locking an inter-axle differential helps increase traction, it makes steering more difficult on higher traction surfaces as it tends to force the vehicle to travel in a straight line.

Disc Brakes - This type of braking system consists of a disc, or rotor, that rotates at the same speed as the wheel to which it is attached, straddled by a caliper. The caliper contains brake pads, operated by small pistons that squeeze against the surface of the disc to slow it down or stop it. Disc brakes operate more efficiently at high temperatures and wet conditions than drum brakes.

DOHC - Double overhead camshaft engines use two camshafts located in each cylinder head. One camshaft operates the intake valves; the other actuates the exhaust valves.

Driveshaft - The driveshaft transmits power from the transmission or transfer case to the differential. A conventional four-wheel-drive vehicle has at least two drive-shafts - one running to the front differential and one to the rear. Also known as propeller shafts, or prop shafts.

Drive-train - This term, also called a powertrain, describes all of a vehicle's components that produce power and transmit power to the wheels - the engine, transmission, transfer case, drive-shafts, differentials, axle shafts and wheel hubs.

Drum Brakes - A drum brake uses a drum shaped (cylindrical) housing, usually made of cast iron that is attached to the wheel and rotates with it. Inside the drum are curved brake shoes

that are forced into contract with the inner drum to provide braking. Drum brakes are simple and generally effective, but less efficient than disc brakes under heavy use or when wet. They also require more frequent service.

Engine Braking - This term describes the driving technique of slowing a vehicle by taking your foot off the throttle, particularly in a lower gear (such as First Gear-Low Range). Engine braking uses the compression of the engine and the low gearing of the transmission/transfer gearbox to slow the vehicle.

Exhaust Jack - These are a large inflatable plastic bladder. They are inflated by a long hose which has one end pushed over the exhaust pipe while the engine is running. This inflates the bladder and lifts the vehicle up. Some exhaust jacks also have an inflation valve that a tyre compressor can be connected to for slower inflation. They are not designed for changing wheels or working under the vehicle and it would be very dangerous to do so without the vehicle being supported by axel stands or some other safe means. Care needs to be taken when positioning to avoid puncturing the bladder.

Electronic Stability Program - Electronic stability control (ESC), also referred to as **electronic stability program** (**ESP**) or **dynamic stability control** (DSC), is a computerised technology that improves a vehicle's **stability** by detecting loss of traction (skidding), or excessive wheel spin. The system uses the **ABS** brakes and traction control systems to create pivot points to direct the vehicle in the direction the driver intended and can also reduce engine power and transmission output to restore control.

Footprint - The amount of tyre tread that is in contact with the road surface.

Free Wheeling Hubs - Free wheel hubs are fitted to some four-wheel drive vehicles on the front wheels. They break the connection between the axle and the wheel for on-road use. The hubs need to be turned into the "locked" position when going off-road to connect the drive forces from the engine and gearbox to the front wheels.

Full-Time 4x4 - This drive system offers both a 4x2 and 4x4 mode. 4x4 can be engaged on dry roads for normal on-road driving because this system uses some type of center differential. A typical full-time 4x4 system offers 4x2 and 4x4 "Auto" and 4x4 Low

Gear Ratio - This is a numerical ratio of a series of gears in relation to each other based on the number of turns of the input shaft, compared with turns of the output shaft. Gear ratios are determined by the number of teeth on each gear. For instance, a gear with 36 teeth meshed with a gear that has 12 teeth gives a 36/12 or 3/1 ratio. This is usually expressed as 3.00:1

Ground Clearance - With the vehicle stationary, ground clearance is the measurement from the lowest-hanging point under the vehicle (usually a differential or the exhaust system) to the ground. A high ground clearance allows a vehicle to more easily drive off- road through rocky sections, deep sand, mud or ruts.

Gross Vehicle Mass (GVM) - Gross Vehicle Mass is the combination of curb weight plus payload (including driver and fuel). It is the maximum rated (by the manufacturer) amount the vehicle can weigh and legally operate.

Half-Shaft - A half-shaft is an articulating rotating shaft used in independent suspension systems to transmit power from a differential to a wheel. The term is also used to describe an axle shaft.

Hi-Lift Jack - Is a brand name for a tall jack. Normally 48" & 60” high and designed to lift a wheel up out of a bog so that suitable packing material can be placed in the bog to assist in gaining traction when the wheel is lowered. These jacks should not be used on their own for changing wheels as they are very unstable. They can be used in many other ways including being set up as a hand winch, tyre bead breaker, clamp and post puller.

Independent Suspension - This describes a suspension system wherein each wheel on an axle is sprung separately and can react independently to bumps. A non-independent suspension uses a solid beam, or rigid axle, to "connect" the suspension of two wheels. Both systems have advantages and disadvantages.

Ladder Frame Chassis - A ladder frame is shaped like a large ladder. Two long "rails" run along the sides, with cross-members connecting the two. This type of frame is used in some 4x4 vehicles. However, differences exist in the shape, structure and thickness of the various frame elements.

Leaf Spring - A long, flat, flexible piece of steel (or a composite material) curved into an arc that bends when forces act upon it. Leaf springs, most often used in pick-up trucks, usually mount to a solid axle.

Limited-Slip Differential - This differential has a mechanism to limit the speed differences between its two outputs. A limited slip differential ensures that some torque is always distributed to both wheels, even when one has very little traction.

Live Axle - A live axle is a solid axle that transmits power to a pair of wheels. It is composed of a rigid axle with a differential and two axle shafts to power each wheel. It is called "live" because it has engine power flowing through it.

Low Lock - All full-time 4x4 systems and most competitive permanent 4x4 systems lock the center differential when you engage Low Range. (Part-time systems have no center differential and so are in effect locked when in 4x4 High or 4x4 Low). The assumption is that when you are 4x4 Low, you want the extra traction of a locked center differential. However, locking the center differential limits Low Range to off-road use.

Monocoque Construction - This is a type of body construction that doesn't require a separate frame to provide structural strength or support for the car's mechanical components. A monocoque design uses an array of strong but light structural elements as an integral part of its construction.

Multi-Purpose Vehicle (MPV) - This is a high vehicle designed primarily for transporting more than five people in comfort, on-road, and offering some seat flexibility for load carrying.

Overdrive - Any gear set in which the output shaft turns faster than the input shaft is considered overdrive (the gear ratio is less than 1:1). Overdrive gears are used in most modern transmissions because they reduce engine RPM and improve fuel economy.

Overhead Cam - Overhead camshaft describes a type of valve-train arrangement in which the engine's camshaft is in its cylinder head - above (or over) the valves. When the camshaft is placed close to the valves, the valve-train components can be stiffer and lighter, allow the valves to open and close more rapidly and the engine to run at higher RPM. In a single overhead-cam (SOHC) layout, one camshaft actuates all of the valves in a cylinder head. In a double-overhead-camshaft (DOHC) layout, one camshaft actuates the intake valves, and one camshaft operates the exhaust valves.

Part-time 4x4 - The most basic type of four-wheel-drive system, part-time 4x4 operates in 4x2 mode (usually rear-wheel drive) for general on-road use, 4x4 mode can be engaged only off-road or when the tarmac is very slippery, because this system forces the front and rear wheels to travel at the same speed. Using 4x4 on dry road will cause excessive tyre wear and may result in drive-train failure. All part-time 4x4 systems also employ a two-speed transfer box.

Permanent 4x4 - As the name suggests, permanent 4x4 sends power to all four wheels continuously, on-road or off-road. There is no 4x2 capability, and the driver does not need to determine when to engage 4x4 mode. Drive selections typically include 4x4 High and 4x4 Low. Most permanent 4x4 systems also have a locking center differential and a two-speed transfer case.

Power-train - This term describes an engine and transmission combination. See drive- train.

Pushrod - In the valve-train of an overhead valve (OHV) engine, push rods are used to transfer the reciprocating motion from the camshaft to the rocker arms and then to the valves. Push rod engines are generally shorter than overhead cam engines and often operate at lower engine speeds.

Rack and Pinion Steering - This system ensures on-road steering precision, as it is the most direct system available - giving optimum feedback and a fast, predictable response.

Ramp over Angle - Is the maximum angle between two planes that a vehicle can negotiate without any part of its underside touching the ground. This is a measure of a vehicle's ability to drive over a sharp ridge or ramp without touching its underside. The included angle measures the angle inside the ramp; the excluded angle measures the combined angles outside the ramp to the horizontal. A short wheelbase vehicle with high ground clearance will have the best ramp over angle.

Re-circulating Ball Steering - This steering system uses steel balls inside a larger screw- and nut mechanism to turn the wheels. The ball bearings in the re-circulating track reduce friction. This type of steering is considered durable and easy to operate.

Rigid Axle - See beam axle.

RPM - Revolutions Per Minute.

Safety Rim - The term is often used to describe a single piece alloy or steel wheel rim.

Shock Absorber - A device used to dampen suspension oscillations.
Single Overhead Cam - An SOHC engine uses one camshaft in each cylinder head to operate both the exhaust valves and the intake valves.

Snatch Strap - A snatch strap is a strap made of elastic nylon with loops on both ends. Unlike a simple rope, chain or tow straps, a recovery strap uses stored "potential" energy to help free a stuck vehicle using another vehicle.

Split Rim - The term is often used to describe a two-piece steel rim wheel.

Staking - A puncture normally caused by a wooden stake being pushed through the tyre casing.

Strut - A strut is a suspension element in which a reinforced shock absorber is used as one of the wheel's locating members.

Sub-frame - A sub-frame is a small, separate frame usually attached to a monocoque body vehicle. A front sub-frame might be used to "cradle" the engine and transmission, while a rear sub-frame would attach the rear suspension to the unibody structure.

Sump - This term refers to a protection cover or plate under a vehicle that covers vulnerable components, such as the transmission/transfer gearbox, engine oil pan or fuel tank.

Suspension Travel - This term refers to the amount of vertical wheel movement allowed by the suspension.

Toe-In-Toe-Out - This alignment measurement is the amount by which the front wheels (when viewed from above) are not parallel to each other. Toe can affect handling and steering feel.

Torque - Torque is the unit of rotational force and is measured in Newton meters (Nm). In an engine, torque is the twisting force measured at the crankshaft.

Torsion Bar - This is a type of spring made of a long solid, or tubular rod with one end fixed to the chassis and the other twisted by a lever connected to the suspension.

Traction - This is the concept of achieving (and maintaining) grip between the wheels and the ground/road surface without slip or skid.

Transfer Gearbox (Case) - A transfer case is a system of gears, or an auxiliary transmission, used in 4x4 vehicles that transfer power from the transmission to the front and rear drive shafts. Transfer gearboxes typically have two gear ranges, High and Low. High Range is used for typical on-highway or light off-road use. Low Range is used for specific off-road conditions. Putting a transfer gearbox in "neutral" disconnects the transmission from driveshafts. Unless the brakes are applied (foot brake or handbrake), a vehicle can roll when the transfer gearbox is in "neutral" even if the transmission is in "park" (automatic) or a forward/reverse gear (manual). A rule of thumb can be used here to help you remember which selection to make; High Range is for *higher speeds* and Low Range is for *lower speeds*.

Transmission - A transmission is a gearbox (either manual or automatic) with a number of different ratios to match the engine's RPM to road speed for conditions.

Universal Joint (UJ) - A UJ "connects" two shafts that aren't in a straight line. Depending on its design, a universal joint can accommodate a large variation between the angle of the input shaft and that of the output shaft.

Viscous Coupling - This complex device relies on the characteristics of a silicon fluid inside it. It can act as a differential, as a means to restrict wheel spin or both. Inside are two sets of slotted metal plates - one connected to a front shaft, the other to a rear shaft. When there is a significant speed difference between the shafts, the silicon fluid heats up, expands and becomes thinner, limiting the speed difference and thereby slippage right-to- left or front-to rear. In effect, it "locks" the shafts together (although not mechanically, as in a locking differential). When there is little or no speed difference between the shafts, the viscous coupling does not work.

Wheel Articulation - This term indicates the ability of one axle to move relative to the other - left wheel up, right wheel down. It is the measure of the ease with which wheels stay in contact with the ground (and retain traction) on a very bumpy, uneven track.

Winch - A winch is an externally mounted device consisting of a cable spooled onto a drum. It is used to pull heavy or bulky objects, or to retrieve a vehicle that is stuck. The drum can be driven by the engine, hydraulic power or electrically.

Wind Up - A condition where due to the locking of driveline components, the driveline is subjected to mechanical stress as the vehicle negotiates corners on high traction surfaces. If ignored, driveline failure is likely.

Worm-and-Roller Steering - This steering mechanism uses an hourglass-shaped worm and a pinion roller in external contact. This type of steering gear is known for its durability.

The structural and handling differences between a conventional two-wheel drive and a four-wheel drive

The structural and handling differences between a conventional two-wheel drive and a four-wheel drive vehicle are manifold.

The first and most obvious is the size. Most four-wheel drive vehicles are much bigger, taller and heavier than a conventional sedan car. They also generally have bigger wheels, a greater turning circle along with varying wheelbases, which affects the turning circle. They normally have a greater breaking distance and are more difficult to control.

One of the most important differences between a standard sedan car and a four-wheel drive vehicle is the higher center of gravity. If no consideration is given to this higher center of gravity, the chances of rolling your four-wheel drive vehicle over are greatly increased.

It's reasonably obvious that in some off-road situations this is not always going to be 100% possible, however much care needs to be exercised if you plan to drive across a side slope. It's Eureka 4WD Training's recommendation that you never drive across a side slope, due to the risk of wheels slipping and/or rolling your vehicle over.

Our strong recommendation is that you try and keep your four-wheel drive vehicle level with the horizon at all times.

Imagine a saucer on the bonnet of your four-wheel drive with a golf ball in it. Drive so as to keep the golf ball in the saucer

The purpose and use of front wheel hubs

Most conventional four-wheel drive vehicles have a type of front wheel hub, known as "Free Wheeling Hubs". These are operated manually or in some cases automatically, with some of the newer four-wheel drive vehicles when 4WD is selected.

The Free-Wheeling Hubs have two positions:

- Locked
- Free

What are the Free-Wheeling Hubs for?

When 4WD is selected, the mechanical drive force from the engine via the gearbox is sent to both front and rear axles. At the front axle, to enable these forces to be transferred from the drive-shafts to the wheels, you must engage the free-wheeling hubs by turning the center of the hub from the free position to the locked position. This then mechanically connects the front drive shafts to the wheel.

Please note that if your vehicle has manual locking hubs, both hubs on the front wheels need to be locked in before the vehicle will operate in 4WD mode. If you select the 4WD mode in the transfer case without locking the hubs in, you will still only be in 2WD mode. The vehicle will drive but only from the rear wheels. Many people have been caught out by this, so please don't become a statistic. We at Eureka 4WD Training mark our hubs to make it easy to identify from a distance if the hubs are locked in or not.

Free Wheeling Hub Locked

Free Wheeling Hub Unlocked

N.B. Some vehicles may need to reverse for a short distance when switching back to 2WD before the 4WD light on the dashboard goes out. Please refer to your owner's manual for more details. Never drive on bitumen roads while 4WD is engaged. This will cause wind up damage which is explained later in this manual.

