Idea transfer and company constraints in the design of a two-seater sports car

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ABSTRACT

In 1992 the principal authors were contacted by Beans Industries, the owners of the Reliant Car Company of Tipton, Staffordshire, and asked to present a proposal for the design and product development of a lightweight sports car based upon Reliant parts bin components. This paper covers some highlights of the exercise and details some of the compromises between engineering excellence, manufacturing practicability, cost constraints and pleasing design. Key aspects identified within the paper are the concepts of idea transfer, transferring technology, techniques and style from one design to another and the merits and process of integrating existing components into a design. The study illustrates the scope for two-seater sports cars in the market and postulates on near-term possibilities.

1 INTRODUCTION

The Reliant Car Company famous for its three-wheeled vehicles has had a checkered history [1]. Acquisition by Beans Industries in 1992 gave the company a small breathing space, but the new company needed to move rapidly if it were to stay afloat. The standard three-wheeled vehicle was unlikely to pass new crash protection regulations and the engine was not Euro III compliant. There were very limited funds available for a new venture and the design constraints were principally:

- As many existing manufactured components to be used as possible including the power train
- The body to be of fiberglass construction as this was said to be a Reliant in-house skill
- Retail price
- Time, to be in volume production within 12 months
- Ease of manufacture and assembly
- Comply with current and projected legislation with regard to occupancy safety and
regulated emissions
- Have a reasonable power weight ratio
- Have customer appeal
- Have low insurance rating

There were skills involved that were clearly outside the remit of the authors who took on a project management/engineering mantle.

2 PROJECT PLAN

The single most difficult aspect was to get agreement from the client, who, as is the norm with all such projects had a tendency to move the goal posts in response to the latest business critical pressures.

Use of the following parts bin components was requested:
- Chassis from 3 wheeler
- Back axel/differential from the Reliant Kitten (4 wheeled derivative)
- Front suspension wishbones from the Reliant Scimitar
- Engine from the 3 wheeler, an 850 cc engine. [Reliant engineers had increased the engine torque by 7.3% to 67 Nm, which resulted in a 14.3% reduction of engine speed.] Economy was good. The new Rialto had a claimed fuel economy of 26 kilometres per litre and despite having decreased power (28.12 kW instead of the usual 30 kW) it was said to race past 150 kph with ease with a top speed in excess of 160 kph.
- Gear box from the three wheeler
- Any other parts/sub-assemblies that could be utilized

As with all projects of this nature, the first priority was to produce a working plan and identify all the long lead-time events. The following immediate actions were undertaken:
- Set clear agreed targets and objectives
- Request a full set of drawings of all the ‘Parts Bin’ components
- Rapidly evaluate the suitability of the ‘Parts Bin’ components

3 REAL WORK STARTS

The Honda Beat two seater open sports car was taken as the target within the market place. The 656 cc power unit produced 48 kW at 8100 rev/min and a kerb weight of 747.43 kg. This performance 35.9 kW/Tonne propelled the vehicle up to a maximum speed of 145 kph and a 0 to 100 kph time of 9.8 seconds. The motoring press considered that this performance would be adequate for such a small ‘fun’ vehicle.

The target vehicle designated the R 931 was designed with a power to weight ratio of 37.5 kW/Tonne, and a on the road selling price of £9,995.0 compared to the Honda Beat at £12,500.0

The long lead times were identified as:
- Increase engine performance and make it emission compliant
- Select a suitable chassis design
3.1 Engine development
Whilst engine performance data was available from Reliant, it proved to be unreliable and not to the standard required. A leading independent engine development specialist was commissioned to oversee the development and design validation testing of the multipoint fuel injection system with closed loop lambda catalyst control and ECU controlled electronic ignition equipment. Webcon UK Ltd a specialist gasoline injection and ignition equipment manufacture and supplier were very helpful in the selection and application of the equipment. The design and development of a suitable induction system together with a modified exhaust system resulted in a performance in excess of 50 kW, and, of equal importance, the unit was emissions compliant. A new overhead camshaft cylinder head was designed for introduction at a latter date, but not manufactured.

3.2 Chassis evaluation
The Reliant Robin chassis, Figure 1, was totally unsuitable for the job in hand.

Fig. 1 Reliant Robin chassis (Figure courtesy of www.3-wheelers.com)

The Reliant four wheeled variant the Fox used a box steel chassis but of a most complex design and did not have the stiffness required for an open sports car. A number of chassis design options were considered:
- Ladder frame
- Space frame
• Monocoque construction

The ladder frame was rejected, Thick gauge relatively large diameter tubes would have to be used, and complex brackets required to affix the body panels and the ladder frame was rejected on the basis of undue cost and weight.

A tubular space frame was considered, and initial design studies undertaken. A very strong, stiff lightweight construction was possible as per the type 60-61 ‘Bird Cage Maserati’, Figure 2, but this solution was rejected due to the high labor costs and time to manufacture. In these structures the order in which the stressed tubes are welded together is critical, and the chassis appears to be badly warped until the last weld is completed when all the stresses are balanced. A job for a skilled work force and not suitable for a low volume production vehicle.

