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Return of the V12: Superleague power

The **MCT** designed V12 powering Superleague Formula has been fitted to **Bloodhound** SSC

These days most major racecar components can be bought off the shelf. Yet, when the new single-seater race series, Superleague, started specifying its spec racecar, it commissioned a brand new V12 engine to be created from scratch. This has provoked responses ranging from 'scary' to 'foolhardy', yet those involved maintain the rationale is entirely reasonable. Also, being a spec engine, it was happy to allow Racecar Engineering to take a close look at the project entirely free from a stifling veil of secrecy. So come with us as we take a tour of this exciting project from conception to ear-splitting reality.

'It was a really brave decision of Superleague to take this route when there are so many other safe options,' says Superleague's technical director Steve Farrell. 'But I'm sure that it's something that will pay off for them.' So why did the people behind a brand new race series opt for the first normally aspirated V12 racing engine for probably a decade?

MCT's managing director Charlie Bamber takes up the story. 'We went to meet Alex Andreu and Robin Webb to pitch for the chassis contract and during the meeting they started explaining their vision for the series. This included creating the right spectacle so I said, "have you considered a V12 engine?" We spent some time looking for reasons why not and kept coming back to how good it would be.' In the end, Bamber picked up the deal for **MCT** to design, build and supply the V12 engines for the series.

However, it was some time before the deal was signed and sealed, but to fulfill it **MCT** had to begin work on the engine in anticipation of it happening. So the project was handed to technical director Dave Bedborough and principle development engineer Steve Jones. 'It started off pretty low key,' recalls Bedborough. 'With no fixed dates or firm commitment from Superleague it was a one-man outfit really. We didn't want to invest a load of money in case it all went, as it has in the past. So it was literally on the back burner with very little investment.'

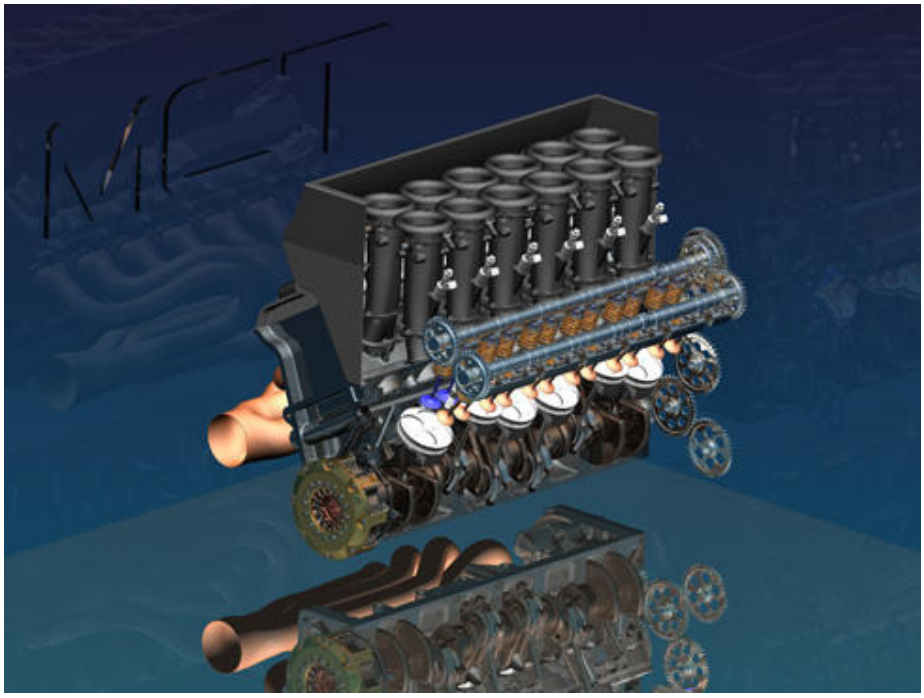
On the flip side, being a spec engine made a big difference to the design approach.

'We are used to having rule books as thick as that,' says Jones gesturing something akin to a telephone directory. 'With this there was the bare minimum of constraints which freed things up a lot. It was quite liberating.' The brief was very simple. It had to be a V12 delivering around 750bhp with a bit extra on demand for push to pass. It must not be longer than 700mm or heavier than 140kg and should have a life of 2500km between rebuilds, all for an agreed price.

To begin with the process was very simplistic. Bedborough: 'We did lots of empirical calculations to start with, going through bores and strokes on Excel, making sure we can achieve the power based on the experience we have.' This gave them all the main dimensions, including bore, stroke, valve sizes, valve angles, block height and rod lengths. This was then put into one-dimensional simulation using a Lotus package that, through 60 or 70 iterations, fine-tuned the dimensions. 'Having done that you then get into the detail design stage of the various components,' explains Bedborough, 'using all sorts of design tools like Lotus Crank Train and Valve Train. Everything was simulated pretty heavily on the computer.'

But without a firm commitment from Superleague, resources were still at a minimum, with still only three involved up to this stage. Then the button was pushed in May 2007 with a request for an engine, initially for October. 'We then put a team of six onto it and got heavily into the design detail.'