Factors affecting tyre size, fitment, rating and pressure

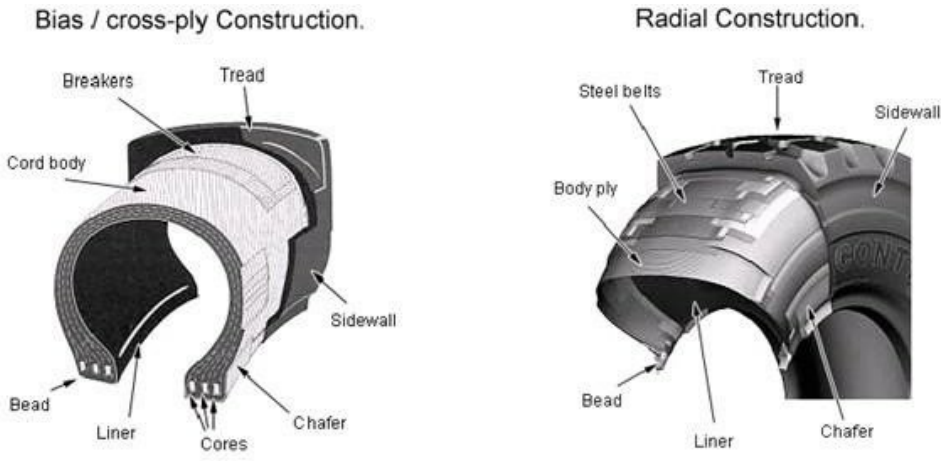
Tyres are one of the most important parts of your four-wheel drive vehicle when it comes to safety and handling. It's very important that all tyres are the same type, size and have the same tread pattern. Using mismatched tyres will result in poor off-road performance but more importantly it will affect your control over the vehicle. This can result in unexpected handling and loss of control. Tyres of different diameters can result in excessive stresses on drive train components, especially when 4WD is engaged or differential locks are activated.

There are two main types of vehicle tyre to consider:

- Bias / Cross Ply Tyres
- Radial Ply Tyres

Bias / Cross Ply Tyres are tougher and less prone to damage in tough bush situations where puncturing of tyres' sidewall is more common. Speed ratings are normally lower than that of radial tyres and handling characteristics of the tyre are poor. Directional stability and cornering are less precise as the tyre "squirms" under sideways load. After parking overnight, the bottom of a cross-ply tyre tends to flatten. Several kilometers of driving will alleviate this; however, until it does, you get a very bumpy ride. Eureka 4WD Training vehicles change tyres from radial to cross ply tyres when we know we will encounter less travelled, harsh terrain during cross country expeditions.

Radial Tyres come in a much larger selection of tread patterns; however, it is the difference in tyre rigidity which provides the handling improvement which has seen radials become standard equipment. Radial tyres will perform considerably better on bitumen than cross ply tyres due to the fact the steel belts hold the shape of the tread surface flat. Radial tyres will give better flotation when tyre pressures are reduced, and in almost all conditions give better traction. Due to their more compliant sidewall, radials generate less heat, resulting in a higher speed rating and reduced fuel consumption.



This is not the forum for recommending which tyres to purchase; however, you will need to make some decisions based on your expected usage.

How much off-road work will you be doing versus how much bitumen work do you expect to do. If you plan to do a lot of mud driving, you may lean towards a more aggressive tread pattern in a "Mud Terrain" tyre. You will then have to accept the extra road noise when on bitumen. There are many All-Terrain (A/T) tyres available which offer a compromise between on and off-road performance.

Tyre and wheel sizes are also a consideration based on your vehicle requirements. Most off-road conditions are suited to a long narrow "footprint" where good traction is required. A larger diameter tyre with a longer circumference like a 205R16LT will give this longer footprint. Sand driving, where more flotation is required, the use of a tyre such as a 10R15LT with a bigger footprint may be of advantage.

Fitment of tyres is also an important consideration. Again, you have two choices:

- Split rims (Two-piece rim)
- Safety rims (One-piece rim)

Split Rims are slowly becoming less popular for various reasons; however, they still have their place and should still be considered. The split rim wheel is made up of two parts, the main wheel and a steel ring which presses into place and "locks" the tyre onto the wheel. If you choose to use split rims, you will always need to use a tube inside the tyre.

Safety Rims or "Steel Rims "are most people's first choice when it comes to buying wheels. The huge range of styles makes them much more appealing to the general four- wheel drive user. They do have some good and some bad points that need to be considered when making a choice for your purpose.

Some advantages of Split Rims are:

- Easy to remove tyre with correct tools
- No bead to seal during inflation
- Spare tubes are easy to fit

Some of the disadvantages of Split Rims are:

- They are very heavy
- You have to use a tube
- Potential fast deflation if punctured at high speed, resulting in damage to the tyre
- They can be **Very Dangerous** during inflation if split rim is not seated correctly
- They should always be inflated in a safety cage
- They don't look good
- Quick, temporary repairs are not possible (you can't use tyre plugs)

Some advantages of Safety Rims:

- Lighter
- Safer when inflating after tyre replacement
- Some punctures can be repaired (temporarily) without removing the wheel
- Aesthetics

Some of the disadvantages of Safety Rims:

- More difficult to remove tyre for repairs
- Ingress of sand under bead can lead to flat tyre (at lowered pressures)
- Sealing the bead can be difficult after puncture repair
- Easier to damage if alloy

Tyre Pressures

Care must always be given to tyre pressures. To ensure safe handling of the vehicle the wheels on each axle must always be set to the same pressure i.e. you may have 40 psi in the front wheels and 45 psi in the rear wheels. Never mix pressures on the same axle. Check with the manufacturer of your tyres what pressures you should be running your tyres at, based on the load you're carrying. Once you have this information you will now need to consider the terrain type you are driving on and expected speeds.

It has been shown that reducing tyre pressures can assist traction and reduce the risk of tyre damage in some off-road conditions. These conditions include rocks, mud and sand. By reducing the pressure in the tyre, the rubber compound is able to form itself around rock surfaces more easily, giving greater traction and less chance of tyre damage from sharp rock edges. In mud conditions reduction of tyre pressures can also help because of the larger footprint, however with the tyre pressures down the side walls will become more susceptible to damage as the tyre "bags out" and in mud conditions this can be a problem as you are often unable to see these hazards.

Tyre pressures for Sand Driving

If your intention is to be driving on sand, you will need to reduce your tyre pressures to successfully do so. Please remember that when you are running your vehicle with reduced tyre pressures you are now outside of the manufacturer's recommendations.

LOW TYRE PRESSURES = LOW SPEED

As a *"rule of thumb"* Eureka 4WD Training recommend that tyre pressures are reduced to 18 psi when attempting to drive on soft sand. If a further reduction is required due to very soft conditions, the tyre pressure should be reduced by increments of 2 psi as this makes a significant difference to performance in both a positive and negative way.

Once tyre pressures have been reduced, extra care needs to be taken to avoid:

- Side wall damage
- The tyre being rolled off of the rim
- The wheel spinning inside the tyre
- Tight turns
- Heavy braking
- Turning the steering wheel while stationery

Also, please note that some vehicle manufacturers advise that tyre pressures should not be reduced. This advice is not given based on driving technique principles, but as a result of the traction system used by the vehicle manufacturer. It is imperative with some vehicles that all tyres are deflated to a pressure which provides exactly the same deformation, ensuring the same rolling diameter between the front and rear. If they are not adjusted this way, damage to the traction control system could arise. Check your owner's manual to ensure your vehicle is not likely to be affected.

Sand driving techniques will be covered later in this training manual.

Recovery hooks and mounting features

All four-wheel drive vehicles should be fitted with approved and rated recovery points front and rear. They should be securely attached to the vehicle with appropriately sized high tensile steel nuts and bolts (not welded). Eureka 4WD Training recommend that you let your local 4WD Accessory Shop fit these for you. The recovery hooks should have a SWL (Safe Working Load) or WLL (Working Load Limit) rating stamped on them and be of a size suitable for your vehicle or larger. It's most important for your own and other people's safety that the recovery points are selected and fitted correctly. They should always be fitted by using high tensile steel nuts and bolts of the correct size. A tow ball is **NOT** a recovery point and should never be used as such.

A number of vehicles come with metal loops under the front and rear bumpers which look like recovery points. Have these checked, as most are in actual fact only tie down points used mostly while shipping.

These are not suitable for use in a recovery situation where a snatch strap is being used. The photographs below show a typical tie down and two which have both broken at 8100kg of pressure.

Tie Down Point

Broken Tie Down Points

You may wish to consider having a set of 4 recovery points fitted (2 Front, 2 Back). The benefit being that you can set a "bridle" up and split the weight distribution across two points rather than putting strain on just one. It may also be better to recover from one side rather than the other for some reason.

Rated Recovery Point

Bridle set up

Hazards associated with incorrect use of vehicle features & equipment

It has already been identified that the four-wheel drive vehicle is very different to a standard family sedan and needs to be driven differently. It's bigger, heavier and will probably be slower to respond. Be aware of this and drive accordingly. Read the terrain a long way ahead. If you can't see or are not sure what lies ahead apply the two rules of four-wheel driving:

1st Principle of 4WD: STOP - GET OUT & LOOK!
2nd Principle of 4WD: THINK, ASSESS & DECIDE!

Familiarise yourself thoroughly with your four-wheel drive vehicle. In particular the 4WD system and how to engage it. With the huge variety of four-wheel drive vehicles on the market today it's very important that you understand the vehicle that you are using. Many are similar but most are unique in some way.
Practice changing a wheel whilst at home. Don't wait for the inevitable puncture to happen whilst in the bush, and then not know what to do. Learn where the jack and its components are stored, check that it works and then learn how to use it. Completely deflate a tyre and see if the jack still fits under the jacking point. It may be that you need to dig a small hole to make it fit under. The vehicle should always be on flat level ground, wheels chocked, in gear, engine off, handbrake on and passengers out, before jacking up.

Four-wheel drive vehicle wheels are heavy and can cause injury if they are handled incorrectly. It may be that you will need two people to change a wheel if you are physically unable to do it yourself. The two most physically difficult parts of changing a wheel are often undoing the wheel nuts and then lifting the new wheel into position. To assist in these two areas Eureka 4WD Training carry a metal tube (handle of the hand winch), this is used to give extra leverage when undoing very tight wheel nuts. We also carry a simple shovel, and this is used to assist in lifting the new wheel into position. Hold the shovel at right angles to the vehicle next to the wheel hub and roll the wheel onto the shovel. The handle can then be used as a lever to lift the wheel the couple of inches needed to align it.

Be aware that all road rules apply, even when off-road, and this includes the use of seat belts. Windows should be wound up as this will avoid injury from bush poking in the car and reduce the potential risk of insects such as ticks being flicked in.

If travelling through areas of long grass or spinifex the risk of fire is greatly increased. Stop regularly to clear grass and seeds from around the exhaust as it could easily ignite. Carrying a water spray bottle or an old **CLEAN** dishwashing liquid bottle filled with water can quickly put out these small spot fires. You should also carry a proper fire extinguisher and keep it close at hand.

Hand placement on the steering wheel is important. Eureka 4WD Training recommend that the steering wheel is held at 9 to 3 and importantly that you keep your thumbs outside the rim of the steering wheel. Should the front wheels fall into a hole or hit a bump the steering wheel could easily spin suddenly. If your thumbs are looped inside the steering wheel the spokes are very likely to cause injury or even broken thumbs. It hurts!

Environment and Eco-Driving

Human impact on the environment

The careless and inappropriate use of four-wheel drive vehicles and many other associated activities can have a detrimental and lasting effect on our environment. We need to be aware, and make provision for this, when planning our activities in an effort to minimise the potential impact.

Some of these could include:

- Pollution with foreign matter (human waste, rubbish, soap, detergent)
- Vegetation tramping and breakage
- Breakage and dislodgement of rock and other formations
- Compaction of soil and other deposits
- Disturbance of fauna
- Introduction of new flora and fauna
- Chemical alteration of environments
- Damage to, or inappropriate behavior, in cultural sites
- Graffiti
- Reduction in decomposing timber
- Campfire scars
- Noise
- Intrusion into private lives and culture
- Development of facilities and signs

Where is damage likely to occur?

- Soft ground
- Muddy tracks
- Vegetated sand dunes
- Disease Risk Areas (Dieback)
- Hills
- Water
- Camping areas
- Unmarked tracks

These lists are not exhaustive and there will be many more examples of areas where damage could occur.

Environmental damage can be avoided and is generally caused through lack of planning or poor education. Occasionally damage may be caused intentionally, and we should all report these incidents if we witness them.

Avoid driving on soft ground where possible. The vehicle's weight will obviously cause it to sink into the soft surface, and the result is evidenced by wheel ruts. If it's not possible to avoid these areas, stop after driving through, and take the time to repair the ruts you have just made. Wheel ruts don't repair themselves and can be seen for decades after being made.

Never drive on vegetated sand dunes. The dunes are very fragile and damage to the vegetation will not only cause it to die but the structure holding the dune together is then removed. This will cause the dune to drift and be moved by the wind. Habitats for birds and animals are then removed, and the cycle of destruction continues. There are often markers installed by Land Managers of where you should be driving. Follow these markers and report those who don't.

Dieback attacks and kills tree roots and is spread by the movement of mud from one place to another. This is normally carried on the vehicle's underbody or wheels. Disease Risk Areas (DRA) are often sign-posted so please follow the signs instruction and Keep Out. DRA are areas not infected with Dieback and by not going into them we are helping to protect them for the future.

Water runoff on hills, accompanied by wheel tracks can lead to soil erosion. Avoid "wheel spin" on hills and this will help to prevent this soil erosion.

Watering holes, rivers & streams are very important for many reasons and should not be contaminated in any way. Never use soaps or detergents in these natural watering places. It will contaminate the water, and animals will not use it. This can cause pain, unnecessary suffering and death to wildlife. If you want to use soap, collect the water in a bucket and move at least 300m away from the water source to use it.

Camping grounds and camp sites in general should be treated with respect. Don't chop down trees to make a campfire, if possible, bring wood for the campfire with you or collect fallen dead wood. Observe fire bans and take special care not to start bush fires. Clear around the area of the intended campfire of ignitable debris and make sure the fire is thoroughly put out before you leave.

Take out what you take in, i.e. don't leave or bury rubbish, take it home with you. When you need to go to the toilet, never go near a natural water course as this will cause contamination. Simply dig a hole 300mm deep and clear around the hole. When you have finished going to the toilet, burn the toilet paper before back filling the hole. This will avoid unsightly used toilet paper being strewn through the surrounding bush.

If you are driving on a track, stick to the track, don't make new or fresh tracks off the main track. Opening up new tracks often causes plant damage and can also lead to expensive staked tyres. Authorities and Land Managers take a very dim view of making new tracks and it can not only lead to environmental damage, but closure of the area if the problem persists.

Assess the Situation

In assessing if a setting is appropriate for your activity, have consideration for others and the environmental impact the activity may have.

Example 1: Imagine a quiet, idyllic spot on the river. A couple are set up with their camping gear and reading their books on bird watching. It's lovely, quiet and they have their binoculars out to spot the birds... you get the idea. This is then probably not the best place for you and your 5 mates to choose to set up your camp, generator and collect firewood with the use of your new chain saw.

Example 2: You're out enjoying some four-wheel driving when you get to a fork on the track. The left fork has a DRA (Disease Risk Area) sign saying keep out, but you know it's 5km quicker to get back to your camp than taking the right-hand fork. Q: What do you do? A: Take the right fork.

Example 3: You are leading a group through the bush and it's time for morning tea. You will need to select an appropriate spot where all the vehicles can fit in, preferably on flat ground with some shade.

Managed Lands often have signs of what is or is not acceptable codes of conduct, and what you can and can't do; obey the signs. Heavy penalties can apply if you disregard these warnings.

Tips and techniques to minimise environmental impact

Making decisions regarding the environmental impact your activity will place on the ecosystem can sometimes be difficult. After all we're not all microbiologists. However, common sense in most cases is going to enable you to make sensible decisions.

