28| Vehicle-Dependent Expeditions

Tom Sheppard

There are two key rules to be obeyed when fitting out a vehicle for an expedition: never exceed the vehicle's design limitations in terms of:

1. Payload, or
2. Terrain

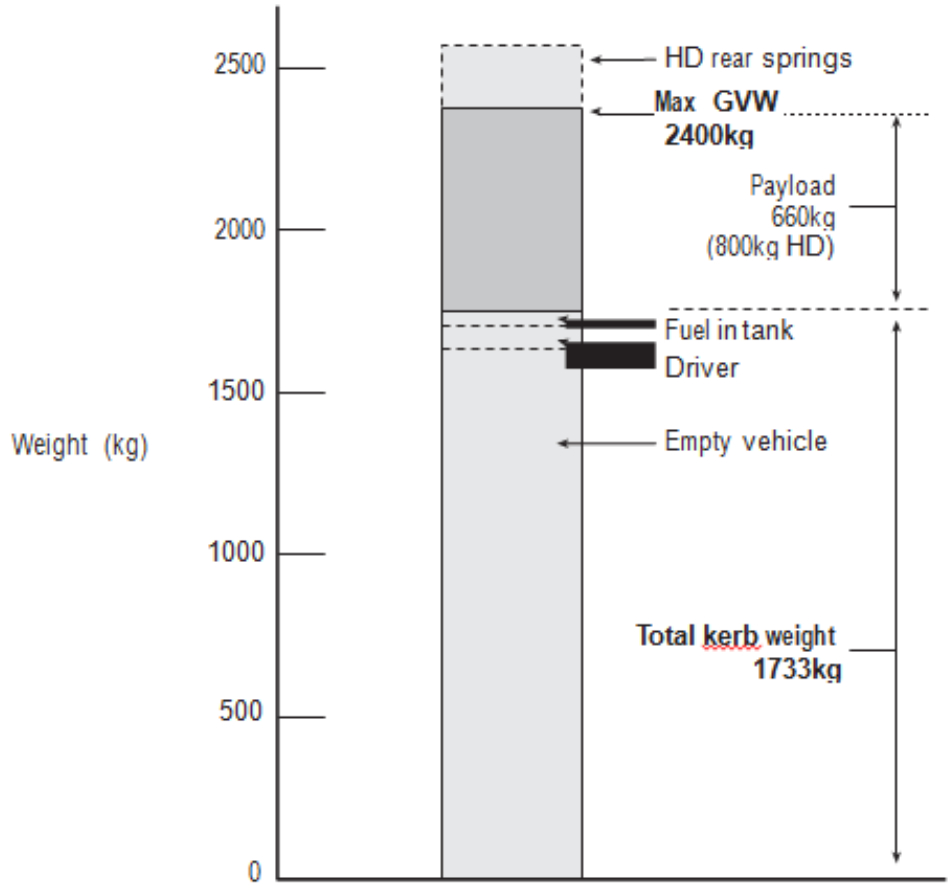
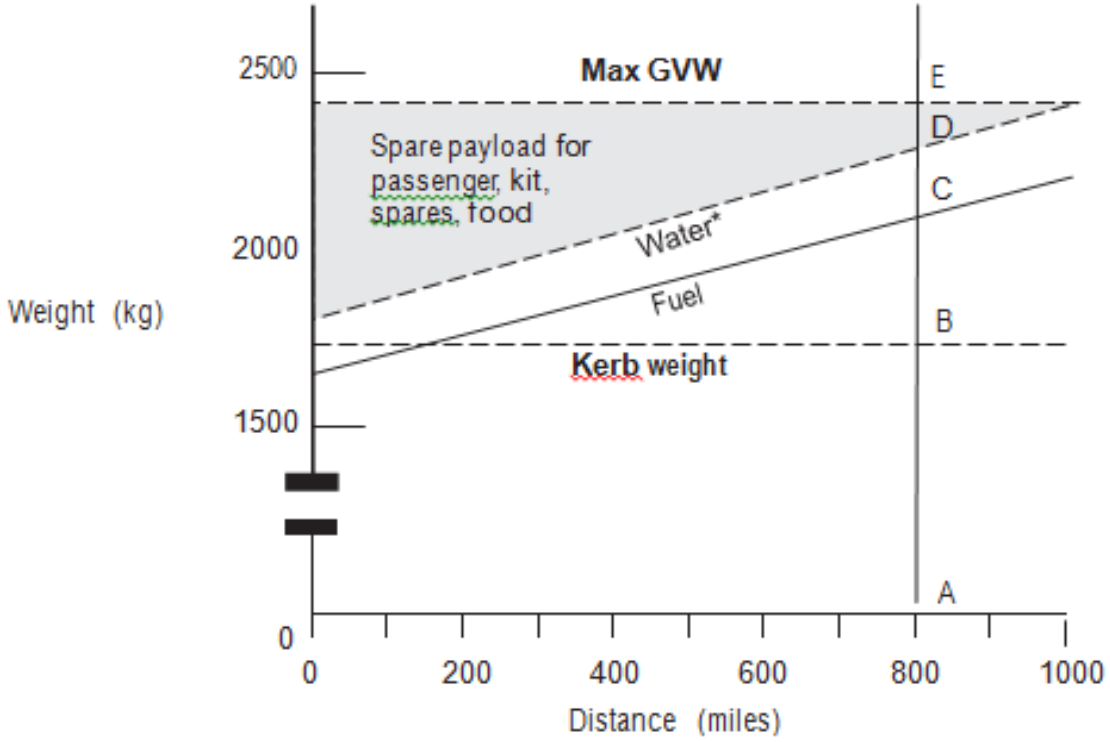


