A Guide to Building a

Junior Trials Vehicle

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Introduction

What is a Junior Trials Vehicle?

The idea behind the JTV is to provide a safe and affordable vehicle to enable youngsters from the age of 8 years old and upwards to compete off road. The Off Road Committee spent over two years discussing the requirements and researched all the known available alternatives. The outline specification sought was for a vehicle small enough to fit in a small trailer, the back of a pick up or van, and that could easily be stored at home. Proposals to build vehicles from cars, either existing kit cars using components from Minis or Fiats, or Suzuki 4x4s were all rejected on the grounds of cost, size and space, not to mention speed.

Trailing is not about speed, it is about driver skill, negotiating a defined course over arduous terrain. A vehicle with a high top speed potential would not only be unnecessary but would also compromise safety. This project parameter was central to the whole philosophy, the need to bring on a new generation of competitors who can read the ground, for this is an essential skill before moving on within the sport to timed events such as Competitive Safaris and Hill Rallies. This need for a vehicle with good slow speed characteristics also ruled out the many commercially available off road karts. By early 2001 the Off Road Committee had started considering a bespoke vehicle using the engine and transmission from a lawn tractor, these being cheaply available second hand and would lead to a vehicle of the size and characteristics sought. Designing and developing a new vehicle from scratch is however time consuming and expensive and when in August of that year the Committee was shown a vehicle built by Kevin Mizen which was essentially an 11HP Toro lawn tractor fitted with a roll cage and safety harness, the way forward was clear.

Lawn tractors are freely available, new and used, they are small, inherently stable and easy to drive, an important consideration for new drivers. By taking an existing vehicle and adding safety features there is scope for the competent DIY mechanic to build his own vehicle at home.

Scope of this Guide.

The purpose of this guide is to share the rationale and experiences gained in the building of the MSA JTV's, together with that of the Mizen's Toro (JTV Proto) and that built by Charles Darby to the draft regulations as proofing exercise.

This is not a definitive build manual, the reader/builder may choose to address matters in a different way, but it is hoped that by sharing our collective experiences in the building and running of these vehicles the reader may be encouraged to proceed and build a JTV of their own.

Additionally there are sections giving advice on the type of tractors suitable and in the Appendices guides to identifying the different types of Westwood and Countax tractors. These British built machines are the most prolific in the new and used market place and we feel are the most likely to be encountered. However the use of one of these makes is not obligatory and many of the imported tractors use the same engines and transaxles so much of what is written will still be useful.

The Basic Principles

The regulations restrict the choice of engines and the modifications to control speed and cost. Similarly transmissions are limited to manual gearboxes, the hydrostatic transaxles were banned from the regulations for three reasons. Firstly they are too easy to drive, and we are trying to train and educate young drivers as well as having fun. Secondly because these are hydraulic drives there is no engine braking effect when the engine is not running. Thirdly the Hydrostatic transmissions are twice as expensive to replace as the manual ones and they are not known to be as robust in the kind of harsh operating conditions of an off road event.

Also restricted by regulation are modifications to enhance the off road articulation of the vehicle. It was decided that unless these features were limited, the natural ingenuity of competitors could lead to vehicles far removed from the original concept. Experience too with full sized trialling has shown that the more capable the vehicles become the more extreme the sections and this compromises safety and increases costs.

Modifications therefore primarily concentrate on adding safety features and allowing modifications to improve reliability. This is complemented by the sporting regulations which limit for example wading depths. Now whilst most off roaders enjoy water, the transaxles fitted to lawn tractors are not intended for immersion and as they are both the second most expensive single vehicle component (after the engine), and are mounted low down underneath the chassis, we have a maximum depth of water that may be included on a trials section.

Types of Tractors

There is no clearly defined set of definitions for the different types and sizes of tractor. This then is a guide based upon common terms and description used within the trade, some of which are obvious.

Ride On Mowers.

These are rear engined machines where the driver sits high up and forward. They feature very small front wheels and are generally light weight entry level machines suited to smaller lawns. They are less stable than a tractor and have little or no front axle articulation. For these reasons they are not permitted. However they do use the same types of engines and some are fitted with the similar transmission so they are a potential cheap source of second hand parts.

Lawn Tractors

Looking like a tractor these are the next step up the evolutionary scale. They are front engined, with a rear seating position, they feature an articulating front beam and tend to be the lighter and cheaper tractors with less features than garden tractors. They are intended primarily for mowing the larger lawn.

Garden Tractors.

These tractors are bigger, though not always by much, and feature more powerful engines and more features such as power take off to drive accessories. Like the lawn tractors, from which most are closely related, they are the ideal basis for a JTV.

Yard Tractors.

A term used to describe the bigger American machines, these have many heavy duty features and are intended to do a lot more than just mow turf. Whilst they will operate a wide range of labour saving accessories their basic design remains that of the lawn/garden tractor. These would be the biggest, and most expensive type of tractor eligible.

Compact and Sub-compact Tractors.

These tractors are size wise about the same as the yard tractor. However they are built along the same design and layout as full size farm tractors, featuring water cooled diesel engines, often 4 wheel drive and 3 point rear linkages. These are intended for commercial use and often for tasks other than mowing. They are much heavier, much more expensive and not permitted by the regulations.

Chapter 1
Getting Started

Choosing Your Base Vehicle.

The first decision will be new or used. It is presumed that the latter will be the preferred option for most competitors, and understandably so. So the search begins, you are looking for a lawn or garden tractor with a vertical crankshaft engine and manual transmission. Most tractors of this type fit this criteria, but a vertical crankshaft engine will have the drive belt running with the pulleys in the horizontal plane underneath the chassis or floor of the tractor to a separate gearbox or transaxle at the rear. Manual transmissions will obviously have a number of forward gears and a reverse with the gear lever typically column mounted next to the steering wheel (recommended for the novice where they do not have to look away from the direction of travel to select a gear) or mounted on the rear mudguards (The MSA JTV's have this location and the smaller drivers have commented on the difficulty in choosing a gear because when strapped in and with a crash helmet they cannot see the gate, compounded by often having the seat further foward). That said the types of transmission fitted to these tractors does not allow for gear changes on the move and it is the lack of experience which is the main problem. Most of our test drivers have preferred a column shift and the drivers confidence in their vehicle is normally translated by a better performance. All that not withstanding you should not rule out the mudguard mounted system if the tractor is the right price and condition as it is in most cases easy to make adjustments.

Suitable tractors are often advertised in local papers, free adds etc, the Exchange and Mart and Autotrader. They may be bought at agricultural auctions and trade sales or from a dealer.

In all cases, buyer beware. If you do not know what to look for take someone with you who does. Much can be judged by the general condition in which the vehicle is presented, but most importantly you need to ensure that the engine and transmission rear in good working order. Avoid excessively rusty tractors, they can be repaired but it just adds to the time and cost of preparation. Do not worry about the cutter deck or grass collection apparatus where fitted, you'll discard these bits any way, although it is worth noting that it is the cutter decks which often are the first to fail leading to the sale of an otherwise solid and highly suitable base vehicle for a JTV. This is because the cutter decks spend their lives caked in damp grass cuttings leading to rust and often hit solid objects in the course of mowing (at least mine do!). A little dull or flat paint work normally responds well to polishing with a cutting compound. Plastic bonnets and panels can be repaired with fiberglass matting and resin, although avoid excessively damaged components which may be hard to replace and expensive.

It is a good idea to look at as many adverts and tractors as possible to get a feeling for a fair price. Private sales can be very reasonable although make sure the vendor has title and it is theirs to sell! If in doubt look elsewhere.

Most dealers take old tractors in part exchange against new machines, but due to the cost of putting an old tractor through the workshops for re-sale, most are disposed of through trade auctions. It is simply uneconomic for the dealer to take on the financial liability. That said if you strike up a rapport with your local dealer, explaining exactly what you intend to do with it, he may be prepared to sell you a part-ex tractor on a sold as seen basis. If you can accept the risk of no come back to the dealer, and know what to look out for there are some bargains about and since many dealers know the machines in question, often having sold them new to the customer and serviced them since this is a good source of suitable donors. It might be a good idea to take along a picture or two, printed from the website or from articles in the off road magazines so that the dealer understands what you have in mind. If you can find a helpful dealer and strike up a good rapport it will be helpful when it comes to repairs and replacing and upgrading.