So how can we reduce the risk of any possible damage?

- Walk the track first to identify if the section or area in question is suitable and would be able to sustain vehicle access without incurring damage.
- Reduce tyre pressures if appropriate i.e. in sand or on soft ground.
- Avoid wheel spin by correct use of gears and accelerator.
- Adjust speed to suit track conditions and to avoid skidding.
- Use engine braking where suitable rather than locking wheels up with the brakes.

Can you think of anything else?

Eco-Driving - The Concept

Golden Rules of Eco-Driving

Eco-driving means smarter and more fuel-efficient driving. Eco-driving represents a new driving culture that makes best use of advanced vehicle technologies, while improving road safety. An important component of sustainable mobility, Eco-driving considerably contributes to climate protection and pollution reduction.

Anticipate traffic flow

Read the road as far ahead as possible and anticipate the flow of traffic. Act instead of reacting - increase your scope of action with an appropriate distance between vehicles to use momentum (an increased safety distance equivalent of about 3 seconds to the car in front optimises the options to balance speed fluctuations in traffic flow - enabling steady driving with constant speed).

Maintain a steady speed at low RPM

Drive smoothly using the highest possible gear at low RPM.

Shift up early

Shift to a higher gear at approximately 2,000 RPM. Consider the traffic situation, safety needs and vehicle specifics.

Check tyre pressures frequently at least once a month and before driving at high speed

Keep tyres properly inflated as low tyre pressure is a safety risk and wastes fuel. For correct tyre pressure (according to loading; highest pressure and speed driven) check with the car's manual.

Consider any extra energy required costs, fuel and money

Use air conditioning and electrical equipment wisely and switch it off if not needed. Electrical energy is converted from extra fuel burnt in a combustion engine, so electrical equipment doesn't work "for free"; it always costs extra energy and money. Avoid dead weight and aerodynamic drag.

Pre-Departure Checks

Routine pre-departure checks under the bonnet, under the body and on external and internal items and accessories

Four-wheel driving puts a lot of strain on your vehicle, considerably more so than normal driving. Therefore, thorough vehicle maintenance is a must. Remember that when you are out four wheel driving you are your own service station.

It is therefore most important to conduct daily vehicle inspections. Prevention is better than cure, so let's take a look at what needs to be inspected. These simple visual checks each morning may identify a problem before it becomes serious.

<table>
<tr><th>External</th><th>Internal</th></tr>
<tr><td rowspan="2">Tyre/Wheels
• Studs/bearings
• Correct pressure for terrain
• Side wall damage (remember both sides)
• Erratic wear
• Spare Tyre
➢ Same size as other wheels
➢ Inflation
➢ Securely mounted</td><td>Seat Position
• Check adjustment
• Security (holts, mechanism, etc.)
• Seat belts (inertia recoil, fraying)</td></tr>
<tr><td>Mirrors
• Check adjustment
• Cleanliness</td></tr>
<tr><td rowspan="2">Glass
• Windscreen
➢ Wiper operation
➢ Wiper blade condition
➢ Washer working
➢ Free of damage
➢ Visibility (clean)
• Lights
➢ Lens clean
➢ Working and correctly adjusted</td><td>Clutch & Brake Operation
• Check for normal operation
• Clutch – some resistance & select gears
 Brakes = firm</td></tr>
<tr><td>Instrumentation
• Check before starting engine that the appropriate warning indicators, light up
• After starting, check gauges are operating and warning lights go out</td></tr>
<tr><td>Bodywork
• Doors close securely
• Loose compartments
• Roof racks, bull bars, etc.</td><td>Handbrake
• Apply normally
• Test on steep gradient</td></tr>
<tr><td>Under Bonnet
 Fluid levels
➢ Radiator expansion tank
➢ Clutch and brake fluids
➢ Battery water
➢ Engine oil
➢ Power steering
➢ Washer bottle(s)
➢ Auto transmission</td><td>Under Vehicle
 Fluid leaks
➢ Water leaks from lower parts of engine
➢ Oil leaks from: ○ Engine ○ Gear box ○ Transfer case
○ Diff
➢ Oil leaks from:</td></tr>
</table>

<table>
<tr><td>Hoses (check for spills, etc.)
• Radiator
• Heater
• Power steering
• Air cleaner
• Air conditioner</td><td>○ Clutch ○ Brake hoses or pipes ○ Clutch hoses or pipes ○ Brakes</td></tr>
<tr><td>Leaks
□ Check for oil and water leaks</td><td>Exhaust
• Shake exhaust
• Damage
• Leaks
• Debris
• Rubber mounts (appears loose but should still be sound)</td></tr>
<tr><td rowspan="2">Loose Items
• Cables
• Nuts and bolts
• Belts
• Clean battery terminals
• Wheel nuts</td><td>Structural Damage
• Cracks
• Mounting points (sheared studs, bolts or rivets)</td></tr>
<tr><td>Loose Compartments
• Shock absorbers
• Wiring
• Fuel lines
• Debris
• Mounts (engine, gearbox, etc.)
• Handbrake cable
• Anything shiny (possible metal to metal contact)</td></tr>
</table>

Actions to correct any deficiency

If you find anything wrong with your vehicle during the vehicle inspection, report it to your supervisor who will follow company procedure. You may find yourself in remote areas and have to affect a repair yourself. This could be as simple as changing a taillight bulb to changing a wheel bearing or more.

The important thing is that you don't ignore the fault. The fault is very unlikely to get better and most likely it will get worse.

You may not personally have the skills to repair whatever is wrong so use your skills to call for help. This could be by radio, telephone, sat phone or any other means at your disposal. Eureka 4WD Training recommend you always carry a service manual for the vehicle you are driving. A person who is willing to assist will be able to offer a great deal more assistance if they have specific vehicle information.

The spare parts you may need to carry are important and you should check with your supervisor, who will check company procedure.

Get to know your vehicle and have a suitable tool kit for it. A lot of repairs that are done in the bush are perfectly acceptable and some need to be viewed as "temporary at the best". There are many makeshift repairs that will "get you out of trouble" and it will depend on what the problem is as to whether you are going to be able to get yourself going again.

The Australian bush is a very dangerous place to be stranded in, so don't under-estimate the importance of a reliable, well serviced vehicle. A breakdown in town is an inconvenience; a breakdown in the bush could cost you your life.

Safe vehicle loading practices Items of personal luggage are safely secured

Loose Objects

This becomes critical if things go wrong. Many people have survived the initial impact, only to be killed by flying objects in the vehicle. You are belted into your vehicle, and you and your vehicle may stop instantly, but your unsecured load may not. Imagine being hit on the back of the head by an article as small as an adjustable spanner travelling at 100Kph. You must ensure that everything, as far as practical, is secure. Statistics show that people are killed by loose objects flying around in vehicles after an accident. Don't become one of these statistics. The installation of a cargo barrier is a good idea and helps protect passengers from those loose objects in the event of an accident.

Loading

All heavy items should be stowed low and secure, helping to reduce the high center of gravity of the vehicle.

You have probably seen four-wheel drive vehicles travelling around with Jerry cans, water supplies, spare wheels, Hi-Lift jack and toolboxes all stacked up on the roof rack. Imaging what this is doing to the dynamics of the vehicle. The center of gravity has literally gone through the roof. I doubt that many of the vehicles loaded in this manner would survive a road swerve test.

Securing the Load

As we have mentioned, loads should be stowed low and secure, but how?

Many vehicles have tie down points inside. Eureka 4WD Training recommends the use of ratchet straps connected to these points rather than elastic shock cords with hooks. Pack soft items around to stop other items from moving about. This will also help to stop those annoying rattles that always seem to develop.

Custom-made storage drawers (and boxes for Ute style vehicles), are also a good option. These storage options are always firmly secured to the vehicle. They help with the organisation of equipment and keep it, and you, safe. You will always be able to lay your hands on what you want, when you want it.

Safety precautions for rough terrain

Conditions inside the four-wheel drive vehicle when being driven off-road can often get very bumpy. Passenger comfort and safety should be considered before undertaking conditions that are too rough.

Many four-wheel drive vehicles have safety handles on the dashboard and above the doors for the passengers to hang on to when the going gets rough. The driver should warn passengers when approaching ground that has the potential to throw the passengers around in the vehicle.

For safety reasons it may also be necessary for passengers to get out of the vehicle. This doesn't happen very often, but the passengers may be able to assist outside the vehicle by giving directions or possibly fixing the track to allow smoother passage.
Be aware that **all** road rules apply when driving off road. This means that these rules should be adhered to and that seat belts should always be worn.

Lives have been lost by vehicles unsuccessfully attempting water crossings. Water crossings comprise a major risk and extra special care needs to be taken with occupants and preparation of the vehicle.

Use Four-Wheel Drive Features in a Variety of Terrain Types

Operating a four-wheel drive vehicle both on and off-road in accordance with road rules, principles of four-wheel driving and OH&S regulations

Knowing and understanding the operation of your own four-wheel drive vehicle is very important. There are many different makes and models available, and you will need to familiarise yourself with your own vehicle. Read the owner's manual on how to select 4WD or the off-road features the vehicle provides. Know what conditions are suitable for these modes. Read the information about tyre inflation in relationship to speed and load carrying. Learn where the car jack is and where it should be positioned to change a wheel. All this information is available in the owner's manual, and you will find it a valuable resource.

We have already advised that all statutory road rules apply, even when off-road. However, you will need to be mindful and probably even more careful off-road than when driving down the freeway. Pay much more attention to blind corners and when cresting a hill, remember there are no white lines, traffic lights or stop signs in the bush.

Keep within the speed limits. Be aware that all speed signs are set for dry, clear conditions; always consider the conditions; and adjust your speed accordingly. Although four-wheel driving is frequently slow and conducted below the speed limit, it's often easy to pick up speed when travelling along a stretch of gravel road, for example. Be mindful that changes in gravel road conditions happen without warning and are sometimes very difficult to see until it's too late. The first and second rules of four-wheel driving should now come into play. They are:

1st principle of Four-Wheel Driving - If in doubt: **STOP - GET OUT, AND LOOK**

2nd Principle of Four-Wheel Driving - **THINK - ASSESS - DECIDE**

Be considerate to oncoming traffic on single vehicle width tracks. Stop, have a chat with the oncoming driver and work out who's in the best position for reversing back or moving over so the vehicles can pass with minimal environmental impact. If on mine site, driving over wind rows (management takes a very dim view to this!) should be avoided at all cost.

You may find that as part of your work requirements you could be asked to drive in remote locations. Consider medical emergencies and we recommend that you should be:

- trained to deal with an emergency
- the holder of a current Senior First Aid Certificate
- in possession of equipment to deal with an emergency, i.e. First Aid Kit, HF Radio, Satellite Phone, Emergency Position Indicating Radio Beacon (EPIRB), etc.
- aware of the quickest way to seek help by road or radio
- aware of your exact location

Transmission Windup

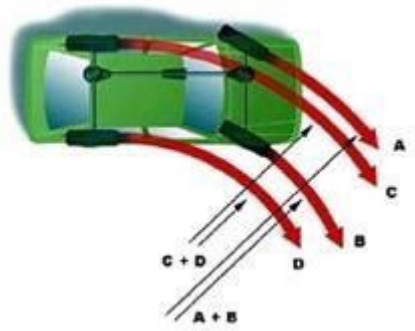
When you select 4WD, make sure your vehicle does not suffer from extreme drive-line wind up, as this can cause expensive damage. It is important that 4WD is disengaged and the warning light is off before travelling on the bitumen / concrete road. Always make sure that your 4WD light on the dashboard is off as this will be 100% correct.

What is it?
Transmission Wind Up is the physical symptom caused by driving a four-wheel drive vehicle on a surface that doesn't have any slippage, (such as bitumen or concrete) whilst the vehicle has 4WD engaged.

How is it caused?
Transmission Wind Up occurs when 4WD is engaged and you start to corner on a high-traction surface (e.g.: bitumen/concrete). The reason for this is when 4WD is engaged, you are driving front and rear axles at the same speed all the time, and when you corner the front and rear must rotate at different speeds, as they take a different track. This causes tension build up within the whole of the drive train and if the tension is not released it increases until something breaks.

Only when going straight are all four wheels turning at the same rate.

As soon as a turn is initiated all four wheels will rotate at different rates since each of them follows a different imaginary circle.



This is what happens during a turn:
The inside wheels must rotate with less RPM than the outside wheels. The differential on the rear axle guarantees that the RPM delivered via the driveshaft from the transfer case is distributed to the left and right wheel as needed. This means equal RPM when travelling in a straight line, less RPM to the inside wheel and more RPM to the outside wheel when in a turn. The differential of the front axle does exactly the same thing. The axle differentials take care of the need for different wheel RPM.

However, in a four-wheel drive a problem exists that during a turn, the front axle needs more RPM than the rear axle.

Here is why:

- The front inside wheel will need more RPM than the rear inside wheel.
- The front outside wheel will need more RPM than the rear outside wheel.
- This means that the front wheels need more RPM than the rear wheels in a turn.
- When you add the RPM of front wheels (A+B) you will find that the number is higher than the combined RPM of the rear wheels (C+D).

How can I get rid of it?

The best way to release Transmission Wind Up is to reverse the vehicle, turning the steering wheel from left to right for a few meters. With severe Transmission Wind Up, you can jack a front wheel off the ground. This can be extremely dangerous and must only be used as a last resort. So therefore, make sure the rear wheel is chocked, and the handbrake is on. All clothing and body parts must be clear as when the vehicle is jacked up and the wheel starts losing traction, it will spin violently.

There are four angles on the 4WD vehicle that we need to know and understand.

1. Approach Angle

The approach angle will determine when the front of your car is going to hang up approaching a hill. It's the greatest angle that a vehicle can approach without grounding ahead of the front wheels.

2. Departure Angle

The departure angle does the same, but at the back end of the vehicle. It's the greatest angle that a vehicle can emerge from a deep rut or level out after a steep descent without the underside of the rear bodywork touching the ground.

3. Ramp over Angle

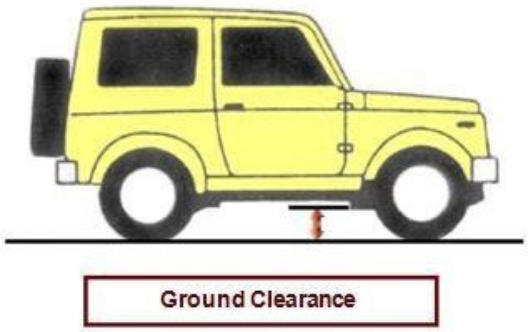
The ramp over angle is the maximum angle your vehicle can traverse between two planes without any part of the underside touching. If you get it wrong, it's not unusual to sit with wheels hanging off of the ground and the car seesawing.

4. Rollover Angle

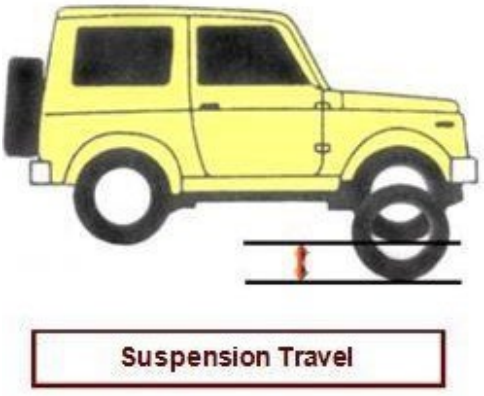
This is the one we don't want to see. This is the angle, or point of balance, where the vehicle will roll over if exceeded.

