

The 1914 Delage Grand Prix Type-S: Resurrecting a sole survivor

This Case Study describes the use of new digital technology to preserve a unique milestone in automotive history - the only remaining Type-S 1914 Delage Grand Prix car in the world. It is another chapter in the long history of this sole survivor – a car of technical and historical significance.

When the heart of the car, the engine block casting, failed, and conventional methods of repair had also failed, it looked like the GP Delage could become a static museum exhibit. However, due to the commitment of the owner to keep the car on the road in its original form, re-manufacture of the engine block was undertaken so that the car would run again. The emphasis was on preservation of a running vehicle in its original form.

But how do you do that accurately and cost effectively when you have no replacement parts, no drawings, and the original methods of manufacture are not feasible? Answer – You clone it using digital technology.

This case study is about how this was done using laser scanning, computer modelling and 3D printing (additive manufacturing). It is an example of the opportunities provided by capturing information digitally and applying it through new manufacturing technologies.

This paper also describes the restoration in its current context, and the issues that must be considered; preservation or restoration, original or replica, and display or driven.

Introduction

This Case Study describes the use of new digital technology to preserve a unique milestone in automotive history - the only remaining 1914 Delage Type-S Grand Prix car. It is another chapter in the long history of this sole survivor – a car of technical and historical significance.

When the heart of the car, the engine block casting, cracked, and attempts at repair all failed, it looked like the GP Delage could become a static museum exhibit. However, due to the commitment of the owner to keep the car on the road in its original form, re-manufacture of the engine block was undertaken so that the car would run again. The aim of The Project was to preserve it as a running vehicle in its original form.

But how do you do that accurately and cost effectively when you have no replacement parts, no drawings, no examples, and original methods of manufacture are not feasible?

Answer: You clone it using digital technology.

This paper is about how that was done using laser scanning, computer modelling and 3D printing. It is an example of the opportunities provided by capturing information digitally and applying it through new manufacturing technologies.

This paper also describes the restoration in its current context, and the issues that must be considered; preservation or restoration, original or replica, and display or driven.

Acknowledgements

First, I would like to acknowledge Mr. Stuart Murdoch - the owner of the Type-S Delage for the past 40 years. Without Stuart's commitment to keep the car on the road in its original form, it could have become a museum piece long ago. His trust in this new technology and the team applying it, and his support for The Project has made this undertaking possible.

Keech3D and its management, with special thanks to Doug Baird, Wojciech Wawrzyniak, WuPing He and the other engineers and foundry personnel who have contributed their expertise.

CSIRO Lab22 and its management, with special thanks to Gary Savage and Andy Yob for their expertise and guidance in applying the sand printing technology.

WYSIWYG 3D, with special thanks to Shane Rolton and Nico Modonesi, for without their precision, the result could never have been right.

Up The Creek Workshop (UTCW), with special thanks to Grant Cowie for his vision to apply this technology, and for asking me to manage it.

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Background

The French car maker Delage was one of the premier sporting and luxury car manufacturers in the early years of the motor car. With numerous technical innovations and motor racing successes, Delage was a leader in automotive technology.

In 1914, Delage fielded a team of three new racing cars, the Type S, for the premier auto race in Europe, the 1914 Grand Prix De L'ACF, at Lyons on 4th July. These cars combined many of the most advanced features of automotive design, resulting in possibly the most advanced vehicle of its day. They embodied many features which did not become common for decades. To quote automotive historian Griffith Borgeson, "they were ultra-sophisticated and prophetic."¹ The designer, Arthur Leon Michelat, drew upon the revolutionary engine designs of Ernst Henry, combined them with his previous Delage innovations seen in the Type-Y, and added other innovations such as desmodromic valve operation and four wheel brakes.²



Figure 1. Delage Type-S Team Cars – Grand Prix De L'ACF, 1914.

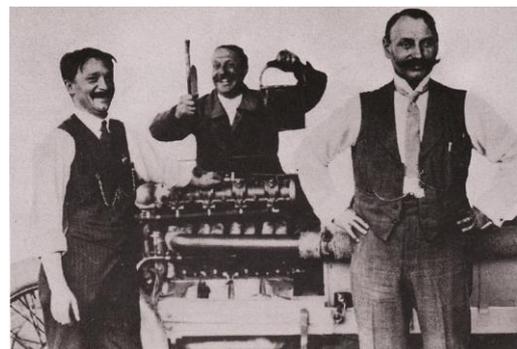


Figure 2. Designer Michelat, Driver Duray, Patron Delage.