'It gets very serious at that stage,' reveals Jones, 'because the moment you start making castings or cutting metal you're in for a big expense. Just paying for the pattern work was a quarter of a million [pounds].'

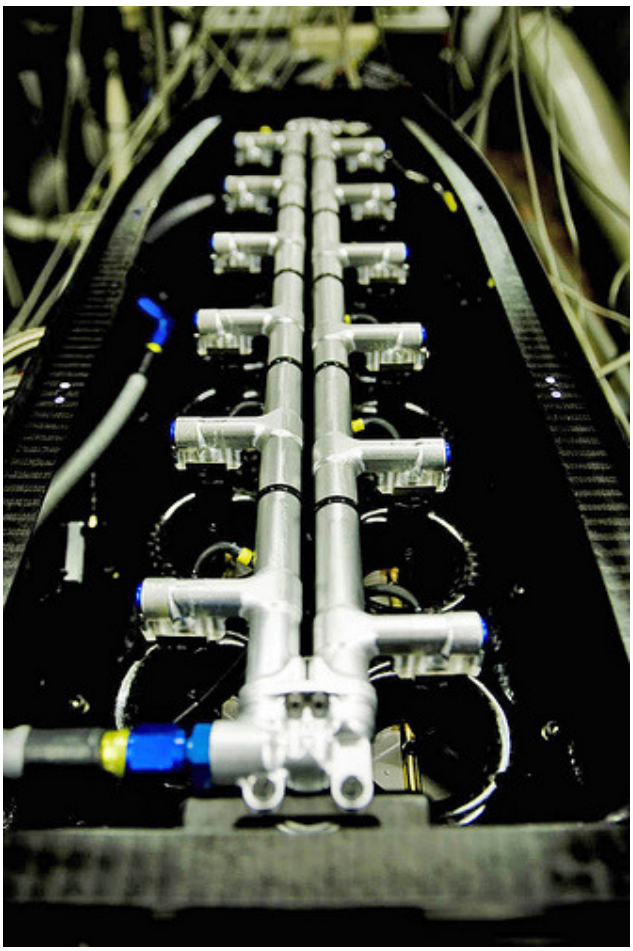


Bedborough again: 'The point that they hit the button was the point that we looked at the specification and had our design reviews, based on what had been done so far.' And how did it look? 'As regards what we'd got, I'd say specification-wise it hasn't changed, but the detail design has.' Jones: 'As more and more people got involved with more and more ideas we started having design reviews on the different components and new ideas came to the table.' Bedborough: 'For example, the head did change extensively. The guy doing it had put some ideas in and, having reviewed those ideas and done a bit of analytical work, we changed the architecture because we realised that with the length of the engine it wasn't stiff enough.'

In the end, the length of the engine emerged as a significant issue, highlighting how far race engine design has progressed since the V12's heyday. While the block is stiff enough, designing enough beam strength into the heads proved challenging, as did the rigidity of the cam journals. 'It gives us issues with line boring and gun drilling,' explains Jones. 'If we hadn't done it in house we may well have struggled to find people who will do it nowadays.'

Also, finding suppliers who could deliver V12 cranks and cams of adequate straightness and accuracy was harder than expected, though in the end the team were more than impressed with the items finally supplied. These problems were magnified by the short timescale and the danger that delayed supply could hold up the whole project. **MCT** tackled this by appointing dual suppliers for many of the items. While

this adds complication it covers the project against delivery problems.
There were other issues with the short timescale. 'We had to start manufacture before the design has been signed off, reveals Bedborough, including taking 50 sets of castings. 'It was a risk but so far nothing major has come up.' The engine has not quite made the weight target so there is some work to be done to meet that. 'It is over 140kg at the moment, but we'll bring that down. We're looking at doing some castings in magnesium - oil pump bodies, cam covers. There's a lot of weight in the block so an over-winter exercise would be a lightweight block.'



The first components to be made were the cam bearing caps, as Bedborough recalls slightly ruefully: 'With hindsight, we wouldn't have started there as we had to compromise another piece of design to accommodate those.' But Jones jumps in, 'Because of the timescale we were under, we had to take a lot of risks.

So within these limitations, what did **MCT** come up with? Looking at the finished engine you would be hard pressed to believe there were any limitations at all. The compact and neatly executed V12 betrays no shortage of time for thought or consideration.
The 4.2-litre capacity agreed with the FIA dictates a 93mm bore and a 51.5mm stroke. In the interests of smoothness and longevity they opted for the classic three-plane, V12 crank with two rods per journal that, in a 60-degree vee, fires once every 60 degrees. In the first season they are planning just one rebuild so the engine has got to do six races. 'Different plane cranks would give different torsional loadings,' says Jones. 'This is the smoothest configuration you can have. It's designed to make sure there are absolutely minimum bearing loads. We put a lot of thought into