A Word About Engines.

The types of engines fitted as standard to lawn/garden tractors are of the restricted type. That means that they have a mechanical or air vane governor which restricts maximum rpm. This serves to limit the maximum speed of the mower blades and limits vehicle top speed. It also means that the engines last a long time. In mower racing, where they allow the removal of the restrictors, engine life is considerably reduced.

Engine sizes typically range from 6HP to 18HP. Power has increased considerably over the last twenty years as the demands placed upon the engine have correspondingly risen with more powered accessories and bigger cutting decks. Twenty years ago entry level machines had 6HP engines with the normal rating being an 8 or 11HP. Ten years ago entry level tractors were typically 10Hp with 12 to 14HP being the norm. Today the entry level Westwood and Countax tractors start at 13HP.

More power is often an unnecessary extravagance for the JTV. With all of the accessories and cutting deck removed, the demand on the engine is significantly reduced. The MSA JTV's have shown that their 16HP engines do not even begin to labour when tackling 1 in 1 climbs. The bigger the engine the more fuel per hour is used and the bigger engines weigh considerably more.

When we built the MSA JTV's they had the 16HP Briggs and Stratton engine fitted because that was what was available at the right price. They also with their huge reserves of torque have proved to be less stressed and easy to drive for the many test drivers who have experienced them this year.

JTV Proto, the Mizen's Toro has an 11HP B&S engine, it is a slightly lighter tractor and has shown that it has ample power. That engine being some 15kg lighter than the B&S Vanguard engines in the MSA JTV's means that much less ballast has had to be added to the rear to achieve a good balance and compensate for the lighter driver.

Most older engines rely upon splash lubrication, whereby the rotation of the crankshaft splashes the oil around the internals to achieve lubrication. These engines are not intended to work at angles far beyond the horizontal and that is one of the reasons for limiting the severity of terrain in the sporting regulations. Later engines have pressure lubrication, like a motor car, and are more effective although the engine manufacturers still cover themselves from any liabilities by quoting very limited operational deviations from the horizontal.

Of the engine makes to be encountered, the most prolific is Briggs and Stratton. There is a huge range of single and twin cylinder engines from this manufacturer and parts are easily available and they have a good website in the States where you can identify your engine, download parts and owners manuals and an FAQ section for simple running faults.

Tecumseh is another American engine manufacturer, whose products may be encountered, notably in the smaller earlier Westwoods.

Honda and Kawasaki engines have become more common since the late 1980's and Kohler were a common fitting for a while.

A Word About Transmissions

The regulations preclude the use of Hydrostatic transmissions for three reasons. Firstly because the concept of Junior Trialling is to teach and train future generations of competitors a manual transmission requires the use of a clutch and thinking about correct gear selection. The Hydrostatic vehicles are too easy to drive. Secondly reliability. Whilst researching this project it became clear that the Hydrostatic transmissions are not as robust as the manual transaxles and suffer particularly from the effects of heat build up affecting the hydraulic fluid and internal seals. Thirdly cost. Tractors with Hydrostatic transmissions attract a higher resale value and the cost of replacing the transaxle is roughly double that of a medium duty manual transaxle. Remember that after the cost of the engine the transaxle is the second most expensive unit.

Most manual transaxles that will be encountered will be those made by Peerless. There are other types certainly but Peerless dominate the O/E market. A separate gearbox with a chain drive to a rear axle may also be encountered on some imported tractors. Whilst this keeps the transmission higher up in the chassis and out of harms way and affords an easier way to reduce the gearing, such systems increase the center of gravity and the chain is more prone to damage from mud and stones.

Chapter 2
Wheels and Tyres

In motorsport more discussion and myth surrounds which tyres to use than any other part of a competition vehicle. No doubt as this new formula develops so shall such discussions prevail in the world of the Junior Trials vehicle. What this chapter will do is provide a basic understanding of limitations and what qualities need to be considered when selecting your wheels and tyres. This is based upon the experiences encountered with the Mizen's Toro (JTV Proto) and the MSA's JTVs.

The overall diameter of the tyre is the first factor. The larger the tyre the greater its ability to climb over undulations and rough ground. A larger tyre will also afford greater ground clearance, particularly under the transaxle or final drive. That is why the JTV's have equal sized wheels front and rear. Simply fitting a taller front tyre greatly improves the tractors off-road ability.

Whilst is not essential that the front and rear tyres are the same, in size and type it certainly makes sense to use the same tyre all round because this reduces the need for multiple spare tyres.

So the first decision is how big a tyre. The transmission is the limiting factor in this and reference should be made to the manufacturers limits. The chapter dealing with transmissions provides this information for Peerless transaxles. If you have that of another manufacturer either contact them or do not increase the tyre beyond that originally fitted.

The margins whilst reasonable in engineering terms do not equate to a big margin for error. During the very early stages of the JTV concept a member of the Off Road Committee fitted ATV tyres of a 23" overall diameter to a Westwood where the design limit for the transmission was for a 20" tyre. The transaxle destroyed itself within 30 yards and cost rather a lot to replace. Those 3" are of course a 15% increase over the limit.

Most tractors suitable for converting into a JTV will have been originally fitted with an 18" o/d turf tyre, whilst later models now come with a 20" which is the limit for most medium duty transaxles.

So having decided which is the optimum o/d for your tyres, the diameter of the wheel is the next factor. The main factor influencing your wheel size will be the type of brakes that you fit. It is unlikely that you will find a brake setup that will fit within the standard 8" diameter of a tractor tyre. Disc brake setups whilst more powerful and less affected by water are wider and bulkier than a drum brake. It is therefore necessary to determine your choice of brakes before returning to your wheels and tyres.

For the MSA JTVs we mixed the rear drum brakes from a Mini (or Metro) with modified drive flanges from larger Countax and late Westwoods because these share a 4" PCD. A 4" PCD is also common with small trailers and to clear the drum brake we selected a 10" wheel. A suitable wheel is commonly available in a 3.5" width with a zero offset making it ideal to use all round. These wheels are a little over £10.00 each. At the front we fitted free running 4" PCD hubs, more of which later.

So we have the o/d of the tyre and the wheel, so next we must choose width and tread patterns. And here the debates usually begin. But before we discuss widths and tread patterns a word about ply's.

Ply for those who don't know is the term used to describe the layers of material that make up the carcass upon which the tyre is molded. For a JTV we need a tyre that is pliable and responds to raising and lowering of the air pressure. This is likely to mean a 2ply tyre rather than that with 4 plies. The disadvantage of the 2ply construction is that such tyres are more prone to punctures. As a guide look for the maximum recommended load for the tyre either individually or per axle. Note that American and Far East tyres usually quote in Lbs and European tyres in Kgs. In our experience a tyre with a design load limit per axle, close to the total weight of the JTV will work well.

The JTV Proto currently runs Carlisle 8.5x18 tyres on 8" rims. These have a cleated or tractor pattern and a design load per axle of 800Kgs. The JTV Proto actually weighs just over 300Kg in total and these tyres hardly flex at all. Similarly the Cheng Shin cleated tyres that we showed JTV 1 with at the NEC in January were 4 ply construction

and sized 8.25x19.5 on 10" rims. When we first ran the JTV in March, when it was a little lighter at 280Kg or thereabouts, even with no air pressure at all those tyres did not flex. However we had a set of Dunlop T84's in 5.00x10 on standby and these worked a treat. These tyres are designed primarily for rotavators and have a two ply construction. They respond well to changes in tyre pressure and have a load limit per axle of 295Kg. The JTV's are now running at a weight of 330Kg without driver and the tyres work well on most surfaces.

Widths. The normal rules of tyre choice apply. A wide tyre is better on most soft surfaces because it will not sink in, provide it has a good tread pattern of course. This is useful given the limitations of ground clearance. A narrower tyre has a higher ground pressure and therefore will bite better, being less prone to sitting on the surface spinning. Your total vehicle weight naturally influences this and no more significant than that is the weight of the driver. Generally a 5" or 6" wide tyre is the best compromise available. Finally note that a wide tyre on the front will limit the angle that the stub axle may be turned reducing the JTV's turning circle, and a tight turning circle is essential for trailing.

