Your Mileage May Vary

My adventure in converting a Mercedes 450SL from D-Jetronic to Megasquirt fuel injection

The reason I'm writing this is that there don't seem to be a lot of people out there who have converted a 450SL successfully from D-Jet to Megasquirt - and those that have seem to have disappeared as they neared the end of the process, either failing to complete the project or just not coming back to the web and confirming their success. So this may be an imperfect resource, but at least it's here.

I didn't take this on voluntarily. I have a 1974 Mercedes 450SL that gave me a couple of years of good service from its D-Jetronic fuel system before, one day, it just quit and wouldn't start. I had it taken to a shop that I thought was competent in this system, and they did get it running; but it ran very badly, used almost twice as much fuel as it had before (which is a lot to begin with), and the price he charged was a very significant percentage of the value of the car. Looking for another place to take it, I came up with dead ends - this system hasn't been used in a new car in 40 years now, and the technicians who knew how to fix it have either retired or passed away, or are just so sick of it that they won't take it on. I thought I had the problem narrowed down to 2 possible components: either the ECU, which might be replaced with a rebuild for about $700, or the manifold pressure sensor, which can be found for about $400 used (maybe working, maybe not) or $1200 new. This is a very expensive "replace and find out" experiment.

Out of desperation, I decided to build my own MegaSquirt ECU, and contacted Matt at DIYAutoTune.com to get advice on what all I needed to buy to put together a system. Following the list that Matt gave me, I bought about $770 worth of components from DIYAutoTune, which included basically:

- **MS230-K Megasquirt-II (PCB3.0)** unassembled kit for the MegaSquirt ECU
- **JimStim-K** - a testing device that mimics engine functions and confirms that you've got your ECU working right before you install it in the car (This is Necessary, unless you buy the ECU already assembled)
- **MSHarness** - the wiring harness to install the ECU in the car, obviously necessary too.
- **TuneCable6** - a cable to connect the ECU to a laptop computer for tuning (also necessary)
- **USB-2920** - the cable above is for a DB9 Serial Port, which no laptops have any more; the USB-2920 adapts this to fit a USB port. It worked well in my case.

Also included in my purchase were some items that turned out NOT to be necessary; had I known this up front, I would have spent less than $500 at DIYAutoTune, so it's worth knowing which things they are:

- **GM air temperature and coolant temperature sensors**: I would have used these, but their thread size is huge compared to the Bosch sensors already in the car, and I didn't find any convenient way to install them. As it turns out, it's easy to calibrate the MS for the original Bosch sensors, so I just kept them in place.
- **O_2 sensor kit with gauge**: This is the biggie. I went for the most expensive kit they had, INNVT-3822, which includes an analog gauge that would fit in well with the instruments on the 450SL. It was $250 for the sensor/cable/gauge kit. It turned out that the O_2 sensor was not only unnecessary in this installation, it made tuning very difficult as it misled the ECU into changing mixture settings that didn't want to be changed. The solution in the end was to disconnect the O_2 sensor from the ECU and let it run as an open loop system, which it does very well. The sensor can still be used as a sending unit for the gauge, but that makes for a pretty expensive dash gauge. At present I've decided to leave the whole thing out and save the trouble of finding a place to install the gauge.

.... And other stuff that you'll need that DOESN'T come from DIYAutoTune:

- **Throttle Position Sensor**: The one I bought is an AC Delco 213-914, I think from a 4-cylinder Chevy although I don't know if it's really any different from other GM units. It cost about $7 on eBay. It didn't include a mating connector; I found a pigtail cable to fit it, also on eBay, for about another $9.
- **Some way to attach the TPS to the D-Jet throttle body**: This is a bit more work. In my case, I made an adapter plate out of 3/8" thick aluminum plate. Tools required included a milling machine and a rotary table, though it would probably be possible to simplify the design and get by with a drill press. I'll include a drawing of my part here; if there's interest I could upload the design to www.shapeways.com and you could have them mail you a 3D-printed copy of it (just be sure to order it in metal, not plastic).
    - Another small complication: the shaft on the D-Jet throttle body is 8mm in diameter; apparently it's 9mm on the GM throttle body that goes with this TPS. To make it fit well I cut a piece of 9mm OD/8mm ID brass tubing and cut away the one side where the flat side of the shaft goes. This tubing can be bought from www.mcmaster.com - part number 88605K28.
- **Lots of "Standard SK21" connectors**: You have a choice here - you can cut all of the connectors off of your old wiring harness and solder them onto your new one, or you can buy new connectors. I like the second way better. Bosch used this same connector for the 8 fuel injectors, the coolant temperature sensor and the air temperature sensor, so I had to buy 10 of them to do the job. Unfortunately these little buggers cost something like $6 each, so it adds up... but I didn't like the idea of cutting apart my wiring harness to reuse a bunch of worn out 40-year-old connectors.
- **Fuse Block**: I think you can get this from DIY, but I didn't ... just found one at a local auto parts store. You need 3 fuse positions: 10A each for the right and left bank of injectors, and 20A to power the ECU.

