

Reviving a broken legend

Deciphering the repair history on a classic sports car has enabled XJR-14 chassis No 591 to ride - and win - again

With advanced composite racecars finding their way into historic racing series, the need to verify their structural provenance, especially cars that have been crashed in-period, has become prominent.

Now, as the perceived potential value of the car increases, the level of documentation of crash repair seems to follow suit. Naturally, it's assumed that Formula 1 cars will typically have high post-racing career value, and therefore it requires any manufacturer tasked with repairing a monocoque in-period to document exactly what was done in order to maximise the car's value once it ends up on the private market.

The issues occur when the car in question is more than 20 years old, dating back when there was a lack of awareness of what the car's value would be decades down the road. The challenge then becomes identifying methods and materials used to repair a composite monocoque and then to verify how exactly the repair was carried out.

Which leads us to a case in point, one of my all-time favourites: the Jaguar XJR-14, and specifically chassis No 591. Back in September 2012, I received an interesting email from Bob Berridge, principal of Chamberlain-Synergy Motorsports, the team that oversees the Gareth Evans-owned Jaguar XJR-14, No 591. Chassis 591 is the only original Jaguar XJR-14 in existence. Berridge understandably took issue with a categorisation I once made of the No 591's 1992

BY MIKE FULLER

repair as being, 'cosmetic only'. He said: 'I would be grateful if you could change your otherwise excellent piece on the XJR-14s to reflect the actuality of the car's current race-fit state, as the existing unfounded assertions are potentially quite damaging.'

But the rub was this: my assertion of 591's 1992 repair status came from none other than Tom Walkinshaw Racing-USA's team manager at the time, Tony Dowe. An 25 April, 2005 email noted:

'The first car we had was 591. This was involved in the Lime Rock accident. We sent it back to England to see if it could be repaired. Well, they did a repair on it, but we were told that the tub should only be used to build up a show car as it was not a very good area to repair (Left front tip corner, where the torsion bar bellcrank was located).'

But a little history first.

Jaguar XJR-14 chassis No 591 first debuted at Round 1, Suzuka, of the World Sports car Championship in April, 1991. With Derek Warwick behind the wheel, 591 qualified on pole, absolutely dominating the rest of the field in the process. Warwick would lead from the start and up until the first fuel stop. His race would stumble, however, with the need to change the starter motor after 591 refused to restart, and 591

ended up 10 laps down to the winner at the finish as a result. A disappointing debut given the start, but it confirmed how completely superior the XJR-14 was compared to its competition at that early part of the season. 591 would go on to win at Round 2 in Monza, with a third place and a second place at Silverstone and Autopolis respectively, to round out its WSC season.

Jaguar Silk Cut/Tom Walkinshaw Racing (TWR) would go on to win and both the Team and Drivers' Championship (Teo Fabi) for 1991.

With the subsequent shutdown of the TWR/Silk Cut Jaguar Group C program, 591 was then shipped to the United States for the 1992 IMSA GTP Championship. 591 would debut in the US at the Miami (Round 3, Rounds 1 & 2 being the Daytona and Sebring endurance races) street circuit. TWR driver Davy Jones subsequently put the car on Pole, though only finished sixth after a late race spin. This was followed by near domination at Round 4, Road Atlanta - pole, fastest race lap, led every race lap, and took the race win.

Next came Lime Rock. But issues cropped up for 591 when Jones speared off the track, following a wheel failure (this would be a reoccurring issue during the 1992 IMSA season), at the high speed and flat out downhill section while leading the race. The damage to 591

Jaguar XJR-14, chassis #591. With no fewer than 60 days in the wind tunnel under development, the XJR-14 model contested races on both sides of the Atlantic and, as the Mazda MXR-01 and Porsche WSC-95 competed in Europe and successfully at Le Mans

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was extensive and consisted of the front and approximately two-thirds the length of the left side of the tub, where the front suspension pickup points, torsion bar, and rocker arms are all located; in the area of primary suspension loading. The XJR-14s had an internal longitudinal bulkhead off set from the primary monocoque wall and damage was transferred to this structure as well.

Given the frantic nature of the IMSA GTP season, the team set 591 aside and TWR-Kidlington shipped chassis 691 to the US. Chassis 691 was race-prepped in less than a week, and the team then headed off to Mid-Ohio and reaped the rewards - a race win (even after missing Friday practice). 691 - and eventually 791 - would see out TWR's IMSA GTP season (though with 691 crashing at Road America, again a victim of wheel failure).

After a wheel failure at Lime Rock, damage was extensive to the front and some two-thirds of the left side of 591's tub



Chassis 591 was sent back to England and repaired, but it sat out the rest of the 1992 season as a show car. Perhaps more interestingly, 591 was overlooked for the TWR-Porsche WSC 95 program a few years later - Chassis 791 was preferred. 591 never raced competitively again, and that was very telling.