Tread patterns. Unlike full size off roaders there is not so much choice available in the sizes suitable for a JTV. Basically there are the wide Turf patterns which come as standard and cleated tractor patterns. Many clubs ban the use of the latter on full size vehicles because with their high horsepower they can do a lot of damage to the ground. For the JTV however, where horsepower is quite modest and tyre patterns are limited, the cleated tractor pattern is unavoidable.

There are some other patterns available. For example there are ATV tyres, but as these are comparatively wide and in sizes of 23" and above they are not really suitable. There also ATV patterns on lawn tractor carcasses designed for snow blowers but these have quite stiff 4 ply construction and therefore are equally less suitable. We did come across a small highway trailer tyre by Carlisle with a tread pattern of the old Goodyear Extra Grip as fitted to Land Rover Lightweights. They looked very interesting but were unavailable and probably too stiff a construction to be useful.

Finally a word about reversing the cleated pattern tyres when fitted to the front. This has been commented upon at every outing, with cries of 'why are the tyres on back to front?'. Well the simple fact is that when un-driven and used for steering the tyres work better backwards and provide more turn-in-bite, especially for climbing out of ruts.

In summary the choice of tyres and wheels is influenced by the design limits of the transmission, the size and type of brakes fitted and the weight of the vehicle.

Chapter 3
Front Beam and Steering

A tractor has no suspension, it does however have a pivoting front beam and the first temptation is to increase the movement of this component. To contain development it was determined from the outset that whilst the beam itself was free within the regulations, no modifications would be allowed to the chassis to allow for increased articulation and the beam must retain its original mountings. This way cost would be contained and full suspensions could not be developed. However it was recognized that the beams themselves would need to be modified to correct the tractors height when increasing front wheel diameters. It was also known that some beams are not very strong, after all they are designed to be used on a lawn and not intended for off roading.

The JTV Proto is based upon an old Toro which featured a solid steel beam. Kevin Mizen pocketed the beam to increase articulation and fitted a pair of coil-over shock absorbers from a small motorcycle to control movement and push the beam down. The Toro, like early Westwood Gazelle's has a chassis open beneath the beam and so this method of increasing articulation is straight forward, however when building JTV, its later Westwood chassis is enclosed around the beam meaning that metal would need to be removed from the top and bottom of the beam. This would of course weaken the beam and so it was decided to build JTV with a standard beam (more of which in a moment). During testing and development it was found with JTV 1 that allowing the front beam to move allowed a rear wheel to pick up and spin, loosing traction and stopping the tractor. In early testing we found that performance was improved by using compliant tyres with good side wall flex at the rear and plenty of rear ballast. This allows the tractor to pick up a front wheel rather than the rear and hence maintain forward motion. However too much rear weight bias will also make the JTV unstable when climbing, so everything in moderation.

A quick word about tyre pressures. We have found with the setup on the MSA JTVs that a high pressure in the front has two benefits. Firstly the tyre does not give and as it climbs an obstacle there is weight transfer to the rear driven wheels. Secondly the increased pressure greatly reduces steering effort, putting less strain on the steering components and the driver. At the rear the lower the pressure the greater the grip and off road performance. With a low pressure the tyres self clean better but note that in top gear with soft tyres the JTV becomes difficult to control, the flexing of the sidewalls is not damped. However too low a pressure increases tyre creep on the rim and the likelihood of punctures. Again everything in moderation. Experimenting with tubed and tubeless set ups we have found no difference in performance. On the MSA JTV's we run the T84's at 30psi at the front and between 10-30psi at the rear according to the terrain.

Before starting to modify the front beam for ride height you must determine the rear axle location. Basically on tractors with an 18" rear tyre as standard the axle is mounted an inch closer to the chassis than the latter machines fitted with 20" tyres as standard. The implications are discussed in a later chapter but you must make that decision first to provide the datum point for modifying the front stub axles.

Whatever the size of the standard rear tyres, most tractors will be fitted as standard with a 15" o/d front tyre. Remember that the height difference is halved when determining the new location for the front stub axle. With the MSA JTV's we decided to run with a standard specification front beam without modifying the stub axle tubes welded on each end because this retained strength and we were able to achieve the increased height for the stub axle within 1/4 " by simply relocating the plate welded to the stub axle which acts as the bottom location and for the track rod and steering stops.

Turning to the front beam, strength is vital in this component because there is no suspension and the beam is likely to be subject to high impact energies transmitted from the tyres either running into an immovable object or from a heavy landing. Standard Westwood beams up to 2000 had plain nylon bushes for the stub axles to turn in. During development we obtained a Countax (the beams are interchangeable with Westwood's from 1986 onwards) in component form when we were still considering relocating the tubes higher up on the beam. The Countax beam offers a distinct advantage over that fitted to early Westwood's in that the stub axles turn within proper bearings. These are so much stronger and also provide for a much lighter steering effort. The beams we used were from the Countax K series produced between 1991-94. The latter C Series have increased rake upon the tubes which mean that the bend in the stub axle is greater, potentially weakening that component. In fact our second and third JTV's

had C series beams and we tried a little negative camber on the stub axles which resulted in one being bent out of shape during a hard landing during testing, and the other stub axles showing stress, whilst those on JTV 1 with the K series beam and no camber either way have shown no stress in this area despite that JTV having done more testing.

On the Darby's JTV 4, built on a 1990 Westwood (badged as Laser L110 for those that notice these things, see later chapter) to test the draft rules, the stub axles have been formed to give positive camber. This is common on full size tractors and provides for a tighter turning circle, better tyre to chassis clearance on full lock and less strain on the bend in the stub axle. So having bent your stub axles to shape and welded the location plate in position you will now have to machine a new slot for the top circlips to locate in. On the MSA JTV's we devised a new top fitting held on with three grub screws, which apart from being less fiddly to fit was felt to be stronger and less prone to failure in the event of high impacts. A circlip could break or pop out of its slot.

On the MSA JTV's we decided to fit four bolt 4" PCD front hubs to allow for interchangeability of tyres. On JTV 1 we used boat trailer hubs available from most trailer outlets. These have ball bearings which are better with side loadings than hubs with taper bearings. On JTV's 2 &3 we used the rear hubs and bearings surplus from the complete rear brakes taken from a Mini or Metro. These too have ball bearings and it keeps the cost down. Note that if using Metro hubs they require the cast ears to be machined off and ideally the studs to be shortened. This is because the Metro hub (and Mini 1984 on) uses a drum with a cast spacer and the studs are longer accordingly but are not fully threaded.

Both boat trailer hubs and those from a Mini or Metro have an internal surface of 1". Now most tractor stub axles are ¾" so it is necessary to machine up a thin sleeve to allow a proper fit.

The steering on most tractors comprises a straight steering column with a small pinion which turns a rack of sheet steel. To this a joint operates a steering arm which with another joint connects to the steering arm on top of one of the stub axles. The other stub axle is connected by the track rod. The standard set up, particularly on older tractors has a number of weak points. Firstly the joints commonly found are not designed for hard use being a ball un-greased in a swivel housing. Secondly the racks are prone to flexing, note later models of Westwoods and Countax have thicker or double thickness reinforced racks. Thirdly and particularly with the pre 2000 Westwoods the steering arms are very weak, there were stronger ones fitted later on with welded fillets added, but even these are weak because they also use a keyway where as the Countax uses two flats machined into the stub axle. This provides for a greater contact area for location. Fourthly the steering link and track rod are made from plated mild steel and are prone to bending. Certainly for the track rod you could sleeve this with a steel tube, like many fit to Land Rover track rods for serious off roading.

On the MSA JTV's we fitted Countax track rods from their bigger A20 series tractor. This is still a plated mild steel rod but it is thicker and uses M12 threads rather than the standard M10 size. We have had no failures yet and these heavy track rods are less than £10.00. This also allowed us to use the M12 track rods ends from the same source. Countax fit a proper rose joint on their tractors and these are quite reasonably priced as rod ends go, and they fit. We used the steering arm from the A20 as well because this is a much heavier duty component. The standard Westwood steering link actually failed on JTV 1 the night before its debut at last January's Autosport show. This was before we had driven the tractor and was simply from stress' caused from pushing it around the workshop. Overnight we made up an M12 steering link in stainless steel. The original steering link was machined without a proper radius where the thread finishes and as any engineer knows this creates a stress point. That said we subsequently bent the stainless steel steering link during the same incident above which bent a stub axle. As you can see our test drivers have been doing the job properly! As a result we down sized the bolt through the rose joint where it attaches to the steering arm to provide a shear point, this saving damaging other steering components and being the most accessible is the quickest to replace in the field.

