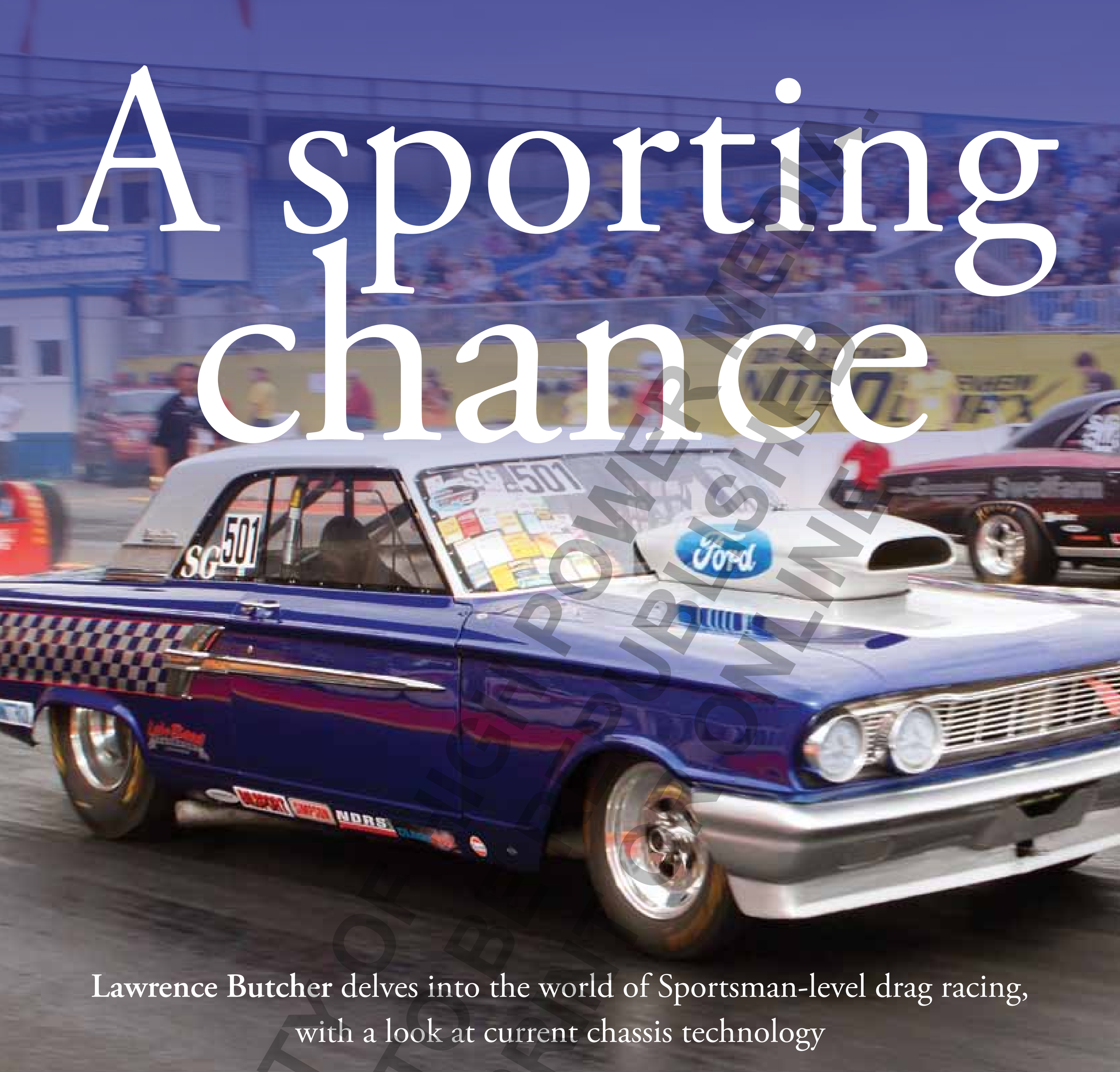


A sporting chance

Lawrence Butcher delves into the world of Sportsman-level drag racing, with a look at current chassis technology

Drag racing encompasses a plethora of classes worldwide and some of the most hotly contested and technologically varied are those referred to as 'Sportsman'. These are the classes run by the non-professionals, slugging it out on a Saturday night at venues ranging from the local eighth-mile drag strip to NHRA Full Throttle rounds.

