

THE 'INSIDER'

With unique access to **Peter Cambridge**, the ex-Prodrive chassis development engineer and now independent tuning consultant, we can provide a deeper insight to the methods by which a limited edition model, such as the RB320, is developed.



Just over 100,000 Brake Horsepower serves as a fitting tribute to the British rally driver Richard Burns (well, 102,400ps, to be precise, spread over 320 numbered editions). The RB320 limited edition Impreza was created by Prodrive and International Motors (IM) to celebrate the 2001 World Rally Champion. It was one of many limited editions created over the years by the two companies but it featured the most significant British input of any of them.

To be worthy of carrying a champion's initials the car had to be special indeed. The mechanical and cosmetic changes needed to work together to make it instantly recognisable and I am delighted to say that one of my neighbours owns a pristine example, so I am often reminded of the fun we expended in developing it.

Creating a limited edition vehicle is a tremendous challenge. The automotive engineers at Subaru had been fine-tuning the Impreza STi over the years to result in an extremely competent road car. It became the job of a small team at Prodrive to continue from where they finished to create something more focussed for the UK's roads. By rote, it had to be fast and fun, while offering religious feedback to the driver and making every outing a blast.

Yet, more importantly, as it was to bear the initials of Richard Burns, it had to be fit for a rally driver and, therefore, more adjustment than usual was engineered into the handling envelope, of which you can read more below.

REFINING THE PACKAGE

The key to any of Prodrive's limited editions lay in the performance pack. Unleashing the potential of the

turbocharged boxer engine was always carried out to a high level of capability by the power-train engineers and calibrators. So much confidence was placed in the work of Prodrive by IM Group that having a kit fitted would not compromise the manufacturer's warranty. With the RB320, the tune was developed and validated to present a reliable 320ps (hence the model name, although the figure is actually 317bhp) in every vehicle.

Careful consideration was given to the throttle progression to ensure that the car felt responsive but also easily modulated by the driver. As always, with a high power turbocharger, keeping 'lag' to a minimum was important. In this case, the calibrators' years of Impreza tuning experience helped to achieve the optimum set-up. The balance of ignition timing and fuelling with throttle

position, boost pressure and air density was crucial. Of equal importance was an assurance that 'knock' was never present. Too complicated for a chassis engineer to develop! My challenge was to make the suspension as good as the engine.

The look of the Impreza had changed over the years, for better or worse depending on your view, and the mechanical alterations had followed suit. The change to a front limited slip differential (LSD) years before had completely altered the character of the car. Its initial crisp turn-in had been denigrated somewhat and there was significant mid-throttle understeer. The earlier cars could be balanced beautifully on the throttle in low-grip situations. Driving a P1 on the wet handling circuit at MIRA was a joy to both behold and experience. It made you feel like a

champion driver. Being fully committed and using full throttle would often resolve the situation but the transition into understeer then suddenly into oversteer could use a fair amount of road. The introduction of the driver controlled centre differential (DCCD) improved matters and made the transitions smoother and less pronounced but the initial understeer was omnipresent.

The character required for the car was an on-going discussion with IM Group. The company always used to joke that the Impreza had to handle like a F1 car and ride like a Rolls-Royce. While these considerations may be mutually exclusive, the inference is that both handling and ride quality needed to reside on another plane. The standard STi had gained a reputation for a hard ride, with a tendency to 'bob' at the front, even on a relatively smooth road surface. Although

the ride characteristics needed to be improved, so did the overall handling dynamics.

BACK TO BASICS

When tuning a suspension system, the start-point is the tyre. As the only element maintaining contact with the road surface, controlling the loads going into it is vital. Car manufacturers develop tyres jointly with their relevant manufacturers to obtain the specific ride, handling, steering, braking and noise characteristics that are desired.

