

High Performance DeLorean Engine Kit

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ABSTRACT

In 1981 the first DeLorean DMC-12 car's rolled off the assembly line. With its sleek styling, stainless steel exterior, and gullwing doors, future owners expected the sports car of the future. The exotic look and design of the DeLorean raises the expectations for the performance of the vehicle. Unfortunately, the original 2.8L V-6 Peugeot/Renault/Volvo (PRV) engine simply does not meet these expectations. Bombarded with emissions regulations of the early 1980's, the DeLorean's drive train de-tuned to a meager 130hp at the crank shaft. At the wheels, it is rare for a DeLorean to produce greater than 100hp. This makes the DeLorean capable of driving from 0-60mph in just over 11 seconds.

In the 30 years since the first DeLoreans were produced, their popularity has grown exponentially. With owners and vendors all over the community, the DeLorean community is able to thrive. Unfortunately, even the most extensive modifications to the original engine only produce 230hp.

For DeLorean owners that wish to have greater than 300hp in their cars, a kit was designed. The kit allows a DeLorean owner to replace their existing 2.8L V-6 PRV with a 5.7L Chevy LS1 V8 engine. The kit contains all necessary drive train components, mounting components, and accessory components necessary to easily install the Chevy V8 into any DeLorean DMC-12.

The kit in question uses the original DeLorean manual transmission, and the Renault UN-1 transmission, mated to the new engine. All necessary shearing and loading calculations were preformed to ensure the safe operation of the engine with this transmission. In addition, extensive solid modeling was preformed to ensure the proper drive train component stack up.

The kit is designed to be safe and easy to install, safe and easy to operate, low cost, as well as aesthetically pleasing. In addition, the kit requires very little modification to the original DeLorean body and frame. All components are designed to be bolted on.

With this kit and engine installed in their car, DeLorean owners can finally have the performance they want in this one of a kind sports car.

INTRODUCTION

BACKGROUND

The DeLorean DMC-12 is an iconic exotic sports car with a strong following, especially in the United States. The vehicle was produced in a factory located in the city, Dunmurry in Northern Ireland, from 1980-1982. In three model years, 81-83, approximately 9,000 cars were produced. Today an estimated 6,000 cars are still on the road, and research is constantly being performed to improve these 30 year old vehicles. Primarily this research is performed by the [new] DeLorean Motor Company located in Houston Texas (DMCH). With a large stockpile of new old stock parts, as well as new improved parts, DMCH is the primary vendor for DeLorean owners worldwide. They are also responsible for creating upgrades for the DeLorean, such as an upgraded exhaust system providing an increase of 15hp (1) and the DeLorean Stage II engine providing an increase of 40hp (2).

Shown below in Figure 1 is a standard DeLorean DMC-12



Figure 1 – Standard DeLorean DMC-12

STOCK DELOREAN ENGINE

All DeLorean DMC-12 vehicles came from the factory with an aluminum 2.85 liter V6 engine (3), shown in Figure 2, designed through the combined efforts of Peugeot, Renault, and Volvo (often referred to as the PRV engine). Though originally specified at 130hp, a DeLorean with its stock PRV engine, will output approximately 100hp at the wheels; far less than what it's styling suggests it is capable of, and less than what owners who are willing to spend \$25,000 would like to have in their cars. Though there are upgraded cams (4) that increase engine output, turbo kits (5), exhaust kits (1), and complete upgraded engines (2). No combination of these will output greater than 215hp on the stock engine. Further information on current available upgrades can be found in Appendix A

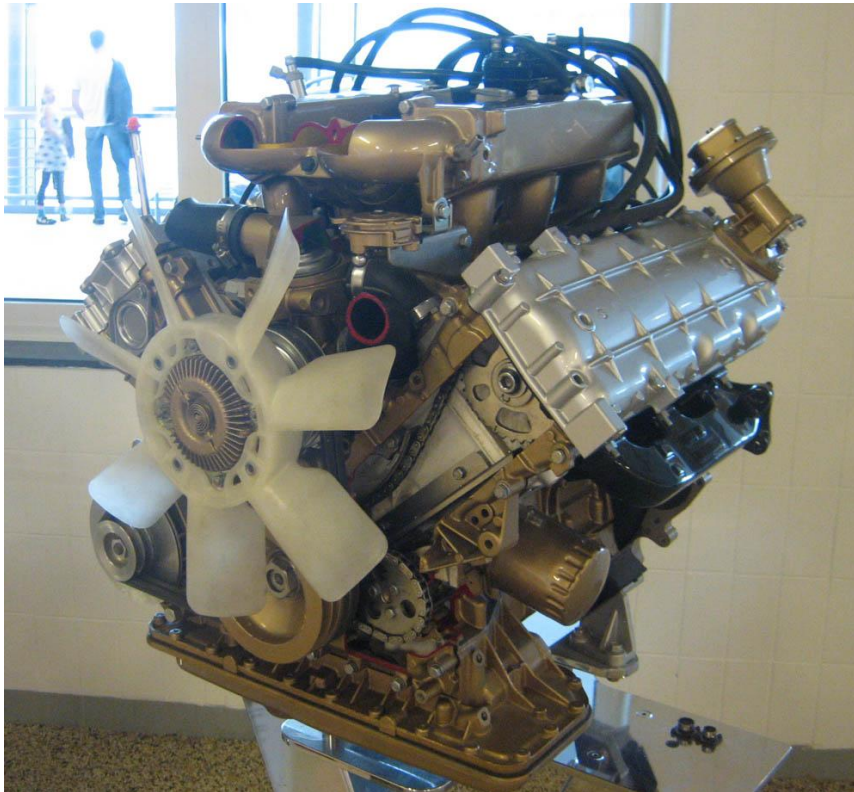


Figure 2 - Stock DeLorean 2.85L Peugeot-Renault-Volvo V6

EXISTING PERFORMANCE ENHANCING PRODUCTS***Stage I Exhaust Upgrade***

The Stage I Exhaust system is sold by the DeLorean Motor Company in Houston Texas and promises a gain of at least 15 horsepower (1). This is a very popular upgrade for many owners for several reasons. After 30 years, many of the stock carbon steel DeLorean exhausts have corroded to the point of leaks requiring replacement. In addition, owners often find that the relatively primitive stock catalytic converters no longer perform properly causing failed emissions tests. This system provides a modern option to those desiring a replacement for their existing system that will increase performance, while also meeting emissions regulations.

Stage II DeLorean Engine

One of the most popular engine performance for noticeable power increase is the Stage II DeLorean Engine (2) available from the DeLorean Motor Company in Houston Texas. The Stage II Engine uses a new old stock zero-mile DeLorean PRV engine as a base. Prior to installation, the engine heads are ported and polished to both increase total airflow and reduce turbulent airflow. In addition, the dual-overhead camshafts inside the heads are replaced with new high-lift cams. These cams open the intake and exhaust valves further than stock cams to allow greater airflow both in and out of the cylinder. Finally, the stock exhaust system is replaced by the previously mentioned Stage I Exhaust (1) to increase exhaust flow and reduce exhaust backpressure. Once installed, the engine is said to produce 170 horsepower (approximately 150hp at the wheels), an increase of roughly 45 horsepower.

One of the difficulties surrounding this upgrade is that the kit can only be purchased and installed at one of the 6 licensed DeLorean Motor Company branches. These branches are located in Houston Texas, Garden Grove California, Bonita Springs Florida, Bellevue Washington, Crystal Lake Illinois, and a single European location in the Netherlands. In addition to the \$7,200.00 required for the upgrade, the customer must also arrange for shipping or transport to and from the nearest location. These costs can be very unappealing to many potential customers.

High Performance Cam Shafts

A product with similar results as the Stage II engine is the High Performance camshaft kit from DMC-California (4). The manufacturer claims an increase of 62 horsepower at the crankshaft with this product (approximately 35hp at the wheels). This product is most appealing to DeLorean owners who wish to perform their own maintenance and upgrades. Though requiring installation after purchase, at only \$600.00, this product is considerably less expensive than the Stage II engine and does not require the vehicle to be transported to a DeLorean Motor Company branch. Unfortunately the installation of this product is very complex requiring the rebuilding of both engine heads and typically the removal of the engine from the vehicle. Even with experience, this process can be very long and difficult.

Twin Turbocharged DeLorean Engine

The final performance enhancement available for the DeLorean is the Twin Turbocharged DeLorean engine kit (5). Of all performance enhancement products available, this provides the greatest increase in horsepower. Similar to the Stage II upgrade, this product uses a zero-mile original DeLorean as a base. In addition to the specially manufactured camshafts, this engine also includes twin turbochargers to force a higher volume of air into the engine. This results in the output of 250 horsepower at the crankshaft (approximately 215 at the rear wheels). Unfortunately the cost of this kit is \$11,000.00 as well as a large core charge if the customer does not provide an original DeLorean engine. In addition, the installation can only take place at DMC-Europe located in the Netherlands. Currently any US based customer is required to ship their vehicle to the Netherlands for installation of this product.

PROBLEM

The stock motor in the DeLorean DMC-12, even with modifications is incapable of producing greater than 215hp. The ability to replace the stock motor with one producing

300hp is desired.

PROPOSAL

The basis of this project was to design a kit that would allow a DeLorean owner to replace their stock DeLorean engine with a V8 Engine that will output at least 300hp while still enjoying all DeLorean accessories. In addition installation would not require major modifications to the transmission, frame, and body, or cause significant increases in vehicle weight. The kit includes all necessary mounting brackets, hardware, adapter plates, and components to interface with the existing systems (ac, heat, cooling, vacuum, ignition), as well as necessary documentation and instructions, for under \$1500.00. The design of the kit is proved by a prototype build in a drivable DeLorean, including dynamometer testing to prove the results. In addition, all necessary calculations are provided.