Ground Clearance and Wheel/Suspension Travel

Ground Clearance is the distance from the ground to the lowest point under the vehicle. The lowest points are normally the transfer case protection plate or the differential housing. Increasing the vehicle's suspension height by fitting a "lift kit" will not improve the clearance between the ground and the differential housing. The only way you are able to increase the ground clearance between the differential housing and the ground is by changing wheel and/or tyre sizes. This will cause other issues to arise, including vehicle legality and the dangers of a higher center of gravity.



Suspension Travel is the distance that a wheel is able to move up and down. This is often referred to as wheel articulation. A number of factors control this movement, but it is mostly regulated by the type of suspension fitted to the vehicle. Good suspension travel is one important aspect in determining how well a vehicle will be able to tackle difficult terrain. Poor suspension travel will result in a loss of traction and result in a loss of forward movement. Obviously, the more wheels you have in contact with the ground the more traction you have.



Workplace Health and Safety (WHS) in the workplace

WHS now forms a real part of our everyday work responsibility. WHS legislation is central to many organisational Work Safe policies; therefore, you need to make yourself aware of them. They have been put into place to help guard your safety while at work.

So, what can you do?

Make yourself aware of:

- State/Territory/Commonwealth Workplace Health and Safety Acts, regulations and codes of practice including regulations and codes of practice relating to hazards in the workplace or industry.

Practice:

- General duty of care under Workplace Health and Safety legislation and common law.

Help with:

- Provisions relating to roles and responsibilities of health and safety representatives and/or workplace health and safety committees.

Face the issues:

- Relating to workplace health and safety issue resolution.

WHS issues may be formally documented or communicated verbally and include procedures which are:

- general to the management of the organisation such as: ➢ job procedures and work instructions
- specific to workplace health and safety, such as
  - ➢ specific hazards
  - ➢ emergency response
  - ➢ consultation and participation
  - ➢ workplace health and safety issue resolution
  - ➢ identifying hazards, e.g., inspections, assessing risks & controlling risks
  - ➢ use of personal protective equipment
  - ➢ reporting workplace health and safety issues

Spend some time to think how you can make your workplace safer. Then apply these principles to your everyday work.

Some of these may include activities such as:

- Checking recovery equipment before work commences (for damage or wear)
- Vehicle inspection (brakes, hoses, belts, fluid levels, mirrors, etc.)

Eureka 4WD Training recommends that you have at least a Senior First Aid Certificate which is kept current. It could be you who's called on to save a life. We also recommend that you carry a suitable first aid kit in the vehicle.

Smooth Accelerator Control

Smooth accelerator control if practiced correctly, is going to make your four-wheel drive journey a lot more pleasurable experience.

Nobody likes being bounced around in a vehicle cabin, and the type of terrain you are going to experience once "off-road" is going to make it more difficult to keep things smooth. We have some simple tips here which are going to help enormously.

Manual Vehicle:

When driving over rough terrain if you find your foot bouncing on the accelerator you will get a rough ride. Lift your right foot off of the pedal and move it across to the right a little. The aim is to get the right side of your right foot touching the right inside side wall of the foot well while still applying gentle pressure on the accelerator. The friction of your foot on the side wall will stop it bouncing around and lead to a much smoother ride.

Automatic Vehicles:

Similar principles will apply to those of the manual vehicle however automatics have another problem to overcome, that being that of the torque converter. As you are driving over rocky ground the torque converter needs to build up energy to enable the vehicle to rise up over a bump or rock. This buildup of energy is then suddenly released when the wheel reaches the top of the rock or point where there is no longer gravitational resistance. The result is that the vehicle can then lurch forward, giving a not too comfortable ride until the driver slows the vehicle down.

The best way to resolve this problem is by using both feet; one on the brake and right one on the accelerator. Gentle application of the brake at the point of energy release slows the vehicle down and keeps the ride smooth. This is a difficult technique to master, and at first you will probably brake erratically causing you to jolt forward a little. With practice you will find it works well and can be used in other areas of four-wheel driving.

Automatic Throttle Controls:

The use of automatic throttle controls or "hand throttles" is covered in our advanced courses rather than here. However, a word of warning, vehicles can get out of control very quickly with inexperienced drivers using the hand throttle to control the acceleration rate. The most common problem is during rocky hill climbs. With the hand throttle pulled out to climb a rocky hill, the directional adjustments required can happen very fast. Consequentially to slow down in a hurry most drivers would jump onto the clutch. This is potentially dangerous and wrong, as the vehicle is now out of control. It will probably start to roll backwards at speed, with the risks associated with that. Eureka 4WD Training recommends that you avoid using the hand throttle until you have mastered the one on the floor.

Recommended braking techniques for on- and off-road conditions

Off- road braking techniques are different to those for normal bitumen driving.

1. What is the braking technique acknowledged by the Motoring Authority for normal bitumen driving?

A. Gentle pressure applied at all times for non-ABS vehicles. For ABS vehicles, firm pressure is applied until the vehicle stops.

2. What is the appropriate braking technique for off-road driving?

A. Gentle pressure at first then harder pressure followed by light pressure until the vehicle stops (commonly known as 'cadence' or 'pulse' braking). **If in an ABS vehicle,** firm pressure is applied but do **NOT** adopt 'cadence' or 'pulse' braking techniques as this will confuse the computer which will therefore render the brakes inoperative.

By using this "gentle at all times" technique the lock up of wheels can be avoided. You will need to read the terrain further ahead, drive slower and start braking sooner with greater consistency of pedal effort and deceleration.

The lock up of wheels should always be avoided. When the wheels are locked up you have very little (if any) control over the vehicle, especially the steering.

Most modern vehicles have ABS braking which, via computer, controls heavy emergency braking by effectively turning the brakes on and off very quickly as if you were pumping the brake pedal. This helps to avoid wheel locking and gives you much better vehicle control under heavy braking situations.

Don't let this happen to you!

Stay in control by reducing your speed and using the correct braking techniques in every situation.

Situations where the engagement of four-wheel drive is required

Once upon a time selecting 4WD was easy, you would lock in the front hubs, select 4H or 4L with the transfer lever (that's the little gear stick) and away you went. This is not the case now. Some vehicles are still this easy, but most others have some sort of automatic traction control system or button to lock the center differential. It would be impossible in this training manual to identify each and every system for each and every vehicle, however it is important that you understand the principles of when and how to engage the 4WD system. Eureka 4WD Training strongly recommend that you familiarise yourself with the 4WD system in your own vehicle, how to engage it and how to release it. This information would normally be found in the owner's handbook. Many systems, especially automatics, need to have the gear lever in neutral before the 4WD system will engage.

So, when to engage 4WD?

You will only ever engage the 4WD system when off-road or off the bitumen. Engaging 4WD whilst still on bitumen will result in transmission wind up as previously described.

Most of the larger four-wheel drive vehicles will give you the options of selecting either High or Low Range gears.

Some conditions that 2WD High Range (H2) might be used are:

- Normal highway driving.

Some conditions that 4WD High Range (H4) might be used are:

- Slippery roads, snow and firm sand.

Some conditions that 4WD Low Range (L4) might be used are:

- Difficult rocky terrain, soft sand or boggy surfaces.

As a rule of thumb and to help new 4WDrivers remember:

- Low Range is used for lower speeds (and if you're unsure the safest)
- High Range is used for higher speeds

Low Range 5th gear should never be used due to the fact that Low Range is for maximum traction and low speeds. If you find you are on a surface where you can change to Low Range 5th gear, you should be in High Range2nd, or 3rd gear.

The correct gear selection will give you the pulling power and momentum required without wheel spin. It is best to avoid a gear change whilst negotiating an obstacle just as it is to avoid harsh braking and sharp acceleration.

Engage correctly front hubs and center differential lock (constant four-wheel drive vehicles)

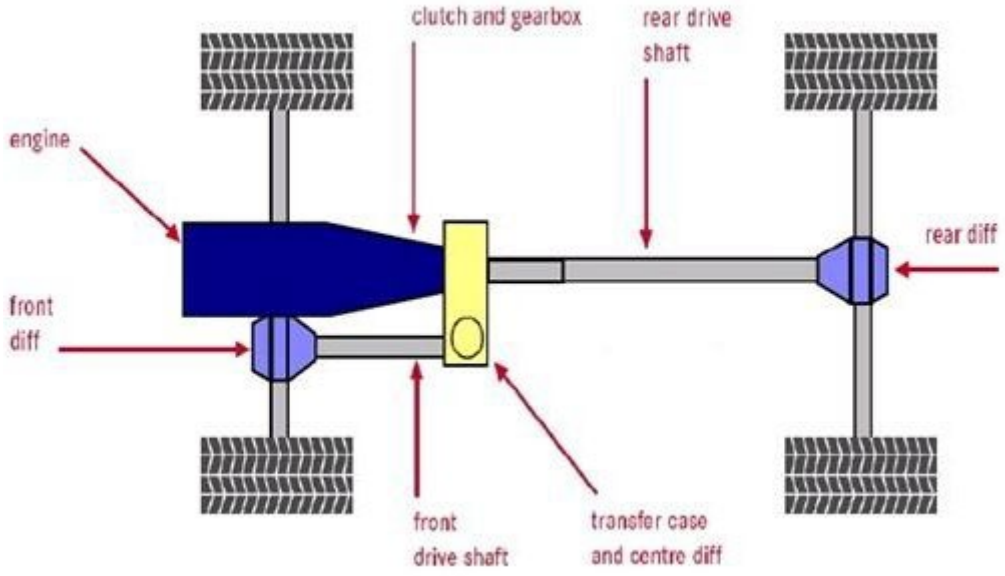
The details and use of the front free-wheeling hubs were covered earlier in this training manual. Remember to engage the front free-wheeling hubs prior to venturing off-road and when selecting 4WD mode.

Eureka 4WD Training recommend that if your vehicle is not being used in 4WD mode very often, you engage the freewheeling hubs once a month, making very sure that if on the bitumen you **DO NOT** select 4WD with the transfer lever. This will help keep mechanical parts moving and serviceable. By doing this the vehicle will still be in 2WD mode and wind up will not occur.

Make sure that the 4WD light on the dashboard is not on. It is a common myth that you cannot drive a four-wheel drive vehicle on the road with your free-wheeling hubs locked on. **This is not the case** - free-wheeling hubs are purely a fuel-saving device.

Constant 4WD vehicles are very different to the normal part-time 4WD. In a conventional constant 4WD vehicle, power and drive is being delivered to all 4 wheels all of the time. So why don't you wind up on the bitumen you may ask? There are many new types of drive couplings used to avoid this with the most common being a third differential called the "Centre Diff". Others include computer controlled and viscous couplings, but they are beyond the scope of this manual.

Let's briefly look at the Centre Diff. This third differential allows the front and rear axle to turn at different rates, therefore avoiding wind up. However, this can cause its own problems when venturing off-road. If one wheel loses traction, drive is lost to the other three wheels, and you are stuck. To get around this potential problem there will be some sort of mechanical or electrical device in your constant 4WD vehicle to "lock" the Centre Diff. Often this is as simple as a switch or button on the dash which needs to be pressed. Other vehicles require the gear shift to be moved into a position marked something like "HLc" or "LLc" or similar (refer to owner's manual). This will effectively turn your constant 4WD vehicle into a conventional 4WD vehicle. Again, remember when returning to the bitumen that you must unlock Centre Diff.



Survey tracks to identify hazards, assess risks, select the best route and minimise damage to the environment

Pre-trip planning is essential. Whether for work or play you should have planned your intended route. This will probably involve surveying maps and working out the best route to take to avoid delays or being stranded.

Attention to the topography and potentially boggy areas will go a long way towards a successful trip. Some tracks or areas may need to be avoided on a seasonal basis to avoid getting bogged or doing environmental damage.

Having planned your intended route and satisfied yourself that you are adequately equipped for the journey is a good start, but things can change. Be prepared for the unexpected. Trees down, roads flooded, new fence lines, etc.... the list is long.

If attempting to negotiate difficult terrain the risk needs to be very carefully analysed. This is where the **first rule** of 4WDriving comes into play:

If in doubt: STOP, GET OUT and LOOK

This is then closely followed by the **second rule**:

THINK, ASSESS and DECIDE

It is often the case that you may need to tackle a more difficult path initially to enable an easier path for the rest of the obstacle. Remember that you are trying to keep your vehicle level with the horizon to avoid rollovers.

Where it's reasonable or at all possible, routes chosen with the potential to cause environmental damage should be avoided or your plans changed to meet this requirement.

Gear selection, stall start techniques and spotter signals

Which is the best gear to select?

All vehicles are going to be different in some way. Whether it's the weight, tyre selection, engine size, transmission type or any other of a million other things they will be different. Because of this, gear selection is going to be different from car to car. Getting to know your vehicle will give you the experience of selecting the correct range and gear.

The correct speed, range and gear combination is going to enable you to make a successful first attempt at an obstacle without wheel spin, damage or strain to the vehicle, damage to the environment or injuring the vehicles occupants. 4WD should always be selected before negotiating an obstacle, making sure that the freewheeling front hubs are locked in. Low range will generally be best suited for the more difficult situations, especially where steep ascents and descents are going to be negotiated.

Make sure you turn your air conditioner off. This will prevent the air conditioner compressor activating and reducing engine power when making a climb. More importantly, it will prevent the engine revs from increasing when going down a steep hill.

We have already advised that it's preferable to keep your vehicle level with the horizon. To this end, avoid side slope driving. The danger of rollover is greatly increased. Wet and slippery side slopes are particularly dangerous and skid correction methods may need to be used.

Spotter's signals

It will often help to have someone outside the vehicle to guide and give instructions to you. Make sure that you both understand what hand signals are going to be used. Misinterpretation of a signal can be dangerous. In-car UHF radios are good for receiving instructions but not for replying as you need to keep both hands on the steering wheel. The hand signals Eureka 4WD Training Trainers and Assessors use are:

Steep Ascent and Descent

Attempting a steep ascent:

Remember, you are aiming for a successful first attempt. Work to a plan:

1. Are the hubs locked in, with 4WD and the correct range selection?
2. Check the track conditions on foot
3. Checking tyre pressures suit conditions
4. Select the safest route, trying to keep the vehicle level
5. Decide how much momentum will be required
6. Air conditioner turned off
7. Never tough the clutch whilst attempting a steep ascent
8. **Do not** change gears whilst negotiating the obstacle
9. Avoid wheel spin

If you are unsuccessful you will need to reverse back down in low range and in a straight line keeping the vehicle level. **Do not** try to turn around on the hill.

Attempting a steep descent:

Remember, gravity can take over control of your vehicle on a steep descent. You will need to determine that the descents are safe. Once you have started the descent you are "committed", it is very difficult and often impossible to reverse back up a steep hill with any safety. Again, work on a plan:

1. Are the hubs locked in, with 4WD low range 1st gear selected?
2. Check the track conditions on foot
3. Checking tyre pressures suit conditions
4. Select the safest route, trying to keep the vehicle level
5. Air conditioner turned off
6. Never changing gears whilst descending the obstacle
7. Engine braking only. For automatic vehicles, apply gentle pressure on the brake
8. Never touch the clutch whilst attempting a steep descent

Automatic vehicles will require more use of the brake than a manual vehicle as the transmission does not convey engine compression as effectively.