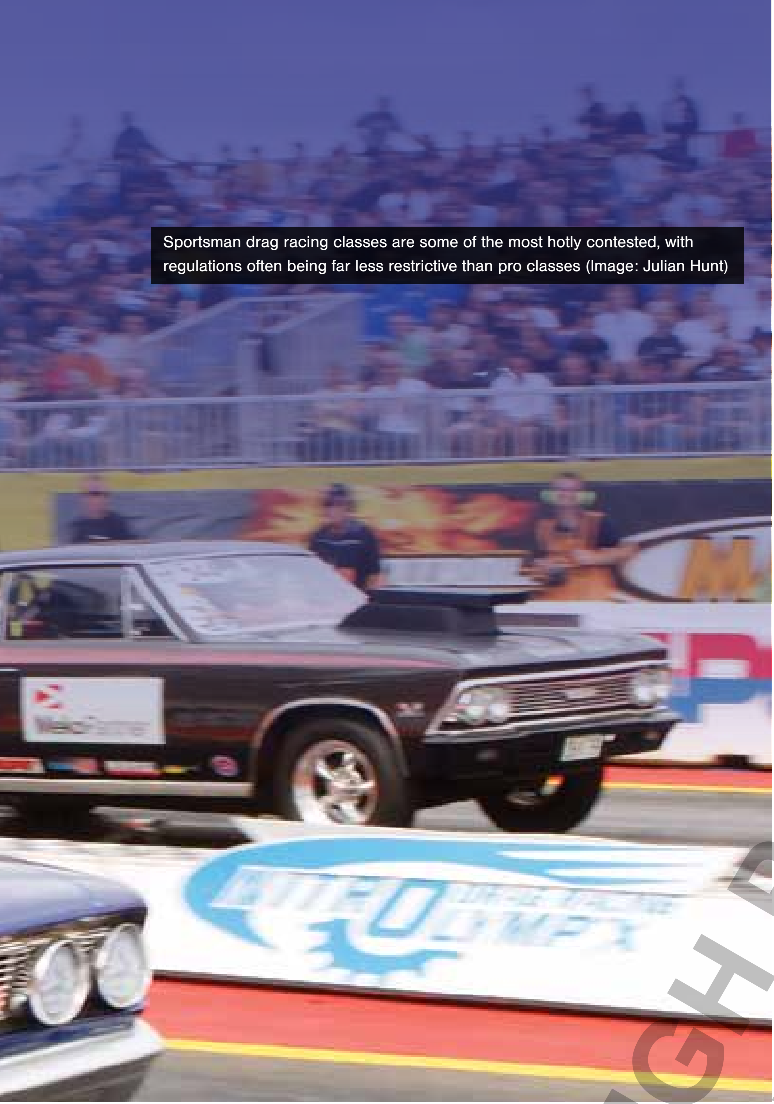
Just because they are not 'professional' teams though doesn't mean that many are not run like professional outfits, and the pace and technical standard of the cars can be phenomenal. Many classes have a fairly high degree of technical freedom not afforded to those running in Pro classes, and as such chassis designers can let their imaginations loose a little. However, the trade-off is the need to control costs; without large budgets flying around, Sportsman cars have to be built with a nod towards keeping prices in check.

So what is the state of play in the Sportsman chassis market in the US and Europe?

Materials

The predominant material used in most Sportsman class chassis is 4130 chromoly steel, due to the weight savings it provides over other steels; however, cold-drawn seamless (CDS) mild steel is still used in some applications. Where mild steel is used, the favored material is CFS 3BK or CFS 360 stock cold-drawn seamless tube. Cold-drawn seamless tubing has much better mechanical properties than seamed tubing, which can have a tendency to split when loaded. CFS 3BK has a UTS (ultimate tensile strength) of 65 ksi (thousand pounds per square inch), while CFS 360 is slightly stronger, with a UTS of 72 ksi.

Some chassis builders will use CDS tubing for chassis, as it is cheaper than chromoly, but Chris Isaacs of Chris Isaacs' Racecars encourages all his customers to opt for a chromoly frame regardless of regulatory requirements. "The chromoly tubing is mandatory for any car running 7.49 or quicker, and optional for 7.50 or slower," he says. "Although a chromoly chassis is more expensive for the



Sportsman drag racing classes are some of the most hotly contested, with regulations often being far less restrictive than pro classes (Image: Julian Hunt)

customer due to the higher raw material costs [the labor times for CDS and Chromoly work out about the same] we usually encourage the customer to go for the chromoly option even if their current requirements don't mandate it.