LS1 Engine

The engine used for this project is the Chevrolet LS1 V8 Engine. The Chevrolet LS1 was first introduced in 1997 in the fifth generation Chevrolet Corvette's. In 1998, the engine was further incorporated in the performance models of the Chevy Camaro and the Pontiac Firebirds. The engine has eight cylinders with a combined displacement of 5.7L and is rated at 315hp with 320lb*ft of torque. It is very compact and simplistic in operation. Unlike traditional engines, it does not use an electric distributor driven by the cam or crank shaft. Instead the engine uses an individual coil pack per cylinder controlled by a central computer receiving data from a crank shaft position sensor. This makes timing and tuning of the engine all possible via a computer. The engine is cast from lightweight aluminum alloy making it only 35lbs heavier than the stock DeLorean PRV engine. Shown here in Figure 3 is a complete LS1 Engine.

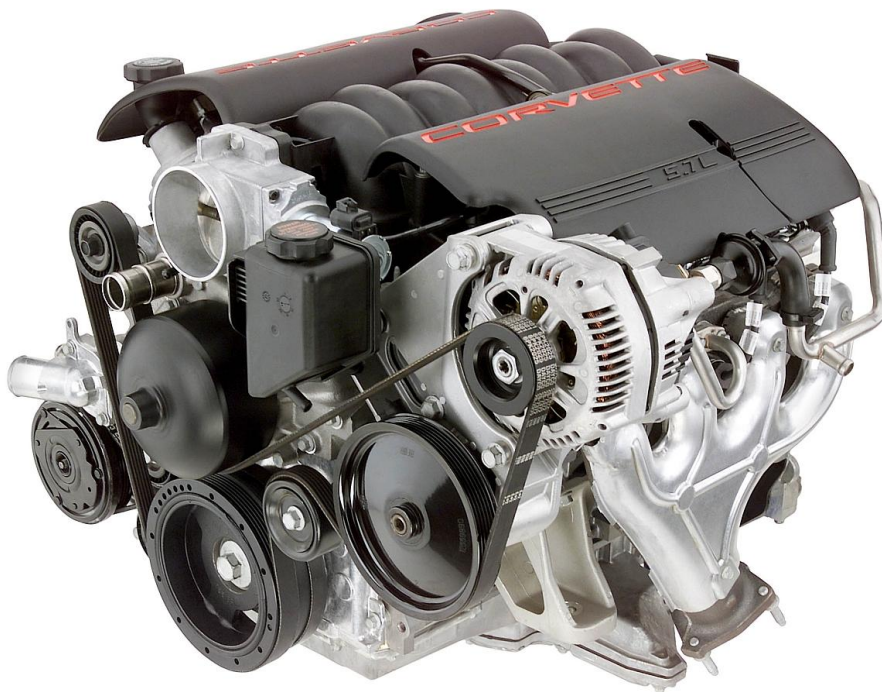


Figure 3 – Chevrolet LS1 V8 Engine

ALTERNATIVE ENGINE CONSIDERATION**Cadillac Northstar**

In addition to the Chevrolet LS1 V8 Engine, the Cadillac Northstar LH2 engine was considered. Like the LS1, the Northstar LH2 is also a lightweight aluminum V8. The engine displacement is 4.6 liters with a compression ratio of 10.3:1, producing 300hp. Most appealing about this engine is its compact design as well as its abundance, as nearly all new Cadillacs since 2004 have used this engine.



Figure 4 – Cadillac Northstar LH2 V8 Engine

The most difficult component to the LH2 is its extensive car specific computerization as well as it's "drive by wire" cable-less throttle system. These two factors increase the cost of the kit, as well as drastically increasing the installation time of the system. These are the primary reasons for not utilizing the Cadillac Northstar LH2 engine.

Subaru Boxer Engine

In addition to the Cadillac Northstar engine, the Subaru Boxer engine was briefly considered. It was quickly determined that due to space limitations, the Boxer engine would not work. The problem was in the layout of the engine itself. The boxer used horizontally firing pistons instead of diagonally, such as those in a V shaped motor. This design causes the Boxer motor to be very wide and cube shaped. As the DeLorean engine bay is designed to accommodate a V shaped motor, the Boxer motor could not be used.

LOADING CONDITIONS

SAFETY FACTOR

The nature of loading from an internal combustion engine is of steady torsional loading. In the case of the Chevrolet LS1 V8 engine, the maximum load is achieved when the engine reaches 5500rpms. As the engine cannot instantaneously start at this RPM, it must ramp up until it finally achieves this rate of rotation and high output. As the increase is a steady increase with no system slippage it is a steady torsional load. According to table 4.1 in Applied Strength of Materials by Robert Mott, shafts subjected to steady torsional loading require a safety factor of 2. (6)

TRANSMISSION LOADING

Aside from the engine, the most important component in the drive train is the transmission. Because the original DeLorean transmission was to be used it was crucial to determine whether or not the existing transmission could handle the loading conditions of the new engine. To do this, the loading conditions of the transmission input shaft had to be determined. The shaft itself is made from AISI 4340. It was necessary to disassemble the transmission itself to take the proper measurements of gear size, load angle, bevel angle, gear spacing, and shaft diameter size. With these measurements, along with the correct loading from the engine, it could be determined whether or not the transmission would fail under the new load. Shown here is the input shaft removed from the transmission.



Figure 5 – Transmission Input Shaft

The following equations were used to determine the required shaft diameters:

Table 1 - Loading Equations

Equation	Value
$\omega_t = \frac{TA}{D_a/2}$	Tangential Loading
$\omega_x = \omega_t \tan(30^\circ)$	Tangential Loading for Bevel Gears
$\omega_r = \frac{\omega_t \tan(20^\circ)}{\cos(30^\circ)}$	Radial Loading
$M_x = \omega_{rx} \times D$	Moment in X-Axis
$M_y = \omega_{ry} \times D$	Moment in Y-Axis
$M_{combined} = \sqrt{M_x^2 + M_y^2}$	Combined Moment
$D_{min} = \left[\frac{32N}{\pi} \sqrt{\left[\frac{K_t}{S'_n} M_{combined} \right]^2 + \frac{3}{4} \left[\frac{T}{S_y} \right]^2} \right]^{\frac{1}{3}}$	Minimum shaft diameter

The equations indicated were used for each gear to determine the minimum shaft diameter required for each gear in order for the transmission to safely receive the load from the engine. Shown below is an example of loading in first gear:

- $\omega_t=2018.33\text{inlbs}$
- $\omega_x=1165.28\text{inlbs}$
- $\omega_r=848.26\text{inlbs}$
- $M_x=920.80\text{inlbs}$
- $M_y=2190.95\text{inlbs}$
- $M_{combined}=2376.58\text{inlbs}$
- $D_{min}=0.99\text{in}$
- $D_{actual}=1.1\text{in}$

The information above indicates that with a safety factor of 2, it is safe to transfer the power from the LS1 engine using the original DeLorean in first gear. Doing the same calculations for each gear provides the following results:

Table 2 – Minimum Shaft Diameters Per Gear

Calculated minimum diameters for safety factor of 2		
Gear	Minimum diameter (in)	Actual Diameter (in)
1 st	0.98	1.10
2 nd	1.44	1.50
3 rd	1.45	1.50
4 th	1.50	1.50
5 th	1.35	1.38
Reverse	1.11	1.50

From table 2 shown above, it is clear that the shaft meets or exceeds all minimum diameter requirements for safe operation with a safety factor of 2.

DESIGN AND MODELING

The most crucial design element of this project was ensuring the proper stack up of drive train components. The tolerance of these components needed to be very precise. Before any precise design or fabrication could begin, it was necessary to determine the spacing and location of each component. A failure in this design could cause poor clutch engagement/slippage, lack of clutch disengagement, lack of transmission input shaft support, bell housing interference, and more. In order to ensure the size and placement of each part, several precise models were created. A sample of these models is shown here:

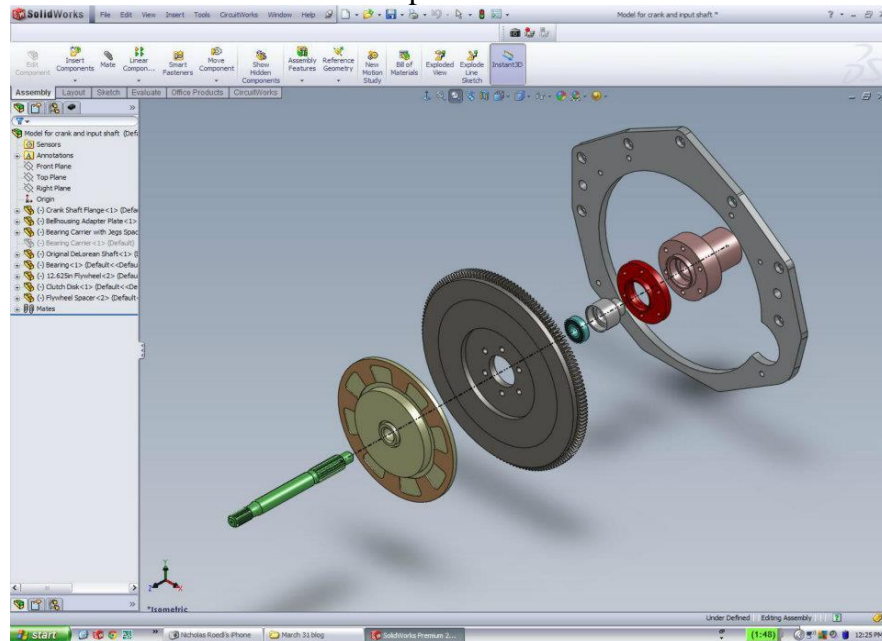


Figure 6 – Drive Train Stack-up Exploded View

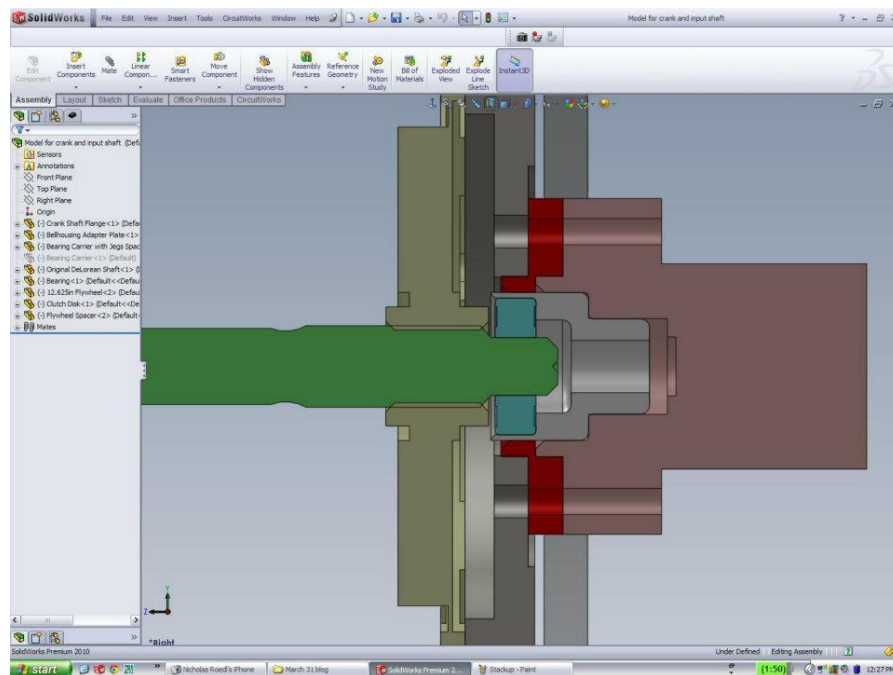


Figure 7 – Drive Train Stack-up Cross Sectional View

SPECIALTY COMPONENTS

DESIGNED AND FABRICATED COMPONENTS

For proper mating and mounting of the new engine, several specialty components were required. These components were either machined by TurboCare or manually in the University of Cincinnati's machine shops. Any drilling, welding, and grinding could be done in house.