Only one Delage finished the race (8th position) but they proved that they were competitive and fast, but in need of further development.³ Unfortunately, the First World War erupted one month later, and all racing in Europe ended.

In 1915 the Delage Type S cars, and probably a spare car, were sold to the USA, where board track racing was thriving throughout the nation.⁴ The mechanical features of this car indicate that it is the car owned and raced by the famous “barnstormer” Barney Oldfield, who raced it on speedways all across the country, including at Indianapolis in 1916. After Barney broke a con-rod, it was rebuilt by Harry Miller who also fitted a new carburettor of his own advanced design.⁵

In 1923 or 1924, the “Oldfield” Delage came out to Australia to race. It easily won the inaugural race meeting at the Olympia Motor Speedway at Maroubra, Sydney in December 1925.⁶

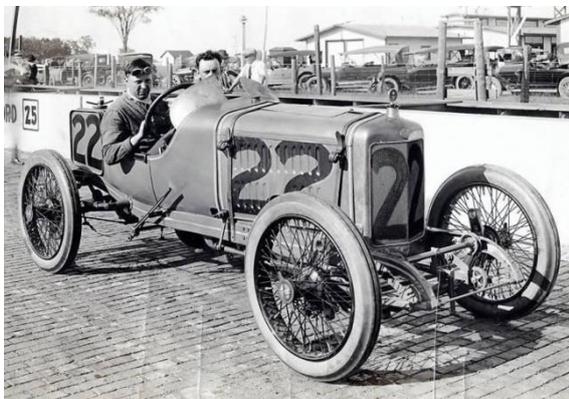


Figure 3. Delage Type-S, Barney Oldfield, Indianapolis, 1916.



Figure 4. Delage Type-S, “A” McCarey, Maroubra, 1925.

The car was owned for many years by four times Australian Grand Prix winner Lex Davison.⁷ After the death of Davison in 1965, his widow Diana sold the car to Mr. Stuart Murdoch in 1975. The Indianapolis Motor Speedway Museum, USA, and the Donington Collection, UK, had missed their opportunity to acquire what is almost certainly the only Delage Type-S in the world.⁸

Stuart Murdoch and his family have driven the Delage on the road, circuits and hill climbs ever since restoration was completed in 1978 by Jack Nelson of Romsey, Victoria.⁹

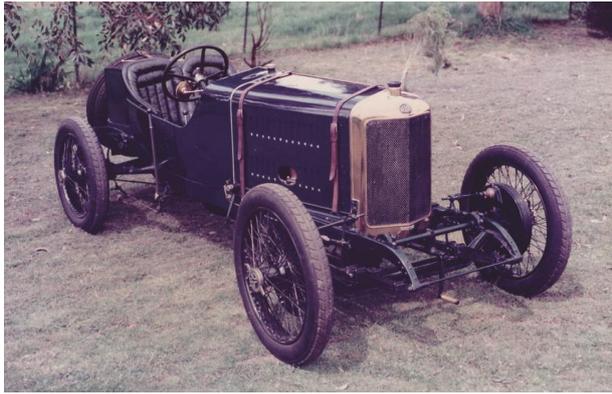


Figure 5. Delage Type-S, car as restored in 1978.



Figure 6. Delage Type-S, engine as restored in 1978.

Eventually in 2014, a known problem area in the engine block casting failed. Due to the design of the engine, the area of failure would be impossible to access without cutting open the block. Also, stresses from welding would be a risk. Localised laser welding and cold metal spraying were both tried without success. Inspection revealed that this failure in the 100 year old casting would likely be followed by others in time. Thus, it was decided that, if the Delage was to stay on the road, a new block was required.¹⁰

Re-manufacture using traditional pattern making techniques was an option, but would have been extremely expensive, reliant on fading pattern making skills, and with a more uncertain outcome.