"Many customers start with a plan and some sort of budget, and their performance expectations are based around that, but as time passes and a bit of spare money becomes available they often want to go quicker, and a chromoly chassis to the relevant SFI specification allows them to step up their performance without any fears of 'running out' of chassis legality." This means that the extra few thousand dollars required for a chromoly chassis will invariably work out as a saving in the long run. The extra percentage on the initial build cost is not that significant, and allows the car to run quicker in the future, as well as adding to the potential resale value of the frame.

The material mandated by the SFI is 4130 chromoly, a low-alloy steel, the properties of which make it very suitable for use in welded steel structures where high strength and low weight is needed. The '30' represents the 0.30% carbon content, which is generally considered to be at the upper level of carbon inclusion that still allows for reliable welds. This does not mean though that higher carbon steels cannot be welded, it's simply that welds made with higher carbon content steels are more susceptible to cracking due to the more brittle nature of the material.

Under normalized conditions, 4130 has a UTS of 90-95 ksi, which can be improved with heat treatment. Also, 4130 has excellent elongation properties, in the region of 28% before fracture takes place, as well as good resistance to crack propagation, making it an obvious choice in structures likely to see impacts, such a car's rollover structure.

To get the best results from 4130 structures, ER70S-2 filler rod is often used for welding. This is a filler wire designed specifically for use with high-grade steels, and is ideal for structural uses. This welding alloy has a very low carbon content, nominally 0.06%, which can handle dilution into the relatively high (in terms of weld metal) 0.30% carbon in the 4130.

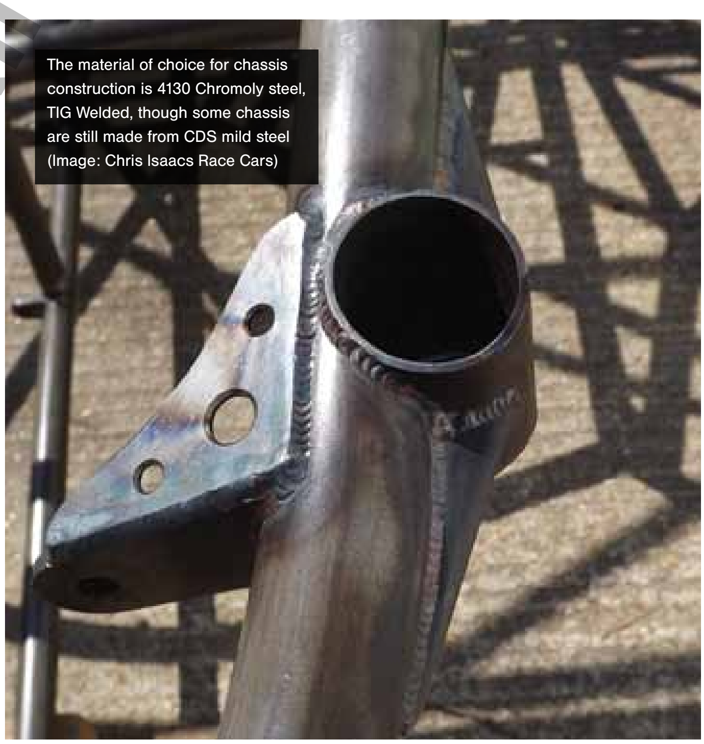
The resulting diluted weld deposit has a tensile strength of about 85-90 ksi; the actual strength will depend on the amount of dilution with the 4130, weld bead size and material thickness. This filler material also has a higher quantity of alloying elements – notably manganese and silicon – than the base material. So long as the correct welding procedures are applied, the result is a crack-free weld with low porosity.

Some chassis builders go to great lengths to ensure that the welded joints are produced as consistently as possible, as Darryl Smith of DSR (Darryl Smith Racing) explains. "All welding in our facility is done with tungsten inert gas [TIG] welding," he says. "We do not and will not even own a MIG welder, which keeps us from taking on tasks that might require it, and that is how we like it."

The tungsten electrodes used in DSR's torches are made in Germany, then shipped to a facility in the US where they are sharpened with diamond tooling to DSR's specific taper and tip specification. "Most TIG welders are not even aware that you must not grind a tungsten electrode to a sharp point," says Smith, "but it is vital to obtaining the optimum weld quality."