Chapter 4
Brakes

During JTV development disc brakes from Karts were researched but were found to be expensive and bulky. A Kart only uses one rear brake as it has no differential and there are no space restrictions. A flash of genius occurred one Sunday afternoon when looking at trailer wheels and hubs, that was the realization that most small trailers use a 4" PCD, and so does the Mini. As mentioned in Chapter 2, some larger lawn tractors also use hubs with a 4" PCD and we found that with light machining these standard Countax parts fitted inside the Mini drum. Even the standard studs on the hubs were long enough.

The standard brake fitted to most tractors is a simple mechanical disc brake on the transmission operated by a combined clutch and brake pedal. When properly adjusted it is adequate for its intended purpose of mowing. For off road work it isn't any thing like good enough and being a transmission brake means that even if fully applied, if one wheel loses traction it may start to counter rotate with the result that the tractor will move despite the brakes being on.

Therefore something better is required. Discs or drums? As discussed in the chapter on wheel selection clearance is a major factor. If you have a transmission with a separate gearbox and chain driven axle you could fit discs inboard of the chassis where there is a lot more room and where the rear skid plate (assuming one is fitted) will protect the sprocket and the discs. Most tractors will have a transaxle and so the brakes must be fitted between the chassis and the wheel.

Cost is a major factor, as with all aspects of the project. If using 10" or bigger wheels there are some automotive disc setups that could be made to fit inside the wheel, the wheel affords some protection. However special carriers would need to be machined to mate the discs to the half shafts, and then carriers made to hold the calipers. On JTV Proto Kevin Mizen made up his own discs and carriers and used calipers from a motor cycle. However that JTV uses 8" rims and the wheels have had to be spaced out to clear the brakes. A wider track aids stability but reduces the choice of route between canes on section, and reduces the turning circle too.

So Mini drums it was. These are cheaply available second hand, fit inside the wheel and take up little space, provide for a hydraulic foot brake and a cable handbrake. To fit the back plate a solid steel billet carrier was made up in two parts. The horizontal billet picked up on standard transaxle bolts whilst the vertical billet has a phosphor bronze bush either side of which machined into the Countax drive hubs are circlips groves. This provides an additional substantial bearing which takes the strain away from the transaxle itself (not all use bearings for the half shafts and rely upon the die cast aluminum casing for support) whilst the double circlips mean that any side loadings are not transmitted up the half shaft and into the differential itself. Our original setup worked well until we fitted fiddle brakes. The trouble was that with the high torque involved with the reduction gearing and the original horizontal carrier we made just using the outer bolt holes in the transaxle casing, we broke the latter. So we redesigned the horizontal billet to pickup on the bolts which also attach the transaxle to the chassis brackets. This has proved reliable during all subsequent testing and demonstrations. However putting the brake carrier between the transaxle casing and the chassis brackets meant that we had to make new shorter chassis brackets. We had hoped to use as many standard parts as possible but a pair of chassis brackets is much cheaper than a new transaxle. Whilst making shorter chassis brackets we redesigned them into a box section for added strength. Note that standard brackets are known to fail even in hard mowing and Countax supply an up-rated part through their service department, we did not use this because we needed a shorter than standard bracket. Also note that on Westwood Gazelles and Mark 4 tractors the chassis brackets are welded to the chassis. Whatever rear set up you choose to build, location height and brake wise it would be a good idea to cut these off and make up stronger bolt on brackets.

To operate the brakes a master cylinder is required and we eventually settled upon the clutch master cylinder from a Land Rover Defender. These are quite cheap new, and are a single bore system. Because the MSA JTV's are demonstrators and were intended to be driven by young people of a wide range of experience and ability we wanted to keep the original single pedal to operate the brakes and clutch. If you are building a JTV which will be similarly driven by people of a wide variety of abilities I would recommend following this principle.

To mount the master cylinder a steel bracket was fabricated bolted to the chassis side and where the master cylinder is located straight in front of the pedal but clear of the engine. This will depend upon which engine your tractor uses. To connect the pedal, a bracket was welded to it with a hole. In this hole a floating rod, adjustable in length passes and as the pedal is depressed this pushes the rod which is threaded straight onto the master cylinder. It is important to build adjustment in at this point and the system was initially fiddly to set up because the brakes must not operate until the drive belt has been declutched. It also allows adjustment for the drive belt wearing and stretching. On the MSA JTV's no flexible hoses have been used which may account for a rather firm pedal.

During the development of JTV 1 we had a lot of problems getting this set up to stop the vehicle. This caused a lot of head scratching because with a slow moving vehicle weighing just over 330kg, brakes from a saloon car weighing twice that and designed to operate at speeds 10 times faster than a JTV really ought to work. After much experimenting we determined that it was the fact that we had used all new parts that was the problem. A JTV simply does not generate enough heat to bed new linings in. We hand faced and scoured the brake linings and machined scavenge slots into the drums which improved matters although it is only now after many hours of use are the brakes beginning to work well. For this reason when building JTV's 2 & 3 we used second hand linings and drums. We did as a matter of course fit new wheel cylinders since they are cheap and you never know what condition second hand hydraulic cylinders are in. The first test of JTV 2 proved the point, with brakes bedded in on the donor vehicle and properly adjusted they worked as intended, sharply!

The JTV Proto also experienced similar barking deficiencies despite using discs and braided competition brake hoses were fitted in an effort to improve performance as it was felt that the ordinary hoses were bulging and not transmitting force to the pads. However it is likely that the discs themselves being machined from steel plate afford a less efficient surface than cast iron. After much use though they are now working extremely well.

Fiddle Brakes.

The regulations prohibit the use of torque biasing or limited slip and locking differentials. This is done for cost, there are no commercially available differentials of this type which fit the transaxles and whilst it is always possible to build your own it was decided that to keep the JTV an affordable proposition they would be banned. However there are times when a wheel will break traction and the easiest and cheapest option was to fit fiddle brakes. Fiddle brakes allow the wheels to be individually braked, this is cheap traction control and of course also allows for tighter turns to be made as the vehicle will turn around the wheel being braked. On the MSA JTVs we opted for simple cable operation using the handbrake. By fitting separate cables to each drum (from a Peugeot 306) and making up a cable pull with a separate lever for each wheel we had fiddle brakes. Our first system used a Metro handbrake lever to provide a mechanical ratchet-locking handbrake. The Metro lever pulling both cables together with the fiddle levers set either side. However we standardized on a Freelander handbrake lever simply because they became available and are much better quality than the Metro ones. Note that wherever you mount the hand/fiddle brakes because of the forces involved the brackets and part of the tractor to which it is fitted must be strong. On the MSA JTV's we mounted the hand/fiddlebrakes on the offside rear mudguard with 3mm thick spreader plates on the reverse side.

The JTV Proto uses a totally different and more sophisticated setup. Two separate foot pedals hydraulically operate the rear calipers separately and independently of the foot brake whilst an over center type lever from a forklift truck pulls a Defender handbrake cable to operate the original transaxle brake as a mechanical handbrake.

Hydraulic or Mechanical Operation.