Figure 28.1 How a vehicle's GVW (gross vehicle weight) is made up. Never exceed it by adding too much payload. Figures shown are for Defender 90



***Water: for two crew, 7.5 ltr/day, 150 miles/day.**

†Fuel: assumes 15 mpg V8 to highlight load. Diesel would yield 25–30 mpg.

Figure 28.2 Payload versus range. This graph, for a V8 Defender 90, shows vividly how operating range (distance between replenishment points) erodes spare payload. In a fairly extreme case, on an 800-mile leg, A–B is kerb weight, B–C is fuel load, C–D is water required, leaving only 150 kg (D–E) for a 75-kg passenger and remaining kit. In real life you would go diesel, shorten legs and/or get a bigger vehicle such as the Land Rover Defender 110 or a robust 4 x 4 pickup such as a Toyota Hilux. Fuel calculations assume reserve, i.e. distance 100 miles 25 per cent. Bigger vehicle equals more payload but less power:weight ratio (see Figure 28.6).

Payload and range

You must stick to load limits. Gross vehicle weight, or GVW, is the “never exceed” or maximum permitted weight of a vehicle. It is made up of the empty (or “kerb”) weight and the load, i.e. fuel, driver, passengers and cargo. In general a big vehicle can carry more cargo for a much longer distance than a small one.

For a given vehicle and crew, the distance (and days) between replenishment points dictate the load of essentials such as fuel and water that you need to carry. The available spare payload for food, spares, camping gear and other cargo follows from there and will diminish as the length of the journey – and thus the fuel load – goes up.

Terrain

The kind of tracks or terrain that you have to traverse, although less easy to quantify, is another dominating factor in defining the task that your expedition vehicle needs to do. There could well be routes straightforward enough to cover in a normal two-wheel drive (4 x 2) van or pickup. If the terrain is more demanding or is uncertain you will want more ground clearance or off-road capability to use or have in reserve.

Figure 28.3 The third generation Range Rover (top), like the up-spec Land Cruiser and Jeep Cherokee (bottom), are rare examples of high-comfort 4 x 4s with exceptional off-road ability. Payload, however, is limited. (© Tom Sheppard)

No-frills functionality
There is no law against having fun in a 4 x 4 or against being luxuriously comfortable when logistics permit but, although the divisions are not hard and fast, it is worth having in the back of your mind the following broad categories of vehicle:

- lightweight “fun” vehicles (RAV4, Jimny, Honda HRV)
- luxury vehicles with not much payload (Range Rover, Cadillac Escalade)
- Working” vehicles for expeditions: no frills, plenty of payload (Defender, Pinzgauer, Toyota Type 75 and 78, simple-spec Land Cruiser, 4 x 4 pickups).

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HOW MANY VEHICLES, LOAD, TYPE?

Spreading the load – and the risk
One big vehicle or two small ones? Some journeys will naturally be multivehicle, for others there may be a choice. Influences will be:

- Degree of mobility required by any subgroups
- Cost of multivehicle ferry fares, etc.
- Difficulty of terrain: large vehicles tend to be less athletic than small ones – but two small ones can tow one large one when it sticks
- Safety in case of breakdown of a single vehicle.

Do not let this last consideration stem from a feeling that breakdown and damage are inevitable. Rather take the opposite view that the implications of breakdown or damage on an expedition can be so dire or so expensive that they must not be allowed to occur. Driving, general care and maintenance standards must be that good.
Nevertheless, random mechanical failures do occur and a backup vehicle and one to help in towing out a stuck vehicle will be invaluable. The payoff in peace of mind is high. If you can, never take fewer than two vehicles – three is best because the entire load from one incapacitated vehicle can in many cases be transferred and spread without overloading the other two.