the design of the crank to make it as easy on the engine as we possibly can.'
The crank is steel, as are the con rods, because producing the latter in titanium would have put the cost up by £2000 ($4000) per engine. Pistons, being an **MCT** speciality, were one of the easiest items to tackle in both design and delivery as they were manufactured in-house at Leafield. They run in wet liners sealed to the cylinder heads with o-rings. Although the engine is not being revved particularly hard at 12,000rpm, it needs some extra headroom for the push-to-pass facility. So the design team, wanting to keep masses as low as possible to reduce the stresses, opted for titanium valves activated by finger followers. The valvetrain is not designed for a great deal more than 12K because over revs are not too much of a problem these days with modern engine management systems. If the car is travelling too fast for the downchange then it will not let the driver execute it. This is convenient because the brief stipulated no pneumatic valvetrain so the engine has to rely on a pair of coil springs on each valve to ensure they return to base on schedule.
The previously mentioned stiffness issues with the head drove a re-think of the way they would normally have done the finger follower mounts which, in its earlier incarnation, may have been vulnerable to cracking. A re-design saw the mountings for these cast integrally with the head and the cam journals stiffened up to produce what they believe is bulletproof head architecture. The cams are driven from a gear train on the front of the engine that also serves the oil and water pumps. Lubrication is consigned to one side of the unit and coolant to the other in the expectation that they should never meet.

The coolant runs at between 85 and 90degC at 0.8bar. 'Nothing clever,' quips Jones. 'I know the F1 teams are into 3bar or so but, again, we are trying to make the most user friendly race engine we can. It doesn't require any pre-heating, it's just ready to go.'
To assist this, a warm-up cycle is written into the ECU map that won't let you rev it too hard while it's cold. Jones: 'We need some protection because obviously we're going to send this engine out to 15 different race teams with varying levels of ability. They're not all F1 teams and they've got to be able to look after it themselves. We want something that's fairly easy to install and can do half a season without anyone going near it, apart from to put oil and new filters in it.'
Steve Farrell has also found the process enlightening. 'I've never been involved in a one-make series like this before, and you realise that from a technical standpoint it's completely different. If you were running a two-car team and you had a race coming up you would say no problem, we'll knife and fork our way through it. In fact there's a

much bigger responsibility in sorting a whole lot more in a one-make series. It's got to be right for everybody. Suddenly, reliability can't be traded off against performance.'

But **MCT** seems to be delivering on its promises. 'To date we've met all the targets we were set,' says Bedborough. 'We got the mock up to them on time, we had the first engine running on the dyno in time and into the car. We've done the shakedown on time and the first test, too.' But there's still a long way to go. 'We're up against it for time now because we have to have 20 cars and 10 spare engines. That's immediately 30 engines,' Jones points out. 'Start of July is the first team tests. That's a big ask.'
'I've got to say the staff here have been awesome,' notes Bedborough. 'The design guys were on 50 and 60 hours a week for a number of weeks and now we've got manufacturing in the same state. Some of the guys in the workshop may as well sell their beds because they are not going to be using them for a number of weeks. You really can't praise them enough.'
So the V12 is back and the passion of the people behind it is clear, with frequent references to Ferraris and Matras. 'At Donington, a few of the teams turned up and the first thing they said as the car went past was "that sounds fantastic", and I thought yeah, it does,' says Farrell. 'In the midst of it all we forget that we are trying to create a spectacle.'
'I'm proud of the engine, full stop,' says Bedborough. 'It's a racing engine for a start. Not mentioning other series by name, but there are those who are trying to shoehorn production engines into racecars and they'll no doubt manage, but that's a compromise. It's nice to know that we've got something that is a real racing engine. It's a lovely looking piece of kit, the noise is awesome and, if it can be sold on the noise, then we've got a winner.'

One of the biggest challenges on a race engine like this is lubrication, particularly the scavenging. The crankcase is divided into six chambers, all hermetically sealed from each other and evacuated by three scavenge pumps on the side of the sump, each one servicing two chambers. Jones: 'We are right at the start of the development just now and the first job is to see that the oil is returned out of the engine properly.' The crank case chambers run at lower than atmospheric pressure and there will always be an optimum depression to give the maximum power. 'If we were competing it would be critical because we would be chasing every horsepower, says Jones. 'As we are not strictly competing we just need to get the system working properly.'
Scavenging is done through a moveable plate to ensure it is in time with the firing order. However, the head drains into the front and rear chambers so they produce more oil. Jones again: 'That all seems to work quite well so far and pressure

fluctuations in the crankcase are not being transferred from bay to bay. We have an air system for bleeding air back into the cam covers through the valley, but then each chamber has got a restrictor so we can tune how much air we feed into the crankcase just to get the depression right.'

'It's finding that happy balance where you're not starving the oil but you're not flowing too much,' confirms Bedborough. 'We struggled initially with oil hanging up in the heads, so we've been reducing the amount of oil that goes to the heads and trying to make the route out of the heads easier.' With six litres of oil flowing at up to 65 litres per minute it's a tricky balancing act.'