UTCW, the vintage car restoration and maintenance business in charge of repairing the vehicle, approached Keech3D to re-manufacture the engine block using the latest in sand casting technology – 3D sand mould printing - through their relationship with CSIRO Lab22.



Figure 7. Delage Type-S engine block, 2015.



Figure 8. Casting failure No. 3 cylinder, area of failed repair.

Specification^{11 & 12}

Designer – Arthur Léon Michelat

Engine – Sand cast in cast iron, integral head and block. Four cylinder, original capacity 4,441cc, bore 94mm x stroke 160mm, compression ratio 5.5:1. Hollow tubular con-rods. Four piece crankshaft on five ball bearing races. Double overhead cam shafts with desmodromic operation of four 90° inclined valves per cylinder, in pent-roof cross-flow combustion chambers. Note: The capacity was increased to 4.8L during the racing life of the vehicle.

Drive Train – 5 speed gearbox, direct on 3rd with overdrive on 4th & 5th. Brakes on all four wheels, plus transmission brake.

Chassis – Wheelbase 2,743mm. Weight (dry) 998kg.

Performance – 113 BHP at 2,800 RPM. 25 BHP per litre. More than 160 KPH.

Note: Desmodromic valve operation had been used on slow revving steam engines. Until very recently, the Type-S GP Delage was thought to be the first high performance engine with desmodromic valve operation.¹³ However, an earlier engine – the previously unknown 1908 Ariés single cylinder Model VT – subsequently came to light in 2014.¹⁴ This marvellous but unsuccessful little engine was very different to Michelat's design but had, nevertheless, desmodromic valve operation. The Type-S remains the first high performance multi-cylinder desmo engine.

Why is this car so significant?

1. It is a team car of one of the great marques of early motor sport – Delage.
2. It is the apogee of a period of great technical advancement in automotive development. It embodies ground breaking design features that were both innovations at the time and harbingers for the future.
3. It is the first multi-cylinder high performance desmodromic valve engine.
4. It was driven by some of the great drivers of the early era, in some of the great races, and was owned by one of Australia's motor racing greats.
5. It is the sole remaining example of the Type-S Delage in the world.
6. It is widely acknowledged to be one of the most beautiful veteran cars in the Australia.
7. But perhaps its greatest significance is that it survives as a driving, living masterpiece, not as a static and silent exhibit. As one motoring historian extolls, "What a privilege it was to examine and ride in this precious relic of an era so crucially important in the development of

Philip Guilfoyle The 1914 Delage Grand Prix Type-S: Resurrecting a sole survivor

the thoroughbred motor vehicle as we know it today. That this one priceless S-type should have survived at all is remarkable. That it lives on in such a state of originality, and is maintained and used by its dedicated long-term owners, rather than gathering dust in some sterile museum, is marvellous indeed.”¹⁵

Issues to be addressed within the project

The vehicle and its engine are unique. All expenditure is on this single vehicle. There is a market for one engine block only. The re-manufacturing process must be cost effective, yet deliver all of the requirements below.

The original engine block is part of the provenance of the vehicle. As such, it must not be destroyed in the process of repair or engineering its replacement.

The original engine block is the only example in the world. There is no other block to substitute or copy. There are no drawings. The only information is the block itself.

The only part to be replaced is the engine block. The replacement engine block must be precisely the same dimensions as the original block. It must be machined to accept all the other engine components, which remain fully serviceable.

The replacement engine block must be exactly like the original, in every way. It must look, function and perform exactly the same as the original. It must be made from the same material and by a similar final process.

The re-manufactured block must be durable and fit for purpose - extended driving on the road.

The GP Delage Project Team

Mr. Stuart Murdoch is the owner of the Type-S 1914 Delage Grand Prix Car, and has been a client of Up The Creek Workshop for many years.

Up The Creek Workshop Pty Ltd (UTCW) is one of the premier vintage car workshops in Australia, and restores and maintains an extraordinary range of exotic and valuable old cars. UTCW is located in Castlemaine, Australia. See www.upcreek.com.au

Philip Guilfoyle The 1914 Delage Grand Prix Type-S: Resurrecting a sole survivor

Philip Guilfoyle (Vintage Restoration Management Pty Ltd) is Technical Adviser / Project Manager of the GP Delage Project, managing the activities of the various parties on behalf of the owner. He is also the author of this paper.