Figure 28.4 Outer limits. Long-range load carrier pushing its luck – two-wheel drive and no support vehicles. Ample manpower, however, is beneficial in boggings (© Tom Sheppard)

Overloading – excuses

Overloading your vehicle must not be considered an option. “Ah, but there are margins…” say some. And margins are exactly what you want on an expedition over difficult terrain in foreign parts. “Ah, but I’ve seen vehicles with roof racks up to here…”, say some, and they will also probably have seen the same vehicles rolled on to their sides as a result of the high centre of gravity or with cracked pillars because of the fatigue loads on elements not designed for the stress. “Ah, but you can fit stronger springs…”, say some, and in doing so merely transfer more road shocks into an already overladen chassis. Don’t be misled by the appearance of rally vehicles operating on a wing and a prayer and having huge backup safety infrastructures. Ordinary expeditions are not like this, and should operate with maximum safety margins. So, when considering your vehicle requirement, do not let the idea of upping the load even enter your head.

Figure 28.5 Classic example of a fuel-carrier trailer off-loading the main vehicle. Note also how the under-tyred tug has bogged whereas the lightly laden trailer on larger tyres at low pressures rides over the soft sand (© Tom Sheppard)

Trailers – 50 per cent more axles

You may well encounter the problem of having a greater load and bulk than the vehicle's size and payload maximum. A vehicle with a trailer is less agile than one without but a given load may be spread over six instead of four wheels. So long as two or three people are available to manhandle it, a trailer can be a solution – provided that it is really robust (e.g. an ex-military three-quarter-ton trailer such as those used behind army Land Rovers). Towing arrangements will have to be similarly upgraded – usually a NATO towing pintle. Be sure that the trailer's shock dampers are in first- rate condition when you buy it; they will keep lateral roll in check.

Keep the trailer load light – not more than about 60 per cent of the rated load. This will not only put the trailer under less mechanical stress but also enable lower tyre pressures to be used, thus reducing sinkage, drag and load on the tug if soft going. Importantly, running light will also reduce the ratio of gross weights between tug (the towing vehicle) and trailer, which has considerable effect on the stability and agility of the ensemble. Keep the centre of gravity of the load in the trailer low down, and keep the high-mass items close to the trailer axle and central to reduce the moment of inertia. Ensure that there is a down-load at the trailer tow bar of about 50–75 kg. Remember that this "nose weight" is

bearing down on the towing vehicle's rear end and will result in a reduction in the tug's payload. To accommodate this and the effect of overhang – as a rule of thumb – remove twice this figure from the towing vehicle's payload. Thus, if the download is 50 kg, take 100 kg off the listed maximum payload of the tug.

THE EXPEDITION VEHICLE: INGREDIENTS

What to consider

Be aware of the ingredients of a competent off-road vehicle – what ingredient yields what reward and at what cost – and so bring together a ghost specification that you can template on to what the market is offering at any given time. See Table 28.1.

The features mix

Bearing in mind that you could start off looking at 4 x 2 vans and pickups, scan the attributes in Table 28.1 and get a feel for what features are to your advantage and why. Some customers want a 4 x 4 only for the safety that it gives on snow and slippery surfaces, without having the need for extra low gears – some even find these "confusing". Hence special specifications for special markets evolve without a two-speed transfer box – a whole raft of "soft roaders" such as the Land Rover Freelander, Nissan X-Trail and Honda CRV being cases in point. It is unlikely that a vehicle without a low-range transfer gearbox will be satisfactory for an expedition.

Table 28.1 A COMPARISON OF VEHICLE ATTRIBUTES IN ORDER OF PROGRESSION FROM SIMPLE 4 x 2 PICKUP

Feature	Benefits	Disadvantages
Leaf-springs	Low cost, simplicity, easy replacement. Springs act as means of locating axles	Inter-leaf friction gives stiff ride, poor traction; limited wheel movement. If springs are very long and one- or two-leaf, less of a problem
Large diameter wheels	Improved under-axle ground clearance. Goes *over* pot holes rather than into them	No functional disadvantage
Torsion-bar front springs	Smoother ride than leaf-springs. Better traction and braking. More wheel movement?	Usually associated with independent front suspension so less ground clearance
Beam axles	Good under-axle clearance, wheels always perpendicular to ground	Clearance above axle needed for wheel movement makes vehicle tall. High unsprung weight difficult to damp
Coil springs all round	Smoother ride than leaf-springs. Better traction and braking. Usually a lot more wheel movement so best off-road capability; best traction on uneven ground	More expensive than leaf-springs as a result of need for alternative axle location links. If too short and stiff, ride is still poor (e.g. Lada)
No anti-roll bars	Permits full axle articulation – twist relative to body – off-road wheel movement enhanced	More expensive than leaf-springs as a result of need for alternative axle location links. If too short and stiff, ride is still poor (e.g. Lada)
Short wheelbase	Improved off-road capability but only noticeable in	Usually associated with lower maximum payload