Questions lingered over the viability of the repair to 591 as the car passed into private ownership. Over the years the details were forgotten. The repair looked OK after all. Looks being one thing, ultrasound testing apparently showed a void-free repair.

But void-free and viable could be two different things after all, as it said nothing at all about what that repair entailed, for example, what materials were used. And, given that the corner was so highly loaded, it was of particular importance to

verify the provenance of the repair, if possible. Says Robert Tetrault, Operation Manager at Astec, Advanced Structural Technologies, Ltd, from 1992-1996, '...from memory the laminating specification in that corner would be up to 15-20mm thick with unidirectional and woven carbon fabric lay up in a very specific way to take account of the loads in racing conditions.' Hence slapping some carbon on the corner and calling it good wasn't going to suffice at all.

And with these question marks making their way into the public domain, Berridge and Evans were concerned that they could

tarnish the car's marketability given 591's very high potential value; it is the only original XJR-14 in existence. So more research was needed.

Heading up that research was Dave Benbow, director of Composites Technologies, the firm ultimately entrusted with executing the contemporary repair on 591, but more interestingly, an engineer with TWR during the XJR-14 time period, 'At the time, when the car was originally crashed, two repair schemes were offered to TWR from Astec. One to make the car complete, and the second to make the car raceable again.'

“When the car was originally crashed, two repair schemes were offered: one to make it complete, and another to make it raceable”

Scheme One entailed removing the damaged section and manufacturing new replacement sections, laid up out of the original mould and from the correct layup schedule. Given the location and nature of the repair, multiple new sections would have to be manufactured. To start, all the damaged sections would be removed as neatly as possible. Then the entire perimeter of the damaged area would then be offset by relieving the honeycomb back 25-30mm, in order to create lap joint for bonding. The replacement panels would then be dry fitted to the tub, to insure a precise fit, and then cold bonded with 3M 9323 structural adhesive, and riveted into place. After full adhesive cure the rivets would be drilled out and black-pigmented adhesive put into the resulting holes.

Scheme Two consisted of Scheme One, but with additional



As you can see, any damage occurring to this highly loaded corner would be a real headache



The high downforce nature of the US circuits in 1992 highlighted the Jaguar's weakness - wheel failure at Lime Rock led to a large accident



Three monocoques were manufactured for the original XJR-14 World Sportscar 1991 programme; chassis 591, 691 and 791

layups, the 'belts and braces,' on the outside and inside of the monocoque across the seam of the replacement sections, in order to tie everything together structurally. The work required on the inside of the tub meant abrading the surfaces to be laid up, laying up, and vacuum bagging around the off-set longitudinal bulkheads, in the very confined space of the foot well; a claustrophobic's nightmare. And in the end, all of this would have added substantially to the cost of the repair.

And as such, Tom Walkinshaw opted for the less expensive of the two repair schemes (roughly £3500 v £5000-£6000 in 1992 costs). It was said, according to Benbow, that even Walkinshaw did not expect the car to race

again, inasmuch as there wasn't any place in Europe for the XJR-14 to race any longer and the US IMSA GTP series effectively imploded at the end of the 1992 season. But what came out of Composite Technologies' research into the work done to 591 back in 1992 was tacit admission that Scheme One was considered, 'non-raceworthy.'

With it confirmed that the original 1992 Scheme One repair wasn't raceworthy, the hard decision was made to carry out Scheme 2. But really there was little choice, the completion of the entire 1992 repair would make the car whole once again and eliminate any questions regarding its provenience.

Naturally there would be challenges. For instance, the

use of 3M's 9323 structural adhesive in the 1992 Scheme One repair would mean that a low temperature pre-preg composite would have to be used for the 2013 Scheme Two repair. The reason for this was 9323 lost substantial strength at temperatures above 180degF. So this limitation had to be taken in to consideration in order not to affect the strength of the original 1992 repair. Composite Technologies was able to source suitable low-temperature pre-preg from PRF Composite Materials out of Poole, Dorset, UK; a 2x2, 200g/sq m (gsm—denotes fabric weight and more importantly, relative ply thickness), twill fabric for the inner ply and a period-correct five-harness satin, 280gsm, outer ply.

But before any layup could be done, Composites Technologies first had to establish a bagging method for the outer and inner repair work. Given the shape changes, awkward bagging locations, insert and through-holes all conspiring against, it took more than one test-try to achieve an inner and outer bag that held acceptable vacuum. After 45 accumulated hours of testing, acceptable leak-down results were achieved and the technicians had a method to complete the Scheme Two repair.