- **Relay**: This is a general purpose relay, I think I got one with 30 or 40 amps capacity. 4 connections: (1) 12VDC+ straight from the battery (add a 30A fuse holder in that line, near the battery, to protect the car in case of a mishap. I connected this fuse holder to the + battery terminal and ran an AWG12 wire from there to the relay). (2) Ground to chassis. (3) 12VDC switched - find a spot in the fuse box that only gets power when the ignition switch is on and hook up to that. (4) Output to the Fuse Block above (use a heavy gauge wire here, I think I used AWG12).
- **A place to put all this stuff**: I made a new kick panel for the passenger's side and attached the fuse block, relay and MS ECU to that. It was handy to be able to pull the entire thing out of the car as a unit if something needed attention during tuning. It doesn't come out quite so easy after you have all of the interior fascia back in place though.
- **A Laptop Computer**: It doesn't have to be a fancy one. I had recently bought a basic laptop for $250 and it worked fine. But you DO need a USB port to hook up the cable (an old style Serial port is even better, if you're an antique computer collector - it will save you the DB9/USB adapter listed above). Even if you're going to have someone else do your tuning (highly recommended), you still need the computer to make sure your pieces are working correctly along the way. And don't load your email and bank account information on this machine - you're going to have to leave it with the tuners for a while.

More bits of random advice:

You can find, I'm sure, all of the information that you need by going to http://www.megamanual.com/mtabcon.htm and following the appropriate links; but it's a little like finding a copy of the Encyclopedia Britannica scattered on the floor as loose pages. Be prepared to spend a lot of time following links and studying. I've put this together to translate some of the more basic points into English to help give you a start.

I bought the ECU as an unassembled kit, partly to save money and partly because I thought I would enjoy building it as a winter project while the weather prevented me from using the car anyway. It turned out to be a bit less enjoyable than I had hoped. If I had it to do over again, I think I would have spent the extra couple hundred bucks and bought it preassembled and tested. Then I think I could have dropped the "JimStim" from my purchase list to offset part of the cost difference.

Once you have all of the pieces together, there's a bit of plumbing required. I waited for this until I had confirmed that the engine would start and run on the new ECU .... so this meant hooking up all of the wiring with the ECU out of the car (in my case, on a table next to the front fender), and then once it was reasonably sorted, taking it all apart to thread the wiring through the car and mount the ECU in place.

The Fuse Block, Relay and ECU all want to be inside the passenger compartment of the car - preferably with the DB9 plug on the ECU easily accessible to hook up the laptop computer. The ECU is NOT designed to survive the harsh environment under the hood