LS1 TO UN1 ADAPTER PLATE

In order to mate the engine to the transmission to the engine, a special adapter plate was designed. The plate was designed to be cut from ½" 6061-T6 Aluminum plate. This material was chosen as it has higher strength than the aluminum used in the casting of either the original DeLorean engine or the LS1 engine. The plate is designed to mount to the LS1 engine using the original bell housing mount holes with six counter sunk class 10.9 M10x1.5 bolts. After the plate is mounted to the engine, the bell housing of the transmission will bolt to the plate using the original 4 M10x1.5 bolt holes.

It was important to note that two shearing planes exist with the adapter plate, one plane between the engine and plate, and one between the plate and transmission. The force from the weight of the transmission is the same in both planes. However, because the transmission only bolts to the plate with four bolts instead of six, the shear stress in this plane is the highest. Using the following equations for area and shear stress, the stress of a single bolt could be found.

$$A = \pi r^2 \quad \sigma_{shear} = \frac{F}{A}$$

The individual shear stress of a single bolt in is 267psi. As the class 10.9 M10x1.5 bolts are rated for up to 961psi, this loading is within save operating parameters.

Shown here is a model of the adapter plate:

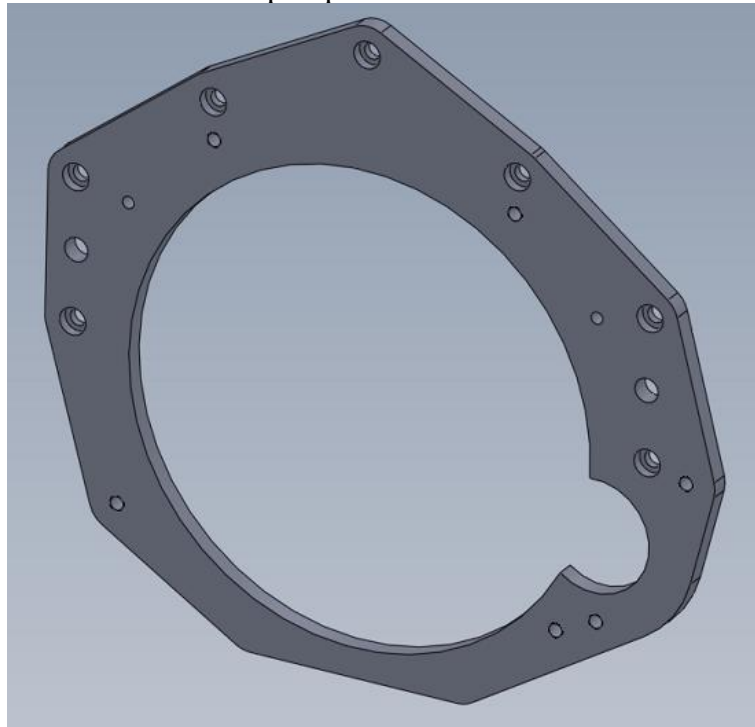


Figure 8 – Adapter Plate Model

The plate for the prototype was water jet cut by Siemens/Turbocare. Shown here is the prototype adapter plate following machining, as well as it being used to mate the engine and transmission.

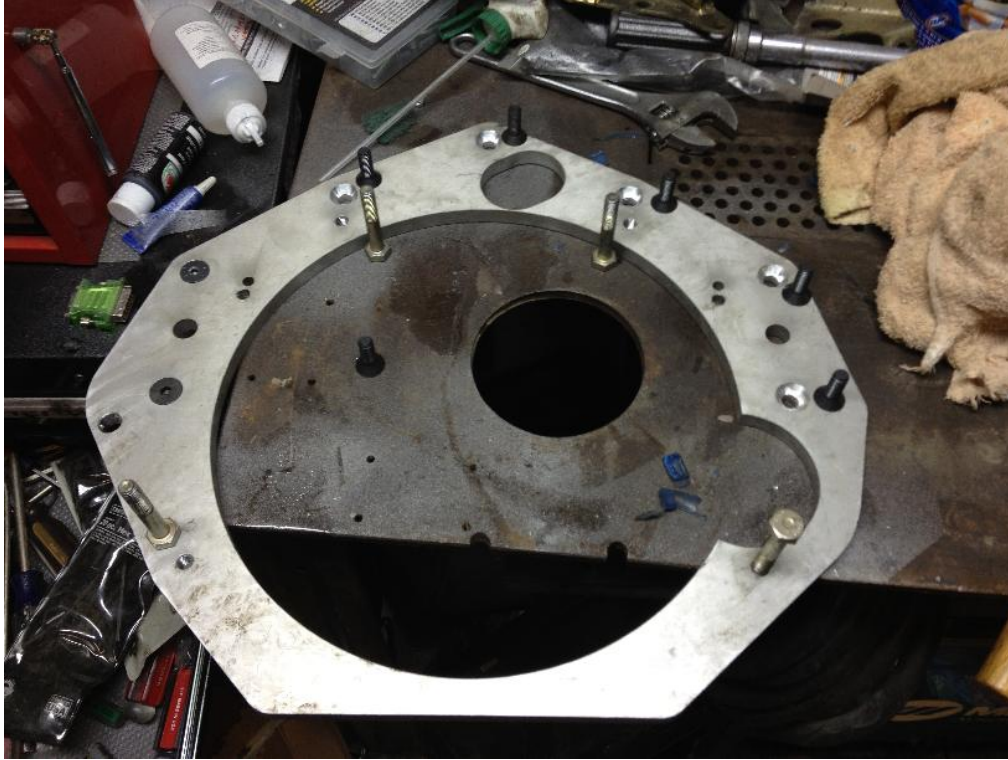


Figure 9 – Prototype Adapter Plate



Figure 10 - Adapter Plate Mounted to Engine

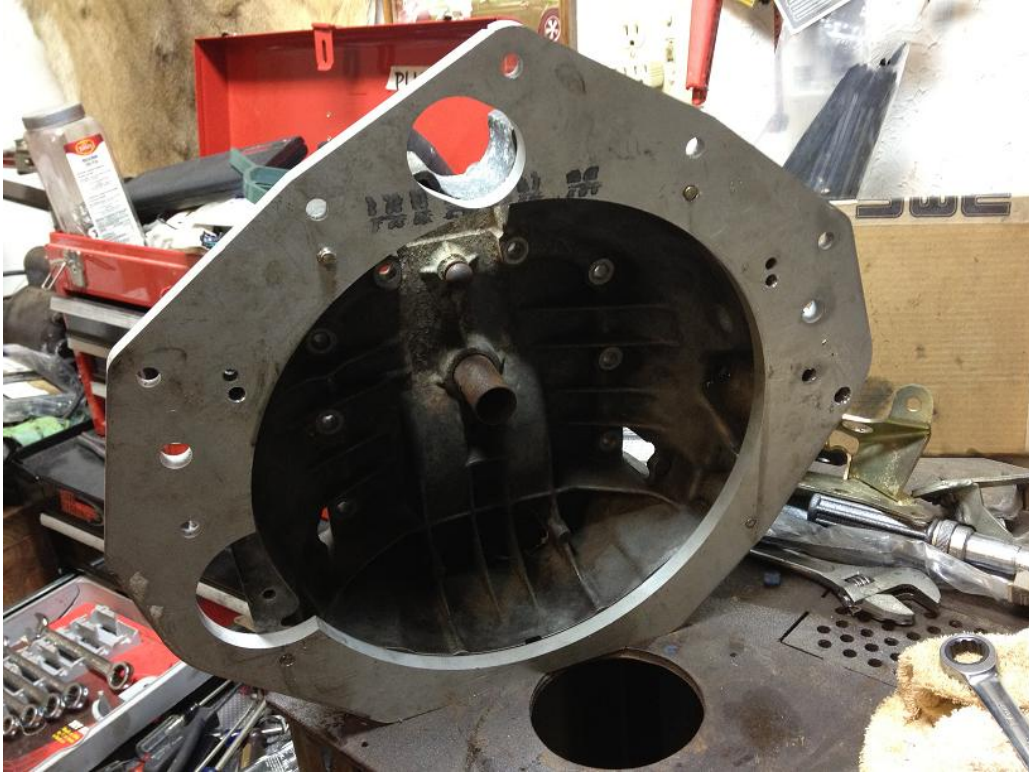


Figure 11 – Adapter Plate Mounted to the Engine



Figure 12 – Engine and Transmission Mated Using Adapter Plate

Technical Drawings for the plate can be found in Appendix E.