Keech3D Pty Ltd (Keech3D) is the Advanced Manufacturing arm of Keech Australia (Keech), a global supplier of castings to the manufacturing and mining industries. Keech3D has a range of engineering, CAD/CAE, 3D printing and pattern making facilities to develop and support advanced casting technology. Keech3D is a Tier One Partner with CSIRO Lab22. Keech is located in Bendigo, Australia. See www.Keech3D.com.au

CSIRO Lab22 is the Manufacturing Innovation Centre of CSIRO, Australia's premier national research organisation. Lab22 provides access to new manufacturing technologies for Australian manufacturing businesses. Lab22 is an incubator for the application of additive manufacturing in Australia. Lab22 provides the Voxeljet 3D Sand Printer, operation training, and on-going support in partnership with Keech3D. Lab22 is located at Clayton, Victoria. See www.csiro.au/en/Research/MF/Areas/Metals/Lab22

WYSIWYG 3D Pty Ltd (Wysiwyg3D) is an engineering company specialising in 3D measurement and modelling. Wysiwyg3D scanned the Delage engine block and created the CAD model of the engine block. Wysiwyg3D is located in Sydney Australia. See www.wysiwyg3d.com.au

3D Printing – A brief overview

Key to the GP Delage Project is the use of 3D printing. This section is an explanation of the basics. Also see https://en.wikipedia.org/wiki/3D_printing

3D printing is also called additive manufacturing. The term includes a number of different technologies, all of which deposit material in layers defined by successive 2D slices through a 3D computer (CAD) model.

Items to be printed can be of any shape. A 3D CAD model of the item to be printed is "sliced" into thin layers by an automated software program. Each layer is then physically re-created in sequence by a computer controlled industrial robot – a 3D printer. 3D printing requires a dedicated CAD model but does not require dedicated tooling.

It is used in engineering, construction, manufacturing, automotive, aerospace, medical, sporting, apparel, food and, increasingly, purely creative applications. It is widely used for

rapid prototyping, rapid manufacturing and mass customisation. In 2015, additive manufacturing was a USD \$5.1 billion industry and growing rapidly.¹⁶

There are a number of processes and a large range of materials available. The process used in the GP Delage Project is sand printing, where successive layers of silica sand are selectively printed with a binder to produce three dimensional parts - a mould set. The unprinted sand remains unbound and supports the parts during printing. Un-bound sand must be removed after printing. Also see <http://www.voxeljet.de/en/services/sand/>

Note that in the GP Delage Project:

1. We did not print the engine block. We printed the mould in which the engine block is cast.
2. No patterns were required to make the sand mould.
3. The sand mould is destroyed in the process of removing the casting. Each casting requires a sand mould to be printed.

Methods Used

1. The engine was disassembled and the engine block cleaned. Paint was removed. (UTCW)
2. The block was digitised using a laser scanner and stylus probe. (Wysiwyg3D)



Figure 9. Laser scanning the engine block, 2015.

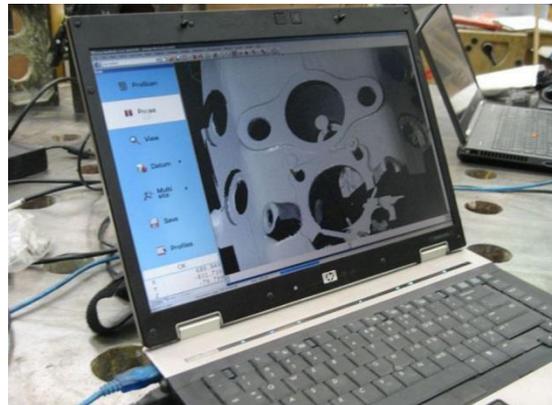


Figure 10. Scanned surface data acquisition, 2015.

