Mando Ramos

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Senior Project

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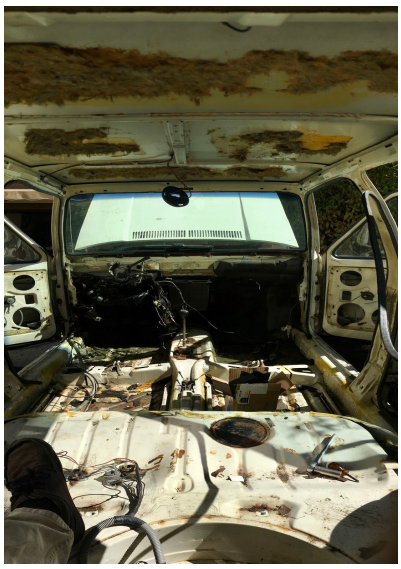
A New Heart in an Old Rabbit

About 16 years ago, my family was living in Puerto Rico and my father was in a period of his life when he was a weekend race car driver. He competed in local races with other locals who quickly became his close friends. This culture that developed around the love for motoring was a very important part of his life. His favorite cars to race were old VW Golfs (the newer Rabbit model). Consequently, my brothers and I were frequently around his project cars and the environment that inevitably followed. As I grew to an age where I was starting to recognize the world in a conscious way, my father started to separate himself from racing and since then he hasn't been back on a track. Although I didn't experience racing in the same way my brothers did, I still feel my roots as a gearhead. When I was thinking about ideas for my senior project, I knew I wanted to build something with an engine but I wasn't quite sure what. So to search for answers I scoured Craigslist.

For my 17th birthday, I bought myself a 1983 VW Rabbit for $200. It had no engine, no transmission and no paperwork. My first order of business was to contact the two previous owners and have them fill out a few papers to release the title so that I could have another one made. However the envelopes were sent back to me blank so the process only got longer until I was finally able to produce enough proof to get a title.



(Disassembling the interior)

I began by tearing out all of the interior components including carpet, seats, door panels, ceiling dashboard along with all the wiring that was attached. I wanted to have a clean platform for me to either paint or leave barren. I then decided to prep and paint the floor yellow to give the car a unique and vibrant quality.

(Interior flooring painted yellow)

It became time to start looking for a donor car so I turned to Craigslist again for a car that would provide me with an engine to put into my Rabbit. I finally found a 1997 Vw Golf GTI and didn't hesitate to start tearing it apart. In preparation for the new engine, I cleaned and then painted the engine bay of the Rabbit with another bright color. Then mounted the engine conversion kit which consisted of engine mounts and extra structural support that enabled the donor engine to be mounted into the old Rabbit body. One of the main reasons I chose this engine swap was because of the aftermarket support. This way I wouldn't have to fabricate custom motor mounts or have axles specially ordered. The donor engine was a 2.8 liter six cylinder naturally aspirated engine that from the factory made 173 horsepower and 172 lb ft of torque. Comparing that to the standard 1.6 liter 4 cylinder diesel engine that originally came in the Rabbit and produced 52 horsepower and around 55 lb ft of torque (Jerew, Benjamin). Since the design of the Rabbit was only intended to have 52 horsepower under the hood, I added some extra steel braces that added much needed structural support. In addition, I removed the power steering pump and air conditioning compressor from the donor engine which probably added about 10 horsepower. Since VW uses a serpentine belt which is a single belt that loops around all the necessary pulleys including the A/C and power steering pumps, I had to measure the new running length bypassing the deleted pulleys so that I could order a special belt that would fit.

The process of putting the engine in took a very long time simply because that engine wasn't meant for that car so everything was very tight and I definitely chipped some of my fresh red paint in the process. But after it was in I started to strip the engine wiring harness from the

donor car to get rid of unnecessary things such as airbag sensors, air conditioning, power steering, horn headlights along with many other unnecessary things.