For safety's sake the JTV like many competition vehicles is required to have a mechanical handbrake. This is so that in the event of the failure of the hydraulics the driver always has a reliable fail safe means of stopping the vehicle, especially important in the event of a failed ascent. However for the footbrake it is permitted to use hydraulics. Whilst this is not mandatory, hydraulics are generally more powerful and easier to connect. It is for example not necessary to have a clear run from the pedal to the brakes and the pipes can be easily routed around other features of the tractor chassis. It is also possible to alter the mechanical advantage by changing the bore of the master cylinder in relation to the wheel cylinders. The larger the bore of the master cylinder the greater the volume of fluid displaced and therefore the shorter the pedal travel required to operate the wheel cylinders. Too short a pedal travel and the brakes will work like a switch with no 'feel' and progression, too small the displacement and the pedal will have a

long travel which can be disconcerting for the driver and potentially mean that the driver may not be able to easily provide full pressure to operate the brakes. It is also possible to introduce a little 'feel' into the system by fitting a short length of flexible hose, because the small but inherent flex in the hose sidewalls allow for a little 'spring' in the pedals' feel. Making your own brake pipes is a very simple operation, kits to flare the brake pipe are commonly available for reasonable sums and will allow you to make and route pipes exactly where you want them. Brake pipe material is available in three types of material, steel, cupro-nickel and copper. Steel rusts and is less malleable, cupro-nickel doesn't rust and is fairly easy to work but copper brake pipe is the easiest to flare and bend without kinking. It is also important to make sure that you use the correct unions for the hydraulic cylinders, imperial or metric. It is easy to mix these up and then you not only run the risk of damaging the threads in the hydraulic cylinders but the connection will leak fluid however much you tighten the union.

Chapter 5
Transmissions

We may ignore any further discussion regarding hydrostatic transmissions since they are not permitted by the regulations, and whilst other makes of manual transmission may be encountered we will concentrate here on the Peerless types because these are by far the most prolific. These further fall into two types being the fully enclosed transaxle and the separate gearbox with a chain drive to an axle.

Transaxles.

Peerless transaxles are commonly 5speed with a reverse, with a constant mesh mechanism which does not allow for gear changes on the move. This is not a problem because the standard gearing is such that in most cases the tractor is able to pull away in top gear. For the JTV this has two marked consequences, firstly that because there is no facility to change gear the driver is not going to be distracted on section by looking for another gear, and secondly the driver will have to learn to assess the terrain and select the appropriate gear before starting the section. Note that worn transmissions will allow hot shifting, but not for long, the combination of existing wear and extra stresses from hot shifting will destroy the transmission quite quickly.

Most Peerless transaxles encountered will also have ¾" output shafts and if working with an older gearbox it is probable that the wheels may have seized onto the shafts and the small locating key will have rusted solid. If you are lucky penetrating oils may release the wheel from the shaft but just as likely you will be faced with replacing the whole transaxle, because if the wheels have become this seized it is likely that the rest of the transmission is also badly worn and will not provide much service. When viewing a used tractor or transmission it is also worth checking the state of the input pulley bearings. This can be easily done by wobbling the input pulley on the top of the transaxle, obviously with the engine switched off. There will be no play on a new 'box, and a small, barely discernable play is acceptable but if the pulley flaps about the transaxle will be in a poor state and require replacement.

Note that replacement is the only real option, the transaxles are not readily serviceable and most older tractors will be fitted with the cheaper and weaker models of transaxle. Fortunately the different models of Peerless transaxle are largely interchangeable.

The transaxles fall into three categories.

Light Duty.
On early tractors these will be likely to be 930 or on later machines a light duty variant of the 801 series. These will all be 5 speed but later tractors may be fitted with the 206 6 speed transaxle. The MSA JTV's all use the 206 transaxle.

Medium Duty.

This is the 801 series in its various models, fitted as standard to most mid power tractors and early model twin cylinders this is a 5 speed transmission. The 801 is the most prolific transaxle likely to be encountered and is that fitted to the Darby's JTV 4.

Heavy Duty.

Not commonly found as a standard transaxle the 820 transaxle is a bigger stronger version of the 801. It is commonly 5 speed with a very low 1st gear ratio, it is suitable for use with ground engaging implements like a plough and so has much stronger internal parts and has 1" output shafts. The Mizen's JTV Proto has an 820 retrofitted.

Interchangeability.

The 930, 801 and 206 transaxles are largely interchangeable. Only the front mounting points may differ. On some early casings the front mountings bolt to the top of the casing, whilst later ones use a side mounting. However all share common rear mounting points and it is very easy to make up front brackets for later transaxles. The brackets are essentially a flat bar with holes drilled to bolt to the casing and the top bent over at 90 degrees to simply bolt to the tractor chassis. If you are not confident to make such a bracket you could always buy the brackets from a later tractor. They share the same fittings for the input pulley and have the same ¾" output shafts. It is therefore a simple matter to swap a worn transaxle for a later and stronger type. The Countax four bolt drive hubs will fit all of these models of transaxle.

The 820 shares the same input pulley fittings and mounting points with the 801 and 206 series. However as it is fitted with larger output shafts the Countax four bolt drive hubs from the Countax A20 series must be sought together with appropriate washers and fittings as required. The other difference is that on the 820 the input quadrant for the gear selection is 1 3/8" further to the side than on an 801. This means that the linkage may foul on the front mounting bracket. On a 2000 model Westwood T1600 with the gearlever mounted on the left rear wing this proved to be an issue when upgrading that tractor with an 820 transaxle. To resolve the matter the linkage was cut and re-welded 1 3/8" shorter to overcome the problem.

Separate gearboxes.

Some of the cheaper imported tractors use a gearbox, likely to be a Peerless 700 series, with a chain drive to an axle. The 700 series may be viewed as an 801 without the integral differential. This set up offers two potential advantages over the more common transaxle. Firstly there is the opportunity to further reduce the gearing, secondly if an intermediate set of sprockets were fitted it would be possible to fit a small sprocket to the axle whilst retaining the same gear ratios but allowing greater ground clearance. This is only theory, we haven't tried this during the JTV project but is an avenue that some will surely wish to explore.

Limitations.

The primary limitation of these transmissions is the maximum size of tyre that can be fitted. Peerless publish these dimensions but for another manufacturers transmission the best advise would be not to fit a tyre with a larger diameter than that originally fitted. From experience fitting a tyre 3" larger than recommended saw an 801 transaxle destroyed within 30'! Do not over do it, it is an expensive experience. For the 930 series 18" o/d is recommended, the 801 and 206 may use up to a 20" o/d tyre as fitted to the MSA JTV's . The heavy duty 820 may use up to a 23" o/d tyre.

Chapter 6
Roll-cages

The regulations require a full rollcage to ensure maximum protection for the driver. With the seating position over the rear axle it is not possible to incorporate the rear stays normally required to brace the roll cage. The cage therefore is braced from the front cage to the rear mudguards and these braces also serve to prevent the drivers feet slipping from the foot rests and outside the extremities of the vehicle. A horizontal brace is fitted to the rear hoop which also serves to guide the seat belts from their mountings over the competitor's shoulders.

The material specified in the regulations has been proven over many years in off road motorsport and its properties allow it to be easily formed using a hydraulic pipe bender. It also welds easily. It is therefore possible for the experienced DIY mechanic to fabricate a safe roll cage at home. There isn't space here to discuss the skills needed, save that the roll cage requires tidy welds which achieve full penetration and when forming bends in the tubing allowance must be made for the inherent springiness of the steel. In other words when you remove the pipe from the bender it will spring out a little. Experience or practice with scrap tube is recommended.

Attaching the rollcage is dependant upon the type of chassis and personal preference. On the MSA JTV's we found it easier to fabricate a cross member in 2" square box section with a 3mm wall thickness which passed completely under the chassis for the front hoop. This additionally provided a strong mounting for the rear of the mid skid plate and stiffens the chassis to prevent flexing. Note that depending upon the mounting position of the transaxle it may be necessary to space this cross member downwards to clear the drive belt. Those tractors fitted as standard with a 20" o/d rear tyre have the transaxle mounted 1" lower. If you use the standard mountings for the transaxle fitted with 18" o/d tyres as standard you will find that it is not necessary to space the cross member downwards. On the MSA JTVs we had to space the cross member by ½". This cross member was then bolted to the chassis. It would be possible to weld a cross member to the chassis or to fabricate outriggers which weld to the chassis.

At the rear the MSA JTVs use a bolt on cross member in the same material described above formed into a bridge because the chassis itself is of course much narrower than the rollcage. When fabricating this mounting it is worth considering spacing this backwards to accommodate a more rearward seating position for the longer legged driver.

Chapter 7
Seating

The regulations require that the seat incorporates an integral head restraint. Most standard tractor seats are too low in the backrest to warrant modification and in most cases it is better to fit a proper competition seat.

Most drivers will probably suit using an adult size of seat, however if the driver is particularly small one of the high back kart seats modified with a slot cut into the backrest for the seat belts is an option.