3. A complete three dimensional computer model of the engine block – a virtual engine block - was built using scanned surface data and solid modelled internal details. Material was added to machined surfaces to be machined off later. SolidWorks and Geomagic were the principal programs. (Wysiwyg3D)

- The virtual engine block was sectioned and reviewed to check dimensions, wall sections and clearances. (UTCW)

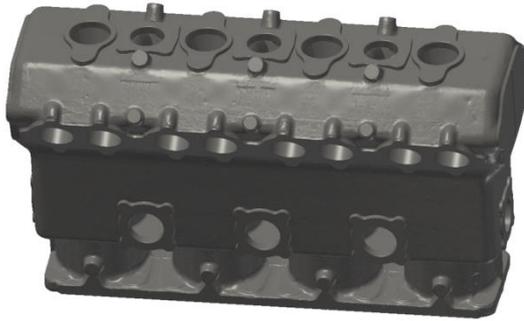


Figure 11. CAD model, with machining material added.



Figure 12. CAD model sectioned for review.

- A piece of the material was analysed to determine composition and hardness. (Keech)
- The virtual engine block was run through a series of mould flow simulations to model molten material parameters and flow characteristics. SolidCast was the principal program. (Keech)
- A contraction allowance was added to the CAD model of the engine block to compensate for material contraction during the casting process. (Keech3D)
- A series of sand moulds were designed in CAD and evaluated. A final design was modelled. (Keech3D & UTCW)

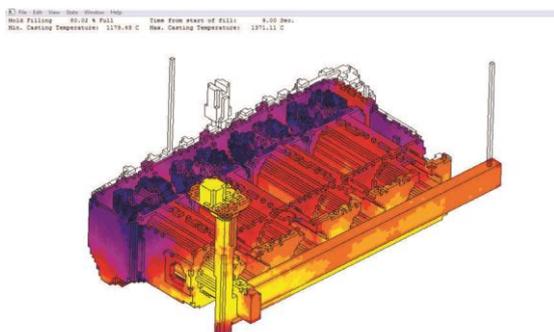


Figure 13. Computer simulation of molten metal flow and temp.

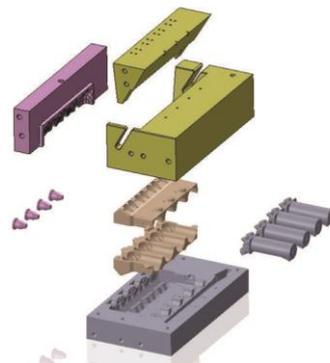


Figure 14. CAD model of 14 part mould set.

- The mould design was 3D printed at scale 1:4 to check fits and develop the mould assembly process. (Keech3D & UTCW)
- A trial sand mould was printed using a Voxeljet VX1000 Sand Printer. The mould set comprised 14 individual parts and cores, printed in two build sets. (The original mould set

comprised at least 42 individual parts and cores.) The sand was 190µm silica sand and the binder was furane resin. Layer increments were 300µm. (CSIRO Lab22 & Keech3D)

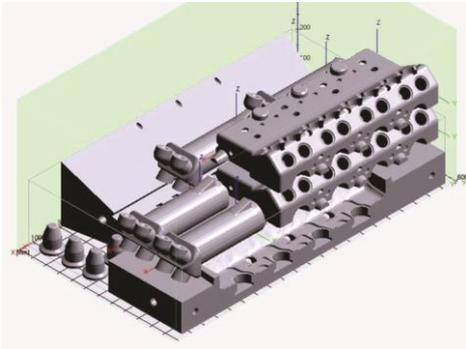


Figure 15. Voxeljet 3D sand print build of 12 parts.



Figure 16. Sand printed main parts of the mould set.

11. The external mould parts were surface finished to remove visible steps. (UTCW)
12. The trial mould was sealed, assembled and poured. The material was a grey cast iron. The trial mould was destroyed in the process of removal. (Keech)



Figure 17. Sealed mould set, partly assembled.



Figure 18. Trial casting emerging from destroyed sand mould.

13. The cast material was checked for composition and mechanical properties. (Keech)
14. The trial casting was cleaned, inspected and measured. It was then cut into several sections to inspect mould function, core location, cast wall thicknesses, and casting quality. (UTCW)



Figure 19. Trial casting (left) beside original engine block.



Figure 20. Trial casting sectioned for inspection.

15. Minor modifications were made to the mould design and block. (UTCW & Keech3D)
16. A final production mould set was printed. (CSIRO Lab22 & Keech3D)
17. The production mould set was surface finished. (UTCW)
18. The production mould set was sealed, assembled and poured. (Keech)



Figure 21. Production mould set.