PILOT BEARING CARRIER

The adapter plate allowing the engine and transmission to bolt together causes a gap between the input shaft of the transmission and the flange holding the pilot bearing on the engine crank shaft. This distance must be accommodated by a carrier to allow the pilot bearing to sit closer to the transmission. The carrier is pressed into the crank shaft as the pilot bearing would ordinarily, and the pilot bearing is pressed into the carrier.

Shown below is the location of the crank shaft flange relative to the input shaft:



Figure 13 - Pilot Bearing Carrier Location

The prototype pilot bearing carrier was machined on a lathe in the University of Cincinnati OCAS machine shop. Shown here are pictures of the part.

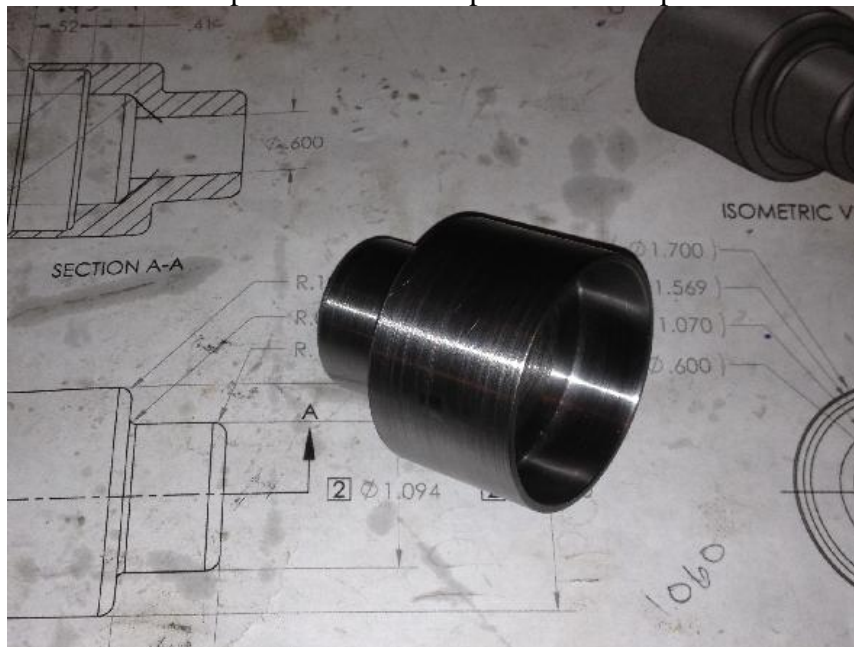


Figure 14 – Pilot Bearing Carrier



Figure 15 – Pilot Bearing Carrier Installed

Technical drawings for the pilot bearing carrier can be found in Appendix E.

EXHAUST PIPE

The exhaust routing for the engine is very short. As the engine already sits in the rear, the engine is quite close to the rear bumper and location of the muffler tips. The exhaust uses Hooker low profile LS1 exhaust headers with a custom bent and welded exhaust pipe, leading to a standard Walker muffler on each side. A technical drawing of the exhaust tube can be found in Appendix E.



Figure 16 – Exhaust Components

The fabrication of the custom exhaust was done using a hydraulic pipe bender.



Figure 17 – Exhaust Fabrication

Shown here are the completed exhaust pieces.



Figure 18 – Custom Exhaust Piping

ENGINE MOUNT MODIFICATION

The engine is supported by standard LS1 engine mounts modified to fit the DeLorean frame. As the DeLorean frame is very similar to the frame of the original LS1 vehicle, original mounts are simply re-drilled to fit the DeLorean frame.



Figure 19 – Modified Engine Mounts

A drill template for engine mounts can be found in Appendix E.

THROTTLE BODY RELOCATION BOX

Space limitations for the engine install requires that the air intake manifold face the passenger compartment and a throttle body relocation box be used to raise the throttle body. The box is designed and machined from a piece of 2"X4" 6061-T6 Aluminum box tubing. The piece is sealed aside from 2 holes for the intake manifold as well as the throttle body. In addition, holes are added for the throttle cable mount, intake air temperature sensor, and mounting. All holes are sealed using Permatex high-temp sealant. Shown below is the part:



Figure 20 – Throttle Body Relocation Box

A technical drawing for the box can be found in Appendix E.

FLYWHEEL

The most important of all custom components is the flywheel. The flywheel links the engine to the transmission, and along with the clutch, is responsible for full transfer of energy from the engine to transmission. Because of the uniqueness of the Chevy/Renault relationship, finding an off the shelf flywheel suitable for this situation was not possible. For the prototype, it was necessary to fabricate a flywheel from raw materials. In order for the flywheel to work, the following criteria had to be met. It was required that it fit inside the Renault transmission bell housing, fit the DeLorean starter ring gear, contain the proper DeLorean clutch step as well as DeLorean clutch bolt pattern, maintain the LS1 flywheel hub thickness, and bolt to the LS1 crank shaft. For the prototype, the flywheel was machined from a piece of 1.25" hot rolled A36 structural steel plate. The plate was fabricated in the University of Cincinnati machine shop at OCAS as well as main campus. The fabrication of this part is shown below:



Figure 21 – Flywheel Fabrication Process

For a flywheel to properly function, it must be both balanced and surfaced. Because the LS1 engine is internally balanced, it is required that the flywheel be neutrally balanced all the way around. In addition, for proper clutch engagement, a friction surface must be added using a flywheel surfacing too. Following the fabrication, the flywheel was dynamically balanced and surfaced by Smyth Automotive. The completed part is shown below:



Figure 22 – Flywheel Following Balancing



Figure 23 – Flywheel Following Surfacing

OF THE SHELF COMPONENTS**GTO OIL PAN**

In order for the engine to properly sit in the engine bay, clearance is required in the lower rear section of the engine. Typically, an LS1 uses a rear-sump oil pump system, however, when the LS1 was used in the 2004-2006 Pontiac GTO, a front sump system was used. This system relocated the low point of the engine to the front of the engine. The oil pan for this system will work with any LS1 engine and will allow clearance for the main engine support frame cross member. Shown below is a comparison between the two oil pan styles:



Figure 24 – Standard Oil Pan (Left). GTO Oil Pan (Right)

DRIVE TRAIN COMPONENTS

The increased power transferred from the engine to the transmission is too great to use original DeLorean components. In order to safely transfer this energy, an upgraded clutch and starter must be used. With the assistance of Centerforce Clutches, a suitable clutch rated for 500hp has been located. In addition, a suitable starter is manufactured by Powermaster Starters.

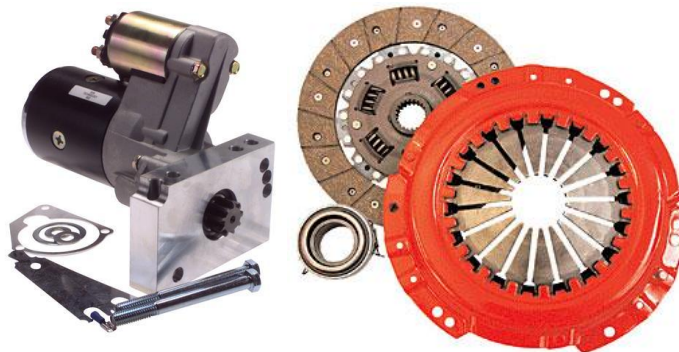


Figure 25 – Starter (Left), Centerforce Clutch (Right)

ACCESSORY SYSTEM ADAPTATION

The last systems to be adapted were the cooling system, vacuum system, electrical systems, and HVAC. For the prototype, the cooling system was adapted using 1.5" flexible cooling hose. The vacuum system was adapted using standard 5/16" vacuum hose. The engine computer was mounted in the passenger compartment and wires were properly routed to required destinations. As the DeLorean by default uses General Motors air conditioning lines, the system connected to the LS1 A/C compressor without issue.

CUSTOMER FEEDBACK AND OBJECTIVES

CUSTOMER INTERVIEWS

Two potential customers were interviewed to gather information regarding the characteristics most important to them and also what they would like to avoid (7) (8). In each interview the interviewee expressed the same concern that no modification to the existing engine would meet their needs, therefore a replacement engine would be required. Both stated that to be worthwhile, the new engine would have to produce a minimum of 250hp (at the wheels), preferably closer to 300hp. In addition, to satisfy both, the new engine would be required to mate with the current 5-speed manual transmission. The primary difference between the two interviewees was the willingness to modify the existing vehicle. The first interviewee, Patrick Conlon (7), was considerably more adamant about not modifying the frame and body than the second interviewee, Ken Koncelik (8). In order to satisfy both, modifications to the frame and body were avoided as much as possible. Further interview Specifics can be found in Appendix A.

SURVEY ANALYSIS

Eighteen potential customers and/or DeLorean owners were surveyed to collect their opinions on different elements and features of the kit. It is clear from the results that the most important feature to please the customers is that the kit be easy to utilize and install. In addition, it is important that the kit be designed such that as few modifications to the existing vehicle as possible be necessary. Table 1 shows the survey results including the designer's multiplier.

Table 3 – Customer Importance

Customer Importance Results			
Feature Surveyed	Importance	Designer's Multiplier	Weighted Rank
Ease of Installation	4.6	1	12%
Minimal Vehicle Modifications	4.3	1	11%
Installation Safety	4.0	1.1	11%
Compatibility with Existing Systems	3.9	1.1	11%
Documentation Quality	3.5	1.2	11%
Reliability/Durability	4.0	1	10%
Operational Safety	3.7	1	9%
Low Cost	3.5	1	9%
Ease of Inspection	3.4	1	9%
Aesthetics	3.2	1	8%

The designer's multiplier was applied to the installation safety, compatibility with existing systems, and the documentation. The installation safety was increased to maintain a continuing emphasis on safety. The safety of the customer during installation of this product is certainly an upmost priority. Compatibility with existing systems was increased to ensure minimal confusion of the customer while interfacing the new technology with existing

DeLorean technology. As much as possible, new systems will be designed to “plug and play” with existing systems. Documentation quality was increased the most, as adequate documentation of the installation is key to successful future installations. A focus on quality installation will ensure that the customer will receive every bit of information necessary to install this kit themselves and will reduce the possibility of incorrect and unsafe installation procedures.