DSR also sources its welding filler rod from an aerospace-approved supplier. The rods are supplied in hermetically sealed packages, which are purged with argon gas prior to shipping. Smith feels that the more usual copper-coated rods introduce too much contamination to the weld pool, and while more costly the higher grade rods provide more consistent results.

Chris Isaacs, of UK-based Chris Isaacs' Racecars, explains his company's welding methodology. "All our chassis and bracketry are TIG welded, whether using mild steel or 4130 chromoly as the ▶



The material of choice for chassis construction is 4130 Chromoly steel, TIG Welded, though some chassis are still made from CDS mild steel (Image: Chris Isaacs Race Cars)

The majority of structure in a chassis centers around the driver safety cell. The choice of engine size dictates the size and quantity of tubing used for the front and rear sections (Image: Chris Isaacs Race Cars)

tubing of choice," he says. "Along with just about all other shops, we use a de-oxidized steel rod – A15 in our case, I prefer this to A31 which I know some shops use – rather than a 4130 rod on chrome-chromoly chassis."

The reason behind the choice of a mild steel filler rod is the fact that 4130 steel welded with 4130 filler rod needs heat treating after welding to prevent embrittlement. This is not always possible on a large chassis; however, the use of a mild steel rod, while not having the maximum UTS of 4130, provides a more ductile joint that is stronger than simple mild steel thanks to the influx 4130 from the parent material. Isaacs is happy that this method provides a joint with excellent mechanical strength that does not require any post-treatment when used properly.

Darryl Smith also ensures that his company uses only 'ultra-high purity' (UHP) argon in its welding processes, as he believes that the local welding suppliers cannot keep a handle on contaminates when bottles are being passed around over a several-year span. UHP gas can only ever have UHP in that bottle, and the strictest standards are imposed on its supply, ensuring yet another variable is removed in the quest for contamination-free welds.

Some racecar manufacturers also offer off-the-shelf chassis kits, allowing racers to self-assemble their own. One such firm is Art Morrison Enterprises, which offers what it calls its 'Supercar' chassis, primarily for Super Street and Super Gas classes. The kits are designed with a flat underside that allows a basic chassis jig to be created using regular plywood and lumber. Once the owner has completed the chassis, it is then simply a case of taking the car to an SFI-certified chassis builder or inspection team to have it tagged to its relevant class.

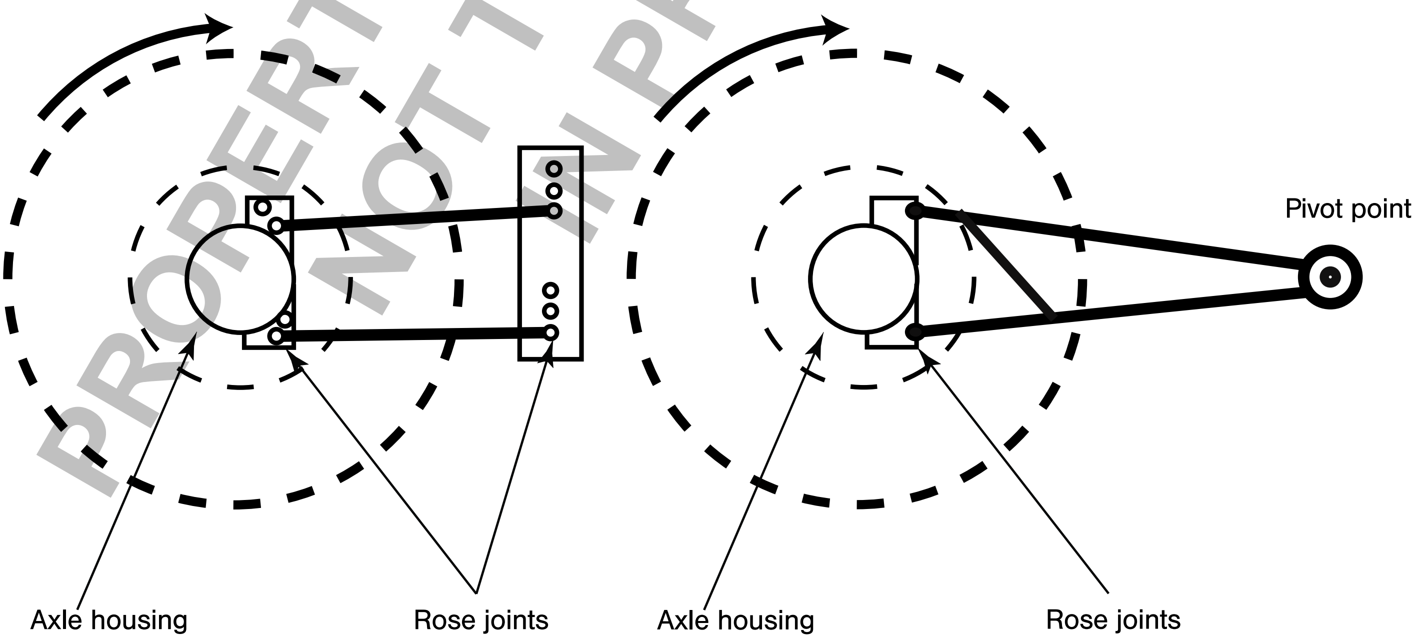
The chassis are all CAD-designed and the tubing CNC-bent and notched, as well as being tailored for specific makes and model years of car. This means that for the home builder it is a simple case of joining the parts together, saving considerably on the labor costs of having a chassis professionally built.