Reverse stall start procedure on a hill:

1. **Must** keep your foot on the foot brake throughout the procedure
2. Turn off ignition
3. Apply handbrake
4. Now you have 3 points of isolation, you can now engage clutch and positively select reverse
5. Release clutch and place foot under clutch pedal
6. Release handbrake
7. Now, and only now, slowly release the foot brake until the vehicle is holding on engine compression alone
8. Put left hand on the steering wheel and check rear view mirrors. Make sure both feet are on the floor plan
9. Turn the ignition key
10. The vehicle will start up in gear and slowly reverse down the hill using just engine braking alone

Automatic gearbox vehicles:

To stop on a steep decline:

1. Apply foot brake with vehicle in gear 2.
2. Once stopped apply handbrake 3
3. Select neutral

to continue:

1. Select drive or reverse gear low range 2.
2. Foot brake on 3
3. Handbrake off
4. Ease of the brakes

You may need to keep a small amount of braking effort on as automatics have very little engine braking effect.

Hand brake hill starts for automatic gearbox vehicles

With the vehicle stopped and held by the footbrake, apply **HAND BRAKE**, select Neutral and start engine, move gear selector to **LOW FIRST** and increase engine revs as you release the handbrake. Fortunately, with an automatic your brake foot is available to assist you with a smooth take-off.

CAUTION: "P" (park) has been avoided because transmission lock up may occur as the full weight of the vehicle rests on the transmission. This can prevent you locating a drive gear. Also, you must pass through the 'R' position to select 'P' which could cause rearward movement especially if the engine is idling fast.

NOTE: In an emergency 'P' will help hold the vehicle and you may then have to chock and winch to a safe position.

Understanding and Controlling a Skid

Skids are generally caused by poor driving techniques, typically rough acceleration, braking or steering. However irregular surfaces and slippery roads can also be contributing factors.

Let's take a look at the 3 skid types:

1. Front Wheel Skid

Here the front wheels lose traction usually because of too much speed when cornering or on deep ruts. It feels like a loss of steering control.

How to correct it: Gently lift off of the accelerator and steer to straighten the wheels. Beware that the tyres may bite before you straighten completely, so move the steering wheel rapidly. Once traction is regained, return the steering wheel to negotiate the corner or obstacle.

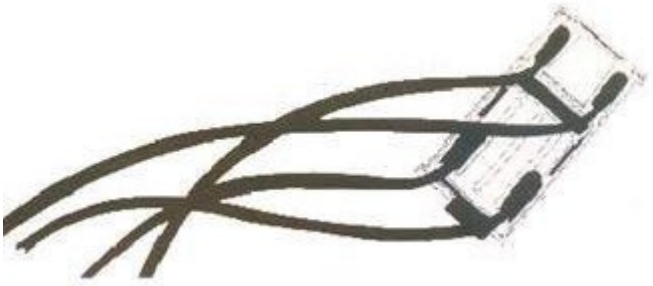
2. Rear Wheel Skid

Here the rear wheels lose traction and the rear of the vehicle "breaks away".

How to correct it: Gently, ease off of the accelerator (do not brake) and at the same time counter steer in the direction in which the rear of the car is sliding ("steering into the skid"). Be careful of over correcting. Once control is regained, return the steering wheel to the direction you wish to travel.

3. Four Wheel Skid

Here under heavy braking all four wheels may lock up. The vehicle will slide forwards as if the brakes are not working.



How to correct it: Immediately release the pressure on the brake pedal so that the wheels regain traction. Then, carefully and quickly reapply pressure on the pedal. The ideal situation for maximum braking effect is one where all four
wheels are just at the point of before

Rock Track Driving

Much care is going to be needed to negotiate rocky tracks. These are normally accompanied by deep ruts, washouts and track erosion. Inspection on foot is often called for if you intend to minimise vehicle damage. Track preparation is a well spent time. Filling deep ruts with rocks prior to driving through them will potentially save you many hours of vehicle recovery. Try not to use branches or sticks as these could flick up and damage under body parts, i.e.: brake lines. If you need to use sticks, place them horizontally across the track. Low range 1st and 2nd gears are generally the most suitable gears over this slow-going ground. At Eureka we recommend, as a rule, 2nd gear low range ascending a hill and 1st gear low range descending a hill. Careful wheel placement to avoid deep ruts and to keep the vehicle level will be required. Track conditions vary greatly, and these will change from week to week. Tyre damage when negotiating rocky terrain is a real risk. It has been shown that a small reduction in tyre pressure (around 10psi) will help reduce the risk of splitting the tyre; however, a reduction in tyre pressure will also make the side walls of the tyre more vulnerable to damage. When driving past sharp rocks, if there is a chance that you may "clip" the side wall of the tyre, it's best to drive straight over the top of the rock with the tread pattern of the tyre. The tread pattern is the strongest part of the tyre and is less likely than the side wall to be damaged.

Mud Driving

If you are able to find a viable alternative to a muddy track, it is suggested you take it. It's easy to irreversibly damage the environment. If no alternative is available, take the time once through the bog to repair any damage you may have caused by filling wheel tracks with rocks and available materials. Keep to any existing wheel ruts and if the ground clearance of your vehicle is insufficient reverse out before getting too bogged.

There is no secret formula for mud driving other than that momentum is often the key to success, however this comes with an increase in risk. Recovering a bogged vehicle from mud can be a major time-consuming activity. The mud acts as a giant suction cup under the vehicle and breaking this seal is often very difficult and can be dangerous if not done correctly. The use of a High Lift Jack or Exhaust Jack may be a good option here. These will enable you to lift the bogged wheel up and pack rocks or wood or any other available material under the wheel. The vehicle is then carefully lowered and now has some traction.

Hi-Lift Jack being used.

If after attempting a muddy section you are not making headway, consider winching the vehicle through. This will result in much less strain on the vehicle and is going to be environmentally a better option.

Sand Driving

The 3 key elements to sand driving are:

1. Tyre pressures
2. Momentum / floatation
3. Gear selection

Let's take a look at each one individually.

Tyre Pressures

It's important to understand that when driving on soft sand you will need to reduce your tyre pressures in order to assist in spreading the weight of the vehicle and help in achieving the floatation required. A common misconception is that reducing your tyre pressure will increase the width of the tyre. In actual fact by reducing your tyre pressure, the tread elongates. You will however notice a bulging on the side walls of the tyres. As previously described, this makes them much more vulnerable to "staking" so be warned.

"What tyre pressure should I be running at"? That's a difficult one, as there are so many variables, and therefore there is no definitive answer. As a starting point Eureka 4WD Training recommends reducing your tyre pressures to 18 psi on soft sand.

You may find dependent upon conditions, tyre size and vehicle mass that you need to go even lower. Beware that you are now operating outside manufacturer's specifications.

The most important point to remember is **LOW PRESSURE = LOW SPEED.**

It's easy to roll a tyre off the wheel rim as well as rolling the car on its roof once your tyre pressures have been reduced, so take care.

You can use a simple test to find out if you have got your tyre pressures about right. On soft flat sand, take off in high range 1st gear, when you're ready to change up to 2nd gear just put your foot on the clutch and let the car roll forward. The car should roll about the full length of itself and come to a smooth stop.

Momentum / Floatation

One of the dangers in sand driving is that you need to keep up the momentum and/or reduce tyre pressures in order to keep up the floatation. This results in things happening at a faster rate and your reactions need to be able to keep up. A further reduction in tyre pressures can also help, however you then face a greater risk of bead separation. Lowering tyre pressures is often the safer alternative to higher speeds. Reading the terrain a long way in front of you helps you anticipate any changes you may need to make. Gear changes should be smooth and fast. This is one of the reasons that automatics are so good in the sand. Try to keep your vehicle in a straight line where you can, and when you do have to turn, keep it smooth, no sudden jerks on the steering wheel or jabs on the brakes. It's also important to know exactly which direction your wheels are pointing. It's very common to see drivers going along the beach following the tracks but with their wheels facing anywhere but forward. This causes your vehicle to "plough" and will make the whole trip on the sand more difficult and increase the risk of rolling the tyre off of the bead, not to mention increasing fuel consumption and adding to the chance of over-heating.

Help make things easier for yourself by anticipating stopping distances and try to stop without using the brakes. This helps you stop without "digging in" as you roll to a stop. Whenever you come to a stop slowly reverse back over your track for about a car's length. This will help compact the sand, which will help when it's time to move forward again. This technique should also be used for self-recovery if you are bogged and will help form a "runway" by compacting the sand forward and behind. You may need to go back and forth a few times.

Gear Selection

This will depend entirely on the condition of the sand and what vehicle you have so we can only generalise. Remember constant 4WD vehicles will need to lock in or select the center diff lock if fitted. The following is a guide.

Automatics

Automatics make it easy on the sand and unless you are trying some serious stuff the car will look after itself. Select High Range 4WD "D" for compacted to medium soft sand. Select Low Range 4 WD "D" for softer conditions. For steeper climbs and dunes, you may need to select Low Range 1st or 2nd.

Manuals

A lot of the beaches and sand tracks we drive on are very well compacted. High Range 4WD will normally work well under these conditions. Make gear selections the same as driving on the bitumen but remember to keep the changes smooth and watch out for soft spots. If you come across a soft spot you will need to drop down a gear and keep the revs up to get through. Once in a soft spot it is best to avoid changing gear as this normally results in loss of forward momentum and a sudden stop. If this does occur best to reverse back over your tracks, select the correct gear and have another go. When reversing back keep the revs low in an attempt to avoid wheel spin.

Soft sand and dunes will require a different approach. Low Range 4WD 2nd gear will be a good choice for most vehicles.

Some of the larger, more powerful petrol engines can cause their own problems by producing too much power at the wheels. The inexperienced driver can be tempted to apply too much power causing wheel spin and "tramping" where the car starts to bounce violently. Simply ease off of the accelerator and traction is soon gained, followed by a smooth ride.

Once the wheels are spinning and you're not moving, back off of the accelerator immediately. All you will achieve by keeping your foot on the accelerator is to dig yourself in deeper, which is going to make it harder to get out.

Now we have covered the three main aspects of sand driving, let’s take a look at some other points to consider.

If you plan to tackle a sand hill, remember to drive **straight up and straight down**. Never ever get sideways across a sand slope. If you do, the lower wheels will dig into the sand (and not slide) the center of gravity will have risen, and you run the real risk of rolling.

Please remember not to drive on vegetated dunes and to have a sand flag fitted to the front of your vehicle. The flag needs to be at least 2 meters above the bonnet and will let on-coming vehicles see you coming. Head on collisions on sand dunes are not uncommon.

Snow and Ice Driving

Some parts of Australia obviously never see snow or ice conditions; however, many do. Having a basic knowledge of driving techniques for these conditions is going to be advantageous.

Roads become extremely dangerous when covered in compacted snow or when the snow has been removed. You will need to adjust your driving speed to suit these conditions.

Snow Chains

One of the most dangerous phenomena is "black ice" caused either when snow has been removed in water run-off areas, in shaded areas or simply by frozen rain forming into ice. It's unlikely you will see the "black ice" if you drive too fast. You will lose control of your vehicle.

Good quality tyres with an aggressive tread pattern will assist with traction on snow and ice. Reducing tyre pressures will also assist. Fitting tyre chains is a good option and is a legal requirement in some areas. You will need to check local statutory regulations.

Also check the shape of the road signs in your State. Snow can cover road signs and make them unreadable. You will see that instructional road signs are a different shape to warning signs etc.

Road Sign Shapes

1. Reduce speed
2. Observe and obey road signs
3. Increase distance between vehicles
4. Test braking conditions
5. Use gears to slow down
6. Keep acceleration smooth
7. Avoid braking when cornering
8. Stay alert
9. Use snow chains when required (as per manufacturer's instructions)
10. Read the road a long way ahead
11. Select H4 in most conditions
12. Select L4 in deep snow drift
13. Keep windscreen and glass clear

Water Crossings

Motor vehicles were not designed to go through water. Because of this preparation and precautions need to be taken before you attempt a water crossing.

All water crossings should be walked first with only two exceptions. They are:

1. If the water flow is dangerous; or
2. Has crocodiles in it

If the water flow is such that you have difficulty walking it, then you wouldn't want to drive it. The vehicle would almost certainly be washed away by the current. If the water has crocodiles in it, wait for some local knowledge to arrive or find another route. Imagine getting stuck halfway across a water crossing that is full of crocodiles; it's not the best position to find yourself in.

If the water depth is going to be above axle deep you will probably be operating outside of the manufacturer's specifications and will need to prepare your vehicle for the crossing.

Other than personal injury there is a big risk of getting water into the compression cylinders of the engine. The water is likely to find its way in through the air intake, which is generally mounted at around headlamp level unless you have a snorkel fitted. It is also possible for the water to be sucked back through the exhaust system. If you stall the vehicle mid-stream and the tail pipe of the exhaust is below water level it is best to be towed to dry land. If you try to restart the vehicle under these conditions you are risking having water sucked back up the exhaust and into the engine. You cannot compress water, and if it gets into a compression cylinder it will damage the engine as the pistons come up. The repair would normally cost many thousands of dollars to fix, so it should be avoided.
Most modern vehicles now have some sort of computer control system. If you get stranded mid-stream or suffer from water ingress into the vehicle it is quite likely that the computer system will get wet. In the worst instance the computer will need replacement at great cost. You may be lucky and find that after a few hours it has dried out. Be aware that if the computer does get wet and you need to be towed, you may find that the brakes are "locked on". If this is the case you will need to trace and remove fuses, etc. Great care needs to be taken under these circumstances.

It is also possible to get water into the differentials and transfer case, all of which have short breather tubes on the top of them. Eureka 4WD Training recommends that these breather pipes are extended up to a high point under the bonnet to avoid water ingress.

Preparation check list for the Water Crossing:

- ✓ Allow a hot vehicle to cool down first, especially if turbo charged
- ✓ Walk the crossing where the wheels will be travelling in both directions
- ✓ Mark holes or obstacles with a stick
- ✓ Select Low Range (L4) 1st or 2nd Gear
- ✓ Air conditioner off
- ✓ If required, tie a tarp across front of vehicle to help avoid water ingress
- ✓ If needed attach exhaust extension pipe
- ✓ Have recovery strap attached to rear if you are the 1st vehicle
- ✓ Have recovery strap attached to front if you are the 2nd vehicle
- ✓ Check entry and exit points

The entry into the water should be made as smooth as possible and not too fast. You are trying to keep a smooth forward progress and to make a small bow wave at the front. Don't change gear mid-stream as you will wet the clutch and cause slippage. Once out the other side of the crossing, your brakes will be a bit weak and will need to be dried out. Applying a little pressure whilst driving will help to achieve this. Remove the tarp to prevent engine overheating once the crossing has been completed.

Brakes and undercarriage are checked en route

The risk of undercarriage damage is real. The types of terrain travelled will determine what type of damage is likely to occur however undercarriage inspections are going to be necessary. Pre-departure checks and daily inspections should be carried out as previously described, but additional checks are often needed en route.

The undercarriage, although protected in some areas by "bash plates", is very susceptible to damage. If you hear the undercarriage grounding it should be checked immediately, it's safe to do so. As a minimum you will be checking:

Transmission

- ✓ Brakes
- ✓ Steering
- ✓ Exhaust
- ✓ Suspension
- ✓ Tyres (inside walls)
- ✓ Fuel tank
- ✓ Fuel lines
- ✓ Brake lines
- ✓ Differentials

If travelling through or across areas of dry grass, you will need to stop on a very regular basis (every 30 minutes minimum) to check and clear grass from around the chassis and especially from around the exhaust system. Under these conditions there is a tendency for dried grass to get packed into these areas. The exhaust and engine do get very hot and if the grass is in contact with them it can catch fire. Total loss of the vehicle is not uncommon. Carry a piece of stiff wire with a hook on the end to assist in getting this grass out from awkward places. Also carry a fire extinguisher and a squeeze bottle or spray bottle of water. Keep all of these close to hand and ready for use in a hurry if needed.