The second half of the survey, shown in Table 2, focused exclusively on the types of modifications owners would be willing to perform to their cars. In this case, the higher the rating, the more willing a customer was to perform a type of vehicle modification. The data retrieved shows that the majority of customers would be willing to drill into or weld onto their frames, and would be willing to drill into the body. It seems most would avoid most modifications to the body and any cutting of the frame. A full survey including results is available in Appendix B.

Table 4 – Customer Willingness to Modify Vehicle

Customer Willingness to Modify Vehicle	
Modification Type	Willingness
Drilling (Frame)	4.2
Welding (Frame)	3.0
Drilling (Body)	2.8
Grinding (Frame)	2.4
Cutting (Frame)	2.2
Cutting (Body)	1.4
Grinding (Body)	1.4

PRODUCT FEATURES AND OBJECTIVES

Below is a list of the objectives for the High Performance DeLorean Engine Installation kit as well as the way in which each measure is achieved. The indicated objectives focus primarily on the installation of the kit. This kit is only to be evaluated when used in a 1981-83, DeLorean DMC-12 with a Renault-UN1 manual transmission. No other vehicle or transmission application is to be considered.

Easy to Install (12%):

- 1.) All necessary components included, no fabrication necessary by consumer
- 2.) All necessary hardware included
- 3.) No custom tools needed for installation
- 4.) Documentation of installation process
- 5.) Electrical connections to use snap together connectors
- 6.) Adaptive hosing to use hose clamps or bolted connections

Safe to Install (11%):

- 1.) Installation will not require consumer to be under suspended load
- 2.) No exposed electrical wires
- 3.) Protective equipment listed in documentation where necessary

Well Documented (11%):

- 1.) Full documentation of included parts and hardware
- 2.) Full documentation of installation process with photos
- 3.) Wiring diagrams included
- 4.) Vacuum hose, coolant hose, HVAC lines, and wire routing diagrams included
- 5.) Documentation of recommended off the shelf parts to be purchased
- 6.) Contact information for technical assistance
- 7.) All torque specifications provided

Minimum Vehicle Modifications (11%):

- 1.) No necessary modifications to the vehicle body
- 2.) Only drilling and welding of frame acceptable
- 3.) No necessary cutting or grinding of the frame

Compatible with Existing Systems (11%):

- 1.) Integration with existing electrical system
- 2.) Integration with existing vacuum system
- 3.) Integration with existing electrical system
- 4.) Integration with existing HVAC system
- 5.) Integration with existing fuel system
- 6.) Integration with existing engine cooling system

Reliable/Durable (10%):

- 1.) FEA on newly fabricated parts
- 2.) All hardware used to be grade 8, class 10.9 or higher if metric
- 3.) Loctite to be used in appropriate areas

- 4.) Anti-seize to be used in appropriate areas
- 5.) High strength materials used where necessary

Safe to Operate (9%):

- 1.) Failure prone DeLorean components will be replaced with stronger counterparts
- 2.) Overall vehicle weight increase to be <200lbs.
- 3.) All hardware used to be grade 8, class 10.9 or higher if metric
- 4.) All wires insulated to avoid possible grounding/shorting

Easy to Inspect (9%):

- 1.) Accessibility of components to allow visual inspection
- 2.) Torque wrench access for crucial hardware
- 3.) Torque putty included for stripping high torque bolts

Affordable (9%):

- 1.) Cost will not exceed \$1500 for custom parts and hardware

Aesthetically Pleasing (8%):

- 1.) Visible components will fit the DeLorean's stainless steel motif
- 2.) Wires to be encased in wire loom

ENGINEERING CHARACTERISTICS

Eleven engineering characteristics were determined to help meet the customer requirements. These are shown below in Table 3.

Table 5 – Engineering Characteristics

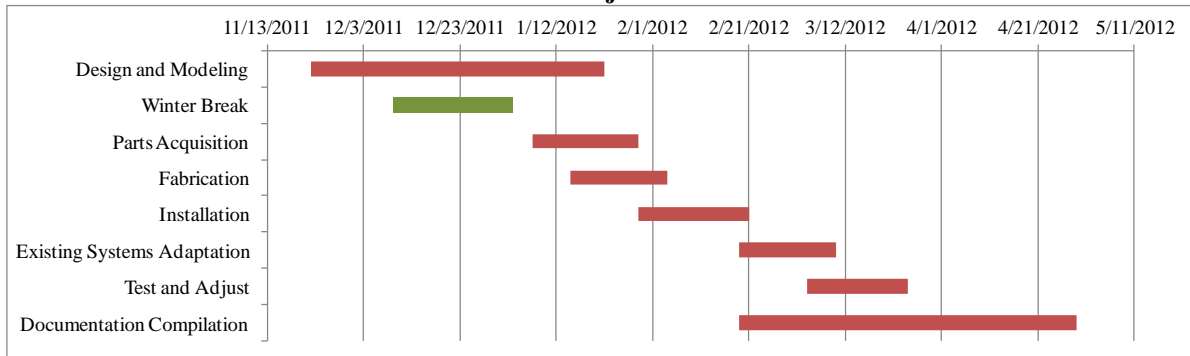
Engineering Characteristics	
Engineering Characteristic	Rel. Importance
Tolerance Requirements	21.83%
Component Weight	14.65%
Bolted Connections	11.08%
Installation Manual	10.64%
Material	10.16%
Reduced number of components	6.50%
No specialty Tools	6.45%
Manufacturability	6.12%
Part Commonality	5.22%
Color	4.49%
Component Size	2.86%

Tight manufacturing tolerances are crucial to ensuring that customer requirements are met. Both this and low component weights keep the customer safer during installation and operation, and ease the installation process. Bolted connections are desirable over welded or other joined connections as they do not require special skill to facilitate. A thorough installation manual will ensure safe installation at all times by avoiding any procedure uncertainties. The material, number and size of components, manufacturability, and community of tools and parts help to keep cost down and reduce the need for specialty skills. Finally, the color and finish of parts affect the customer's perception of kit aesthetics. A full quality function diagram is located in Appendix B.

SCHEDULE AND BUDGET

The project schedule began on November 23, 2011 with the proof of design meeting. The schedule included 27 weeks with the project completed by May 27, 2012. The project was broken down into different phases. These phases are: design, part acquisition, part fabrication, installation, existing system adaptation, test and adjust, and documentation compilation. Each phase is crucial to the overall success of the project. A condensed schedule is shown below in Table 4.

Table 6 – Project Timeline



It is believed that the design portion of the project maintained the proposed schedule where the fabrication did fall behind in the month of April. This was due to an inaccurate time table of deliverables provided by the original drive train component manufacturer. Despite this delay, the time was recovered and the project was completed on time. The full project schedule can be found in Appendix C.

The cost of this project was estimated at \$6,500.00. The majority of the expense is in the acquisition of a replacement engine. Following this is the cost of the parts involved in power transfer as several of these components will need to be custom fabricated. At completion, the proposed budget was under around \$600.00. The majority of costs were accurate; however there were several unforeseen costs. Most of these involved the cost of machining different parts or the cost of materials. A simplified budget plan is shown below in Table 5.

Table 7 – Project Budget

Budget		
System	Estimated Cost	Actual Cost
Engine	\$3,195	\$2,900
Power Transfer	\$1,155	\$1,015
Transmission	\$1,150	\$1,500
Air Conditioning	\$300	\$100
Electrical	\$50	\$130
Vacuum	\$25	\$30
Literature	\$120	\$140
Miscellaneous	\$500	\$1,320
Total	\$6,495	\$7,135

The full budget can be found in Appendix D.

Despite the project going over budget, there were several opportunities to recover costs. The original DeLorean engine and transmission were sold for \$3,000. The original stainless exhaust system was sold for \$1,000. A total of \$4,000 was recovered. Taking this into consideration, the project as a whole only cost \$3,135, significantly less than anticipated.

TESTING AND ANALYSIS

Following completion of the project, the prototype vehicle has been driven regularly without incident. In order to prove the power increase, it was necessary to put the car onto a dynamometer and take readings on horsepower and torque. These results were then compared to the original 99.7hp/92ftlbs from the car's stock engine.

The results of the test are shown here:



Figure 26 – Dynamometer Final Test Results

According to the post-install test results, the car produces 349hp and 343ftlbs of torque. These results indicated that the goal of replacing the original engine with one that creates greater than 300hp was indeed met.

CONCLUSION:

As the testing proves, this kit exceeds the expectations of performance requirements. Producing greater than 300hp is a feature many DeLorean owners desire. With this kit, 300hp is now possible. In addition, all accessory systems still function properly and the install is very aesthetically pleasing.

Though some of the primary requirements for this kit are safety and ease of installation, it should be noted that an individual without prior automobile knowledge should not attempt the installation of this kit. For a person with a prior knowledge of automobile maintenance, this kit should be rather straight forward. Though the work involved in replacing an engine is extensive, it is not impossible. For individuals without any knowledge of automobile repair or restoration, it is recommended that this kit be installed with the aid of someone more familiar with the subject.

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2. Stage II Engine Upgrade. *DeLorean.Com*. [Online] DeLorean Motor Company. [Cited: September 26, 2011.] <http://delorean.com/landing-performanceparts.asp>.
3. PRV Engine. *Wikipedia.org*. [Online] [Cited: September 26, 2011.] http://en.wikipedia.org/wiki/PRV_engine.
4. High Performance Cams. *DMCCAL.com*. [Online] DeLorean Motor Company California. [Cited: September 26, 2011.] http://www.dmccal.com/102707hp_high_performance_cams.html.
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6. **Mott, Robert L.** Applied Strength of Materials. [book auth.] Robert L Mott. *Applied Strength of Materials*. Englewood Cliffs, NJ : Prentice Hall, 1990.
7. **Conlon, Patrick.** *DeLorean Owner*. September 24, 2011.
8. **Koncelik, Ken.** *Multiple DeLorean Owner*. September 24, 2011.