(sorting out engine wiring harness)

This process took a lot of time and patience and was a big learning curve for me. There were days when I didn't know if I had made any progress so I became quite unmotivated around this stage in the project. I spent many hours on the internet looking for wiring schematics. I also went to the local VW shop and borrowed the owner's hardcopy Bentley manual (Robert, Bentley) which provided me with some of the needed diagrams. I used the engine wiring harness with the attached fusebox from the donor car to control and regulate the engine. Separate from that, I used the accessory harness (headlight, turn signals wiper, etc.) from the old Rabbit to power all my accessories from the stock fusebox. After many months of sometimes not working on it for weeks out of frustration, I finally was able to turn the ignition and hear the engine run. The feeling that I experienced when I finally heard the engine running in my Rabbit was unlike anything else I have ever experienced. It was an intense mixture of excitement, relief and pure joy. There are a handful of things in this world that give me unmeasurable levels of joy and satisfaction and

among them is the sound of project firing up. If that had been the end of my project, I would've been content with the amount I was able to complete however, that event only gave me more motivation and energy to materialise the rest of my dreams that I had for the car.

Although my senior project was making progress, that didn't erase that fact that I still had the donor car sitting stagnant in the driveway. Alongside my Rabbit project I started the process of parting out the donor car. This car came with some quality aftermarket parts some of which I bolted onto my Rabbit but for the majority of them, I sold separately. I was able to sell the front seats, wheels and tires, and bumpers. When the donor was not much more than a shell of a car, I went out on a whim and posted it to see if anyone would take it off my hands. Just about when I was ready to put it up for free, a guy from Gilroy said he would take it for $200, the same amount I bought my Rabbit for. Getting rid of the donor was an accomplishment for me because not only was I able to take what I needed from it and sell what I didn't, it has a new life driving the streets again and didn't have to be crushed, melted and made into a refrigerator.

To make sure my engine didn't overheat, I installed a radiator from an early model Rabbit pickup. This was the only radiator that would fit in the very small section just behind the grill and I still had to flip it upside down so that the inlet and outlet coolant lines were on the correct side. Usually a radiator in a car has plenty of room around it for you to easily access other parts and such. Since my new engine was much larger than the original, I had just enough room to fit two auxiliary fans. When doing an engine swap, one must not only focus on the part they are installing at the moment, but also how it fits into the puzzle to function efficiently. The radiator offered me a chance to test my spatial awareness. I had to mount it close enough to the front of the car so that I had enough room between it and the engine in case of aggressive engine

torque, but far enough back so that I could fit cooling fans in front of it. I chose to instal a thermo switch inside the inlet coolant line so that when the coolant reached a certain temperature, one of the fans got a signal to turn on therefore cooling the engine. I could have accomplished this by just having a simple switch inside the car for me to turn on and off the fan but I decided to design the automated version to eliminate human error.

Although the engine was running, it only had about six inches of exhaust piping. This made it very loud and inefficient. Instead of buying a prefabricated downpipe off the internet, I decided to make my own. I cut up the stock downpipe from the donor car into many pieces so that I could then use them to fabricate an exhaust that snaked around the steering rack and straight along the bottom of the car.

(modified exhaust downpipe)

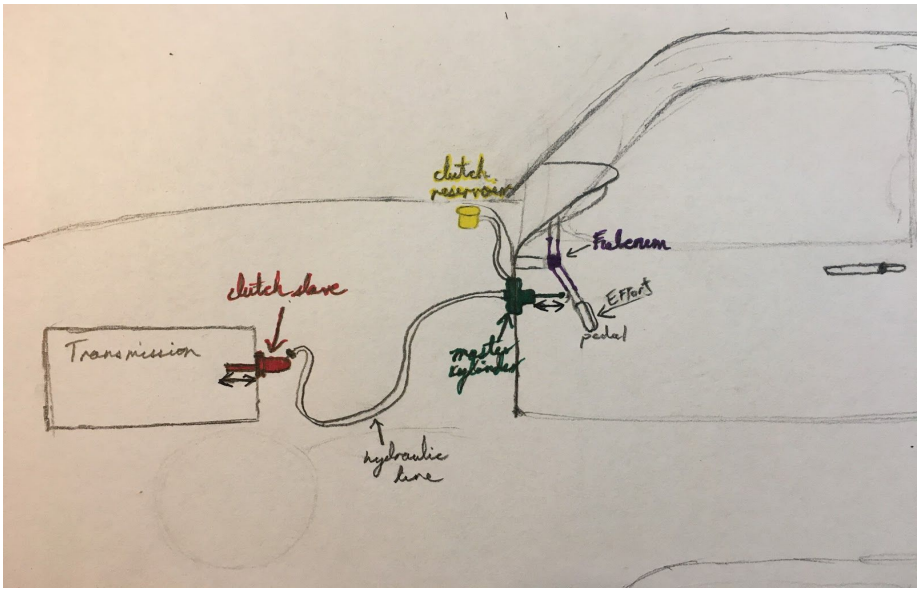
I also had to make sure I left enough room above for oxygen sensors as well as the shifting mechanism. The shift cables ran from the shifter inside the car to the transmission by going underneath the body of the car. I got a lot of practice sharpening my welding skills and by the end of the afternoon I had fabricated an entire exhaust system complete with two oxygen sensors, catalytic converter (Woodford, Chris), resonator and muffler.

This significantly reduced the sound of my engine and also produced a low and throaty sound which was just the sound I was hoping for.

At this point you might be wondering how is this car going to be street legal with most of its stock components missing? One of the main concerns with engine swaps is the smog inspection. There are many specific laws such as you can't swap a truck motor into a car and vice versa. You also can't swap a motor from an older model car into a newer model due to the smog requirements. The main worry for engine swappers is the DMV inspection. Fortunately I found a loophole. It is the law that no diesel vehicle needs to be smogged or inspected if it was made in the years 1997 or older. Since my 1983 Rabbit was originally a diesel and the title shows the same, I had the ability to put any engine I wanted into it and still qualify for registration because no one was going to check. Turned out that from the research I did, the gasoline motor I swapped in polluted significantly less than the stock 1.6l diesel engine.

One of the most important steps in my project was designing the clutch system. The system was composed of both the clutch slave master cylinder from the donor car, a 52 inch steel braided hydraulic line, a fluid reservoir and the pedal assembly from the Rabbit.

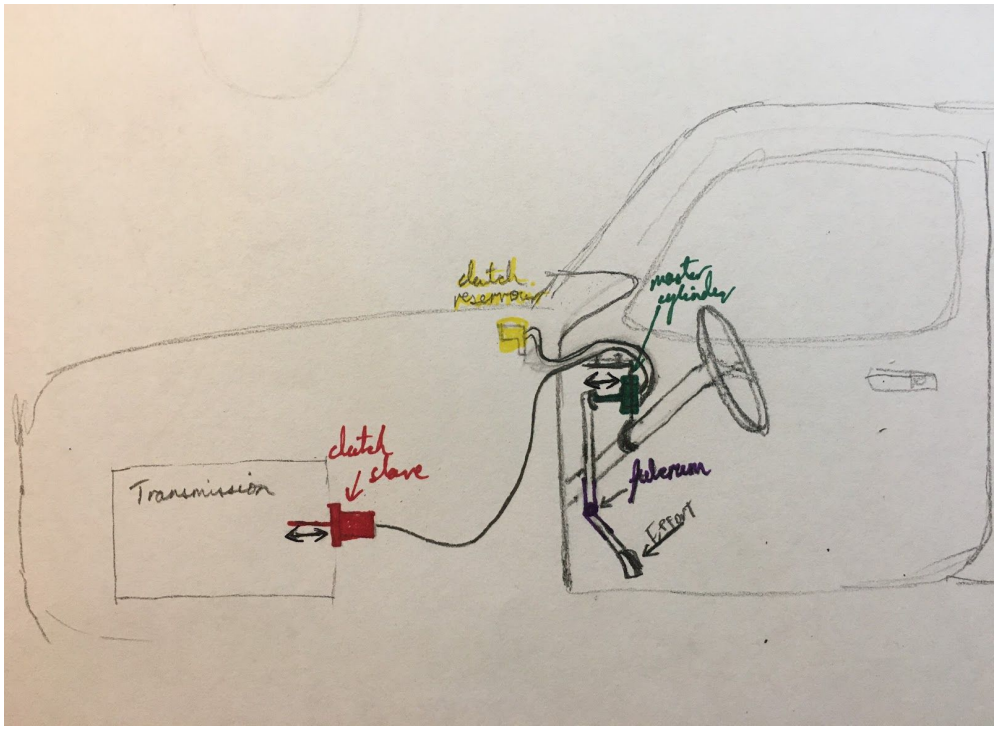
The above diagram illustrates the clutch system that was in the donor car. I had to modify it to fit into my Rabbit because the pedal configuration in relation to the fulcrum of the clutch pedal was different than that of the Rabbit's. In order for me to use the stock Rabbit pedals, I had to fabricate a mount (shown below) for the clutch master cylinder so that it could be positioned to