Brakes need to be thoroughly checked for fouling by stones, mud and twigs, etc. After water crossings they will be wet and will need to be dried out as previously described. Hand brakes on four-wheel drive vehicles are notoriously ineffective and subject to damage. Have yours checked, cleaned and adjusted by a professional on a regular basis. Don't rely on your handbrake when parked on a hill. Leave the vehicle parked in reverse if facing down a hill or in 1st if parked facing up a hill. In both situations make sure the ignition is turned off to avoid the vehicle starting if it should roll. Automatic vehicles should be left in "P" with handbrake applied.

Repairs to damaged tracks are performed if necessary

Even after considering any planning for minimal environmental impacts, some damage to tracks is inevitably going to happen from time to time.

If you do the damage - it's up to you to fix it up.

Take the time to get out with a shovel and fix up any damage you may have caused. Fill the rut in the first instance with the displaced materials. Then with rocks, sticks or other materials available. If using sticks lay them across the rut rather than along the length of the rut. This will help avoid the sticks flicking up and causing damage to other following vehicles.

Failure to "do the right thing" will ultimately result in track closures or impassable track conditions in the future.

Track Damage

Track Repairs

Convoy Procedure

Travelling in a group is always a good idea if your intention is to be in remote locations. Safety in numbers will also mean that less equipment will need to be carried. For example, there is not much point in every vehicle carrying a Hi-Lift Jack or every vehicle carrying two snatch straps, etc. Prior planning will determine who carries what. Each vehicle should have a fire extinguisher on board and some sort of first aid equipment At least one vehicle should be carrying a fully comprehensive First Aid Kit.

There should be a nominated "Trip Leader" and "Tail End Charlie". It is also best to try and keep in the same convoy position as this will assist in communication with the trip leader knowing who is where at all times. In general, you will be responsible for not losing the person behind you. This will involve waiting at intersections until they have seen which direction you have gone. The following convoy procedure should be followed at all times.

1. Observe all road rules even when off-road. On the bitumen allow sufficient distance between vehicles to permit other road users to overtake.
2. Trip leader has ultimate authority and will appoint a “Tail End Charlie”.
3. Tail End Charlie is to keep the trip leader informed of progress and is responsible for leaving gates as found by the trip leader.
4. All vehicles to be responsible for the vehicle behind them i.e. at turn-offs, etc. wait for the following vehicle until they have seen you make the turn, plus periodic check for breakdowns.
5. Any vehicles leaving the convoy to notify the Trip Leader and/or Tail End Charlie. **Nobody** is left or unaccounted for.
6. No vehicle to pass leader, unless by agreement or in an emergency.
7. Keep a safe distance behind vehicle in front at all times. If a problem arises notify following vehicle immediately.
8. Only one vehicle at a time should be on any difficult obstacle. When the obstacle is clear the next vehicle should be called through.
9. Trip Leader or nominated persons to oversee difficult conditions and/or recovery.
10. Vehicles carrying emergency and/or recovery equipment to be given right of way.
11. In the event of an emergency, all vehicles and persons not involved are to remain clear.

Single Snatch Strap Use with Minimal Environmental Impact

Risks associated with vehicle recovery are identified and plans to minimise risks are developed and implemented

If a vehicle is in a situation that needs to be recovered it is because the driver has done something wrong. It could be many things like lack of preparation, failure to inspect the track first, selecting the wrong gear, not enough momentum, too much momentum; the list goes on and on. In any event, things have gone wrong, and they now need to be recovered safely. Just about every recovery situation is going to be different and have a different degree of difficulty and risk associated to it.

Personal safety must always be the first consideration.

Once people are safe, consideration can then be turned to the vehicle’s safety. This could be anything from potentially rolling over to being washed away to sea.

The speed at which you work will depend upon the situation. For example, if the vehicle is level going up a hill and simply lost traction the application of the brakes to stop it rolling backwards will hold the vehicle and there is probably no great rush. However, if the vehicle is bogged in sand on the beach with the tide rising and water lapping around the wheels, you are going to need to work fast to save the vehicle from total loss. The danger is that in these situations people tend to forget about creating extra risk. It's bad enough to have one vehicle in a recovery situation, don't rush in with another vehicle to attempt a recovery if it means both vehicles are going to end up in trouble.

The vehicle needing to be recovered often needs to be secured before the recovery takes place. This can be done by many varied methods including using ropes and/or winches to stop the vehicle rolling over. Half a dozen people standing on a sidestep on the high side of a vehicle leaning over can be a big help, however personal safety has to be your first priority. Everybody should keep well clear of the low side of a leaning vehicle. If it should rollover the people on the low side would be crushed, it happens fast, and you will have no chance to get out of the way. Bystanders should all be kept well clear of the recovery.

Selection of the correct equipment and recovery vehicle is going to play a big part in a successful recovery. Who is the most capable in the group and which vehicle is best suited for the task? There should only be one "Recovery Boss". The Recovery Boss can have many helpers, but he/she is the one issuing the instructions. The driver is ultimately responsible for their own actions, and they should discuss any concerns with the Recovery Boss.

Recovery hooks, mounting points on the four-wheel drive vehicle and use of rated recovery equipment

Please ensure that all recovery equipment such as shackles have a SWL (Safe Working Load) or WLL (Working Load Limit) stamped on them.

All recovery points should be fitted directly to the chassis where practicable, with high tensile steel nuts and bolts of an appropriate size. Eureka 4WD Training recommends that this is done by professionals. Recovery points should **NOT** be welded.

Due to the forces which can be applied during most recoveries, equipment that is **not rated** and of suitable size or strength should **not be used**.

Shackles with WLL (working load limit) &SWL (safe working load) Rating

Procedures for preparing vehicles for recovery

As we previously advised, if a vehicle is in a situation that needs to be recovered, there is a good chance the driver has done something wrong. This part of the manual deals with preparing the vehicle for recovery.

The first job is to select a "Recovery Boss". He, or she, should be judged to be the most knowledgeable person to deal with the current situation and be in the best position to do so.

The vehicle needing recovery has to be made safe as previously described. You will then need to select the most suitable vehicle to perform the recovery. The "most suitable" vehicle has many variables attached to it. It could be that it's in the best position to get to the stranded vehicle or that it's the only one with a winch (if that's what's needed) or that it's the only vehicle with rated recovery points. All recovery situations will be different and need to be treated with caution.

Passengers should be at least 1.5 times the length of the snatch strap away from the vehicles.

As you will see from this picture, the vehicles are set up in a straight line, and the use of a bridle will divide the load on the vehicle being recovered. This will also place less stress onto one side of the chassis.

There is a "dampener" placed 1metre from each end of the recovery snatch strap. This will then help drop the recovery gear to the ground should something break.

Bystanders who could be observing the set up will be moved at least one and half times the length of the outstretched strap away.

Both vehicles will be in 4WD with the recovery vehicle normally being in low range 1st and the vehicle being recovered one gear higher in low range 2nd.

Techniques to minimise impact on the environment during vehicle recovery

Recovering a vehicle bogged in mud is likely to cause track damage. We need to try and avoid this as much as possible and take actions as previously described to repair any damage caused.

Select 4WD and a gear that is less likely to cause wheel spin. Wheels spinning will not only cause more damage to the track but will dig the bogged vehicle in further making it more difficult to recover.

Try to keep people movement around the surrounding area to a minimum. This will help in avoiding extra damage being caused.

If you are part of a convoy of several vehicles, consider taking an easier alternative route rather than churning up a larger area by trying to get more vehicles through.

Any damage caused during the recovery should be repaired by back filling with displaced soil and/or available materials.

Technique for joining 2 snatch straps

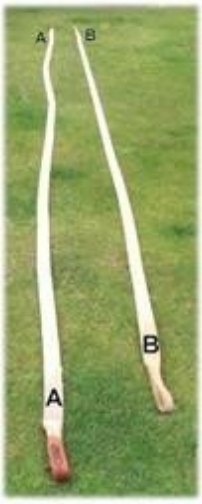
It is not uncommon to have a recovery situation where one snatch strap is not long enough to affect the recovery. This is often because the recovery vehicle can't reach the bogged vehicle without getting themselves bogged. Most 4WD snatch straps are 9 or 10m long and the recovery vehicle will need to get to within about 6m of the bogged vehicle so that there will be a couple of meters of slack strap in the middle.

So, we are going to need to know how to join two snatch straps together.

Please note: There is only **ONE** way to join two (2) snatch straps together. You should never join a snatch strap together using shackles or any solid object. You should only join 2 straps of equal rating together; never join a strap and a tow strap together. The dynamics (stretching and energy build up) of the snatch strap means that they should not be connected to a winch cable.

Joining 2 Straps Together

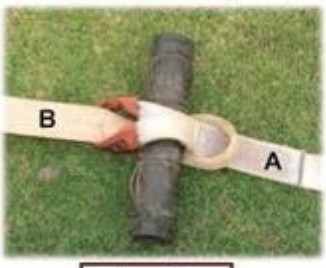
1. Lay the 2 straps out side by side. Let's call them "Strap A" and "Strap B".
2. At one end thread the eye of Strap A through the eye of Strap B.
3. At the other end thread, the eye of Strap B through the eye of Strap A.
4. Pull the eye of Strap A at one end and B at the other. The straps will pull together to form a figure 8.
5. Place a rolled-up newspaper, rolled up car mat, beach towel, or some other strong item between the straps at the figure 8 join to stop them knotting and binding up when put under load.



Step 1

Steps 2 & 3


Step 4



Step 5

Safe recovery of a four-wheel drive vehicle using a single snatch strap

The snatch strap is potentially one of the most dangerous pieces of recovery equipment you are likely to use. Dependent upon brand and size, the average snatch strap is capable of stretching up to 30% of its own length. There is a huge amount of force involved and will break other components in the "recovery chain" if not used correctly. That could include **you** so keep well clear.

The strap is used to recover a bogged or immobilised vehicle and operates similar to a giant rubber band, joined between two vehicles. The straps are known by a variety of names including Snatch Strap, Tug Em Strap, Snatchem, Mean Green, Black Rat and so on, however more correctly they should be known as Potential Energy Straps. They should not be used for normal towing of a vehicle due to the elasticity and the risk of damaging the strap if dragged along the ground. To be able to safely use a snatch strap, both vehicles **must** be fitted with rated recovery points that have been secured to the vehicle with high tensile steel nuts and bolts and fixed to a point that will withstand the applied load, generally the chassis.

Under no circumstances should a tow ball be used as a recovery point. These have killed people in the past when the tow ball has sheared off and come back through the windscreen. Any snatch strap showing signs of wear, fraying, nicks or cuts should not be used and should be destroyed.

Never use marker pen to write on your strap, the acetone in the pen will destroy it.

Appoint a Recovery Boss, as previously described. He/she can have lots of helpers if needed (for digging, etc.) but ultimately it is the job of the Recovery Boss to make sure all is safe. Also, please remember that if while you're helping a bogged vehicle out of their situation, you happen to damage their vehicle, it's your insurance company that has to pay the claim.

Snatch Strap in use

Recovery Using a Snatch Strap

1. Clear all obstacles that may impede the forward progress of the vehicle to be recovered.
2. If in a group, select most appropriate vehicle as the recovery vehicle. This would normally be the one closest with best access and correct recovery points
3. Check your strap prior to use for any cuts or wear and check the wear indicator. **Do not use worn out straps.**
4. Attach snatch strap to both vehicles' recovery points. **Never attach a snatch strap to a tow ball**. Ensure that the strap is not twisted and is free of knots
5. If connection must be made by a shackle use only quality bow shackles with a safe working load (SWL) suitable for the heavier of the two vehicles, normally 3.25 tonnes, giving a minimum breaking strength of 16.25 tonnes.
6. Place a wet hessian bag, blanket or towel over each end of the strap to act as dampeners should the strap break. This will also help prevent the strap flying up in the air should it break. These should be placed approximately 1 meter from each end.
7. Bystanders **must** be clear at least 1.5 times the length of the strap(s)
8. Both drivers should communicate with each other by pre-arranged signals on the horn
9. The recovery vehicle should leave about 2-3 meters of strap slack before commencing recovery.
10. The vehicle being recovered must have the engine running and attempt to drive in the direction being recovered. This would normally be done with low range selected, and in 2nd gear.
11. The recovery vehicle moves off at a moderate pace to put the kinetic energy of the recovery vehicle into the strap. This would normally be done with low range selected, and in 1st gear.
12. If the recovery is not successful on the first attempt repeat the procedure but use either more pace by the recovery vehicle or more slack on the snatch strap.
13. If after 3 unsuccessful attempts put the strap away and use another one. **Only use a strap 3 times in a half hour period.**
14. As soon as the recovered vehicle cleared the obstacle the driver sounded the horn as arranged to indicate to the driver of the recovery vehicle to stop.
15. Both vehicles slow down before coming to a halt. The recovered vehicle must not run over the snatch strap as this could cause damage to the strap and render it unsafe for use.
16. Both vehicles should apply their handbrakes and turn their engines off.
17. All recovery gear is now collected, inspected and securely stowed away

NOTE: Snatch strap recoveries can be performed forward or reverse.

Post recovery checks and repairs

Once the recovery has been completed a number of checks need to be made:

- ✓ Check both vehicles are safe with hand brakes on and engine off
- ✓ Check under the recovered vehicle as previously detailed in this training manual for damage to brakes, steering, suspension tyres, etc. ✓ Inspect all recovery points for damage
- ✓ Inspect all recovery equipment for damage
- ✓ Clean and stow recovery gear away safely
- ✓ Repair any damage caused to the track

If damage has occurred to the vehicles which render them un-roadworthy or dangerous, make the repairs if possible, or secure them for later recovery. If you leave a vehicle unattended or for later recovery leave a note on the dashboard with your intentions, lock the vehicle and make it safe.

The life of your snatch strap will be greatly increased if you look after it with care. The snatch strap can and should be washed. This can be done in a washing machine but only using a neutral cleaning agent such as baby shampoo or dish washing liquid or a detergent with a pH of 7.

Never leave your snatch strap in the sun to dry as the UV will damage it. Always leave it under a patio or anywhere away from direct sunlight.

Maintenance and Minor Repairs

Select maintenance equipment, including spares and fluids before departure

On long journeys to remote locations, you are probably going to be your own mechanic and workshop. You will need to be fully equipped to handle almost every situation. The rugged outback does and will take its toll on your vehicle. A well serviced and maintained vehicle is going to be vital for your survival in the outback.

For shorter journeys you will still need to be prepared for the unexpected and you will still need to carry some tools and spares.

Eureka 4WD Training recommend that you always keep a workshop and/or owner's manual in the vehicle. You may not be a mechanic yourself, but if you have a manual for the vehicle and meet someone who is, they may be more able to offer you some help.

The following list is not exhaustive and will need adaptation to suit your own work situation or recreational environment.

Some of the things to carry:

- Plenty of water
- A suitable tool kit for the vehicle which as a minimum should include:
- Spanners, socket set, mixed pliers, hammer, multi grips, file, selection of screwdrivers, multi meter, 12-volt soldering iron, multi core solder.
- Tyre repair kit
- Tyre compressor and pressure gauge
- Serviceable vehicle jack and a Hi-Lift jack if suitable for vehicle
- Engine fan belts & radiator/heater hoses
- Brake, clutch and power steering fluids
- Fuses & bulbs
- Air & oil filters
- Shock absorbers
- Bearings & seals (to suit)

Check vehicles regularly during trips and perform routine maintenance/repair tasks

Eureka 4WD Training vehicles are all fully serviced every 5000km. If any problems arise between services, they are fixed immediately. You should do the same. This may sound expensive (and it is) but the vehicle is your lifeline when out in the bush

Records are kept of fuel, oil and water use so that any changes can be monitored as it could be an indication of a potential problem. We suggest you do the same.
On extended trips you may wish to split your inspections into daily and weekly. The daily inspections have been covered.