APPENDIX A – MARKET RESEARCH

Interview with customer, Sept. 24, 2011
 Patrick Conlon, DeLorean Owner, Mackinaw City, MI, 49701.
 1981 Black Interior Manual Transmission DeLorean.
 Disappointed with the stock engine output.
 Does not want to spend money on original DeLorean engines.
 Would like the ability to put a different engine in the car.
 Must mate with the stock transmission
 Wants to have at least 250hp on a dynamometer.
 Wants a kit with brackets, adapters, and instructions to for engine replacement.
 Has considered the upgraded camshafts but does not think they're cost effective.
 Does not want a significant weight increase.
 Wants all additional engine mounts to be bolt on, not weld on
 Will not modify frame
 Will not modify body

Interview with customer, Sept. 24, 2011
 Ken Koncelik, DeLorean Owner, 10330 Chester Road, Cincinnati, OH 45215
 Owns four DeLoreans, has owned over 15 DeLoreans in the past. .
 Has a large stockpile of DeLorean parts from salvaged cars and would like to build an all custom DeLorean
 Does not want to use the original DeLorean motor.
 Wants a 250-300hp engine that can mate to the existing manual transmission.
 Willing to modify the drive train but not the body.
 New engine has to mate with existing HVAC and cooling system.
 Would be willing to weld additional mounts on the frame.
 Motor must be naturally aspirated.



http://en.wikipedia.org/wiki/DeLorean_V6_engine
 9/26/11 Stock
 DeLorean V6 Engine -.
 wikipedia.com

Rear mounted, liquid cooled - Light Alloy V6, 2.85 Liter - Dual overhead camshaft - Bosch C.I.S. mechanical fuel injection - Cylinder Bore 91mm - Stroke 73mm - Displacement 2849 cc - Power Rating 130 SAE NET HP @5,500 RPM - Maximum Torque 208 Nm @ 2,750 RPM - Compression Ratio 8:8:1

- Stock DeLorean Engine
- Reliable once restored
- Lightweight
- Low Compression
- Underpowered
- Drive train losses result in only 95-105hp at the wheels.
- Few upgrade options available
- 0-60 in 9 seconds

<div data-bbox="365 199 803 283" data-label="Text"> <p>http://delorean.com/landing-performanceparts.asp 9/26/11 DeLorean Stage II Engine. DeLorean.com</p> </div> <div data-bbox="267 304 649 640" data-label="Image"> </div> <p>The most popular performance upgrade for DeLorean Cars. Get a new, zero-mile, factory engine with performance camshafts, ported and polished heads, Stainless Steel headers, catalytic converters, and muffler exhaust system.</p> <p>Final crankshaft output - 170hp</p> <p>Price: \$7,200</p>	<ul style="list-style-type: none"> -Very costly for an increase of 40hp -Car must be driven, towed, or shipped to Humble, Texas for installation -Illogical to replace an original engine with a second original engine. -Does not require an engine as a core -Price includes professional installation -Engine Warranty
<div data-bbox="365 976 803 1060" data-label="Text"> <p>http://www.delorean.com/store/p-10337-stage-i-exhaust-upgrade.aspx 9/26/11 DeLorean Stage I Exhaust Upgrade. DeLorean.com</p> </div> <div data-bbox="243 1081 649 1386" data-label="Image"> </div> <p>Includes complete stainless steel headers, catalytic converters, muffler and tips, K&N air filter, cold air intake, Bosch ignition coil, oxygen sensor.</p> <p>Horsepower increase: 15-20hp.</p> <p>Price: \$2,035</p>	<ul style="list-style-type: none"> -Exhaust tone is much more appealing -Dynamometer tests before and after installation have shown increases of 10hp -Not a cost effective performance enhancement -Headers block access to crucial components such as the starter -Higher exhaust air flow

<div data-bbox="341 210 803 325" data-label="Text"> <p>http://www.dmccal.com/102707hp_high_performance_cams.html 9/26/2011 High Performance Cams. DMCCAL.com</p> </div> <div data-bbox="243 357 641 462" data-label="Image"> </div> <p data-bbox="235 535 828 619">Pair of high performance racing cams which are street legal, pass smog and gives 62 more horsepower to your DeLorean.</p> <p data-bbox="235 651 365 682">Price: \$800</p>	<ul style="list-style-type: none"> -Most cost effective upgrade available -Very Labor intensive; engine must be removed or engine heads must be removed -Requires full rebuild of both engine heads during installation -Good for an owner that can perform their own engine work -High labor costs to have installed by a vehicle maintenance facility.
<div data-bbox="284 714 747 808" data-label="Text"> <p>http://www.delorean.co.uk/delorean_performance.html 9/26/11 DeLorean Twin Turbo Engine. Delorean.co.uk</p> </div> <div data-bbox="235 829 706 1239" data-label="Image"> </div> <p data-bbox="235 1249 828 1522">Combining original parts from DeLorean and Renault engines, as well as brand new, modified and custom parts, this scratch-built solution has been designed to safely and reliably replace your original engine, giving your car the performance it always deserved. This engine is unique and should not be confused with upgraded standard engines offered by other DeLorean specialists. The difference in performance speaks for itself.</p> <p data-bbox="235 1543 828 1701">* plus exchange of old engine OR components required from it, purchased separately. ** allowing for a drive train loss of 45hp, a stock 130hp engine provides 85hp at the rear wheels. 250hp gives 215hp at the rear wheels</p> <p data-bbox="235 1732 487 1764">\$10,900 +Core Engine</p>	<ul style="list-style-type: none"> -Highest performance upgrade available -Very expensive \$11,000 + Shipping -Must be ordered and shipped from the UK -Original engine must be shipped back to UK to avoid Core Fees. -215hp at the wheels -Requires an engine as a core -Does not include installation -Uses all original DeLorean mounts -Mates directly to DeLorean transmission

APPENDIX B – CUSTOMER SURVEY & QFD

HIGH PERFORMANCE DELOREAN ENGINE KIT

CUSTOMER SURVEY

The following survey consists of a list of features to be included in the design of this kit as well as questions regarding customer willingness to modify their existing vehicle. Completing the survey will help us to prioritize design efforts for the indicated features, as well as determine whether or not permanent vehicle modifications are acceptable.

Features - Results shown in parenthesis

Please indicate the importance of each listed feature of the engine installation kit.

Please circle the appropriate answer. 1 = low importance 5 = high importance

							RESULTS
Ease of Installation	1 (0)	2 (0)	3 (1)	4 (6)	5 (11)	N/A (0)	(4.6)
Ease of Inspection	1 (0)	2 (0)	3 (11)	4 (6)	5 (1)	N/A (0)	(3.4)
Installation Safety	1 (0)	2 (0)	3 (3)	4 (12)	5 (3)	N/A (0)	(4.0)
Operational Safety	1 (0)	2 (0)	3 (6)	4 (11)	5 (1)	N/A (0)	(3.7)
Reliability/Durability	1 (0)	2 (0)	3 (2)	4 (14)	5 (2)	N/A (0)	(4.0)
Documentation Quality	1 (0)	2 (0)	3 (9)	4 (8)	5 (1)	N/A (0)	(3.5)
Low Cost	1 (0)	2 (0)	3 (11)	4 (5)	5 (2)	N/A (0)	(3.5)
Aesthetics	1 (0)	2 (3)	3 (10)	4 (3)	5 (2)	N/A (0)	(3.2)
Minimal Vehicle Modifications	1 (0)	2 (0)	3 (3)	4 (7)	5 (8)	N/A (0)	(4.3)
Compatibility with Existing Systems	1 (0)	2 (0)	3 (6)	4 (7)	5 (5)	N/A (0)	(3.9)

Vehicle Modifications – Results shown in parenthesis

Please indicate your willingness to modify the following areas via each indicated method as part of the installation process.

Please circle the appropriate answer. 1 = very UNwilling 5 = very willing

FRAME						RESULTS	
Cutting	1 (5)	2 (6)	3 (5)	4 (2)	5 (0)	N/A (0)	(2.2)
Welding	1 (2)	2 (3)	3 (6)	4 (7)	5 (0)	N/A (0)	(3.0)
Drilling	1 (0)	2 (1)	3 (3)	4 (6)	5 (8)	N/A (0)	(4.2)
Grinding	1 (5)	2 (5)	3 (6)	4 (3)	5 (0)	N/A (0)	(2.4)
BODY (Fiberglass)							
Cutting	1 (11)	2 (6)	3 (1)	4 (0)	5 (0)	N/A (0)	(1.4)
Drilling	1 (4)	2 (3)	3 (5)	4 (4)	5 (2)	N/A (0)	(2.8)
Grinding	1 (13)	2 (3)	3 (2)	4 (0)	5 (0)	N/A (0)	(1.4)

For the indicated kit, how much would you be willing to spend? Please circle:

AVERAGE

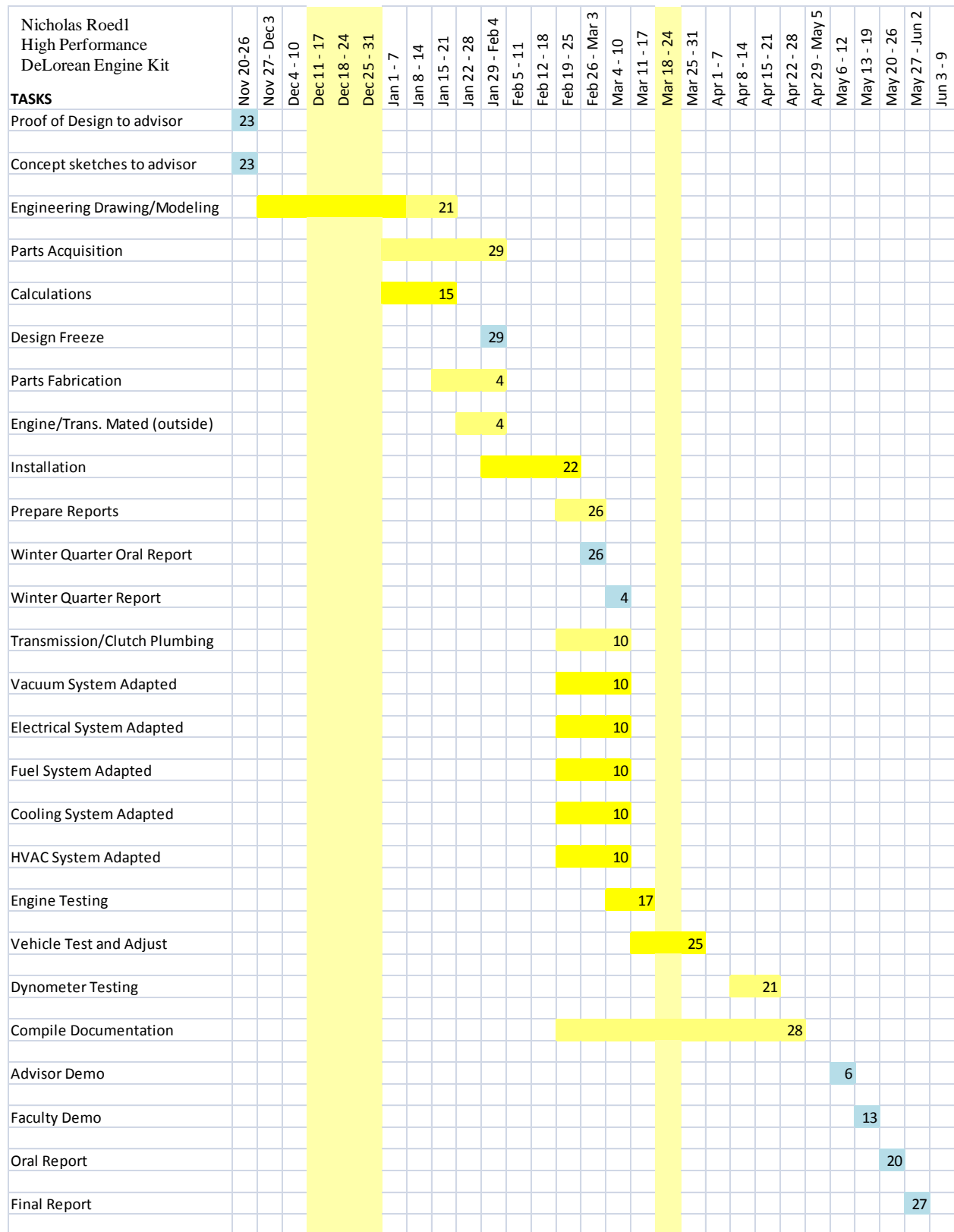
\$250-\$750 (5) **\$750-\$1500 (11)** \$1501-\$2500 (2) \$2501-\$4000 (0)

Thank you for your time. Your feedback is greatly appreciated.

Quality Function Diagram (QFD)

Nicholas Roedl High Performance DeLorean Engine Kit 9 = Strong 3 = Moderate 1 = Weak	Component Size	Reduced number of components	Component Weight	Material	Color	Manufacturability	Tolerance Requirements	Bolted Connections	Part Commonality	No specialty Tools	Installation Manual	Customer importance	Designer's Multiplier	Planned Satisfaction	Modified Importance	Relative weight	Relative weight %
Ease of Installation	3	3	9				9	9	3	9	9	4.6	1	4.5	4.6	0.12	12%
Ease of Inspection	1	9			3					3		3.4	1	3	3.4	0.09	9%
Installation Safety	1		9				3			1	3	4	1.1	4.5	4.4	0.11	11%
Operational Safety			9	3			3					3.7	1	4	3.7	0.09	9%
Reliability/Durability		3		9		3	9					4	1	4	4.0	0.10	10%
Documentation											9	3.5	1.2	4.5	4.2	0.11	11%
Affordability				9		9	3		9			3.5	1	3	3.5	0.09	9%
Aesthetics	1			3	9	3		1				3.2	1	3.5	3.2	0.08	8%
Minimal Vehicle Modifications			3				9	9				4.3	1	4	4.3	0.11	11%
Compatibility with Existing Systems							9	3				3.9	1.1	4.5	4.3	0.11	11%
Abs. importance	0.63	1.42	3.21	2.23	0.99	1.34	4.79	2.43	1.14	1.41	2.33	21.9			39.6	1.0	
Rel. importance	0.03	0.06	0.15	0.10	0.04	0.06	0.22	0.11	0.05	0.06	0.11						