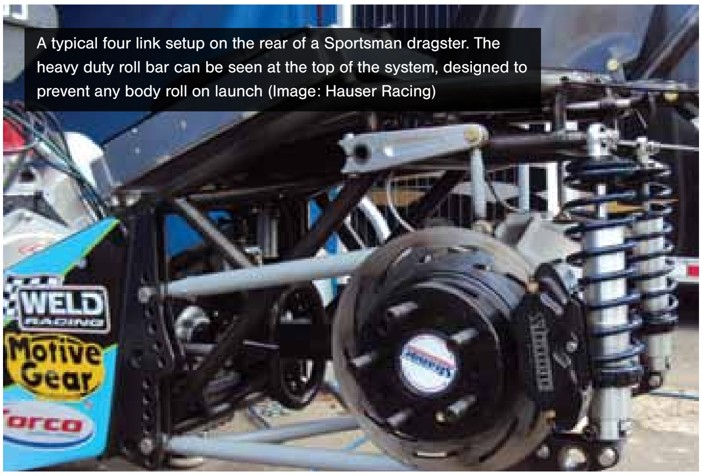
Design considerations

The wide range of car types present in Sportsman classes naturally means there are many different chassis designs. These can be broken down into two main categories – full tubular chassised and 'back half' cars, which retain the standard front floor plan and suspension.

The core of all chassis is of course a safety cage designed to protect the driver in the event of an accident. As with many other types of racing, there are differing levels of safety requirement depending on the performance potential of the cars, with most governing bodies adopting specifications developed by the SFI. These steps in requirements are based on the maximum ET (elapsed time) the car is intended to run and the weight of the vehicle. For example, the requirements for 'Door Slammer' cars – those with working doors – are as follows:

This diagram shows the difference between a four link (left) and ladder bar (right) rear suspension system. Note that the instant centre on the ladder bar is permanently fixed, while the four link's can be adjusted to change the suspension's characteristics





A typical four link setup on the rear of a Sportsman dragster. The heavy duty roll bar can be seen at the top of the system, designed to prevent any body roll on launch (Image: Hauser Racing)

- 11.99 to 8.50 s – a six-point roll cage as specified in various rulebooks around the world (for example, the UK's MSA Blue book), all of which are based on the NHRA's basic specification.
- 8.49 to 7.50 s – SFI spec 25.4 as a minimum. This is either a mild steel or chromoly cage for cars with a maximum weight of 3600 lb. Also SFI 25.5 for back-half cars.
- 7.49 s and quicker – the specification depends on the race weight of the car. Those up to 2800 lb must meet SFI 25.1E; up to 3200 lb, SFI 25.2 and cars up to 3600 lb, SFI 25.3. Each specification mandates the use of 4130 chromoly tubing.

As for engine choice, most Sportsman drag racers still use a 90º V8 and two- or three-speed automatic transmission, and chassis design has evolved around this. Although other engine packages are used, ranging from I4s to naturally aspirated V10s, this does not have a huge impact on the overall chassis design, as Geoff Hauser of Hauser Racecars explains. "People do run different engines, but despite this the majority of the car's structure stays the same. If you run a smaller engine then the car's weight and packaging requirements are obviously different, the result being that you can use smaller tubing sizes in certain areas, without compromising the performance.