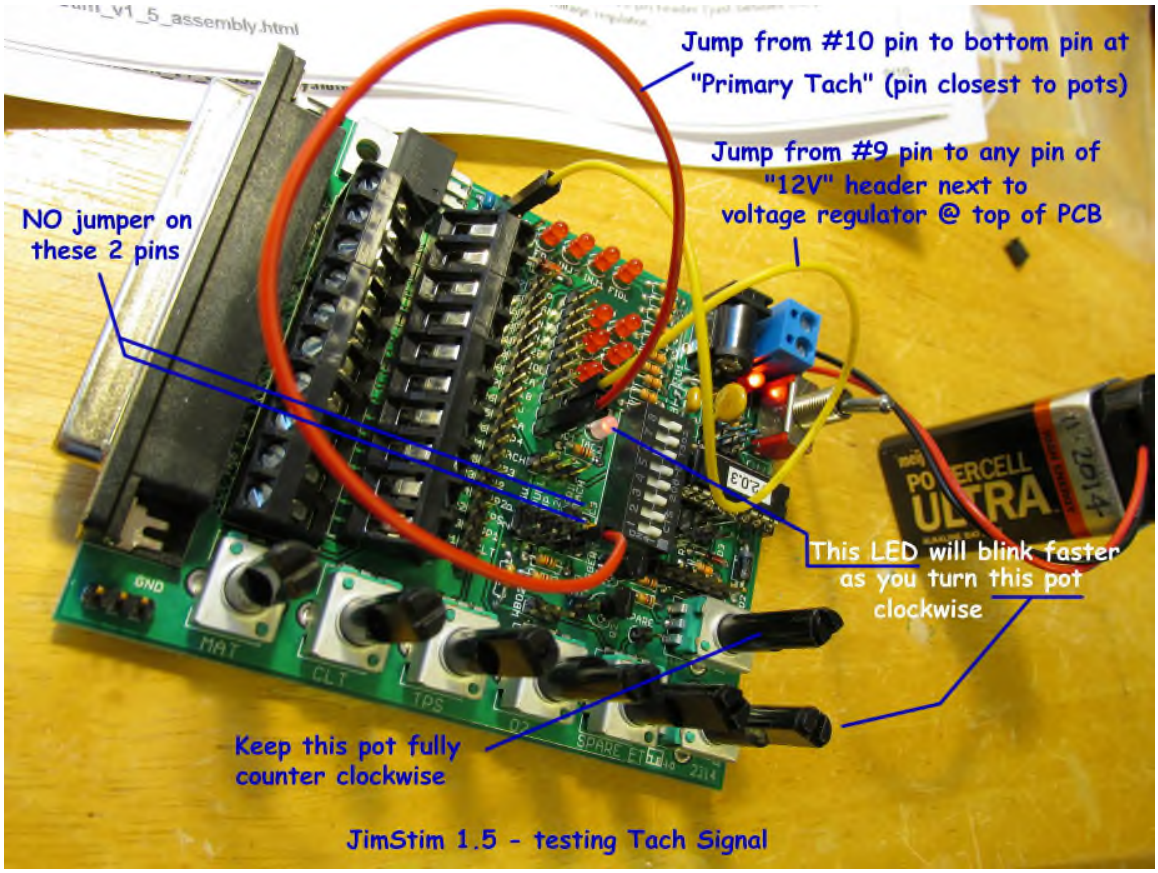
of the car. Between the passenger compartment and the engine compartment, you have to thread the main **wiring harness** (it's almost an inch in diameter as it comes from DIY, but for D-Jet replacement you don't need all of the wires - I got some 3/4" OD wire organizer flexy tubing and repackaged my harness to help fit it through the available spaces), the **vacuum line** from the intake manifold (you need to step this down from the 8mm M-B hose to the 4mm MS hose - you can get 4mm tuning and adapters at the local auto parts store), and the **12VDC+ wire** from the battery. In my case this meant 3 new holes through the firewall, and a rubber grommet for at least the 12VDC wire. Finding a way to thread all of this stuff through will vary by vehicle. The 450SL is probably one of the more tightly packed - I found a passage from the heater blower compartment (just forward of the windshield under the hood) to an opening downward above the passenger's footwell, which was very lucky.

You're going to need a tuner before this is done. Find one ahead of time so you know you won't get to the 99% point and not be able to finish the project. I might have been able to tune this on my own - I had scheduled about 6 months to a year to get it dialed in that way, but I think I may have been optimistic - but the shop got it done in a couple of weeks, while along the way resolving a handful of other issues that I had not taken into account in my original schedule.