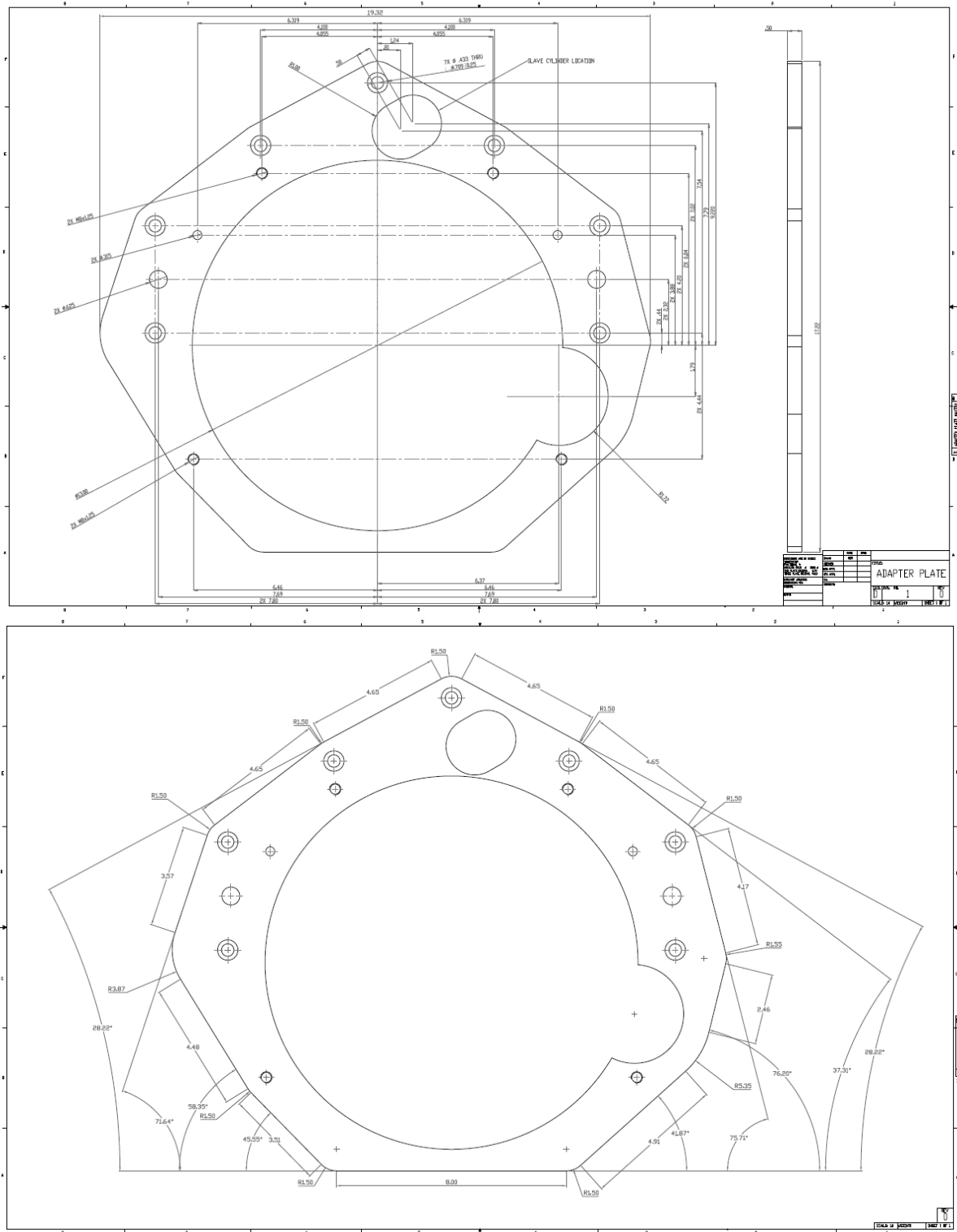
APPENDIX C - SCHEDULE



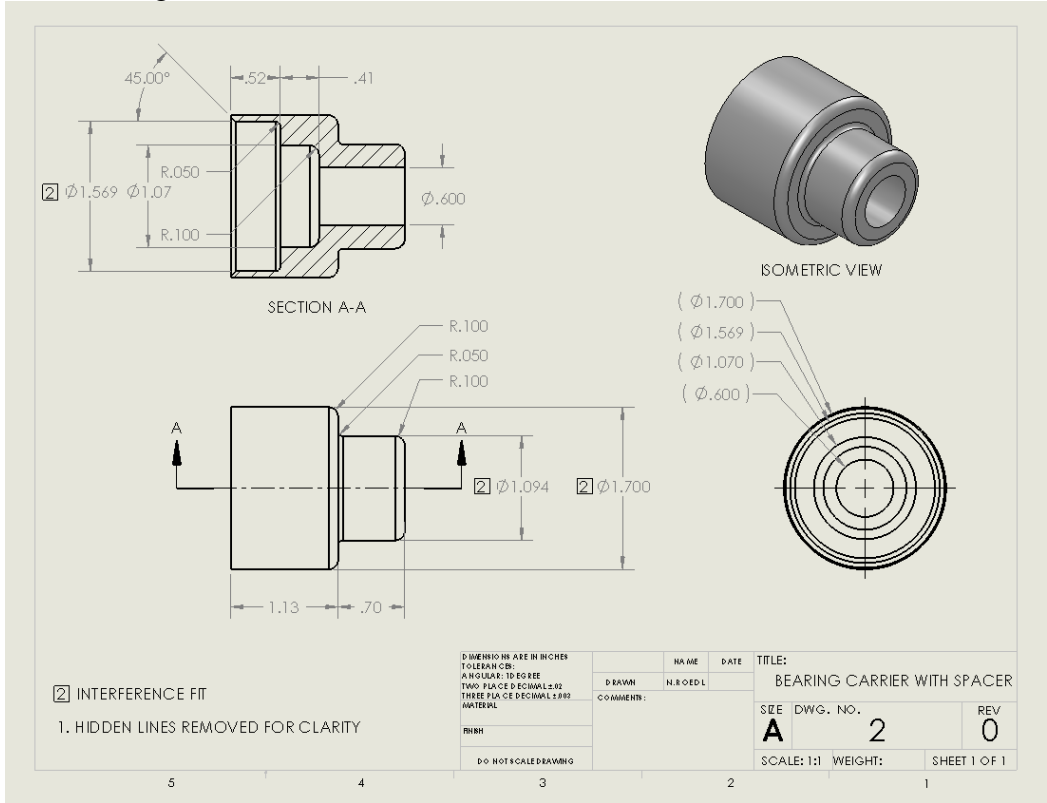
APPENDIX D - BUDGET

Category	Component	Cost	
		Forecasted	Actual
Engine			
	LS1 Engine	\$2,500	\$2,500
	Mounting Brackets	\$200	\$100
	Serpentine Belt	\$20	\$20
	Pilot Bearing	\$10	\$10
	Oil Pan	\$200	\$110
	Coolant Hoses	\$35	\$20
	Hardware	\$30	\$30
	Gaskets	\$200	\$110
		\$3,195	\$2,900
Power Transfer			
	Bell housing	\$180	\$0
	Flywheel	\$90	\$110
	Clutch	\$200	\$400
	Pressure Plate	\$200	\$210
	Hydraulic Clutch Cylinder	\$160	\$150
	Hardware	\$25	\$25
	Bell housing Adapter	\$300	\$120
		\$1,155	\$1,015
Transmission			
	Miscellaneous	\$500	\$300
	Input Shaft Coupler	\$200	\$250
	Mounting Brackets	\$200	\$100
	Linkages	\$150	\$350
	Plumbing	\$100	\$500
		\$1,150	\$1,500
Air Conditioning			
	A/C Lines	\$300	\$100
		\$300	\$100
Electrical			
	Wiring	\$30	\$70
	Miscellaneous	\$20	\$60
		\$50	\$130
Vacuum			
	Hose	\$25	\$30
		\$25	\$30
Literature			
	LSx Engine Rebuild Book	\$20	\$20
	Additional Manuals	\$100	\$120
		\$120	\$140
Miscellaneous			
	Miscellaneous	\$500	\$1,320
		\$500	\$1,320
TOTAL		\$6,495	\$7,135

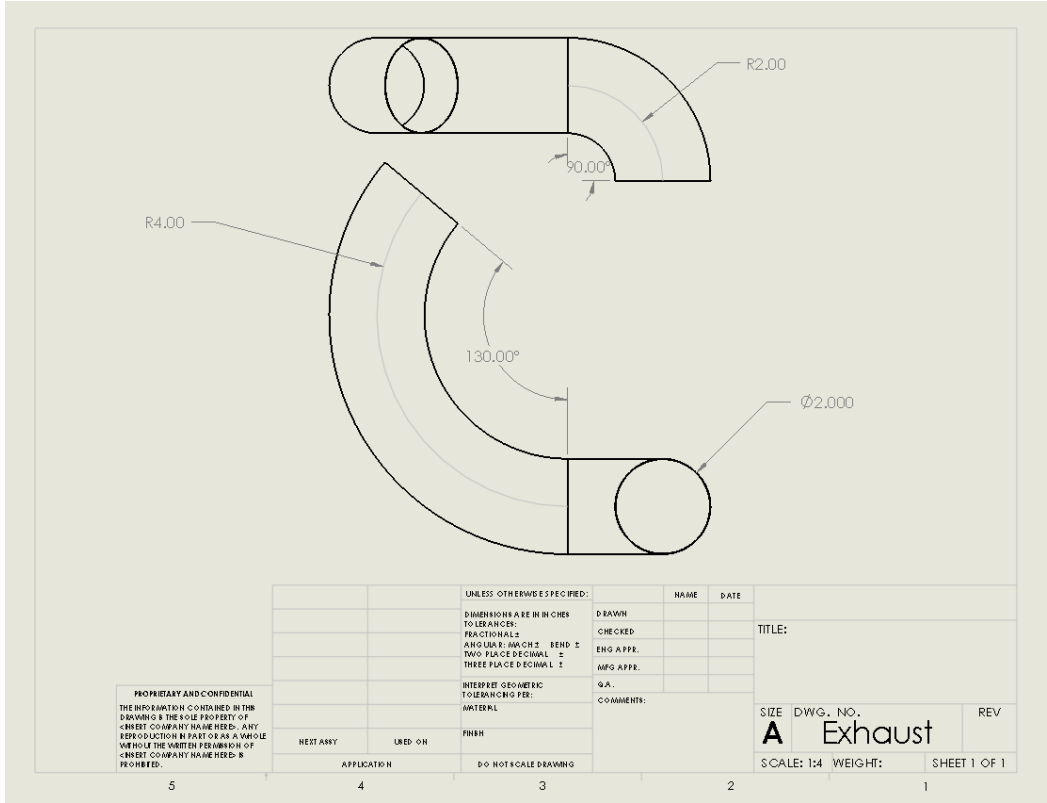
Adapter Plate:



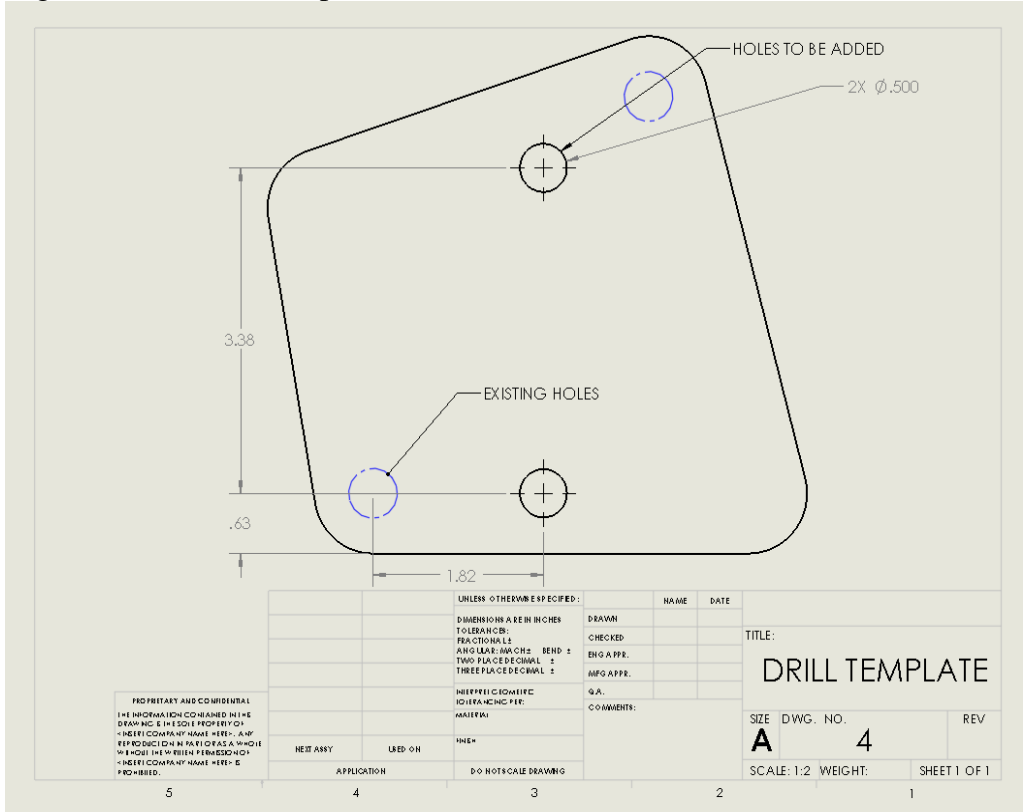
Pilot Bearing Carrier:



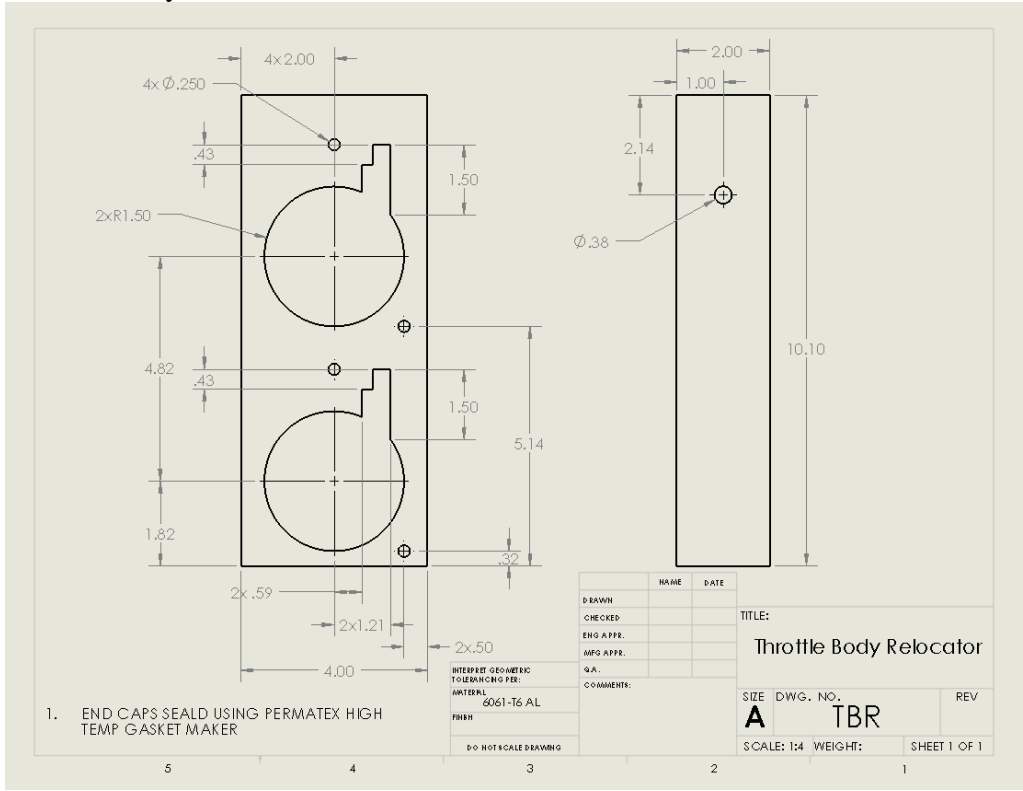
Exhaust Tube:



Engine Mount Drill Template:



Throttle Body Relocation Box:



Flywheel:

