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The International Journal

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October 2005 · Vol 15 No 10 www.racecar-engineering.com UK £4.50 · USA $8.95

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Sam Collins

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The end of Spring

A Catalan-Flemish company is developing a system that eliminates all the compromises normally encountered in springing and damping on a racecar

Words	Charles Armstrong-Wilson
Photos	Sam Collins; LAT

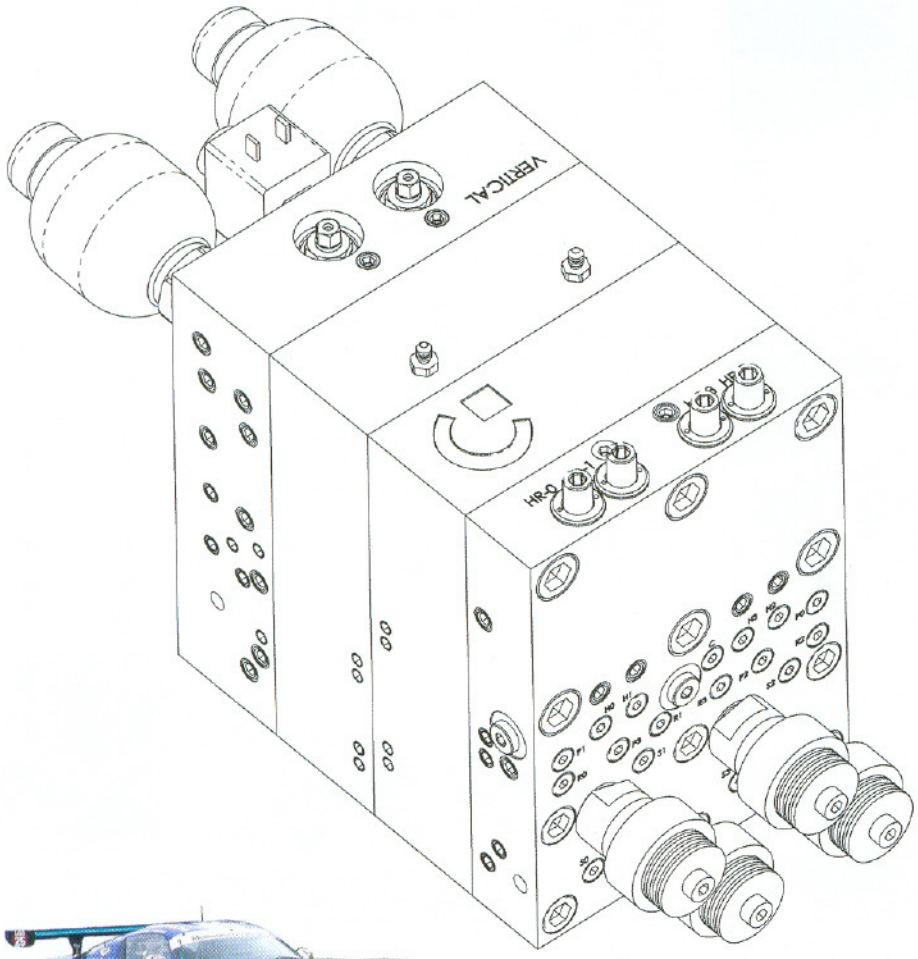
A 24-hour endurance race calls for reliability and durability above all else, so it comes as no surprise that adventurous and innovative ideas are rare in the pitlane at Le Mans. However, the Racing For Holland (RFH) team was bucking the trend with its Dome at this year's race. The car was equipped with a very unconventional suspension medium incorporating hydraulic rams and long lengths of high pressure hose. To the uninitiated it looked like some form of active suspension, although that technology is specifically banned under the ACO's rules. The way the system operated was passive, but no less clever for all that.