And most would have stopped there. But given the intrinsic value of the car, reputedly upwards of \$3m, it was thought

it would be prudent to 'prove' the effectiveness of the work. Delta Motorsport Ltd, an automotive and motorsports engineering consultancy (notably carrying out the FIA's yaw-blowover study for LMP sportscars), was contacted to devise and execute a series of tests to verify the suspension mounting point stiffness and monocoque integrity, and to ultimately validate 591's track suitability.

However, prior to any design work being executed, the XJR-14's suspension geometry needed to be defined. Let us harken back to the days in which the XJR-14 was designed; these were still the days of drafting boards, and the paper drawings that defined the XJR-14 are gone, or essentially so, and very difficult to acquire. And even if CAD was utilised to define elements of the XJR-14, data such as that is no easier to acquire than paper drawings given obsolete CAD programs and corrupted data. Therefore it was up to Delta Motorsport's technicians, using height gauges, linear calipers, and digital scanners, to inspect all the relevant suspension elements, mounting points, and monocoque surfaces, and then model these, using Catia, into 3D CAD space.

But additional information was needed. Lacking knowledge of representative static ride heights,

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The chassis was repaired after Davy Jones's accident at Lime Rock in 1992 and saw out the year as a show car

former TWR race engineer for the No 4 Jaguar XJR-14, Steve Farrell, joined the project as a consultant. Farrell had access to XJR-14 aero maps (loadings), engine power figures, weight distribution, and could confirm static ride height dimensions, as well as a multitude of other details, having engineered the cars during the championship-winning 1991 World Sportscar season.

Farrell confirmed an 880kg race weight (driver and fuel), 56mm static front ride height, 40 per cent front weight distribution, and a staggering 7845lbs of downforce at 200mph with 38 per cent front aero balance in high downforce configuration. Farrell indicated the XJR-14 could generate upwards of 4.8G of braking deceleration and 4.5G of lateral acceleration; clearly the XJR-14 had been a serious racecar in its day, hence the need to acquire actual loading data as opposed to best guesses.

With knowledge in hand, Delta Motorsport was able to couple this information with the CAD reconstruction of the XJR-14's monocoque and front suspension geometry, developing a load and suspension geometry analysis using kinematic geometry software.



Chassis 591 has now been proven to be ready to race

With the downforce loading information provided by Farrell, static load (linear) figures could be generated for any single suspension component, and the concentration was on these four loading scenarios: maximum deceleration, end of straight, maximum cornering acceleration, and end of straight coupled with a 2G kerb strike (vertical impact).

Analysis of these four cases showed that the highest loads were achieved during the braking event and from the vertical strike. A test rig was then designed to individually load the front top wishbone for the braking event,

the lower front wishbone for the same, in addition to a pushrod fixture to load for the vertical strike scenario.

These tests would be carried out first on the undamaged right-hand side and then on the repaired left-hand side, and so the fixtures had to take this requirement into account. Additionally, the fixturing needed to remove any compliance as well as constrain the monocoque during the testing.

With all the requirements laid out, Delta Motorsport set out designing and having the test rigs manufactured. They also sourced

a suitable testing facility, with the Cranfield Impact Centre being chosen due to their experience in structural and non-destructive vehicle testing.

And the results? Analysing the upper wishbone on the left-hand side, the forward leg mounting point averaged 7 per cent stiffer, while the aft leg mounting point averaged 8.5 per cent stiffer. The lower wishbone showed similar (13.8 per cent and 29.1 per cent stiffer for the front and aft wishbone legs respectively) as compared to the right. So too the pushrod mounting point - 8.5 per cent stiffer. Given the results, Delta Motorsport concluded in their report: '...the monocoque and its suspension mounting points are fit for purpose and have an acceptable stiffness level to receive on track loads.'

The only thing left was to take 591 out on to the track at the Silverstone Classic. Driver Nic Minassian subsequently put the Jaguar on pole with a lap time five seconds ahead of the next competitor (Sauber C11) with a 1:46.425 lap. 'I've been smiling all week,' said Minassian. 'The car did exactly what I wanted and it feels like a proper race car. Easily one of the best cars I've ever driven.' 591 performed to expectations all weekend, and then some, with Minassian admitting he could have been faster, but that he 'didn't push it'. Minassian nearly lapped the entire field in the main event, on his way to first place.

It's not often that a car owner does the right thing, but as Bob Berridge indicated: 'It was a case where being 99 per cent certain wasn't good enough, leaving 1 per cent provenance on the table left us no choice.'

Given the ultimate value of the car, it made little sense in not clearing up this part of the car's history once and for all - and that has now been done in spades. The transparent process, coupled with the testing procedure verifying the repair, will allow any questions about the car to be dispelled for future owners of 591.

IMAGES BY MICHAEL J. FULLER



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