"However, the area in which the driver sits is governed by the regulations, so the engine is not a deciding factor. Additionally, the suspension set-ups used are still the same, generally a four link on the rear and struts at the front, so it is more detail changes than anything else," he says.

Isaacs agrees that most of the cars his company builds do not vary greatly from this standard layout, although certain powerplant or class requirements lead to some detail changes and considerations early in the design process. "When you get into turbos or belt-driven superchargers such as the Procharger, you have to design the power adder and associated pipework at the same time as the chassis in order to maximize the efficiencies of the powerplant and chassis," he says.

In classes such as Street Eliminator, which have to be road-legal and take part in a 25-mile street cruise as part of qualifying, the exhaust system may also need to be designed alongside the chassis, as some of the front-running cars are using 5 in OD (outside diameter) tubing on their silenced exhaust systems. In this case, some of the lower chassis structure may have to be positioned a little differently to a race-only application, and you have to do this at the design stage in order to make it all fit while maintaining chassis performance and rules legality.

Engine power also has a bearing on the finer details of chassis design, particularly the engine's placement. Different racers will want their cars to have different characteristics depending on the demands of their particular class of racing. For example, a Top Sportsman racer, who competes in heads-up racing, will want a chassis with the greatest possible acceleration potential. This requires an engine and suspension layout that gets the car 'up' off its tires early, allowing the engine and transmission to accelerate quickly.

This type of set-up will, however, be more susceptible to changes in track condition, resulting in the tires completely breaking traction and going up in smoke – the price you pay for being potentially the fastest. On the other hand, an index racer will want a chassis that is far less ready to get the tires up, allowing for far greater traction off the line, at the cost of outright engine revs. The benefit here is a car that is far more consistent and thus the driver is less likely to 'break out'.

Different chassis builders also have varying ideas on how stiff a chassis should be, depending on their target market. The idea is that a flexible chassis softens the rear weight transfer on launch, allowing the tires to load more gradually. This is achieved through the use of slip joints that allow the chassis rails a degree of freedom to move. Conversely, a stiffer chassis can potentially load the rear tire more suddenly, leading to a loss of traction.

Isaacs explains why his company tends to shy away from building flexible chassis. "Personally, we prefer to build a fairly stiff chassis and let the suspension do the job it's supposed to. A flexible chassis is essentially an undamped spring, and if either the initial design is flawed or the vehicle demonstrates any loss of traction partway through its launch phase, any unwanted chassis flex or oscillation cannot be 'tuned' in the way that a suspension damper can."

However, he acknowledges that a flexible chassis can be made to perform well, but that many Sportsman racers potentially do not have the chassis engineering experience needed to exploit this fully. Geoff Hauser also agrees with this sentiment, recognizing that while a flexible chassis has greater performance potential, it comes at a cost both financially and in terms of set-up complexity.

As with all forms of motorsport, CAD and CAM systems are prevalent in the drag racing world, though many chassis builders are what could be referred to as 'old school' and still favor pencil and paper for laying down initial design ideas. Isaacs says, "In the case of suspension we do use a couple of CAD programs, one of which is a specific drag-race four-link program, the other being a more general front-rear suspension program we use for our circuit-racing projects, although it can also be handy for some drag-race suspension set-ups too."

For the initial designs though, Isaacs is a proponent of the more traditional design approach. "We don't use computer aids in our chassis design. All our chassis designs are drawn out by hand, old-school style," he says. "I do find this approach useful, as it highlights any problem areas in packaging before metal is cut. Here in England, most shops are relatively small, and as such every project is a bit different to the next and thus has its unique problems. As I am usually laying out the body style before designing the chassis, I find it just as ▶

CLASSES

Depending on where you live, the term 'Sportsman' can mean slightly different things, owing to variations in governing bodies' definitions, but as a general rule they are for non-professional outfits, so here we concentrate on full-body cars from classes run in the US and Europe, and highlight some of the more popular.

In order to keep things under control, in terms of both safety and cost, nearly all Sportsman classes run on a handicap basis, so as to place the emphasis on driver reaction and consistency. These handicaps are based on an 'index' ET (elapsed time), set by the organizers, that a well-built car of that class should run, the intention being to run as close to the index as possible without going faster – known as 'breaking out'.