Figure 22. Production casting poured 10th June 2016.

19. The production casting was cleaned, inspected and measured. (Keech3D & UTCW)
20. The production casting was machined to the same dimensions as the original. The external surfaces were finished to match the original. (UTCW)



Figure 23. Production casting before machining.



Figure 24. Machined castings – original and replacement (front).

21. The engine will be reassembled, tuned and tested. (UTCW – underway September 2016)

Discussion on historic vehicles today

Restoration or Preservation

There has been a marked shift in attitude to the treatment of vintage and classic vehicles. For an increasing proportion of collectors, provenance and originality is paramount. The trend is away from “concourse standard” restoration towards “sympathetic preservation” and authenticity. Many current restorations include applied patina to create a more original look.

This attitude is reflected in events like “oily rag” rallies¹⁷, judging categories like Preservation Class¹⁸, and the proliferation of “barn find” stories in the motoring press¹⁹. There are even motoring clubs devoted to the use of “feral” vehicles²⁰.

At the extreme, criticisms have even been made of “uneven dirt distribution” caused by driving the “Baillon barn find” Ferrari 250GT Spider California.²¹ It can be argued that originality has become counter-productive and an end in itself.

Dr. Fred Simeone of The Simeone Foundation Automotive Museum declares in his Automotive Hippocratic Oath, “The balance between originality and perfection could be attained if one realises that while cosmetic perfection is very difficult to achieve, historic perfection is even more elusive and, therefore, more desirable.”²² Attitudes emanating from the world of art and antique furniture are being applied, where “it becomes less acceptable than it once was to re-paint and re-upholster an historic car at the owner’s whim.”²³

By the time a competition car gets to be a century old (as in the case of the GP Delage), there are inevitable changes from the original specification of the car. These can be due to development, repair or practical improvements. These changes become part of the provenance of the vehicle but all may not be desirable. Discretion must be used as to which point in the history of a vehicle it is to be restored to.

In the case of the GP Delage, the specification remains basically that of the original 1914 “works” racers with changes made by Harry Miller (1916) - i.e. Miller carburettor and manifold, capacity increased to 4.8L.²⁴ An electric starter motor was recently fitted to permit the owner to start and re-start the car.

Genuine or Recreation

There is much discussion about the proportion of original manufacture necessary before a vehicle must be classified as a “reproduction”. This is presently a very active issue affecting values, particularly in relation to iconic marques like Bugatti²⁵ and Bentley²⁶, because vehicles are being created out of combinations of original and reproduction parts. This is not an issue for the GP Delage because there is, and will remain, only one example.

The GP Delage will soon have an exact replica engine block fitted, while the rest of the car remains original. This is the replacement of a single mechanical part which failed, albeit a significant one. The original block is preserved but no longer fitted. There is no engine number stamped on either block.

Due to the resolution at which a part can be reproduced using digital technology, the ability to discern whether a part is original or reproduction is difficult and “passing off” may become a bigger problem in the future. This is the flip side of the ability of this technology to replicate parts so accurately. The method of making the sand mould to cast the replacement Delage engine block is radically different from that employed 100 years ago. But the method of casting the engine block is largely identical, and the two blocks are difficult to tell apart.

Intellectual property rights include enforceable patents, registered designs, copyright and trademarks. Infringement is not an issue confined to scanning and printing technology, but it makes infringement easier. Infringement is generally only pursued in commercial instances.²⁷ No intellectual property rights are infringed in the GP Delage Project.

Static or Driven

Scanning technology, in particular, is used in the analysis and display of historical artefacts. By creating a virtual object, it can be integrated into other media for additional purposes. An

example is the scanning of “Mephisto”, the last surviving First World War German A7V battle tank. It has been scanned by Chris Little of Griffith University for ballistics analysis and to provide virtual access to the immobile and physically inaccessible actual tank.²⁸

Myles Russell-Cook of Swinburne University, speaking about items taken from indigenous cultures, said museums can be seen as “tombs where objects go to die”. The artefacts become disassociated from their cultural context.²⁹ To some degree, this happens to vehicles displayed as static objects rather than operating machines. Concept cars and sculptural extravaganzas (e.g. some Fagnoni et Falaschi coachwork) may be considered exceptions because their primary and original purpose was for display.³⁰ Whether an historic vehicle is most appropriately preserved as a static display or as running car can depend on the context.

Few would argue that the Gräf und Stift tourer in which Archduke Franz Ferdinand and his wife were assassinated in 1914, is inappropriately displayed in Vienna’s Museum of Military History - with bullet holes and dirt still on the tyres, beside his blood stained jacket and surrounded by the consequences of the war that followed.

Yet, a row of seven inanimate Bugatti Grand Prix cars in The Schlumpf Collection (The National Automobile Museum – Mulhouse, France) looks totally dead – like butterflies on a pin. The dominant context is not the capability and beauty of the machines, but the collectors’ obsession with perfection and possession³¹.

The primary aim of the GP Delage Project is to keep this 100 year old road racer on the road in its historically significant form – restored and running with originality preserved.



Figure 25. A set of Bugattis - Schlumpf Collection.



Figure 26. The GP Delage – On The Road.

Conclusions

At present, this is an innovative method of historic vehicle restoration. However, I believe it will become the default method for casting replication in the future, due to its advantages in cost, speed, detail and accuracy.

In the future, the historic vehicle sector will be less dependent on remnant stocks of parts and fading skills. Instead, we will realise more opportunities due to the “Economy of Scope” in digital manufacturing, augmenting the diminishing legacy of the industrial era’s “Economy of Scale”.

Digital technologies made the GP Delage Project technically and financially feasible. These methods can be applied to an infinite variety of low volume, high value, or specialised projects due to the editability of the data and the flexibility of the methods.

But at the core is authenticity. The final part is the same as the original, only the method of copying the part and making the mould is different.

The anticipated result is that the GP Delage will be on the road by the end of 2016, a working example of automotive innovations of the past and manufacturing opportunities of the future.

List of Illustrations

Figure 1 - *Delage Type-S Team Cars – Grand Prix De L’ACF, 1914* – Unattributed. Widely published in books, magazines, internet.

Figure 2 - *Designer Michelat, Driver Duray, Patron Delage* – Unattributed. Widely published in books, magazines, internet.

Figure 3 - *Delage Type-S, Barney Oldfield, Indianapolis, 1916.* – Owner’s photo collection.

Figure 4 - *Delage Type-S, “A” McCarey, Maroubra, 1925.* – Owner’s photo collection.

Figure 5 - *Delage Type-S, car as restored in 1978.* – Owner’s photo collection.

Figure 6 - *Delage Type-S, engine as restored in 1978.* – Workshop photo UTCW.

Figure 7 - *Delage Type-S, engine block, 2015.* – Photo by author.

Figure 8 - *Casting failure No.3 cylinder and area of failed repair.* – Photo by author.

- Figure 9 - *Laser scanning the engine block, 2015.* – Photo by author.
- Figure 10 - *Scanned surface data acquisition, 2015.* – Photo by author.
- Figure 11 - *CAD model with machining material added.* – Image Wysiywg3D.
- Figure 12 - *CAD model section for review.* – Image Wysiywg3D.
- Figure 13 - *Computer simulation of casting molten metal.* – Image Keech.
- Figure 14 - *CAD model of 14 part mould set.* – Image by author.
- Figure 15 - *Voxeljet 3D sand printer build of 12 parts.* – Image CSIRO Lab22.
- Figure 16 - *Sand printed main parts of mould set.* – Photo by author.
- Figure 17 - *Sealed mould set, partly assembled.* – Photo by author.
- Figure 18 - *Trial casting emerging from destroyed sand mould.* – Photo by author.
- Figure 19 - *Trial casting (left) beside original engine block.* – Photo by author.
- Figure 20 - *Trial casting sectioned for inspection and review.* – Photo by author.
- Figure 21 - *Production mould set.* – Photo by author.
- Figure 22 - *Production casting poured, 10th June 2016.* – Photo by author.
- Figure 23 - *Production casting before machining.* – Photo by author.
- Figure 24 - *Machined castings – original and reproduction (front).* – Photo by author.
- Figure 25 - *A set of Grand Prix Bugattis – Schlumpf Collection.* – Photo by author.
- Figure 26 - *The GP Delage – On The Road.* – Owner's photo collection.