One last side note: This project was done on a 1974 Mercedes 450SL, which was originally built with Bosch D-Jetronic electronic fuel injection. This system was introduced in 1967 Volkswagens and was used in the 450SL from its beginning in 1972 through 1975 (It was also used in a number of other European cars during that period). Beginning in 1976, the 450SL changed to Bosch K-Jetronic mechanical fuel injection. The conversion that I did was relatively easy (everything's relative), since I could use the existing injectors on the engine and just needed a new way to control them. Converting a post-1975 SL from K-Jetronic to Megasquirt would be a very different, more complicated and more expensive project, because you would have to replace the mechanical injectors with electronic ones in addition to all of the work shown here. Therefore, **the information that I have in this report DOES NOT APPLY TO CARS BUILT AFTER THE 1975 MODEL YEAR.**

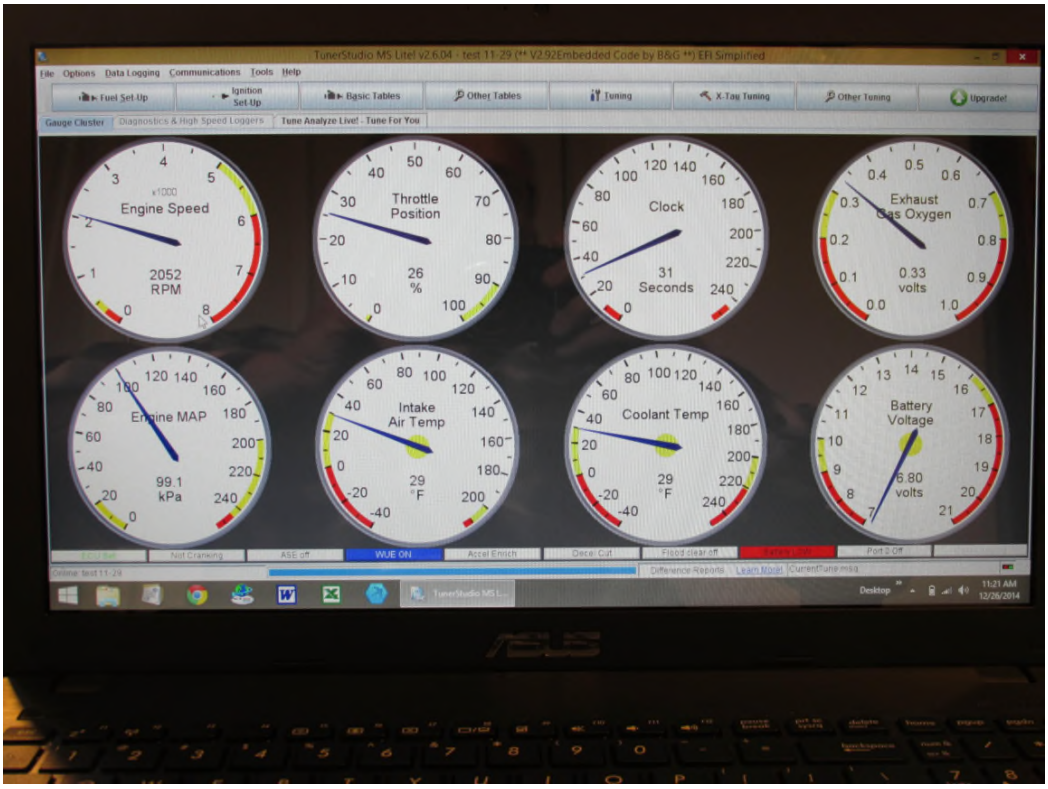
If you have any questions about taking on this project, feel free to write and ask at rick.oleson@gmail.com. I may not be able to give you a good answer, but I'll be happy to try.

Construction & Installation

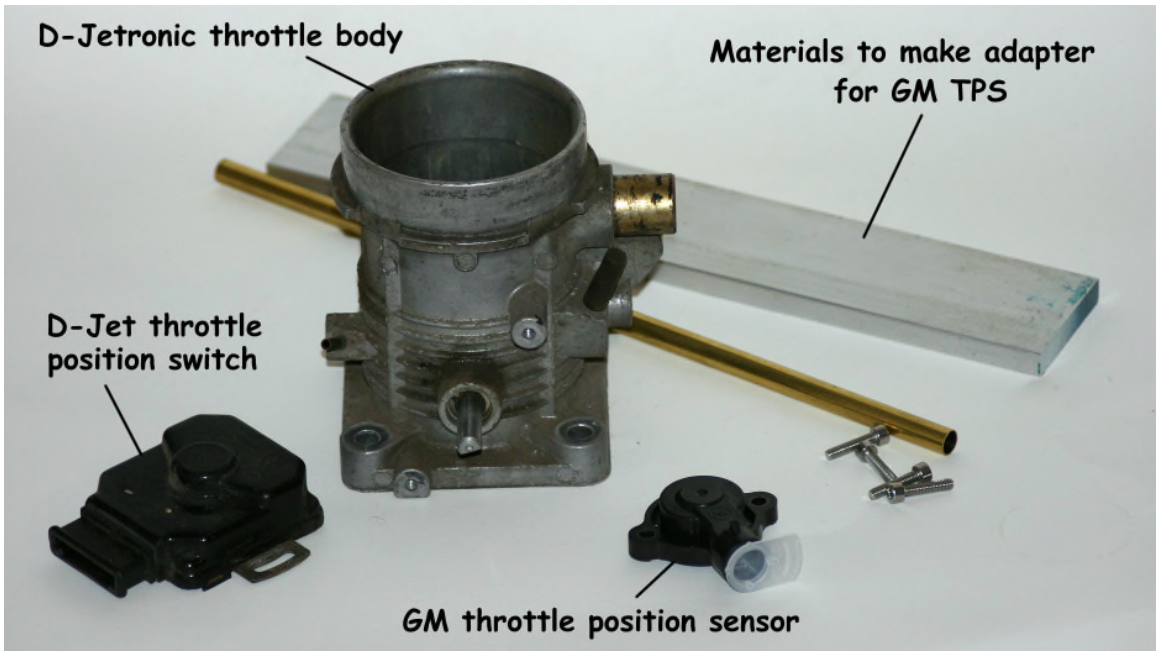


If you build your own ECU, you'll have to build a JimStim first. This is the tester that you use to make sure your ECU works before installing it in the car.

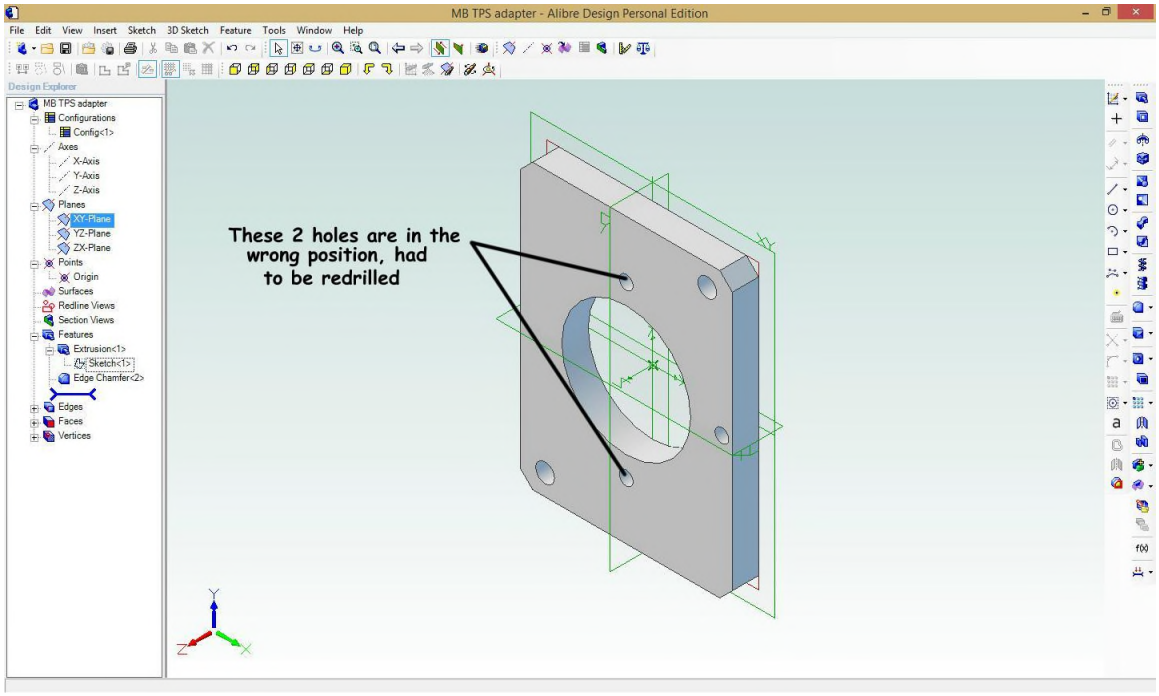
The JimStim attached to the unfinished ECU. You can test each stage before going on to the next.