Should you visit a tyre fitting centre, you may note that tyres are labelled with codes, which signify that they are designed specifically for BMW, Porsche, Jaguar and other brand fitments. A great deal of investment is made by the tyre companies but the volume expectations are substantial. Prodrive's



and colours and finishes were tried in the virtual world. The twin seven-spoke design was favoured early on and detail changes were made to create the wheel, which would become synonymous with the car. The 'T' section spoke outline of the original P-WRC1 wheel was carried across to provide a family look and it also added significant strength. The wheel was engineered with Rimstock in the UK. The Midlands-based company designed, manufactured the tooling, cast, machined, painted and then tested the wheels all in-house.

DYNAMIC DIVERSIONS

Having spent years tuning the suspensions of Imprezas, we knew what worked on cars destined for UK roads and drivers. With the RB320 we wanted to try something slightly different, a little more extreme, which would satisfy the demands of a rally driver. In order to achieve this level of change, the springs, bump stops, dampers and rear anti-roll bar were revised. This involved a lot of changes and also created a lot of 'scrap' from the original parts being removed from the vehicles.

The stance of a vehicle is important. If it is right, a car can look purposeful or aggressive. If it is wrong, then it can look as though there is a lot of weight in the boot. The Impreza always possessed a much greater gap between the tyre and wheel-arch lip at the front than at the rear. It always made the car look nose-high and it always drove with that impression. I had found on previous Imprezas that by lowering the front, relative to the rear, the turn-in could be improved and understeer would be reduced. This was primarily an effect of lowering the front roll centre. I had a discussion with one of the rally engineers to see if a similar effect had been found on the WRC and it had. It was good to

more limited edition programmes may have similar parameters but there is never enough volume potential to develop a specific tyre. Instead, we assessed a range of tyres in the size required from a number of manufacturers and selected the one that gave the best overall compromise. If the work was intended for an external client, then I would have presented the results of the assessments, together with the tyre costs, to establish the cover with which we would run. The client may not have selected the best tyre, had it been the most expensive. Cost was an invariable part of the compromise.

With the RB320, we were in an unique position. Subaru had developed with Pirelli an 18-inch diameter tyre specifically for the S204 model in Japan. It was part of the Corsa System range. We obtained a number of sets of these tyres and assessed them alongside the standard Bridgestone REO70 17-inch tyre as a benchmark and a number of other 18-inch submissions

for comparative purposes. It possessed an excellent blend of attributes, with first-class steering feel and responses, a sensible level of compliance, gentle break-away at the limit and good wet-weather grip. It did not boast the ultimate dry surface grip of the REO70 but proved to be a better compromise for the UK, as it performed better in nearly all other areas. The tyre was homologated for European sale by Pirelli UK for Prodrive.

A brand new wheel was designed as preferable for the RB320. The in-house designer at Prodrive researched the current wheel market, both original equipment and aftermarket, to understand the latest styles and trends. We needed to create a wheel that was up-to-date in terms of style and embodied an original appearance, rather than an aftermarket or even motorsport-style addition. Keeping the un-sprung mass to a minimum also demanded that it would be lightweight.

Many consultations took place with IM Group, as the style was developed

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> know that the road and rally cars were 'in sync.'. By raking the car, we had the added visual benefit of balancing the front and rear wheel-arch gaps, to provide the purposeful stance that we sought.

Lowering a car presents a disadvantage of reducing the bump travel of the wheel. It cannot be increased though, as the tyre would hit the inner arch and the driveshaft, steering and anti-roll bar joints might over-articulate and potentially fail. The travel has to be controlled by the bump stop, spring and damper rates. It is here that the fun arises as a car's suspension is altered to achieve the desired balance and to augment the ride and handling character.

The bobbing ride and some of the understeer in a standard STi is a characteristic of the hard front bump stops. I spoke with a Subaru engineer about this matter on a visit to Japan. The factory requires it to control the pitch behaviour of the vehicle, in conjunction with the spring rate philosophy adopted. I used a different philosophy, which allowed a slightly stubbier and initially softer bump stop to be used.

We achieved the required ride behaviour by making changes to the front and rear spring rates and bump stops but the handling became too understeer biased, which was fixed by making a small increase to the rear anti-roll bar diameter. This overall set-up was great for the road but we wanted to give the car more adjustability, to behave more like a rally car, which would be great for on-track activities.

We accomplished this in two ways. As we were having a new larger rear bar, we designed-in an extra hole on each arm to provide a shorter lever, so that the bar could be slightly stiffer by just moving the drop-link. This increased the lift-off oversteer and made the car very 'chuckable'. It also reduced the steady state understeer. The new struts being made by Bilstein were bespoke and brand new foot brackets were manufactured. We revised the position of the two mounting holes to allow an extra half a degree of negative camber to be set at the front. This allows the cars to be set-up more aggressively for track use, if desired. If this setting is used on the road, there is likely to be an increase in the wear on the inner edges of the tyres, especially if a lot of motorway miles are covered.



Tuning dampers is the work I enjoy mostly. I mentioned in my previous article that the S204, available exclusively in Japan, was a significant influence on our limited edition and we based the damper rates on it. The car enjoyed good body control, yet it had a compliant ride and was different to any previous STi. The damper tuning took place at the Bilstein UK Technical Centre at Broughton Astley in Leicestershire. Driving there from the Prodrive site, near Warwick, was always tremendous fun. There are several key features on the roads around Bilstein UK and we focussed on including the speed humps in the village. There are now so many on our roads that a tuned car must be capable of

handling them. Having sufficient high-speed bump compliance is the key. The damper tune has a very significant effect on the ride quality and how the driver is isolated from altering road textures. We discovered that the roads around Bilstein provided a smoother, more-rounded texture than the roads in Warwickshire, which meant that a car tuned exclusively around Leicestershire would ride a little harsher in Warwickshire and so on. Again, it is all about compromise.

FINE TUNING

The final aspect to be established was the static geometry. Truly the icing on the cake of a suspension tune, if it is right, the car feels connected and confidence-inspiring. If it is wrong, the entire balance can be upset. The rear camber is fixed and can be quite high, if you see the standard tolerances. The lower the rear negative camber can be, the better.

A good tip for keeping it at a minimum is to jack-up the rear of the car completely. Undo the bolts that fix the struts to the knuckles, so that the joint is loose. The wheels fall naturally to the least negative camber, taking up all the clearance in the holes. They can then be tightened up in that position. Following this procedure is often worth a reduction of a quarter of a degree. We usually ran as much negative camber as possible on the front, to give good grip on low-speed corners. It is not so good for inner shoulder tyre wear, if the vehicle does a lot of motorway miles, as mentioned earlier. The front and rear toe settings are very important. The factory always establishes them at zero, which works on some suspension and tyre set-ups but a little toe-in at both ends provides better handling results.

In parallel with the engine and suspension developments, the equally important cosmetic aspects of the project were taking place. Polished stainless steel grille meshes added to the classy look and complemented the Obsidian black paint and Anthracite wheels. IM Group worked closely with the Richard Burns Foundation to ensure that the logo and distinctive colour details were correct. They were featured on the gear knob, floor mats, seat backs, tax disc holder and on the exterior badges. The RB logo was also included on custom-made wheel centre-caps. It was the attention to detail that made the limited edition work so proficiently.

The launch exercise held at Prodrive, where the first batch of cars was collected by the new owners, was a special day. The RB320s were lined-up precisely on the track allowing some very creative photographs to be taken. Petter Solberg supported the event. He loved the car. He said it was the best road-going Impreza he had ever driven. He especially liked the adjustable handling, with the rear anti-roll bar in its stiffest position. Mission accomplished! We had developed a limited edition road car fit for a World Rally Champion. We think Richard Burns would have approved and spotting an RB320 around and about helps to keep his memory alive.

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