On the MSA JTVs where we knew that we would have to accommodate a wide range of driver sizes and we went to Tillett Racing seats for a solution. Kart seats are made in particular shapes in different sizes and Tillett had some moulds for a full size high backed seat in the T7 shape. This meant that using the special foam inserts tailored to fit the T7 seat a smaller T7 high back kart seat could be quickly inserted for small drivers. Because the system is designed to work in a modular way it provides a very neat and safe solution to the problem.

Composite seats require care when mounting. If they are not properly braced and supported they may fracture, especially as many are not designed for the kind of pounding and twisting loads that occur off road. Advice should be sought from the manufacturer. Tillett recommend that in addition to attachment points at the seat base the sides are braced approximately at a point below the drivers shoulder. On the MSA JTVs we elected to bond studs welded to larger spreader plates to the seats rather than drilling and bolting the seat, although this is acceptable and the Tillett seats were supplied with bolt mounting kits. Note that we discovered that there are essentially two types of resin used in composite seats and they require different adhesives. It is also essential when bonding to make sure that the seat has cured otherwise the gases that escape from the resin during the curing process will prevent the adhesive from properly bonding.

The Darby's JTV 4 uses a composite seat from QT Services. This is designed as an off road competition seat and doesn't require additional side braces.

The seats may be mounted to a plate similar to that originally fitted to the tractor, however it is likely that a wider plate will be needed and whilst it may retain the adjustable forward and aft location of the original a method of preventing it tip forward should be fitted.

Chapter 8
Electrics

The standard electrics fitted should suffice save that you will need to add a cutout switch. Remember that most lawn tractor engines will happily continue running without a battery so the cut out switch needs to be the type fitted with additional contacts and a resistor so that the ignition circuits are isolated in addition to the battery. The cutout switch should be fitted where it is easily accessible to the driver and marshals and either side of the steering wheel on the center console is ideal.

Most tractors will have the battery fitted underneath the bonnet, however some older machines and some imports will have the battery located underneath the seat. Unsealed acid batteries are dangerous when inverted and so if your tractor has a location under the seat you must either fabricate a leak proof cover or relocate the battery under the bonnet. Note that the same applies to under-seat fuel tanks, these really should be moved under the bonnet.

There will doubtless be a temptation to fit lights. Many tractors have lights fitted as standard, however note that these are low wattage units and ordinary automotive spotlights will be far too powerful for the tractors charging system. Early tractors typically had sealed beam lights whilst more modern machines have separate 21watt bulbs.

You will need to take a good look at the original wiring. In time vehicle wiring deteriorates, the insulation hardens and cracks, causing short circuits, whilst the wires themselves become blackened and loose their conductivity. Garden tractors typically suffer more than a motor car of the same vintage commonly living outside all year round and with infrequent use the effects are accelerated. Fortunately a garden tractor has a fairly basic wiring harness and so fault finding or even making a replacement loom is not a major task.

Chapter 9
Other Modifications

Bumpers & Skid Plates.

The fitting of a front bumper is a fairly sensible modification, especially if you have headlights. On the MSA JTV's we also used the front bumper to provide a front mounting for the front skid plate. This skid triangulates the bumper, allows the tractor to ride over obstacles and protects the front beam and on the MSA JTV's protects the relocated exhaust silencer moved from the side of the tractor to provide clearance for the larger front tyres..

The rear location of this skid on the MSA JTV's locates on the chassis where it wraps around the front beam and from these standard bolts an intermediate skid plate runs rearwards and upwards to pickup on the front roll cage cross member. This intermediate skid protects the engine pulley and the clutch mechanism from impact and mud. We shortened the engine pulley block in a lathe. The pulley block itself is a large solid steel machining with a single or triple pulley at the top providing drive to the transaxle and Power Take Off where fitted whilst extending downwards by 4-5" to where a larger pulley is typically bolted on to provide drive to the cutter deck. Whilst simply removing this bolt on pulley will improve clearance, shortening the block itself allows for a better angle for the skid plate, improving ramp break over angles. This shortening was approximately 2" and we had to shorten and rethread the original bolt.

On the MSA JTV's both the front and intermediate skids were made up in 3mm plate steel. This provides additional weight below the chassis and helps improve stability on side slopes. When we were rushing to prepare JTV 1 for its launch at the Autosport Show January 2002, we made a front skid in 2mm aluminum which looked good but which suffered at the hands of our test pilots at the vehicles first test in March.

The rear skid on the MSA JTV's was also totally reworked after the ARC National Rally in June. We had made a substantial skid plate to protect the transaxle in 6mm steel plate. The reason for using such thick plate was again to add weight low down and over the driven wheels. This plate and the two 20kg steel blocks which are fitted each side of the transaxle and form part of the skids attachment to the chassis adds approximately 55kg in total to the rear of the tractor. Because the transaxle itself reduces ground clearance it is important to shape the rear skid to fit as closely as possible to the transaxle casing. This was the subject of our reworking.

Even so it is still possible to belly out the JTV and this will nearly always be on the rear skid.

Appendix A

JTV Regulations

Authors Note: The regulations are presented here in the format submitted to the Motor Sports Council. Whilst definitive and as they will appear in the 2003 MSA Yearbook, they should be read in conjunction with the current MSA Yearbook.

Section P.
Definition
Junior Trials Vehicle. A two wheel drive vehicle adapted from a front engined lawn or garden tractor with the cutter deck and associated ancillaries removed, and fitted with a four stroke petrol or diesel vertical crankshaft engine of the Industrial and Commercial restricted type.

Section E

To add to the minimum ages table;

Discipline	Driver	Navigator	Front Seat Passenger	Rear Seat Passenger	Notes
Junior Off-Road Trial	8years old	n/a	n/a	n/a	

Section H

H.6.2 **Junior Trial**
Must be organised in accordance with 1,2,6-6.1.7, and 6.1.9-6.1.10.

H.6.2.1 At all times during the event Junior Trials Vehicles may only be driven under the instruction of an official.

H.6.2.2 Where a Junior Trial is held concurrently with another event at the same venue, the area for the Junior Trial must be adequately separated and clearly defined.

H6.2.3 Special consideration must be given to the terrain chosen, particularly with regard to side slopes and drops, and water should generally be avoided.

H6.2.4 The maximum depth of any water shall be 0.2metre.

H6.2.5 There will be three classes, Novice, Intermediate and Expert. The severity of sections shall be determined as follows;

	Novice	**Intermediate**	**Expert**
The maximum longitudinal gradient	50%	60%	none
The maximum Transverse gradient	25%	35%	none

H.6.2.6 An MSA Observer may be appointed.

H16.3.2 Drivers at events other than Competitive Safaris, Timed Trials, Team Recovery, Point to Point and Hill Rallies up to and including Clubman status must produce a valid Club Membership Card at signing-on. At events of National B status and above and all Competitive Safaris, Timed Trials, Team Recovery, Point to Point ~~and~~ Hill Rallies **and Junior Trials**, Drivers must produce a Competition Licence [as detailed in Section E], and Passengers must produce a valid Club Membership Card.

H17.1.8 The minimum age for a Junior Trial is 8 years old. Competitors are no longer eligible for a Junior Trial on or after their 18th Birthday. All competitors must comply with E2.7.

H25.4 **Junior Trial**
Must be organised in accordance with 16,17,19,25.2,26-26.3.13, and 27.

H25.4.1 There will be three classes, Novice, Intermediate and Expert. Competitors must finish four Novice Junior Trials before being eligible to enter an Intermediate Junior Trial. Competitors must finish four Intermediate Junior Trials before being eligible to enter an Expert Junior Trial. Proof of finishing a Junior Trial will be by the signing of the competitors Competition Licence by the Clerk of the Course.

H25.4.2 Sections for the different classes may either be set out separately or so that a section increases in severity with separate finishing points for the respective classes.

H25.4.3 At all times during the event Junior Trials Vehicles may only be driven under the instruction of an official.

H25.4.4 Fiddle brakes may only be used by competitors in the Expert class. If fitted to vehicles entered in the Novice or Intermediate classes they must be rendered inoperative.