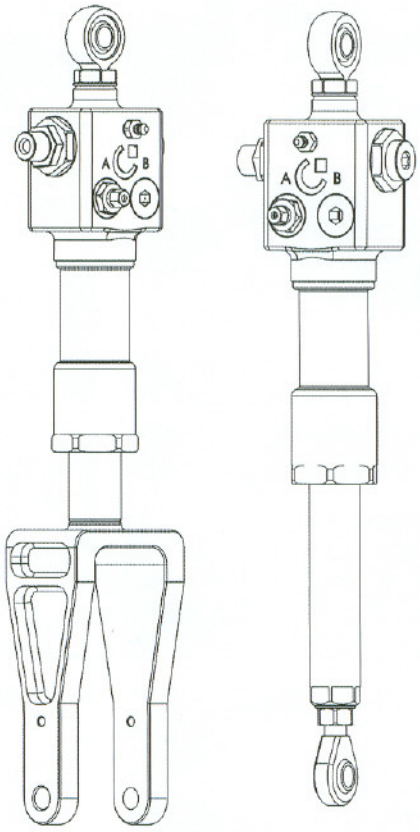
Racecar suspension always brings compromises. Even avoiding that favourite source of pub arguments – suspension geometry and all the permutations of camber control and kinematics – just the spring and damping alone are a complex interaction of trade-offs and compromises. Bump rates are determined by spring stiffness, but to accommodate roll control additional transverse torsion springs are added as anti-roll bars. However, these not only have no influence on pitch which it would be desirable to control, they have an unwelcome influence on diagonal stiffness or warp.

Add to this the problems of tuning spring rates for aero loadings and it can soon be seen that the traditional application of four springs and four dampers can easily be found wanting. Many modern racecars use third spring systems to take these extra loads. Or alternatively they resort to a monoshock and allow for roll through lateral compliance in the rocker system. But this leaves the roll mode undamped, creating a further compromise. Even with a normal spring and damper per wheel, damping for bump and roll is a compromise. Modern four-way adjustable dampers capitalise on the separate frequencies of these different modes to apply unique damping rates, yet even this technology cannot deal with the separate rates of roll and pitch.

"IT ALLOWS A DIFFERENT SPRING AND DAMPER RATE TO BE SET FOR EACH DYNAMIC MODE OF THE SUSPENSION"

In contrast, the suspension fitted to the RFH





The suspension comprises four hydraulic cylinders, one on each corner, connected to a central block with four spring chambers where the springing and damping occurs

Early experiments on a Belcar Dodge Viper were overly complicated but showed promise

Dome at Le Mans claims to be able to deal with all these demands without any compromises. The difference is, instead of fitting a single spring damper unit to each corner, it allows a different spring and damper rate to be set for each dynamic mode of the suspension. A car's chassis experiences four distinct modes of behaviour: roll, pitch, bump and warp. And it was from this position that Catalan company Creuat – pronounced 'craewat' – approached the problem of springing and damping.

The result is an interlinked suspension concept where each of the four main modes of chassis behaviour has its own rate of springing and damping which can be adjusted independently from the others. Two equivalent versions have been developed – a mechanical system consisting of torsion bars and coil springs intended for rugged applications, and a purely hydraulic system that offers complete control of all suspension parameters. The Mechanical version is better suited to off-road vehicles and SUVs, while the hydraulic version provides the greater adjustment needed for sports and racing applications. It was the latter that RFH was testing at the 24-Hour classic with a view to using it in the race.

Behind Creuat is a Catalan engineer, Joesep Fontdecaba, who was intrigued with suspension and the compromises conventional systems imposed on engineers. 'I started thinking about this maybe seven years ago,' he says, 'and I was mad enough to file a patent in 1999. Then I started building some prototypes, typical amateur stuff.' Three years ago Joesep, together with Patrick Cuyvers, the Belgian partner from IFHS, manufacturer of suspension spheres and hydraulic accumulators, formed Creuat to develop and market this concept.

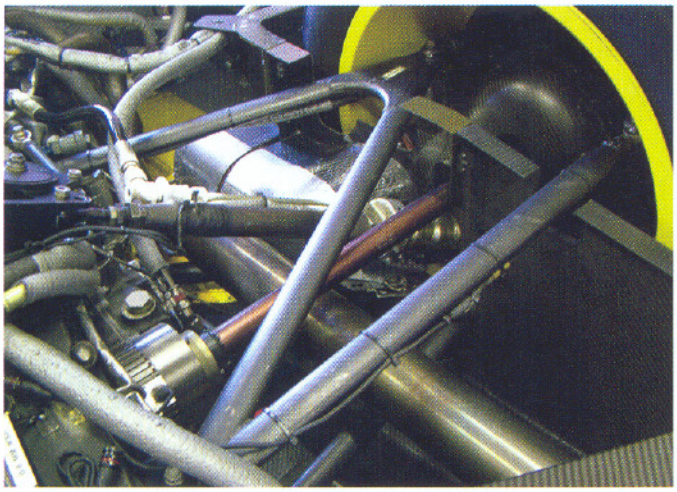
Josep admits to being inspired to some degree by Lotus' experiments with active suspension although the Creuat system has always been passive. Early work concentrated on off-road vehicles and the results of these experiments can be seen on the company website, www.creuat.com. More recently work has centred on motorsport applications.

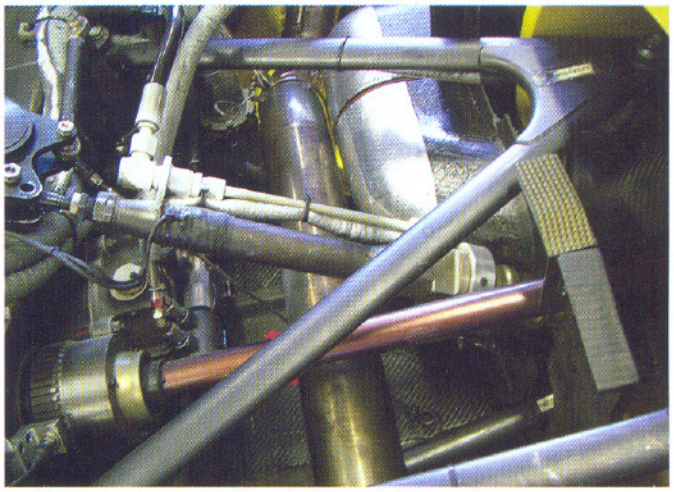
In its hydraulic form, the suspension comprises four hydraulic cylinders, one on each corner of the suspension. They are connected by hydraulic lines to a central block where the springing and damping takes place. The springing medium is gas which is separated from the oil by pistons in cylinders that work on the same principle as Citroën's hydropneumatic suspension. In fact, the Creuat system uses the same LDS oil in its system as Citroën.

"IT TACKLES HEAD ON THE PROBLEMS OF ROLL VERSUS BUMP DAMPING"

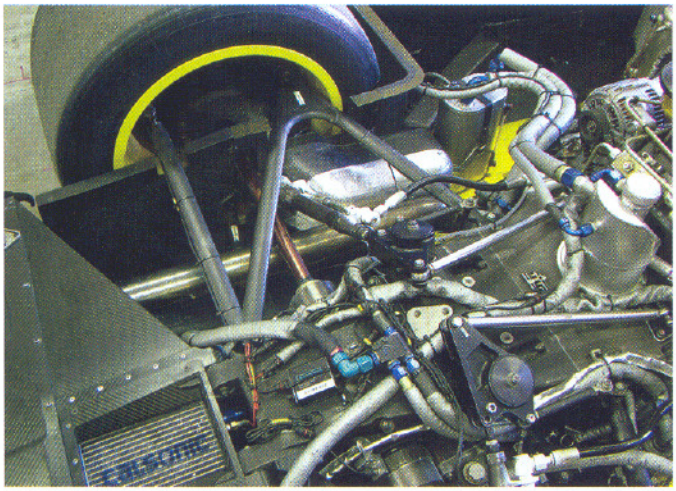
The big difference in the Creuat system is although it has four gas spring chambers, they are not allocated one to each corner of the car. Instead, one handles each mode of chassis behaviour. The stiffest mode is roll so this chamber is given the greatest resistance. However, when the suspension needs to operate in another mode, for instance bump, then the galleries in the unit are designed to allow some of the roll stiffness pressure to be bled off in a way that allows the softer bump compliance to operate. The same applies for the remaining suspension modes of pitch and warp.