End Notes

1 Griffith Borgeson. "The 1914 Grand Prix Delage." *Automobile Quarterly* Vol. XXIV, No. 3 (CBS Inc. 1986). 308.

2 Griffith Borgeson. *The Classic Twin-Cam Engine.* (Dalton Watson, 1979). 109.

3 Daniel Cabart and Claude Rouxel. *Delage – France's Finest Car.* (Dalton Watson). Vol. 1. 316.

4 Dick Wallen. *Board Track – Guts, Gold & Glory*. (Wallen, 1990). 97-98.

5 Borgeson. “The 1914 Grand Prix Delage.” 311.

6 John Blanden. *Historic Racing Cars in Australia*. (Blanden, 1979). 136.

7 Graham Howard. *Lex Davison - Larger Than Life*. (Turton & Armstrong, 2004). 27 & 128.

8 Borgeson. “The 1914 Grand Prix Delage.” 313.

9 Geoff Burford. *Racers and Rascals – The Vintage Sports car Club of Victoria*. (Peleus Press, 2002). 14 & 122.

Also, various discussions with Stuart Murdoch (owner), 2016.

10 Various discussions between Stuart Murdoch (owner) and Grant Cowie (UTCW) related to author. 2015.

11 Daniel Cabart & Claude Rouxel. *Delage – France’s Finest Car Vol. 2* (Dalton Watson, 2007). 19.

12 Borgeson. “The 1914 Grand Prix Delage.” 315.

13 Borgeson. “The 1914 Grand Prix Delage.” 323.

14 Sébastien Faurés Fustel de Coulanges and Henk Cloosterman. “1908 Ariés - The First High Performance Desmodromic Engine”. *The Automobile Vol. 33 No. 4, June 2016*. (Enthusiast Publishing Ltd, 2016). 53 to 58.

15 Douglas Blain. “Ground Breaker” *The Automobile. Vol. 19 No.8, Oct 2001*. (Enthusiast Publishing Ltd, 2001). 28.

16 Author not stated (Wohlers Associates). Accessed August 30th 2016.

<https://wohlersassociates.com/press71.html>

17 For example: “The Second Oily Rag Run”. *The Automobile. Vol. 29 No.4 Jun 2011*. 31.

18 For example: “Travel With Style – Concours d’Elegance”. *The Automobile. Vol. 29 No.4, June 2011*. 43.

19 Numerous examples, see: “Finds& Discoveries Section”. *The Automobile, each issue*.

20 Author not stated (The Feral Sports Car Club Inc.) Accessed 14th June 2016. Website: www.feralsportscarclub.net

21 Winston Goodfellow. “The Resurrection – Baillon Ferrari”. *Octane Issue 149, November 2015*. (Dennis Publishing UK, 2015). 62.

22 Frederick A Simeone. *The Simeone Foundation Automotive Museum - The Spirit of Competition*. (Coachbuilt Press, 2009). 26.

23 Jonathon Rishton. "The Simeone Foundation - Automotive Museum". *The Automobile Vol. 29 No.3 May 2011*. (Enthusiast Publishing, 2011). 52.

24 Borgeson. "The 1914 Grand Prix Delage." 314.

25 "The Thin End of the Wedge", Ignition Section. *Octane Issue 148, October 2015*. (Dennis Publishing UK, 2015). 20.

26 Andrew Whittaker. "BDC – Alleged incorrect corporate practices." Website Vintage Bentleys.org. 12th January 2016. <http://www.vintagebentleys.org/bdc-news/>

27 Online edit. Accessed 14th June 2016. Website: https://en.wikipedia.org/wiki/3D_printing

28 Cameron Atfield. "Mephisto's Final Days: 3D modelling to reveal WWI secrets". *The Brisbane Times*. February 5 2016. See www.brisbanetimes.com.au/queensland/mephistos-final-days-3d-modelling-to-reveal-wwi-secrets-20160205-gmmx6e.html

29 Myles Russell Cook. Interview with Michael Mackenzie, *ABC RN Afternoons* 6/4/2016.

30 Author's opinion.

31 Author's opinion.