H39 Junior Trials Vehicle

H39.1 Chassis and Body

The chassis and bodywork must be standard except where modified to comply with these regulations and must be that from a proprietary machine. E12.3.1 does not apply in respect of the seat cushion being below the top edge of the adjacent body. H36.1. does not apply

H39.2 Engine

H39.2.1 Must be fitted with four-stroke petrol or diesel vertical crankshaft engine of the Industrial and Commercial restricted type designed for use on a Ride on Mower or Lawn/Garden Tractor.

H39.2.2 The engine must be fitted in its original location and retain its governor or restrictor which may not be modified or removed.

H39.2.3 The engine must be fitted with an effective silencer. The silence and exhaust manifold are free as to type and location but must be fitted with shields where located outside of the bodywork or chassis.

H39.2.4 The engine must be fitted with an air filter, the type and location are free.

H39.3 Transmission

H39.3.1 Must be fitted with a manual, constant mesh transmission of the type originally fitted to the vehicle. Transmissions of an alternative make or model may be fitted.

H39.3.2 The driver must be protected from all drive belts/chains.

H39.3.3 Must not be fitted with a locked, locking or torque-biasing differential.

H39.4 Wheels and Tyres

H39.4.1 Wheels and tyres are free.

H39.5 Brakes

H39.5.1 Must be fitted with a brake system operating on both rear wheels simultaneously. The brakes will be operated by a single foot pedal and may activate the brakes either mechanically or hydraulically and must be capable of locking the wheels when applied at maximum speed.

H39.5.2 Must be fitted with a mechanical handbrake operating directly on both rear wheels, which is capable of holding the vehicle on a 45-degree longitudinal gradient.

H39.6 Steering

H39.6.1 The steering system must retain its original location and operation, and must be un-assisted. Steering system components are free and may be strengthened

H39.6.2 A steering damper may be fitted.

H39.7 Front Axle

H39.7.1 The location and mounting of the front axle must be standard to the vehicle and no alteration may be made to the chassis or bodywork to increase articulation.

H39.7.2 The front axle may be modified or replaced.

H39.7.3 Movement of the front axle may be controlled by the addition of springs and/or dampers, or friction materials between the axle and the chassis.

H39.8 Safety

H39.8.1 A roll cage (see drawing 1 below) must be fitted comprising a front and rear hoop which extend the full width of the bodywork and which maintains the minimum clearance above the competitors helmet when properly seated (Q31)

H39.8.2 Sidebars must be fitted which prevent the driver's feet from involuntarily leaving the confines of the vehicle.

H39.8.3 A rear brace must be fitted to the rear hoop to guide and locate the shoulder straps of the seat belt.

H39.8.4 The roll cage, comprising the front and rear hoops, lateral bars, side bars and rear brace must comply with Q1.3 or be to BS1387 medium weight, blue band, being of a minimum 42.30x3.2mm external diameter and wall thickness.

H39.8.5 The roll cage must be bolted to the chassis with 3mm thick spreader plates and a minimum of two 10mm high tensile bolts at 25mm between centres per mounting (drawing Q13) or;
bolted to outriggers of 3mm wall thickness bolted/welded to the chassis, using 3mm thick saddles and two 10mm high tensile bolts at 25mm between centres per mounting (drawing 2 below)or ;
welded to outriggers of 3mm wall thickness bolted/welded to the chassis as drawing Q51.

H39.8.6 A seat belt to Q2.1.2 must be fitted.

H39.8.7 A circuit breaker to Q8 must be fitted which is operable by the driver when properly seated and which is clearly marked.

H39.8.8 A crash helmet to Q10 must be worn.

H39.8.9 The battery must be securely mounted and fitted in a sealed container or under the bonnet.

H39.8.10 A strong and clearly marked recovery point must be fitted to the rear of the vehicle.

H39.8.11 The seat must be rigidly located and designed to securely locate the driver up to and including the shoulders. A head restraint must be fitted where not integral to the seat (Q13).

H39.8.12 The fuel tank must be located under the bonnet and comply with Q14.1.2.

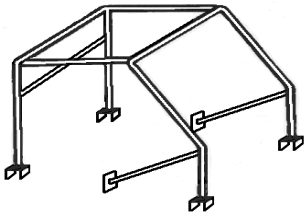
H39.9 Miscellaneous

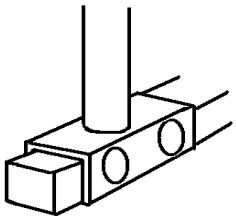
H39.9.1 A front bumper or bush guard must be fitted to protect the chassis and bodywork and which may provide location for under chassis protection and which must provide a suitable towing point. .

H39.9.2 Under vehicle protection skid plates/guards may be fitted to protect the steering, engine and transmission.

H39.9.3 Ballast may be added to the vehicle provided it is securely attached to the chassis and or skid plates. Ballast must be located below the floor line.

Drawing Number 1





Drawing Number 2

Appendix B

Identifying Westwood Tractors

Information on the earliest Westwood Gazelle's is sparse. The first tractors seen had a single central bolt front axle mounting, a red bonnet with grey chassis, mudguards and console and had white plastic nose and a gear lever which came up through the area between the console and the seat box. For the purposes of this guide we shall refer to these models a Gazelle Mk 1. No information is readily available regarding the transaxles fitted to these models.

Gazelle Mk 2.

The Mk 2 was introduced in 1980? and ran until 1983. These differ from the Mk 1 in so far that the gear change was now a column shift with the gear shift being a hollow tube around the steering column. It was normal to find an auxiliary black plastic fuel can fitted into the cavity between the console and the seat box. In 1982 Westwood introduced a sweeper mounted on an implement bar and driven by rollers rubbing on the rear tyres. Such models equipped as standard with this new sweeper were fitted with a black plastic nose. Note that a Baby Gazelle was also available which had smaller tyres and a flat metal nose with a mesh grille.

Gearboxes were;

Model	Westwood Part No	Peerless
Baby 6	2017	665A
Baby 8, W8E &W11E	2018	832
W16E	2019	801-030

Gazelle Mk 3

1984 saw the introduction of the Mk 3, the chief change being the introduction of the twin bolt front axle mounting, still used until the last Plymouth built machines in 2000. The Baby 6 & 8 were now respectively the S600 and S800, and retained the mesh grille whilst the T800 & T1100 were as the old models but had the black plastic nose as standard. Introduced during the period of the Mk3, 1984-86, was the first PTO which was fitted to the T1600 and the new Diesel D1200. The gear change remained as a column shift but was now a separate column running down beside the steering column.

Gearboxes were;

Model	Westwood Part No	Peerless
S600,S800,T800 & T1100	2018	832
D1200 & T1600	2019	801-030

Mk4

1987 saw the dropping of the name Gazelle and the introduction of one colour for the tractors. This was now an all over orangey-red which fades with time. The T models continued with the same black plastic nose, but the bonnets now extended further down each side except for the T1600 and D1200. PTO was standard on all T models, and all models featured a higher console which was now proud of the top of the bonnet.

Gearboxes were,

Model	Westwood Part No	Peerless
S600,S1000 & T1200	2018	832
D1200 & T1600	2019	801-030

Mk5

The Mk5 of 1989, was a radical redesign of all body parts. A new rounded black plastic nose featured on all T models whilst S models had a new pointed steel profile to their fronts. The bonnet was now much deeper at the side except for the T1600 & T1800 which had large cut outs for their twin cylinder engines. The T1800 being diesel. A new console was fitted with a black plastic shroud. Rear mudguards were still bolted to the side of the seat box but now featured rubber mating continued from the foot rests.

Gearboxes were,

Model	Westwood Part No	Peerless
S800,S1000		
T1200	2018	832
T1600 & T1800	2019	801-030

Mk6

In 1993 the Mk6 arrived, this was the first step through model and the console was now a separate item to the seat box. Both parts were essentially the same as for the Mk5 except for the deletion of the welled area where the extra fuel can had been located. The rear mudguards were exactly as those fitted to the Mk5.

Gearboxes were,

Model	Westwood Part No	Peerless
All models	2019	801-030

Mk7

1994 saw the Mk7, essentially as a Mk6 except that the seat box and separate mudguards changed to a one piece pressing. A new lighter duty transaxle was introduced for the 1000 series which replaced the S models. The gear change was now moved to the nearside mudguard.

Gearboxes were,

Model	Westwood Part No	Peerless
1000	8222	940-016
All T Series	2019	801-030

Mk8

The Mk8 arrived in 1995 and ran until the last Plymouth build tractors in 2000. There was a mid-life reclassification of models from 1997, but all tractors from this period are regarded as one mark. The change from the Mk7 was on the bonnet and matching console. The tractors were now all red, the new bonnet had a black plastic grille for all models except the 1012 from 1995-1996, From 1997 all models had the lights and plastic nose.

Gearboxes were,

Model	Westwood Part No	Peerless
‘95- 1012/36	8222	940-016
‘95’96 T series	2019	801-030
‘97-‘00 S1300 & S1600 ‘96 1012/36	9478	200 6 speed (206-526)
‘97-‘00 S1300 Deluxe,S1300 Agro, T1600,& T1800	2019	801-030

Mk9

The Mk9 arrived with the acquisition of Westwood by Countax and a move to their Oxford factory. The Mk9 is a radically different tractor, being mechanically a Countax C Series fitted with the bonnet and console from the Mk8 Plymouth Westwood. Only one model has the manual gearbox and this is the S1300.

Gearboxes were,

Model	Westwood Part No	Peerless
S1300	NSS	206-526

Mk10

The Mk10 is just about to be announced for the 2003 model year and is the first major restyling with an all new bonnet since 1995. At the time of writing information is scarce but it is expected that the model range will be similar to the Mk9.

2000 Series

Introduced in 1992 and available until 1994, the 2000 featured unique styling. Obvious differences from the other models were the fully enclosed engine, headlamps behind a single piece protective shield and distinctive swept up rear mudguards. Only the earliest models featured a manual transmission.

Gearboxes were,

Model	Westwood Part No	Peerless
2012,2014 & 2018	2019	801-030

Appendix C

Identifying Countax Tractors

Countax made their first tractors in 1991, having been an independent design company to the trade for many years previously. These tractors, the K Series are quite similar in general to the Westwood, unsurprising when one considers that they both feature a solid 3mm plate chassis and use similar vertical crankshaft engines and transaxles. Countax tractors have always used a plastic molding for the bonnet. These tractors were made with a variety of engines and transaxles, manual and hydrostatic until 1995 when they were superceded by the C Series.

Countax tractors have always been innovators and have featured high quality fittings. For example where other tractors uses simple ball joints for steering, Countax fit proper rose joints as standard, roller bearings instead of nylon bushes in the front beam for the stub axles etc.

Countax also produce a bigger range of tractors with a deeper section chassis and bigger engines. The A20/50 and diesel D18/50 are aimed at the commercial user and those with a very large area of grass. However these tractors have always been fitted with heavy duty hydrostatic transaxles from Tuff Torque and so will require quite extensive re-engineering to convert to a manual transmission, although it is possible using many standard parts.

Around 1995-6 the Countax C Series were also marketed under the Haytor brand. Both models were hydrostatic and were finished in a dark green.

K Series
The early models were fitted with the Heavy Duty version of the Peerless 801 transaxle, and were fitted with following engines;

K12.5	Briggs & Stratton I/C Quiet	465cc
K14	Briggs & Stratton Vanguard	435cc
K14 Twin	Briggs & Stratton V Twin	480cc
K18	Briggs & Stratton V Twin	480cc

By 1994 the range was as follows, the manual retained the H/D Peerless 801 transaxle whilst the newly introduced hydrostatic models featured either the Tuff Torq K55 or Hydrogear 322/0750 transaxles;

K13	Briggs & Stratton Diamond Plus	465cc
K15 H	Briggs & Stratton Vanguard	465cc
K18T H	Briggs & Stratton V Twin	480cc

The C Series arrived in 1995 and with it a change for the manual transmission to the Peerless 206/536A transaxle, whilst only the Tuff Torq K55 featured on the Hydrostatic versions.

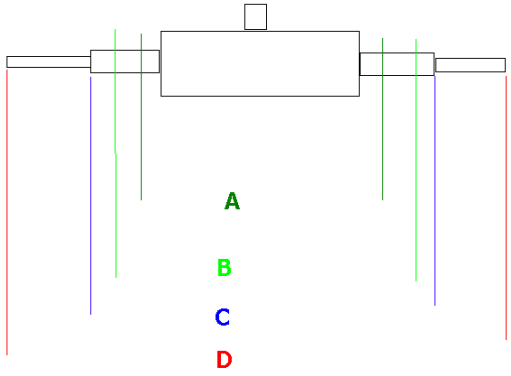
C300M & H	Briggs & Stratton Diamond Plus	465cc
C38H	Honda GXV390	389cc
C400H	Briggs & Stratton V Twin	480cc
C600H & HE	Briggs & Stratton V Twin	480cc
C800H & HE	Briggs & Stratton V Twin	570cc

The current range of C Series is as follows;

C300M & H	Briggs & Stratton Diamond Plus	465cc
C38H	Honda GXV390	389cc
C550H	Briggs & Stratton Intek	465cc
C400H	Briggs & Stratton V Twin	480cc
C600H	Briggs & Stratton V Twin	480cc
C800H	Briggs & Stratton V Twin	570cc

Appendix D

Common Peerless Transaxle Dimensions



Where A is the dimension for the chassis brackets;
Where B is the dimension for the extra mounts on certain models;
Where C is the total width of the casting
Where D is the total width with half-shafts (pushed in)

Peerless 206-526
A 13”
B 16 ¼”
C 19 5/8”
D 29”

Peerless 832 & 801-030
A 13”
B n/a
C 17”
D 28”

Peerless 801-020F
A 13”
B n/a
C 17”
D 30 7/8”

Appendix E

Components

This is a summary of the components sourced during the building of the MSA JTVs.

Used Parts
Mini or Metro rear drums.
Note post 1984 Mini, and all Metro drums have built in wheel spacers which will require machining.
Land Rover Freelander handbrake lever.
We originally used a Metro lever but were generously supplied with 3 from the Freelander which are stronger and of better quality.
Mini or Metro rear hubs.
On JTVs 2&3 we used the hubs from the Metro rear brakes sleeved down on the front stub-axles when we had problems sourcing boat trailer hubs as used on JTV .

New Parts Various

Component	Source
Land Rover Defender Clutch Master Cylinder	RCV
Dunlop 5.0x10 T84 2 ply Stabilarge tyres	Dunlop
3.5x10 trailer wheels	Towsure
Boat Trailer Hubs (ball not taper races)	Towsure
FIA Cut Out Switch	Scorpian Racing
Foam Handle Bar Grips (used on the fiddle brakes)	Towsure
Competition Seats	Tillett Racing Seats
4 Point MSA Specification Competition Harness	Securon

New Parts Countax
These parts are available through the Countax Dealer Network

Component	Quantity	Part No
¾" drive hubs (except Peerless 820)	2	198002000
M10 wheel nuts	8	04123400
M12 Track Rod (A20/50 model)	1	183012900
M12 Rod Joints (A20/50 model)	4	10872800
M12 Nuts (for Track Rod & Steering Arm)	4	049381100
Steering Arm (A20/50 model)	1	32702500
Front Beam (K Series)	1	32700500
Bearings to suit beam (62032RS 40mm x 3/4")	4	10802200

In addition you will require assorted fixings, too numerous too list.

If using the existing ½" UNF Westwood steering link and track rod, a spherical rod end is available from Rally Design, Part No:CR8F ½ x ½ RH CARBORAC

Useful Contacts

BCT Engineering 4 Manor Way, Old Woking, Surrey GU22 9JX: Contact Tony Ryan	01483 767756
Countax For your nearest dealer visit	www.Countax.com
Towsure Camping and Caravan Supplier	www.towsure.co.uk
Scorpian Racing 4x4 Off Road Specialist Equipment 3 North Western Commercial Center, Broadfield Lane, London NW1 9YS	www.scorpion-racing.co.uk/ 020 7485 5581
Tillett Racing Seats Specialist Racing Seats : Contact Steve Tillett	01795 420312
RCV Independent Land Rover Specialists : Contact Richard Moller	01622 873000
Securon Competition Harness Manufacturers	01494 434455
Dunlop Contact your local dealer	
Rally Design	www.raldes.co.uk