Top Sportsman This is the NHRA class that spawned Pro Modified, which gives an idea of the caliber of these full-body racers. Covering the spectrum of passenger car body styles and power plants, Top Sportsman racers are not encumbered by displacement limitations or customizing rules, offering some of the most radical vehicles – visually and mechanically – in drag racing. The drivers are allowed to use electronic driving aids, and the teams calculate their own predictions of elapsed time to determine handicaps during eliminations.

Comp This is the most varied class in the NHRA, featuring dragsters, altereds, street roadsters, coupes, sedans, front-engined nostalgia dragsters, sport compact cars and trucks, filling 87 sub-classes. The engine combinations are just as diverse as the vehicles, from turbocharged four- or six-cylinder engines to Pro Stock-style V8s and nitrous-oxide-equipped mountain motors. Most cars are classified using a formula that divides total car weight by cubic inches. Each class is assigned an index based on what a well-built car of that type should run, and races are handicapped accordingly.

Super Stock Outwardly, these racers bear a resemblance to ordinary passenger vehicles. The category features primarily late-model sedans and vintage muscle cars, and entries are classified using a system that divides factory shipping weight by NHRA-factored horsepower. Significant engine modifications are permitted, but the vehicle must retain the correct engine block, cylinder heads, and carburetor for that model. The top class is SS/AH, which is exclusively for '68 Dodge Dart and Plymouth Barracuda factory race cars. Cars are handicapped using an index system, and the breakout rule is enforced.

Super Street These compete at selected NHRA national events, and race to a fixed 10.90 s index. All vehicles must be full-bodied cars and weigh no less than 2800 lb, except for six-cylinder cars that may have a minimum weight of 2000 lb, and four-cylinder or rotary-powered cars at 1200 lb . Engine and chassis modifications are virtually unlimited.

Street Eliminator A class run in the UK under the UK MSA's regulations. Cars must be road legal and are required to drive on the roads to prove this during qualification. Don't think though that this means they are slow – the top competitors regularly run in the low 7 s bracket.

The above is just a brief overview of some of the classes competed under the 'Sportsman' banner, and there are many more across the globe – the NHRA alone regulates more than 200 distinct classes in the US.

easy to use a drawing board as a computer".

He acknowledges, however, that a CAD package with an FEA capability would be very useful to allow greater optimization of the chassis structure, but while a newer generation of engineer can happily 'sketch' in CAD, Isaacs still finds it rather cumbersome. DSR, on the other hand, has fully embraced computer-aided design, which allows it to streamline its production processes and make changes to its designs rapidly. "We use several different forms of software for our chassis construction," says Darryl Smith. "We use Solid Works, AutoCAD and BobCAD-CAM in-house. We also have FEA work conducted by an outside contractor on all of our designs."

Suspension types

Ignoring fully rigid dragsters, the chassis of which were covered in depth in *Drag Race Technology* 2011, the most common rear suspension set-ups found on Sportsman drag cars are of the 'ladder bar' and 'four-link' type, with predominantly a strut and lower A-arm arrangement at the front. This type of front suspension gives a very compact package, particularly above the front wheel centerline, maximizing the space available for the engine – very useful when putting physically big engines into small cars!

A ladder bar is essentially a traction device that serves as an extremely rigid, bridge-type truss that locates the rear axle housing directly to the chassis. Without this location, as a car launched, the pinion would try to 'climb' the ring gear, causing the entire rear axle to rotate backwards. As the axle rotated it would meet resistance from the suspension spring mountings, which would try to snap the housing back to its original position, and the process would start again. This is known as 'wheel hop', and every time the wheel hopped the tire would break traction, and the only result would be a plume of smoke instead of a successful pass.

With the ladder bars holding the axle housing firmly in place, the torque applied to the differential is now transferred immediately through the bars and into the chassis. This transfer of force to the chassis means that the front end of the car reacts by rising. As the front of the car travels upward, rapid weight transfer to the rear is created which 'plants' the rear tires and propels the car forward. However, the disadvantage of a ladder bar system is that it lacks adjustability, making it hard to change the launch characteristics of a car to match changing track conditions.

Enter the four-link system therefore, which provides the same benefits of a ladder bar but with more adjustability and higher torque-handling capability. A four-link system consists of two bars locating the rear end on each side of the chassis, forming essentially an open-ended ladder bar. The links can be moved up or down, and the length of the bars adjusted to alter the characteristics of the suspension by changing the imaginary intersect point of the bars, otherwise known as the instant centre. By moving the instant centre forwards or back, the way that the car hooks up the rear tires can be altered whereas with a ladder bar system the instant centre is always fixed.

Isaacs explains the specifics of the systems favored by drag racers. "The non-parallel four-link [non-parallel viewed from the side, parallel when viewed from the top] is usually the rear link set-up of choice, in conjunction with coil-over dampers and sometimes a very stiff anti-roll bar," he says.

In theory, a non-parallel four-link suspension produces zero roll effect, as any attempt at axle/body roll produces bind in the suspension. The exact magnitude of roll resistance is governed by the orientation of the links – the more parallel they are, the less roll resistance there is, and in practice the position of the link bars is governed mainly by achieving the desired anti-squat values more than the roll-resistance figures. Plus sometimes, by the restrictions of packaging, body style and having a suitable sized hole for the driver to sit in, the chassis mounting points for the four-link bar rod ends can be compromised in torsional stiffness, and allow a tiny amount of flex to take place here.

This can be countered by the use of very stiff anti-roll bars, which in drag racing are intended to do exactly that: prevent any body roll. This is in order to ensure equal traction at both contact patches, with zero corner weight change, even when subjected to several thousand horsepower. This means that bars need to be of a very high rate and thus mounted to a stiff part of the chassis, something that is easier to do than eliminate flex in a four-link system.

The usual mounting spot for a rear anti-roll bar [around the top mounts for the rear dampers] is a relatively easy place to make very stiff. This allows the anti-roll bar to take the roll forces while the four-link brackets take longitudinal ones – something which is much easier to accommodate within the confines of a drag race chassis."

Developments

Technology in drag racing, as in all motorsport, does not stand still, and development in the Sportsman drag racing classes is no exception. While the cars are built to much tighter budgets than those in the Pro classes, owner-drivers still want the best performance possible and to beat their competitors. This is apparent in the development of chassis designs over the past decade as racers chase ever finer performance margins.

Isaacs notes, "While many of the basic minimum safety requirements haven't actually changed all that much in the last decade – the blossoming of specs for cars of different weights being the exception – I would say the biggest change has come in the specific tailoring of chassis to a particular requirement."

An example of this is in the Street Eliminator class, where treaded rear tires are required by the regulations. Isaacs says this has had a considerable effect on the chassis development of these cars. This is due to the coefficient of friction for these tires being lower than those of racing slicks, so that the whole weight distribution and centre-of-gravity height requirements change. This also entails an increased reliance on the front suspension extension to slow down the speed of weight transfer and help the tires keep gripping.

To this end, the 60 ft times [a good yardstick of launch forces] on these cars tend to be slow compared to slick-tired cars of similar quarter-mile performance, and so the chassis structure can, in terms of managing the launch forces, be a little less robust and therefore lighter without compromising efficiency in a class where there is no other real performance restriction.

For cars that run in bracket classes – where the target is to run as close to a set ET as possible, without running faster – customers are generally looking for more durability from a car than those in classes where all-out performance is the goal. Isaacs is keen to point out that this is where communication between the customer and chassis shop comes to the fore. "The customer needs to have a clear idea of what sort of class they intend to race in, so that the chassis shop can build them a car most suited to their intended use," he says. "In conclusion then, the evolution I have seen is the ability of racecar builders to tailor a racecar to the specific needs of the classes the customer wants to race in, whilst giving them a chassis and suspension package which still has some 'growth room' for quicker times later on."

Darryl Smith points out that the developments have tended to be in terms of overall car packages than just the chassis. "Sportsman racecars are now the equivalent of what professional racecars were not too many years ago," he says. "Often a Sportsman car might use more lightweight fiberglass and less carbon fiber for body components. Rear-end housings for Sportsman are still fabricated units from 4130 steel, but not nearly as detailed [as Pro cars], and steps like heat treating and weld conditioning are omitted. Other parts like the brakes are steel instead of carbon."

This view is echoed by Fred Smith of Smith Performance Specialties, who recognizes the clear evolution of cars over the company's history. "From when we constructed the first NHRA-approved front-to-rear wheel drive Super Stockers, both Stock and Super Stock chassis have become sophisticated and complex over the years. This is partly due to the competitive nature of the class as well as the increase in power levels today. It is safe to say that today's Super Stock chassis is as complex as a Pro Stocker of 10-15 years ago." ■

It is imperative that a drag car's chassis has minimal variation in weight distribution as the car launches, especially if the front wheels are not in contact with the ground (Image: Julian Hunt)