(simple diagram of donor car clutch system)

work with the pedal. The top of the homemade mount bolted to part of the firewall and the bottom rested on the steering column for extra rigidity. In the next diagram you can see that the plunger of the master cylinder (green) is pointing forwards compared to how it used to point backwards in the donor car. I then connected a feed line from the clutch reservoir to the master cylinder and then a steel braided line from the master cylinder to the clutch slave. This was a very unique design but it turned out to work well and perform flawlessly.

(custom clutch master cylinder bracket)



(simple diagram of modified clutch system in Rabbit)

At this point my project was able to start with the turn of a key, cool itself with a cooling system complete with radiator and fans, and pump gas from the tank into the engine all without the need of my assistance in any way. I started to then install the dashboard and seats. I found black leather seats out of a newer Vw Jetta and modified the mounts so that they were able to slide back and forth in the stock Rabbit seat rails. This was done by cutting the legs and then re-welding them to satisfy the width of the rails in the Rabbit.

(modified Jetta seat legs to fit Rabbit)

In preparation for the dashboard to be reinstalled, I replaced the heater core. This is a kind of radiator that sits underneath the dashboard and is inline with the coolant system. As the engine warms up, coolant will circulate through the system and as it passes through the heater core, an interior fan blows air through it and directs it through air vents on the dashboard resulting in heated air for the driver and passengers to enjoy. One of the most challenging parts of the installation of the dashboard was fitting the gauge cluster. I chose to use the gauge cluster from the donor car because it was much more modern looking and complimented the old interior. However, after many hours of troubleshooting the wiring, I was unable to properly wire the gauge cluster to have a functioning tachometer and speedometer. This meant I had to use a phone to calculate my speed while driving.

After completing the final steps before my first drive, such as steering wheel, brake check and wheel and tire check, I was ready to take it around the neighborhood. It was an incredible experience to finally be able to drive the car I had been working on for a full year. The feeling is difficult to explain to someone who has never built something from the ground up. It was a feeling of knowing every part of the car and knowing how it all works. It was a feeling of knowing that there was no other car quite like mine. I knew so much about the car that during the first drive around the block, I was able to feel and recognize certain sounds and vibrations that shouldn't have been there. The first drive gave me the opportunity to feel the parts of the car that needed more attention. Once I had ironed out all those kinks and quirks, I was able to enjoy a drive in my project without the worry of parts falling off. After a few drives I was able to calculate my mpg (miles per gallon) and discovered that it was getting a surprising 26 mpg.

Taking my Rabbit out on a drive has been one of the most satisfying things I have ever done. I felt pride for creating such a unique car and I felt love for knowing every part of it.

Several days passed and I was beginning to feel confident in my project. It had completed multiple drives around town with no issues but none exceeded more than 20 minutes in length. I felt it was time to take it for a longer drive out to the town of Sebastopol. The 50 minute drive there was no problem. The car was running great and I was cruising alongside cars at 65 mph on the freeway. When I decided to return home, my Rabbit had different plans. It developed a loud knocking noise from the bottom end of the engine. I knew the sound meant bad news for my engine so I decided to spend the night in Sebastopol. In the morning I towed my Rabbit on a trailer back home where I could assess the damage. After draining the oil and removing the oil pan, there was a sparkly layer of metal shavings that coated the bottom of the pan. After studying the damage in the engine I concluded that my engine was being starved of oil. This was a result from the bearings wearing down and littering the engine with metal shards. As these metal shards circulated through the engine, they blocked up some of the oil port holes in the crankshaft. These holes supply the bearings with circulating oil lubrication so when they started to clog, the bearings started to heat up and deteriorate more and more which only created more blockage in the engine's oil circulation. In the picture below, the bearing on the right was the old one and the other on the left was the replacement. It is clear to see that the old bearing was flattened like a pancake due to extreme heat and lack of oil. This made it significantly thinner than the original thickness which gave the connecting rod room to move. This was the reason for the knocking noise I heard.

(left: old destroyed bearing, right: new bearing)

As a result of this, the crankshaft journals (cavities where the bearings sit) were severely scarred from the friction. During this time I was contemplating replacing the engine because the cost of fixing it would be about the same as a new crankshaft. I decided to go the cheap route (considering it was a week or two from the scheduled presentations) and took some strippes of sand paper and started to pollish up the barely salvageable journals. I then went through the process of cleaning the engine of all the metal shards. I first put the oil pan back on and replaced the oil filter. I then filled the engine with diesel fuel inplace of oil and disconnected the fuel filter so that the car wouldn't start. I then turned the key and cranked the engine for short bursts of a few seconds. I then drained the oil filter of all the metal shards that were collected and repeated

the process. Diesel fuel is a natural residual product of gasoline production. It is a great cleaning agent because it has some corrosive strength but isn't too light to be extremely flammable. For this reason, it worked perfectly for cleaning the inside of my engine because it was able to get into places easier than heavier oil and was able to break down the residual oil to collect all the shards of metal. I repeated the process until the oil filter didn't have any more shards of metal in it. I then replaced all the connecting rod bearings, topped it off with real engine oil and started it up. It ran smoother than it ever had and continued to do so for a long time after. Although this was a technique you would never find in a repair manual, it solved my problems and didn't cost nearly as much as it could have.

At this point in my senior project, I had a fully functioning car that I took on grocery runs and leisure sunday drives, but I wasn't satisfied with the exterior condition. The paint was old and peeling, there were rust spots and dents that needed to be fixed. This next step of my project could be considered a separate project in itself due to the lengthy process. I began by filling in the indentation that went the length of the car on both sides. It was about an inch wide and half an inch deep and was used for a strip of body trim. However I didn't want the trim so I blindly started my first auto-body project. I had to work quickly so that the body filler didn't dry before I could apply it. Once a section was dry, I would sand and sand and sand. In the photo below you can see the body filler (discolored strip along the side of the car). I spent many days in the sun and rain sanding the body so that there would be no detectable transition between the metal and filler.

After completing this on both sides, I then began sanding the entire car first with dry sandpaper and then with wet. The grit range started at 200 and ended at 1200 in incremental

steps. In places where there were still pin holes (places where the body filler couldn't fill) I sprayed with primer and then sanded again.

(body filler primed and sanded)

The final step was to then mix paint and spray it on. I used a single stage Ermine white paint which had the clear coat combined which made the process much easier and faster. I used a spray gun attached to an air compressor set to 40 psi and completed two coats on the entire car over the course of two days.

(car back together with a new paint)

The paint job turned out pretty well for a first timer painting a car in the driveway. The new paint job gave my car a clean and simple appearance and most importantly was well worth the time and effort.

Just a few days after I finished my paint job and I had taken it out for some beauty pictures, I realized that having two daily drivers was not a financially smart thing to do. I had recently bought a Jeep Cherokee and I wanted to focus more on that vehicle because it was the one I would drive more. That night at around 9 pm I decided to post my Rabbit for sale on both Craigslist and Facebook. Within minutes people started to respond to my posts which surprised me because in the post I had explained all the good parts but mainly all the bad parts about the car. I was beginning to realize that I wouldn't have my Rabbit for very long. I was happy about this because it would be one less vehicle to worry about, but on the other hand, I would be sad to let the car go that I had been putting my time and money into for the past year and a half. Early the next morning I received a phone call from a man who wanted to come check it out. He seemed very interested so I was convinced that he would drive away with it that afternoon. After hanging up with him, I took my homemade Rabbit out for a drive on the town. I filled it up for the last time with gas and that afternoon it was being driven away by someone else. As I watched it drive away, all I had left was a hand full of cash and the memory of an amazing car.

I knew I had done the right thing but I was still a bit uncertain because I had created that car from the ground up. But I comforted myself with the thought that some other day I would build another just as cool. I calculated all the expenses for my Rabbit including items small as trailer rentals and engine degreaser to larger items like the donor car and back fees on

registration. I then subtracted the $860 that I sold in parts from the donor car to have a net total of $2700 on the Rabbit build. I was able to sell it for $2800 giving me a whopping $100 profit.

Looking at this project from the financial point of view, I didn't do so well considering the time and effort I put into it. But I started this project not looking to make money, but rather to learn from my mistakes and inwardly develop through the process. I wouldn't have been able to learn how to paint a car or modify a wiring harness to make a car run without the hands on experience that my Rabbit allowed me to have. If it wasn't for the struggle and frustration that came with the project and all the mistakes I made that I had to fix, I wouldn't be nearly as confident around the internal workings of cars as I am now. My dad was one of the key components in the making of my Rabbit. He had answers for me that even the internet didn't have and was there to give me moral support when all I wanted to do was throw wrenches. One of the most memorable moments of my senior project was sitting in the passenger seat of the Rabbit with my dad driving. I was proud of myself when even my dad couldn't keep a smile in while he was behind the wheel.

By stepping back and looking at my project as a whole, it is now clear for me to see that it was quite an undertaking. When I was first throwing around ideas for my senior project, they were purely just ideas and I wasn't quite sure how difficult they would be. One of the main realizations that I had as a byproduct of my project, was what makes things work. When doing an engine swap was just an idea for a senior project, I had no conception of the effort and thought that must go into such a project. Through my senior project I have gained a perspective on how things work. I learned that some things are much more difficult to accomplish than they may appear. There were so many details of my project that were invisible to me at the start but

were crucial in the functionality of the car. Through this experience I have gained an appreciation for the moving parts that I can't see. My newly developed ability to recognize and appreciate the small parts of a car that make it work, also translates to the other details in life that I hope to recognize and appreciate in good time.

Bibliography

Robert, Bentley. *Volkswagen Bentley Manual.* Bentley Publishers, 1980.

"Carburetors- Explained"

uploaded by Engineering Explained, 5 November 2011,

www.youtube.com/watch?v=oIU-lGc3DL4.

Deaton, Jamie. "5 Ways Modern Car Engines Differ from Older Car Engines"

auto.howstuffworks.com/5-ways-modern-car-engines-differ-from-older-car-engines.htm.

"Exhaust Emissions from a Diesel-Powered Volkswagen Rabbit" *National Service Center Environmental Publications (NSCEP),* pp. 6-11,

https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9100X4YJ.txt.

Jerew, Benjamin. "Carburetor vs Fuel Injection"

www.knowhow.napaonline.com/carburetor-vs-fuel-injection-short-history-pros-cons/.

"The Differences Between Petrol and Diesel Engines."

uploaded by Car Throttle, July

21, 2017, www.youtube.com/watch?v=rlK7JIAz9WY .

"What Makes a Fuel Efficient Car"

www.carsdirect.com/car-buying/what-makes-a-car-fuel-efficient.

Woodford, Chris. "Catalytic Converters"

www.explainthatstuff.com/catalyticconverters.html. Accessed 2 June 2019.