	extreme conditions	than long wheelbase versions
Large approach, departure, ramp angles, "high stance"	Off-road agility without danger of grounding body parts. Short tail overhand specially valuable exiting ditches	High centre of gravity can cause body roll
High payload	Obvious advantage when there are long distances between provisioning points	Stiffer springs give less pliant ride. Classic division between luxury/working
Automatic transmission	Helps driver. Smoothest gear changes safeguard driveshafts, precludes lost traction through jerkiness. Very good	Cost mainly, some weight. Perceived loss of manhood by some. Prop shaft may need disconnecting for towing
"Part-time" (selectable) four- wheel drive (4 x 4)	Huge improvement over two-wheel drive in soft sand, mud, snow, etc.	Compared with 4 x 2, cost. Must be selected when needed and de-selected on hard surfaces. Full-time 4 x 4 better
Part-time pseudo (or "automatic") 4 x 4 (common in "soft roaders")	As above but speed differences between front and rear axles have to be sensed before 4x 4 is engaged with viscous coupling	As above but things have to get bad before they get better, i.e. some wheelspin. Not totally positive drive
Two-speed transfer box	In effect a second set of extra-low gears for off-road use. Highly desirable for expeditions	Cost and complexity but a must-have for any serious expedition

On-the-move range change (Lo to Hi range)	Invaluable when you have to start in Lo and need to change to Hi without stopping. Can't be done with "electronic" range changes	No real disadvantage except some skill/technique required to do it on most vehicles. G-Wagen has synchro
"Full-time" 4 x 4 (permanent) with centre differential	Much better than part-time or "automatic" because it is there all the time, ready for anything. Best kind has manually lockable centre differential	Compared with part-time 4 x 4, more cost as centre differential is needed. Must remember to unlock diff if on hard ground unless VC controlled
Locking axle differentials	Overcomes those "one spinning wheel" situations superbly to preclude getting stuck	Cost. Risk to half-shafts if not properly engineered. Must remember to de-select
Traction control	Foolproof way round wheelspin. Automatic	Electronic-dependent, brake heat, wear. Not as good as manual-select diff-locks
Portal axles (Pinzgauer)	Dramatic increase in under-axle clearance for rough ground and deep ruts	Very expensive to produce, high centre of gravity, higher unsprung weight
Roll control	Limits on-road body roll while preserving off- road articulation	Electro-hydraulic systems complex, expensive. "Mechanical" ones are simpler but still electrics-dependent for selection

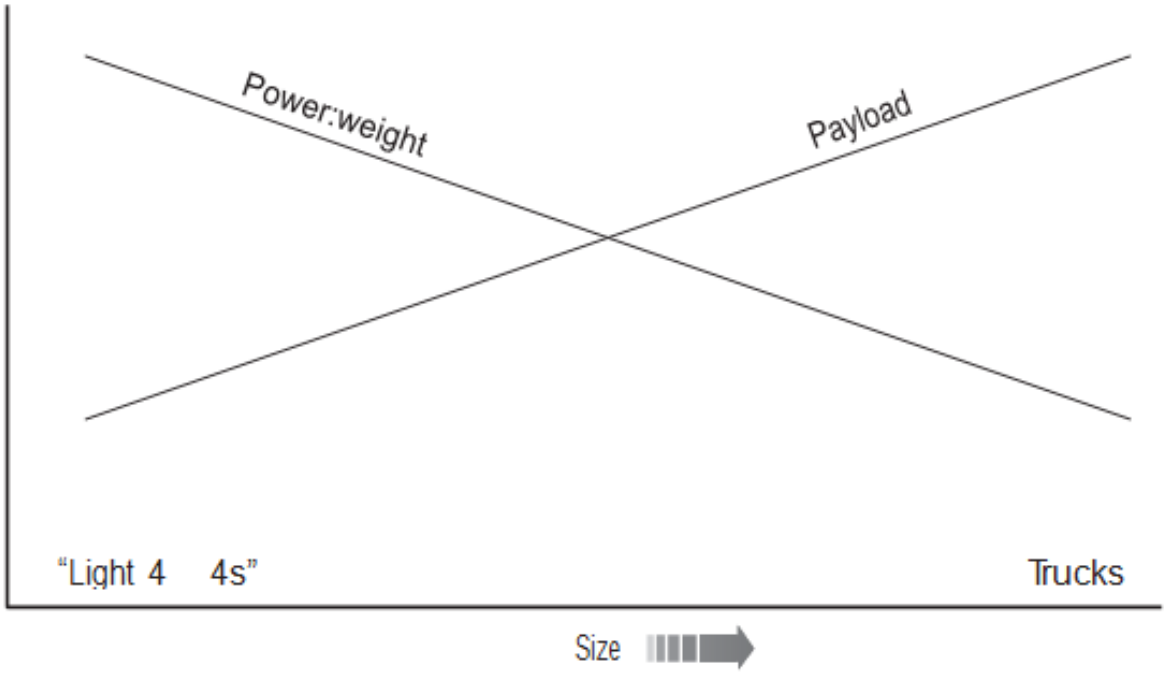

Figure 28.6 The size trade-offs: power:weight ratio and payload

Size, power:weight ratio, payload

In general a medium truck (say 4 tonnes) can support itself and a team over a greater distance and/or longer time than a "light 4 x 4", such as a Cherokee or a Defender. It is a direct function of payload (the fuel or supplies it can carry) and there is no substitute for detailed and accurate calculations of requirements in this area. These calculations would be based on the number of people to keep in the field for how long at given consumption rates, the distance between resupply points and whether there are basics such as water close to the worksite or along the route. The general picture looks like that in Figure 28.6.

Power:weight – where it matters

If payload is what gets you long distances then, all other things being equal, power:weight ratio is what gets you up a sand dune, a steep loose slope or through a boggy patch for which you might have to use speed. The power:weight ratio is the number of bhp per tonne of GVW; as Figure 28.6 shows, small vehicles with big engines have lots of it (4.0-litre Jeep Wrangler, RAV4, Range Rover); trucks don't. So long as there is grip – which there isn't on a sand dune, a loose slope or a sticky mud patch – a vehicle with a low power:weight ratio will, by sheer low gearing, crawl over rocks or slowly up a steep climb. Power:weight ratio equals dynamic off-road capability and is usually, as Figure 28.6 implies a direct trade-off for size, carrying capacity and – importantly – fuel consumption. Over-powered vehicles are very uneconomical.

Tyres
Steep, loose, short inclines are still going to need power to achieve the momentum that they need to "ballistic" to the brow; on the level or with moderate slopes, however, wide, sometimes deflated, tyres can help a low-powered vehicle "soft shoe" through without sinkage or excessive demands on torque. Enormous all-wheel drive trucks on big soft tyres can be seen performing astonishingly well in the Sahara despite low power:weight ratios. But remember, low tyre pressures demand low speed; reinflation is essential if rock or hard going is encountered. Tubeless tyres will be virtually impossible to refit in the field – massive amounts of compressed air are required. Consult with tyre specialists (the manufacturers if need be) and fit tubes before departure.

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TRANSMISSION SYSTEMS

Two-wheel drive or four-wheel drive?
Will a 4 x 2 do? A robust 4 x 2 with big wheels and a couple of willing crew to push is surprisingly capable if firm roads – surfaced or unsurfaced – are available. "Dual cab" or "crew cab" pickups (with two rows of seats and four doors ahead of a smaller load bed) are a popular solution where small groups are concerned. If considering this approach in a 4 x 2 (or even in the 4 x 4 versions), check carefully the payloads, ground clearance, wheel size and wheelbase before making your choice. A 15-inch rim size should be regarded as the minimum to provide adequate ground clearance and tyre footprint.

Driving standards
Remember, equally, that the wrong tyres, tyre pressure and driving technique can see a bogged 4 x4 passed by a well-operated 4 x 2. Having said that, a novice in a 4 x 4 will do better than a novice in a 4 2. So will an expert. It is clear, therefore, that existing and potential driving skills come into the list of parameters to assess when considering vehicle choice.

So, 4 x 2 or 4 x 4?
The choice has to be to go for 4 x 4 if you can. Cost could well be the deciding factor but even this can be accommodated to some extent in the various types of 4 x 4 available today.

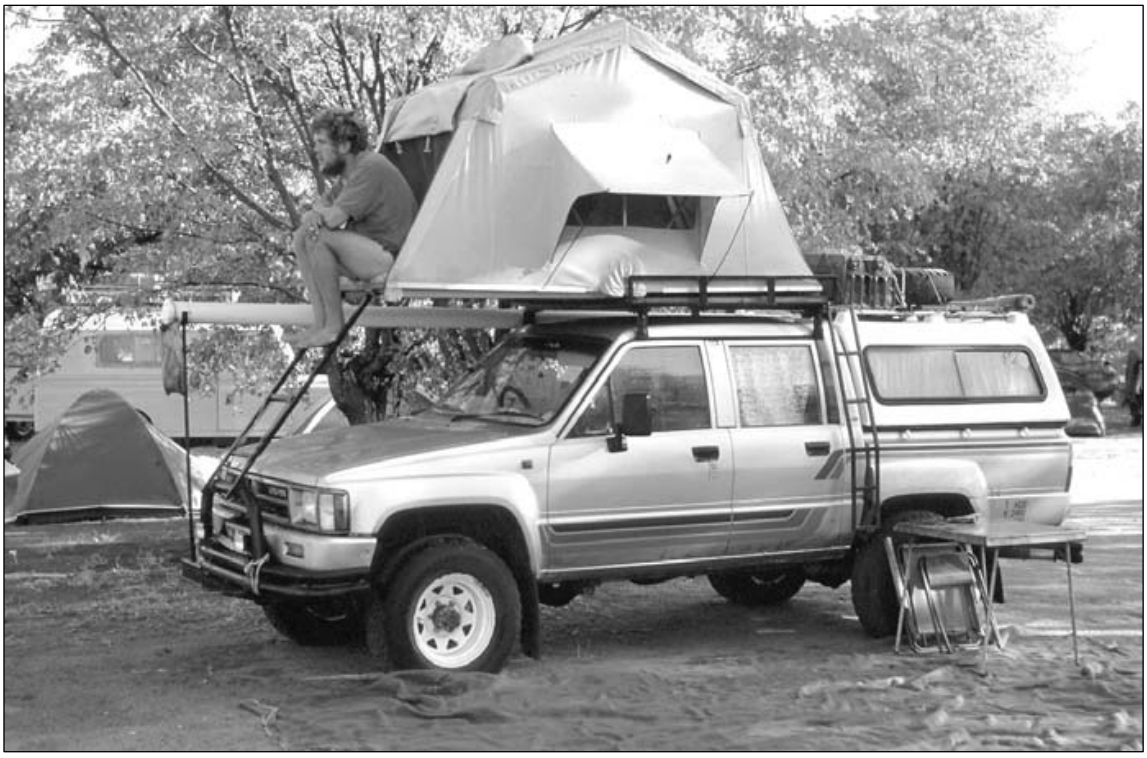

Figure 28.7 Classic application of the crew-cab 4x4 Toyota pickup in short-range expedition role, very popular in South Africa. Note that any heavy cargo will all be over the rear wheels (© Tom Sheppard)

Types of four-wheel drive

Some argue – shakily – that four-wheel drive uses more fuel so the facility should be used only when needed. The result is a bunch of different driveline design philosophies – and terminologies – when looking at 4 x 4 vehicles:

- "Part-time" 4 x 4 (selectable) – many pickups, simple, straightforward
- "Auto" 4 x 4 (so-called "when needed") – "soft-roaders", Freelander, Honda CRV
- "Full-time" 4 x 4 (permanent) – all current Land Rover and Toyota models
- A blizzard of trade names such as Selectrac, Super Select, Quadra-trac, Control Trac to cause you further confusion, but they all fit into one of the above three categories
- Not all of the above systems (RAV4, Honda CR-V, Freelander, Nissan XTrail, BMW X5, Volvo XC90, etc.) are combined with a two-speed, selectable transfer gearbox that gears the final drive down by a factor of two or more, giving you a "second set" of extra low gears. For expeditions, use a 4 x 4 with a low-range transfer box.

Part-time 4 x 4 OK – but not on tarmac
A selectable 4 x 4 system, the simple type found on most pickups, is not as desirable as a permanent 4 x 4 for everyday driving but, for most expedition applications, on/off tracks with 4 x 4 selected, performance will be identical. As it lacks a centre differential, however, for accommodating different axle speeds front and rear in turns, it should never be used in four-wheel drive on tarmac or other hard grippy surfaces.

Figure 28.8 A 4 x 4 is best. Here, as with rock crawling or steep washouts, low-range gears are virtually essential (© Tom Sheppard)

AUTO OR MANUAL

Elegant and gentle

Automatic transmissions are neither a sissy option nor the passport to high-fuel consumption that they once were considered to be. Looking at the revolutions per minute (rpm) an automatic transmission asks of the engine on a given off-road section, in comparison to a white-knuckle manual driver, it is easy to see that the opposite is sometimes the case. On a track where a soft patch takes you by surprise, the down change can be lightning quick and in rough-track “forest floor” situations the auto really shines, reliably executing countless gentle gear changes in long day conditions where, with a manual, driver fatigue may rear its head. An automatic will make immaculate UP changes on steep loose inclines

when you are in danger of provoking wheel spin. An automatic will also reduce shock loading on drive shafts and differentials. Many vehicles used as standard in the armed forces worldwide are equipped with automatic transmission – the operational advantages in terms of driver workload and vehicle durability are seen to win over the slightly increased costs.

Do use low range
Don't let an auto lull you into laziness, though. Be sure to get into low ratio when required or you will be using the torque converter like a slipping clutch and will induce overheating of the transmission fluid. Remember also to select "1" for steep descents.

Reliability, service
The reliability of automatics is, if anything, better than that of a manual box and clutch – partly because they are difficult to mishandle. One expert summed it up: "If an auto is OK for the first year, it'll live forever." As vehicle dealers encounter so few faults with autos and may lack experience, go to a specialist automatic gearbox engineer for a pre-expedition service or if you want a second-hand vehicle checked; they are working on them every day and will know what to look for. Be sure that your vehicle has a transmission oil cooler (mounted up front where the engine fan is). Some automatics have clunky changes; clunks are not why you opt for an auto. Try before you buy.

PETROL OR DIESEL

Characteristics
Generally, petrol engines are lighter, more powerful, more thirsty and cheaper (to buy) than diesels. Diesels, however, have advanced dramatically in recent years in terms of power, responsiveness and efficiency. Above all they are a lot more economical. They are also "greener". Turbo-charged and intercooled diesels cost more than a simple diesel but offer improved power and lower fuel consumption, the very essence of the expedition requirement. Not all turbo-charged diesels are intercooled – a cost compromise again.

High power conversions
Beware of "performance conversions". On expeditions, durability and reliability are all and high-power conversions will usually compromise the structural margins of an engine.

Fuel: availability, load, cost

Know your route. If use of a petrol engine is a real possibility, know its generic type (leaded, unleaded, etc.) and find out the grade of fuels available en route. Petrol engines have to be designed (or tuned) to the fuels available and most modern engines cannot be tuned to use very low-grade gasolines; they will destroy themselves if you try. But the bottom line is that wherever you are you'll always find usable diesel; finding the right type of petrol may be a lot harder. And diesel is always cheaper.

Figure 28.9 Classic robust simplicity – the Australian spec Toyota Type 78 even comes with long-range fuel tanks as standard. This one has coil springs at the front. Never imported into UK, earlier all-leaf-sprung Type 75 in diesel form is highly valued in continental Europe for expedition work (© Tom Sheppard)

Reputations: assessing reliability

Solid repairable simplicity has an attractive ring. But there are parts of some modern engines that cannot be repaired in the field and electronic control units (ECUs), engine management chips, fuel injection pumps and injectors are among them. Repair by replacement is often the order of the day even in maintenance centres and then sometimes accompanied by electronic analysis or facilitated by the use of special tools. If your engine does have an ECU check out the failure case. Is there a "limp home" mode? That said, the reliability of such components is generally very high.

Question specialists about known faults. Early Land Rover 300 Tdi engines could suffer random cambelt failure with catastrophic consequences, but a modification to preclude this is available. Be sure that yours has it. Traditionally diesels "have a long life" because we all

think back to trucks that go on forever. Modern but not too modern (i.e. beyond their teething troubles) is probably the best phrase to have in mind.

The choice

All things being equal, a modern, established, turbo diesel is probably the best engine for an expedition vehicle – especially where distances are large. Diesels tolerate poor fuel better than petrol engines. The days of diesel vehicles being underpowered are gone.

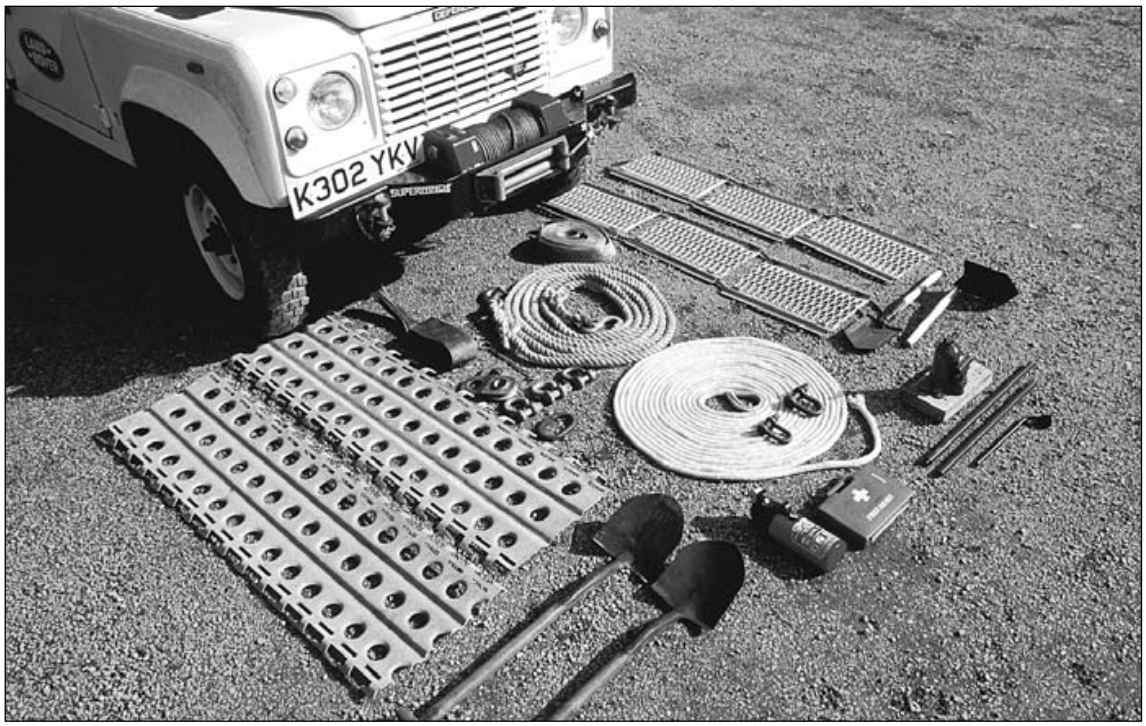

Figure 28.10 Give careful thought to recovery equipment: "sand channels" of some kind to put under the wheels for flotation in slippery mud or soft sand; shovels and long tow ropes so the tug does not get stuck in the same hole as the stricken vehicle. Winches are heavy and expensive; rarely useful except with multi-vehicles in forests or jungle (© Tom Sheppard)

SIMPLICITY, SERVICE, SPARES

Keep it simple

Keeping the specification simple will certainly be a good start. Deleting air conditioning is a case in point where hot climates are concerned – a lot of cost, climatic shock every time you get in and out of the vehicle, a lot of weight, a lot of complexity.

Service, spares

You will still have to make your own assessment of the reliability record of your chosen vehicle. Is the design "bedded in" or a brand-new model? What if there really is a problem? Are there dealers in the area that you are visiting – or the country? Is there a course you can go on before

departure? Are there good service manuals? What is a sensible spares pack? What about the need for special tools?

Figure 28.11 Be ready to improvise. Electronic control unit (ECU) defaulting to "limp home" and suspected fuel contamination demanded drain and filter for all fuel on board – an all-day job. Rocks provide handy ramp for jerry can access; failing that a dig-down hole would have sufficed (© Tom Sheppard)

Operation: mechanical sympathy

Ponder the fact that very rarely do things break of their own accord. More usually they are broken by people – usually through insensitive driving, overloading or inattention. The acquisition of mechanical sympathy, that sensitivity to the operation of equipment, especially in conditions of stress, is an attribute almost beyond price when it comes to keeping going on an expedition. Of course there will come times when you must operate the vehicle to its full potential but even here it can be done with sensitivity – feel for it, care for it, don't break it. Prepare the vehicle impeccably, secure the load; drive impeccably too.GGO

INSPECTION, PREPARATION

New buy? Independent inspection

Have an independent inspection carried out before purchase. Be there, if possible, when it is done. Depending on your vehicle and its servicing

intervals, have a major service done (again, be there if possible) before leaving. As well as all-round oil changes (with synthetic for the engine), consider renewing hoses, accessory drive belts, camshaft drive belt (if applicable), brake shoes or pads, battery(s) and tyres. Even if new tyres are not needed, have the old ones removed and replaced using proper rubber lubricant; it will pay at your first repair. Learn how to change a tube; it is easier than it looks.

ONCE YOU HAVE IT, TAKE CARE OF YOUR VEHICLE. IT IS THE LIFE BLOOD OF YOUR EXPEDITION

This chapter is based on the author's books, Vehicle-dependent Expedition Guide (second edition now available) and Off-roader Driving.

FURTHER INFORMATION

Further reading

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Scott, C. (2000) *Sahara Overland: A route and planning guide*. Hindhead: Trailblazer Publications. Shackell, C. and Bracht, I. (1993) *Africa by Road: 4WD – Motorbike – Bicycle – Truck: The Bradt travel guide*. Chalfont St Peter, Bucks: Bradt.
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Land Rover Driver Training

Land Rover have been supplying expedition vehicles to the Royal Geographical Society (with the Institute of British Geographers or IBG) since 1977. Land Rover's world-renowned reputation as manufacturers of permanent four-wheel drive vehicles makes them an ideal choice for use by scientific and adventurous expeditions. However, motor incidents are a major cause of injury abroad. To help raise the safety and effectiveness of small teams operating in remote areas, the RGS–IBG's Expedition Advisory Centre and Land Rover have teamed up to provide a practical course covering key driving and safety techniques.
For further information, see www.rgs.org/eacseminars

This chapter originally appeared in the *RGS-IBG Expedition Handbook* published by Profile Books, 2004 and is now out of print