![Fig. 2 The type 60-61 ‘Bird Cage Maserati’ (Reproduced from [2])](image)

Monocoque construction has a number of key attributes. One famous example is the Le Mans winning Ford GT40, Figure 3. The Ford Motor Company originally approached various people to design the new Ford GT car. They decided upon Eric Broadley of the then "small company of Lola Cars", who had just produced for racing a Lola GT mid-engined car powered by the Ford 4.2 Litre engine and driven through a Colotti type 37 transaxle. By mid 1965 and with the ZF transaxle now available [solving the Colotti reliability problems] Ford decided that the GT40 had reached a sufficiently advanced state of design to go into limited production and build 50 GT cars to qualify them for the Production Sports Car Category. The principal designer of the GT 40 production chassis, Len Bailey kindly viewed some of the monocoque designs put forward by the authors and made suggestions that resulted in a much simpler yet stiffer and crash resistant chassis.
In the design of the monocoque chassis, the primary design considerations were:
- Passenger safety/ crash worthiness
- Stiffness, a prerequisite for a good driver feed back and vehicle handling
- Ease of manufacture
- Cost

The monocoque chassis comprises of a series of boxes, each interconnected and, hence distributing the loads evenly through the structure. Earlier cars of low cost and limited power were reviewed to see what lessons could be learned.

The Austin Healy Sprite Mark 1, was a similar sized vehicle, it used steel body and chassis panels, to produce a unitary construction vehicle, but with 50 pressings in the floor pan alone it was clearly too complex and expensive for this exercise, Figure 4.
Colin Chapman of Lotus as always, proved to be an inspiration with his classical seemingly simple design of the Lotus Elite. This design used three primary fiberglass moldings, floor pan, engine and passenger box and skin, Figure 5. Taken individually each item was weak and flimsy, when assembled provided a very lightweight and strong assembly. A weak point was the transmission of road loads and torque wind up through the rear shock absorbers, which resulted in cracking of the internal mountings for the shock absorbers which under racing conditions frequently drove through into the cockpit resulting in on road instability. The design was not suitable for volume production due to the time required for each skin to be hand laid up and then the time required for curing of the fiberglass resin. Nonetheless the car was a classical design and much admired.

![Image of Lotus Elite](image.png)

**Fig. 5 The Lotus Elite (Reproduced from [2])**

A new monocoque chassis was designed, and material selected. Aluminum sheet, treated standard body pressing sheet and brushed stainless steel were considered. Brushed stainless steel was favored for the following reasons:

- Consistent finish and thickness for production
- Customer appeal
- Structural strength
- Ease of machining

It was a design constraint that there be the minimum number of bends in each panel and that they be simple. Compound bends were kept to a minimum. The cutting of the sheets was
investigated and the following options studied: -

- Guillotine
- Laser cutting
- High pressure water jet cutting

Of this high-pressure water jet cutting was found to be the most cost effective solution.

Joining the sheet panels presented further challenges. Again a number of options were reviewed, and it is worth restating that the authors were working to a very limited budget and the final vehicle had to have very low investment and production costs.

Joining methods reviewed included:

- MIG & TIG welding
- Spot Welding
- Laser welding
- Gluing

Gluing was the final favored method as it presented high strength, zero panel distortion, and low production cost (parts and labor).

The final chassis design consisted of a series of strong, lightweight, interconnected boxes fixed to a honeycombed sandwich floor pan. The format was as follows.

- 2 deep sills, filled with energy absorbing foam for structural strength and side impact resistance.
- A double skin propeller shaft tunnel.
- A box section front bulkhead blending into a Kevlar reinforced ‘A’ post and rollover windscreen support.
- A box section rear bulkhead being the last item of a very strong rigid passenger protection zone.
- Special design deformable energy absorbing rails passing through the sills provided the mounting points for the powertrain, suspension and body panels.
- This design presented a chassis that required a low tooling investment, together with ease of manufacture and assembly.
- It was seen as a lightweight, stiff and cost-effective solution.

This design presented a chassis with a low tooling investment, together with ease of manufacture and assembly. It was a lightweight, stiff and cost effective solution. Quotations were received from MIRA for full VCA (Vehicle Certification Authority) type approval crash tests, including front, rollover and side impact and seat and seat belt fixing integrity.

4 STYLING

The styling of the R 931 concept was undertaken in an organic fashion, allowing the car to draw and develop itself. The profile was drawn on a wall full-size. The engine, gearbox, differential, wheels etc were placed against the side-elevation and their final location determined. A standard SAE two-dimensional manikin was scaled to full-size with articulated joints and positioned in the vehicle and adjustments made accordingly. This resulted in the GA and then the 3D models developed as illustrated in Figures 6 & 7. A 3D CAD model was used to enable a sculpted clay to be cut, Figures 8 & 9. The result was right first time and the clay was digitized to produce the panel geometries.
Fig. 6 The R 931

Fig. 7 The R 931 fixed head coupé

Fig. 8 Clay model
5 OPPORTUNITY LOST AND THE SPORTS-CAR MARKET

Unfortunately Beans Industries collapsed and with it the opportunity for this product at that time although it is interesting to note persistent rumours of the production of a design based on the Chapperele vehicle by the re-born Reliant Car Company. Of significance is the potential of the international small sports-car market. There is no doubt that the correct mix of marketing, business aptitude, design and engineering can result in sustained demand for small sports cars. Table 1 lists sale number details for north American two-seater roadsters. There is evidently room for both mass-produced and niche car manufacturers.

Table 1 North American Roadster (Two-seater) Body-style sales (Data courtesy of DRI)

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<th>Brand</th>
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<th>2001</th>
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<td>114</td>
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<td>BMW</td>
<td>Z3</td>
<td>17962</td>
<td>14976</td>
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<td>Z8</td>
<td>358</td>
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<td>27</td>
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6 CONCLUSIONS

The sports car market remains an area where designs generate interest and sales. This study shows that it is possible to transfer technology from one vehicle to another and produce an attractive and viable design. In this case business factors precluded demonstration but the possibility remains and it is the challenge to entrepreneurs of today to exploit the design talent available.

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REFERENCES