Damping can be set individually for each mode as the resistance is generated the same way as in a conventional damper by restricting the flow of fluid with valves. Consequently, when the oil in the system moves in→





No spring and no damper are the most obvious visual differences in the system, replaced instead by a single hydraulic gas and oil filled cylinder at each corner



RFH car was equipped for swap to standard springs and dampers for the race

Central block allows individual spring/damper control of each chassis mode

response to a single chassis mode, damping is only applied to that mode.

All this allows individual control of spring and damping rates of each mode of chassis behaviour, independently of all others. Obviously it tackles head on the problems of roll versus bump damping that four-way dampers attempt to address. Moreover, it can deal with roll and pitch separately, something that conventional systems are unable to do. This is of particular value as cars normally have significantly different roll and pitch frequencies and tuning one rate to deal with both of them will always be a compromise.

The other mode that the system deals with so successfully is diagonal weight transfer or warp. This is often neglected on conventional systems as little can be done to cater for it. The Creuat system, however, can be tuned for this as easily as the other three modes.

It even incorporates an 'isostatic valve' that allows the warp resistance to be removed altogether. This is of limited use on the track as any weight transfer onto one wheel of more than 50 per cent of the vehicle's total would cause that corner to run out of travel and the diagonally opposite wheel to lift off the road. However, it is a big help when setting up the car, as opening the valve instantly creates the optimum diagonal weight distribution. Once the valve is closed again this balance is retained, eliminating the need for corner weight scales.

Ride height is also easily adjusted, being governed by the amount of oil in the system. Oil is pumped in until the vehicle reaches the desired ride height then the system is closed off. There is some ride height change with temperature as the fluid expands, but not enough to cause problems.

> **"ONE [CHAMBER] HANDLES EACH MODE OF CHASSIS BEHAVIOUR"**

In 2003 the team at Creuat met Ludo Helven who runs a Ford Puma in the Belgium Rallycross Championship. This presented unique challenges with the combination of sealed and loose surfaces on each lap. Also the McPherson strut suspension created its own challenges. Being a motorsport application, it was the intention to use a hydraulic version of the system, but installing a set of hydraulic cylinders into the car was not straightforward as they had to form part of the geometry. Consequently they had to design and manufacture from scratch a self-guided McPherson strut.

To assess the spring and damping rates required a complete analysis of the car had to be conducted. The vehicle's dynamic characteristics such as roll and pitch inertias were carefully measured so a useable starting point for the suspension settings could be established. Once installed on the car the driver was pleased with the results and was even able to run the car stiffer than before, gaining more stability without sacrificing grip on the rough parts of the track.

Work has also been progressing on a Dodge Viper being run in the Belgian Belcar series by the GLPK team. Initial analysis showed that some gains could be made, so a system was developed for the car and fitted. Initially, in an attempt to cover all options, the hardware was configured with more elements than were needed, including 18 gas chambers and 24 damping adjusters. Despite the over complication the system did work, covering 250km at Zolder. The drivers reported better and safer corner entry and very good behaviour beyond the limit, but a lack of steering feedback in fast corners. This last trait confused the engineers for a while until they realised it may be due to the lower torsional stiffness of the→

system. The Viper 'shell is not overly stiff and high diagonal inputs make it act as a large, undamped spring that, over bumps, creates effects that can be felt through the steering. With the lower diagonal stiffness, the 'shell was receiving lower twisting loads and was better able to ride bumps.