Minimum Additional Weekly Checks:

- ✓ Checking the oil in the differentials and gear box
- ✓ Check the winch, if fitted, to ensure that it operates both in and out
- ✓ Check UHF and/or HF Radios
- ✓ Use test button on EPIRB (if you have one) to test it
- ✓ Check shock absorbers & springs
- ✓ Check air filter and clean

If you are undertaking repairs and servicing whilst in the bush, ensure that all old oils and fluids along with filters and any other waste, is collected and disposed of correctly when you return to work or home.

Vehicle performance reports

The condition and safety of a vehicle is the driver's responsibility. It is the driver's responsibility to report any deficiencies found during daily and weekly vehicle inspections. Any number of minor repairs can often be made by the driver in the field; however, these should also be reported and checked when the vehicle is next in the workshop.

Keep a logbook of faults you have found and the dates when they were reported for repair. Then check that the work has been carried out when you get the vehicle back, don't just assume that the work has been done.

If in your opinion a vehicle is unsafe to use, **don't use it**. For example, nobody is going to thank you for running off the road and rolling the vehicle if you knew that the steering or brakes were faulty.

Example of a Eureka 4WD vehicle log:

Vehicle Log

Rego Number:_____ **Driver Name:** _____
Department: _____

Date	Fault	Date Reported	Date Repaired	Checked By	Comments

Safe use of a jack to support a four-wheel drive vehicle on uneven ground

At some time, you will get a puncture and it's important that you know how to safely change a wheel. Loss of vehicle control is not uncommon when a tyre is quickly deflated or suffers a blowout. Keep the vehicle in as straight a line as is possible and gradually reduce speed. If possible, find a flat firm surface where you will be changing the wheel. If the surface is made up of soft sand or mud, you will probably need a jacking plate to prevent the jack from sinking into the ground. The ground must, however, be level.

There are a number of safety checks and actions to be made prior to changing the wheel.

- ✓ Stop vehicle on flat ground
- ✓ Handbrake on
- ✓ Ignition off and key removed
- ✓ Passengers off-loaded to a safe position away from traffic
- ✓ Leave in 1st gear low range if changing a front wheel
- ✓ Leave in reverse gear low range if changing a rear wheel
- ✓ Check jack and its operation (Hi-Lift Jacks should not be used to change wheels)
- ✓ Check and remove the spare wheel, place it alongside the car next to flat tyre
- ✓ Locate the manufacturer's recommended jacking points

At this point you are ready to start changing the wheel and the following sequence should be followed:

1. Chock the wheel diagonally opposite the one being changed
2. "Crack" (undo) the wheel nuts half of one turn on the punctured wheel
3. Position the jack under the manufacturer's jacking point and gently take up the weight of the vehicle
4. Gently rock the vehicle to ensure that the jack is correctly positioned
5. If it is, lift the vehicle to a height which will enable you to refit a fully inflated wheel
6. Remove loosened wheel nuts and remove wheel with the puncture

NO PART OF YOUR BODY SHOULD NOW BE UNDER THE VEHICLE

7. Fit spare wheel. You can use a shovel to assist in lifting the wheel on. Place a shovel at right angles to the hub and roll the spare wheel onto the blade of the shovel. By pushing down on the shovel handle this will help lift the spare wheel up.
8. Put all wheel nuts back on and gently "pinch" them up without trying to over tighten
9. Lower vehicle jack and remove jack
10. Tighten wheel nuts in a diagonally opposed order to give even pressure
11. Check the wheel nuts are still tight after driving for 5 kilometers and again after another 50 kilometers

Stability Control Systems

Some safety experts rate Electronic Stability Control (ESC) as the most important vehicle safety innovation since the introduction of seat belts.
Mercedes-Benz introduced ESC as standard equipment in 1999 and found that stability control equipped vehicles were involved in 42% fewer driver error related crashes than vehicles that did not have the system. Recent research by Monash University has shown similar significant reductions in single vehicle crashes.

ESC systems very effectively control understeer and oversteer by sensing the vehicle's attitude and altering engine power and brake application to correct it when necessary.

Electronic Stability Program ESP ®

Components of the Electronic Stability Program ESP

- ESP-Hydraulic unit with integrated ECU
- Wheel speed sensors
- Steering angle sensor
- Yaw rate sensor with integrated acceleration sensor
- Engine-management ECU for communication

To do this wheel speed sensors provide information about the vehicle's speed and acceleration, steering input and G-forces acting on the vehicle. The vehicle's rotation around its perpendicular axis and its lateral and longitudinal deceleration is also measured.

By analysing these inputs, the system's computer can calculate the appropriate curve or line the vehicle should be travelling along. Some manufacturers call this the "Target Yaw Rate".

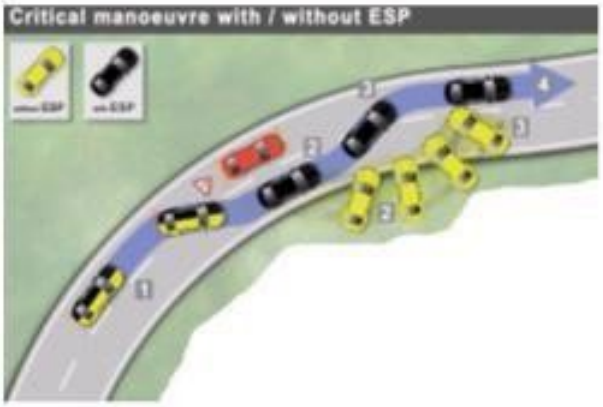
By comparing the vehicle's actual yaw rate to the target yaw rate, the computer can identify to what degree it is understeering or oversteering, and what corrective action, if any, is needed. Corrective action can involve reducing engine power and applying the brake on one or more wheels to realign the vehicle.

Current stability systems work hand-in-hand with the vehicle's Antilock Braking System (ABS) and in fact the two systems usually share wheel speed sensors and other hardware, while the ABS unit is used to apply the brakes as required.

Different systems have differing thresholds of intervention and vehicle manufacturers tailor the stability control system's operating characteristics to match the vehicle's desired handling characteristics. Some systems are switchable so the driver can choose if assistance is wanted.

Stability control is a worthwhile feature and is a mandatory safety feature on all new passenger vehicles built for Australian sale since November 2011.

Note that the preceding explanation is a general overview of the topic. Different vehicle manufacturers have different terms for components and their operation and may achieve the desired outcome in slightly different ways. There are also various names for the systems. Vehicle Stability Control, Vehicle Stability Enhancement, Dynamic Stability Control, Active Stability Control, Vehicle Dynamic Control, Vehicle Stability Assist and Electronic Stability Control are some.



Vehicle without ESP ®

1. Vehicle approaches an obstacle
2. Vehicle goes off course, enters oncoming traffic lane and driver loses control 3. Counter steering causes the vehicle to go into a skid

Vehicle with ESP ®

1. Vehicle approaches an obstacle
2. Vehicle threatens to break away. ESP intervenes and restores full steerability
3. Counter steer results in threat of renewed breakaway, ESP intervenes again
4. Vehicle is stabilised

- With modern vehicles that are equipped with this safety technology, you will have to turn this feature **OFF'** when driving over soft terrain such as sand, dirt and mud. Consult your owner's manual for instructions on how to fully turn this feature off.

- There is a lot of confusion between ESP and Traction Control. The feature that you will want to turn **OFF** is ESP and this could be by pressing the button from anywhere between one to 8 seconds to fully turn off the ESP program.

- If you do not turn **OFF** the ESP correctly whilst driving over soft terrain the system may behave as though you are in an understeer or oversteer situation and you will experience poor vehicle behavior such as power loss and braking features becoming a hinderance to forward progress. In most modern four-wheel drive vehicles, the ESP is automatically turned **OFF** once Low range 4WD is selected. If turned **OFF** manually once you turn off and re start the ignition the ESP will be turned back on by default due to its safety feature.

Conclusion

This publication is an important recourse tool for you to keep and reference whenever the need arises.

Please feel free to use this Trainer Manual as a reference for any situation you find yourself in whilst travelling in your four-wheel drive.

safe work australia

Guide for MANAGING THE RISK OF FATIGUE AT WORK

NOVEMBER 2013

Safe Work Australia is an Australian Government statutory agency established in 2009. Safe Work Australia consists of representatives of the Commonwealth, state and territory governments, the Australian Council of Trade Unions, the Australian Chamber of Commerce and Industry and the Australian Industry Group.

Safe Work Australia works with the Commonwealth, state and territory governments to improve work health and safety and workers' compensation arrangements. Safe Work Australia is a national policy body, not a regulator of work health and safety. The Commonwealth, states and territories have responsibility for regulating and enforcing work health and safety laws in their jurisdiction.

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TABLE OF CONTENTS

1. INTRODUCTION

This document provides practical guidance for persons conducting a business or undertaking and other duty holders on how to manage fatigue to ensure it does not contribute to health and safety risks in the workplace.

The information in this guide can be applied generally to all types of work and workplaces covered by the Work Health and Safety (WHS) Act. It is not designed to provide information on managing fatigue in specific industries and does not replace requirements related to fatigue under other laws, for example heavy vehicle driver fatigue laws or rail safety requirements. This information is available in the National Transport Commission's Guidelines for Managing Heavy Vehicle Driver Fatigue and the National Rail Safety Regulator's Guidance on Fatigue Risk Management Program. Working hours may also be subject to industrial awards or enterprise agreements.

What is fatigue?

Fatigue is more than feeling tired and drowsy. In a work context, fatigue is a state of mental and/or physical exhaustion which reduces a person's ability to perform work safely and effectively.

It can occur because of prolonged mental or physical activity, sleep loss and/or disruption of the internal body clock.

Fatigue can be caused by factors which may be work related, non-work related or a combination of both and can accumulate over time.

Chapter 2 provides further information about factors which may cause fatigue.

Why is fatigue a problem?

Fatigue can adversely affect safety in the workplace. Fatigue reduces alertness which may lead to errors and an increase in incidents and injuries, particularly when:

- operating fixed or mobile plant, including driving vehicles
- undertaking critical tasks that require a high level of concentration
- undertaking night or shift work when a person would ordinarily be sleeping.

The effects of fatigue can be short or long term. In the short term a person may show the signs or report the symptoms of fatigue outlined in section 1.3.

The longer-term health effects of fatigue can include:

- heart disease
- diabetes
- high blood pressure
- gastrointestinal disorders
- lower fertility
- anxiety
- depression.

How can you tell if someone is fatigued?

The following signs or symptoms may indicate a worker is fatigued:

- excessive yawning or falling asleep at work
- short term memory problems and an inability to concentrate
- noticeably reduced capacity to engage in effective interpersonal communication
- impaired decision-making and judgment
- reduced hand-eye coordination or slow reflexes
- other changes in behavior, for example repeatedly arriving late for work
- increased rates of unplanned absence.

A fatigued worker may also experience symptoms not obvious to others including:

- feeling drowsy
- headaches
- dizziness
- difficulty concentrating
- blurred vision or impaired visual perception
- a need for extended sleep during days off work.

Who has health and safety duties in relation to managing the risks of fatigue?

Everyone in the workplace has a work health and safety duty and can help to ensure fatigue does not create a risk to health and safety at work. Fatigue is not only caused by work-related activities – it is affected by all activities carried out when a person is awake.

Table 1 Health and safety duties in relation to managing the risks of fatigue

Who	Duties
Person conducting a business or undertaking (section 19)	Has the primary duty to ensure, so far as it is reasonably practicable, workers and other persons are not exposed to health and safety risks arising from the business or undertaking. This includes ensuring, so far as is reasonably practicable: • provision and maintenance of a work environment without risks to health and safety • provision and maintenance of safe systems of work, and • monitoring the health of workers and the conditions at the workplace for the purpose of preventing illness or injury of workers arising from the conduct of the business or undertaking. The duty on the person conducting the business or undertaking is not removed by a worker's preference for certain shift patterns for social reasons, their willingness to work extra hours or to come to work when fatigued. The person conducting the business or undertaking should adopt risk management strategies to manage the risks of fatigue in these circumstances.
Officer (section 27)	Officers such as company directors must exercise due diligence to ensure the business or undertaking complies with its work health and safety duties. This

Who	Duties
	includes taking reasonable steps to ensure the business or undertaking has and uses appropriate resources and processes to manage the risks associated with fatigue.
Worker (section 28)	Workers must take reasonable care for their own health and safety and must not adversely affect the health and safety of other persons. Workers must also comply with any reasonable instruction and cooperate with any reasonable policy or procedure relating to fatigue at the workplace, such as policies on fitness for work or second jobs. Workers' duties in relation to fatigue do not mean they must never work extra hours. However, they should talk to their manager or supervisor to let them know when they are fatigued. They should also avoid working additional hours and undertaking safety critical tasks when they know it is likely they are fatigued.

How can the risks of fatigue be managed at the workplace?

Measures to manage the risks associated with fatigue will vary from one workplace to the next, depending on the nature of the work, environmental conditions and individual factors.

The risks associated with fatigue can be managed by following a systematic process (described in more detail in Chapter 2) which involves:

- identifying the factors which may cause fatigue in the workplace
- if necessary, assessing the risks of injury from fatigue
- controlling risks by implementing the most effective control measures reasonably practicable in the circumstances, and
- reviewing control measures to ensure they are working as planned.

Further guidance on the general risk management process is provided in the Code of Practice: *How to manage work health and safety risks.*

Consulting workers

Consulting workers at each step of the risk management process encourages everyone to work together to identify fatigue risk factors and implement effective control measures. Consultation also helps to raise awareness about the risks of fatigue.

Section 47: A person conducting a business or undertaking must consult, so far as is reasonably practicable, with workers who carry out work for the business or undertaking who are (or are likely to be) directly affected by a work health and safety matter.

Section 48: If the workers are represented by a health and safety representative, the consultation must involve that representative.

Consultation involves sharing information, giving workers a reasonable opportunity to express views and taking those views into account before making decisions on health and safety matters.

Workers and their health and safety representatives (if any) must be consulted, so far as is reasonably practicable when:

- planning and designing work schedules and rosters
- making decisions on how to manage the risks of fatigue
- proposing changes to working hours, work schedules and procedures
- making decisions about providing information and training on fatigue
- after an incident or 'near miss where fatigue was a factor.

Consulting, co-operating and coordinating activities with other duty holders

Section 46: A person conducting a business or undertaking must consult, co-operate and co-ordinate activities with all other persons who have a work health or safety duty in relation to the same matter, so far as is reasonably practicable.

Sometimes more than one person conducting a business or undertaking may have responsibility for health and safety because they are involved in the same activities or share the same workplace. In these situations, they must communicate with each other to identify and assess health and safety risks associated with fatigue and work together in a co-operative and coordinated way, so these risks are eliminated or minimised so far as is reasonably practicable.

For example, if a business provides on-hire workers who carry out shift work for a host business, both businesses have a duty of care to the workers. The business owners will need to discuss whether fatigue may be a potential hazard and consider issues such as the mental and physical demands of the job, shift rosters and working hours. The on-hire business will need to consider the cumulative effect of fatigue arising from all the different workplaces the worker is sent to and agree on arrangements to manage the risks of fatigue with each business.

Further guidance on consultation is available in the Code of Practice: *Work health and safety consultation, co-operation and co-ordination*.

2. HOW TO MANAGE RISKS ASSOCIATED WITH FATIGUE

Factors that may contribute to and increase the risk of fatigue

The first step in the risk management process is to identify all reasonably foreseeable factors which could contribute to and increase the risk of fatigue. There may not be obvious signs of fatigue at the workplace, but this does not mean it is not occurring or factors which may increase the risk of fatigue are not present.

Fatigue is often caused by a number of inter-related factors which can be cumulative. The major factors contributing to and increasing the risk of fatigue involve:

Work schedules – shift work, night work, hours of work, breaks

Work schedules which limit the time workers can physically and mentally recover from work may cause fatigue, for example early shift start times or late finishes, short breaks between shifts, shifts lengthened by overtime or double shifts and not enough non-sleep rest breaks during a shift.

Working at night when the body is biologically programmed to sleep can interrupt a person's body clock. The body clock is the body's natural rhythm repeated every 24 hours. It regulates functions including sleeping patterns, body temperature, hormone levels and digestion. As it is programmed for different levels of wakefulness, people experience different levels of alertness depending on the time of the day.

When a person's body clock is out of step alertness decreases, making them feel fatigued. This increases the risk of making errors and causing incidents and injuries, either in the workplace or outside of work, including on the way to and from work.

Job demands

Some types of work, for example concentrating for extended periods of time, performing repetitious or monotonous work and performing work requiring continued physical effort can increase the risk of fatigue.

Workers can be mentally and physically fatigued at the same time. Work, which is reactive and performed under high pressure, for example emergency services, may also increase the risk of fatigue.

Sleep – length of sleep time, quality of sleep and time since sleep

While tired muscles can recover with rest, the brain can only recover with sleep. The most beneficial sleep is deep undisturbed sleep taken in a single continuous period.

The optimum amount of sleep varies for each person; however, an adult generally requires seven to eight hours of sleep daily.

When individuals get less sleep than they need in a day, they build up a sleep debt which accumulates until they can get enough sleep to overcome the sleep debt. Each extra day without enough sleep increases the debt, and when it becomes large enough fatigue can occur. It may take several days before a person recovers from a sleep debt. Sleep debt is common with night shift workers as they often experience difficulty getting enough undisturbed sleep during the day.

One sleepless night can have similar effects to someone as drinking too much alcohol.

Environmental conditions

Working in harsh and uncomfortable conditions can contribute to fatigue, for example, exposure to heat, cold, vibration or noisy workplaces can make workers tire quicker and impair performance.

Non-work-related factors

Factors occurring outside of work may also contribute to fatigue. A worker's lifestyle, family responsibilities, health (e.g. insomnia, sleep apnea, some medication), other work commitments, and extended travel between work and home may all increase the risk of fatigue.

How to identify factors that may contribute to or increase the risk of fatigue

Methods to identify factors which may contribute to or increase the risk of fatigue can include:

- *Consult with workers*, including managers, supervisors and health and safety representatives (if any) about the impact of workloads and work schedules, including work-related travel and work outside of normal hours (for example work a person has taken home to complete).
- *Examine work practices* and systems of work, for example:
    - the degree of choice and control workers have over work hours, the pace of work and rest breaks, and
    - the type of work culture, for example, where there is accepted practice of working long hours.
- *Examine worker records*, for example sign-in-out sheets, billing sheets and shift changeovers, to determine working hours and in particular whether excessive hours have been worked or hours have been worked at times which may have led to body clock disruption.
- *Getting advice and information* on fatigue from relevant experts, research, guidance materials and data published by regulators, industry associations, unions or other sources.
- *Review workplace incident data*, including incidents travelling to and from the workplace, and ask the following questions:
    - What is the likelihood fatigue is contributing to the incidents?
    - What time of day do incidents occur?
    - When incidents have occurred, how long have the workers involved been working? For example, time since start of shift, number of hours worked that week and in the preceding three months.
    - Do the incidents often happen when a worker's body clock slows down and concentration is poor?
- *Review human resource data*, for example rates of unplanned absenteeism, staff turnover and workers compensation claims. Those with an injury or illness may be at greater risk of becoming fatigued.

The checklist at Appendix A can be used to assist in identifying factors in your workplace which increase the risk of fatigue.

Workers at high risk of fatigue

Some workers are at a higher risk of fatigue because their work typically involves some or all of the factors which contribute to fatigue, for example:

- shift workers
- night workers
- fly-in, fly-out workers (FIFO)
- drive in, drive out (DIDO)
- Seasonal workers
- on-call and call-back workers
- emergency service workers
- medical professionals and other health workers.

Safety critical tasks

It is particularly important to identify fatigue risks which might arise when safety critical tasks are carried out. Safety critical tasks are those where the consequences of a mistake or error in judgment could cause serious injury, for example:

- driving a road vehicle, such as a taxi or courier van, or operating a crane or other high-risk plant
- working at heights
- participating in medical or surgical procedures and settings
- working with flammable or explosive substances
- other types of work identified as hazardous, for example electrical work.

Assessing the risks

A risk assessment can assist in finding out:

- where, which and how many workers (including contractors and subcontractors) are likely to be at risk of becoming fatigued
- how often fatigue is likely to occur
- the degree of harm which may result from fatigue
- whether existing control measures are effective
- What action should be taken to control the risk of fatigue
- how urgently action to control the risk needs to be taken.

When assessing risks, contributors to fatigue should not be considered in isolation. For example, job demands, hours of work and environmental conditions may all increase the risk of fatigue in the workplace. The risks of injury from fatigue may increase if workers work long daily hours in a physically or mentally demanding job. This risk of fatigue may increase when new workers begin their job and are adjusting to work demands.

Risk assessment methods are similar to the methods used to identify factors contributing to fatigue in section 2.1 therefore these steps can be carried out at the same time.

It is not necessary to conduct a risk assessment in all circumstances.

Controlling the risks

The best way to control the health and safety risks arising from fatigue is to eliminate the factors causing fatigue at the source.

If elimination is not reasonably practicable, the risks must be minimised.

What is reasonably practicable to do to manage the risk of fatigue will vary depending on the type of industry, the structure of an organisation as well as the person carrying out the work.

For example, control measures a small business implements to manage the risk of fatigue may differ from those implemented by a large corporation with 300 shift or night workers, or those implemented by an emergency service organisation when it is operating under emergency response conditions.

Factors contributing to the risk of fatigue are often interrelated. Incorporating a combination of control measures into general workplace systems, as well as control measures specific to the work, can help to minimise more than one contributor to fatigue. For example, increasing the amount of time between shifts and adjusting shift starting times may improve the opportunity for sleep.

Work scheduling

Control measures for fatigue risks which can be built into a work schedule may include:

- designing working hours and rosters to allow for good sleep opportunity and enough recovery time between workdays or shifts for travelling, eating, washing and sleeping
- developing a working-hours policy on daily work hours, maximum average weekly hours, total hours over a three-month period, on-call work and work-related travel
- developing procedures to manage and limit excessive working hours, for example requiring minimum breaks on a regular basis, especially during longer shifts
- ensuring workers have and take adequate and regular breaks to rest, eat and rehydrate
- scheduling safety critical work outside the low body clock periods between 2am and 6am, and between 2pm and 4pm
- managing workload and work-pace change caused by machinery breakdowns or planned and unplanned absences
- avoiding work arrangements which provide incentives to work excessive hours
- managing overtime, shift swapping and on-call duties
- implementing processes to manage accrued leave balances and requests for leave, for example setting maximum limits of leave accrual to encourage workers to use it
- considering future rosters and schedules when approving request for leave or shift swaps, and ensuring leave is reflected in rosters
- having access to on-call workers for unplanned leave, emergencies or where workload increases
- developing plans to deal with workload changes due to absenteeism
- filling vacant positions as soon as reasonably practicable and maintaining a relief pool of staff in high demand areas where fatigue is a risk
- considering alternative options for face-to-face meetings, for example teleconferencing so workers are not required to spend time travelling to meetings.

Shift work and rosters

When planning work schedules and rosters for specific work arrangements, including shift and night work, FIFO, DIDO, seasonal, on-call and emergency services work arrangements, consideration should be given to implementing additional specific control measures.

Specific control measures may include:

- structuring shifts and designing work plans so work demands are highest towards the middle of the shift and decrease towards the end
- avoiding morning shifts starting before 6am where possible
- avoiding split shifts or if there is no alternative to split shifts consider their timing, for instance whether they are likely to disrupt sleep
- setting shift rosters ahead of time and avoiding last-minute changes, to allow workers to plan leisure time
- allocating shift and night workers consecutive days off to allow for at least two full nights' sleep including some weekends
- aligning shift times with the availability of public transport or if required, provide alternative transport at the end of a long shift
- overlapping consecutive shifts to allow enough time for communication at shift handovers
- avoiding overtime allocation after afternoon or night shifts
- consider if night work is necessary and rearrange schedules so non-essential work is not carried out at night
- keeping sequential night shifts to a minimum, and
- providing information to shift workers containing tips for them to prevent and manage the risk of fatigue.

Appendix B provides further guidance for designing shifts.

Job demands

Control measures to prevent or minimise the risk of fatigue can include:

- ensuring fit-for-purpose plant, machinery and equipment are used at the workplace (for example, ergonomic furniture, lifting equipment and anti-fatigue matting for repetitive tasks performed while standing)
- encouraging workers to report concerns they may have about work-related fatigue
- redesigning the job to limit periods of excessive mental or physical demands
- introducing job rotation to limit a build-up of mental and physical fatigue
- developing contingency plans for potential situations where workers may have to unexpectedly work longer hours, more shifts or a long sequence of shifts, and
- planning for expected changes in workflow including anticipated peaks and troughs during the year.

Environmental conditions

- Avoid working during periods of extreme temperature or minimise exposure time through job rotation.
- Provide a cool area where workers can take a rest break and rehydrate in hot work environments.
- Install ventilation and mechanical cooling devices in hot, small and enclosed spaces such as truck cabins.
- Provide adequate facilities for rest, sleep, meal breaks, onsite accommodation (if appropriate).
- Install adjustable, low-vibration seats in machinery and vehicles and provide low vibration handheld equipment.
- Provide and maintain a workplace which is well lit, safe and secure.

Non-work-related factors

Work and lifestyle often impact each other. For example, if a worker leaves their job tired and exhausted, they may be less able to perform out-of-work activities or could be a danger to themselves and others when driving home tired. Likewise, if a worker arrives at work fatigued, they may be less productive or could be a danger to themselves and others in the workplace.

A person conducting a business or undertaking cannot control what a worker does outside of work. Workers have a duty to take reasonable care for their health and safety, and this includes enough sleep so they can arrive at work ready for duty. However, controls can be implemented to avoid potential conflicts between personnel and work demands, for example:

- develop a fatigue policy for all workers including managers and supervisors,
- consult workers about managing fatigue not just when at work, the risks associated with fatigue and how it relates to their health and safety duties.

Workplace fatigue policy

A fatigue policy is not mandatory but may be an effective way to communicate the organisation's procedures to workers. Consider including information about:

- roles and responsibilities of supervisors and workers
- maximum shift length, average weekly hours and total hours over a three-month period
- work-related travel
- control measures for specific tasks, jobs and operations
- self-assessment checklists
- procedures for reporting potential hazards and fatigue risks, and
- procedures for managing fatigued workers, including what will happen if they are too fatigued to continue work (e.g. temporary task re-allocation).

A fatigue policy can be included with other work health and safety policies, for example policies on bullying, drugs and alcohol and fitness for work and should be developed in consultation with workers or their health and safety representative.

A risk management chart at Appendix C provides further guidance on identifying, assessing and controlling the risks associated with fatigue.

Information, instruction, training and supervision

Section 19: A person conducting business or undertaking must provide, so far as is reasonably practicable, any information, training, instruction or supervision necessary to protect all persons from risk to their health and safety arising from work carried out as part of business or undertaking.

Providing information and training to workers about the factors that can contribute to fatigue and the risks associated with it will help them to not only do their job but also implement control measures to minimise the risk of fatigue in the workplace.

Training about fatigue and relevant workplace policies should be arranged so it is available to all workers on all shifts. Information and training for workers should include:

- the work health and safety responsibilities of everyone in the workplace
- the factors that can contribute to fatigue and risks that may be associated with it
- symptoms of fatigue
- the body clock and how fatigue can affect it
- effective control measures for fatigue, for example work scheduling
- procedures for reporting fatigue
- effects of medication, drugs and alcohol
- nutrition, fitness and health issues relating to fatigue
- balancing work and personal demands.

Managers and supervisors

Managers and supervisors should be trained to:

- recognise fatigue
- understand how fatigue can be managed and how to implement control measures, including how to design suitable rosters and work schedules in consultation with workers
- take appropriate action when a worker is displaying fatigue related impairment.

An appropriate level of supervision should be provided (for example a higher level of supervision for safety critical tasks), which may include monitoring work to ensure safe work practices are followed.

Monitoring and reviewing

Once control measures are implemented, they should be monitored and reviewed to ensure they continue to effectively manage fatigue. Consider implementing trial periods for any new work schedules and encouraging workers to provide feedback on their effectiveness.

To determine the frequency of monitoring and review consider the level of risk — high-risk hazards need more frequent assessments. Control measures should also be reviewed when:

- there is any indication risks are not being controlled
- new tasks, equipment, procedures, rosters or schedules are introduced
- changes are proposed to the work environment, working hours, schedules and rosters
- there is an incident due to fatigue at the workplace

- new information regarding fatigue becomes available, and
- the results of consultation, including a request from a health and safety representative, indicate that a review is necessary.

The case studies in Appendix D provide examples of ways to implement control measures in managing the risk of fatigue in the workplace.

APPENDIX A – FATIGUE CHECKLIST

This checklist provides guidance to assist in identifying risks of fatigue but is not an exhaustive list of risk factors. If the answer is yes to any of the questions, fatigue risks may need to be further assessed and control measures implemented.

Mental and physical work demands	
Does anyone carry out work for long periods which is physically demanding? (for example, tasks which are especially tiring and repetitive such as bricklaying, process work, moving bags of cement, felling trees)	Yes/No
Does anyone carry out work for long periods which is mentally demanding? (for example, work requiring vigilance, work requiring continuous concentration and minimal stimulation, work performed under pressure, work to tight deadlines, emergency call outs, interacting/dealing with the public)	Yes/No
Work scheduling and planning	
Does anyone consistently work or travel between midnight and 6am?	Yes/No
Does the work schedule prevent workers having at least one full day off per week?	Yes/No
Does the roster make it difficult for workers to consistently have at least two consecutive nights sleep per week?	Yes/No
Do work practices include on-call work, call-backs or sleepovers?	Yes/No
Does the roster differ from the hours actually worked?	Yes/No
Does the work roster include rotating shifts?	Yes/No
Does anyone have to travel more than one hour to get to their job?	Yes/No
Work Time	
Does anyone work in excess of 12 hours regularly (including overtime)?	Yes/No
Does anyone have less than 10 hours break between each shift? (for example, split shifts, quick shift changeovers)	Yes/No
Is work performed at low body clock times (between 2 am and 6 am)?	Yes/No
Environmental conditions	
Is work carried out in harsh or uncomfortable conditions? (for example, hot, humid or cold temperatures)	Yes/No
Does anyone work with plant or machinery that vibrates?	Yes/No
Is anyone working with hazardous chemicals?	Yes/No
Is anyone consistently exposed to loud noise?	Yes/No
Non-work factors	
Are workers arriving at work fatigued?	Yes/No