The diagonal stiffness can also be used to control the degree of understeer – a feature that could prove particularly useful in changing conditions. Two configurations can be set up, one for a dry track and the other for wet. Then, should it rain during a race, the suspension can be switched to the wet option in less time than it takes to change the tyres at a pit stop.

So far the team is still experimenting with the system and has yet to race it but the benefits to lap times have already been seen.

Creuat first spoke to RFH three years ago but initially the team was reluctant to commit to a programme. More recently, RFH engineer Davy Lemmens spent two days in discussion with the company and, seeing the results of the work on the Viper, was sufficiently impressed to give it a try.

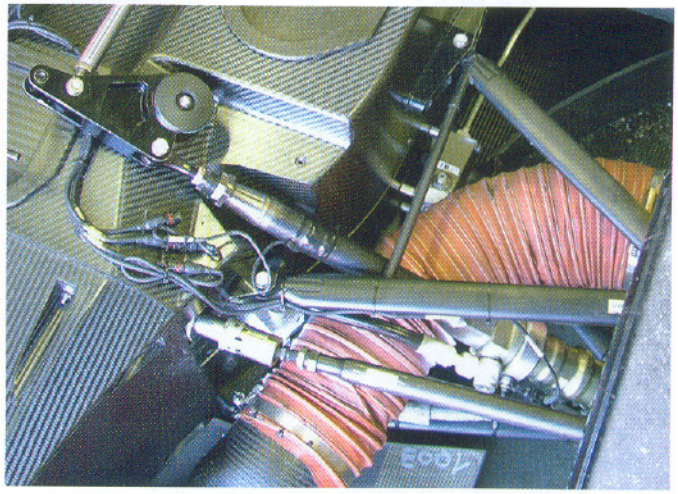
For Le Mans they developed a way of installing it that allowed a quick switch back to conventional suspension. The spring damper units were replaced with solid links and the pushrods replaced by the hydraulic cylinders. That way the anti-roll bars remained fitted but were disabled. With this set-up, the team could swap from one system to the other in four minutes. The hydraulic lines merely act as mechanical links to the central box and, due to the small displacement of the suspension, they can be reasonably narrow without inducing hysteresis. In total, the system contains about 600cc of oil.

Currently the springing and control units are mounted in the cockpit and are bulkier than they could be due to the prototype nature of the system. However, the Dome is already carrying around 100kg of ballast so there is no weight penalty. Also the low and central mounting position is an improvement over the high-mounted spring/damper units.

Once again Creuat did an analysis of the car to arrive at the optimum settings and the car ran on those first time out. 'We just drove out of the box and the driver came back in immediately and said this is fantastic,' recalls Lemmens of that first test. Since having his convictions confirmed, he has become an enthusiast for the system. 'I think splitting the movement is a big gain. When they drive with shock absorbers over the kerb you can really feel it, but with this system you don't know you are on the kerb.

'At the moment we are just looking for mechanical and if we can find all the mechanical grip we need that is fine. Then we have to concentrate on the aerodynamics and, if we can control the aero, then I'm sure that the gain will be much higher than for the mechanical stuff.'

Although the team was finding benefits from the system at Le Mans, there were still some issues regarding the spring and damping rates that they were trying to resolve. In the end prudence made them opt for the conventional suspension in the race. Running such a radical concept for the first time in a 24-hour race may well have been seen as reckless. It seems the benefits of Creuat's interlinked concept are worthwhile and, rule makers permitting, we may be seeing it more often on racecars in the future. RE



Unlike conventional systems, Creuat set-up deals with roll and warp separately

"THE LOW, CENTRAL MOUNTING POSITION IS AN IMPROVEMENT OVER THE HIGH-MOUNTED SPRING/DAMPER UNITS"

Although testing at Le Mans showed definite benefits, in the end Racing for Holland played safe and ran with conventional springs and dampers in the race itself