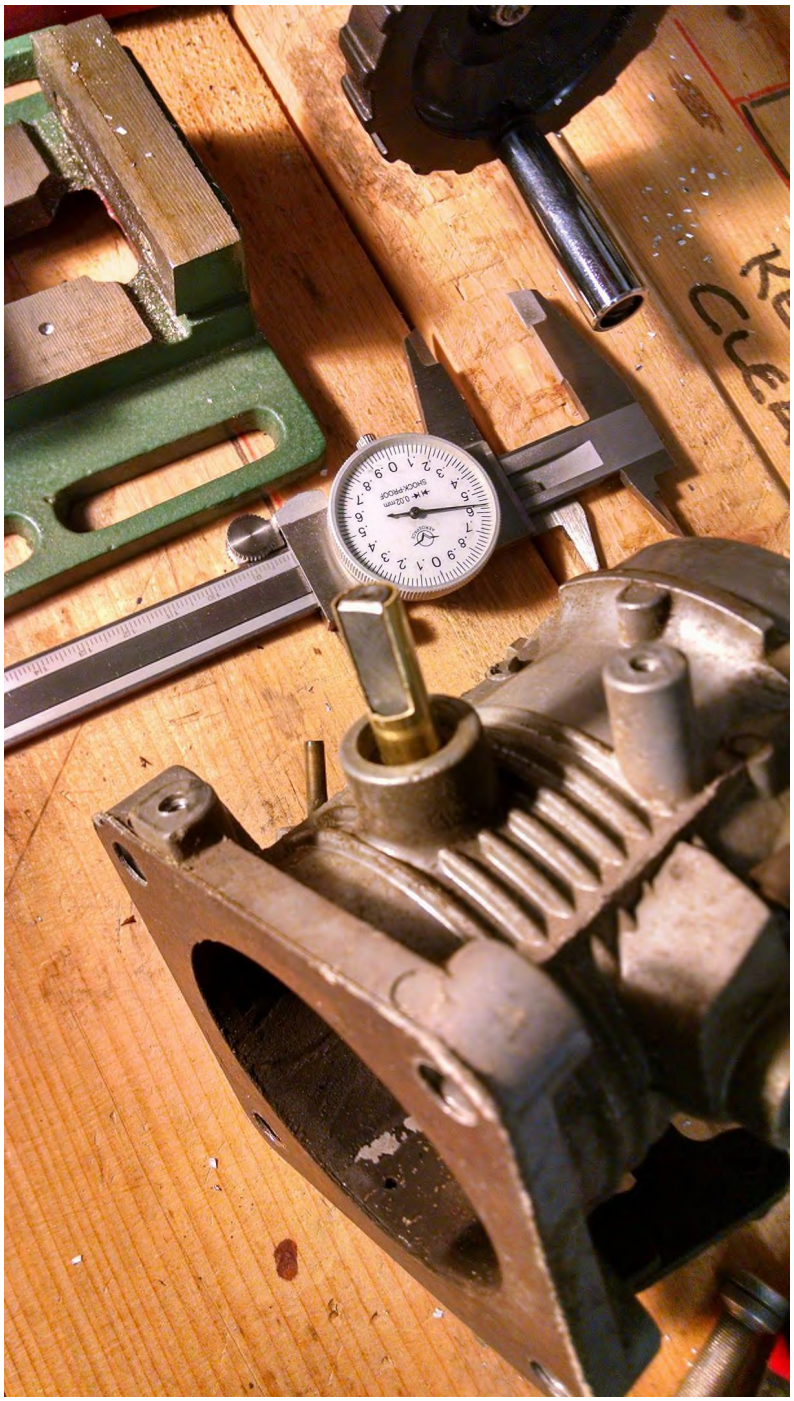
This is what the Tuner Studio main screen looks like on your PC when all of the functions of the ECU are working. You can dial the values up and down with controls on the JimStim.



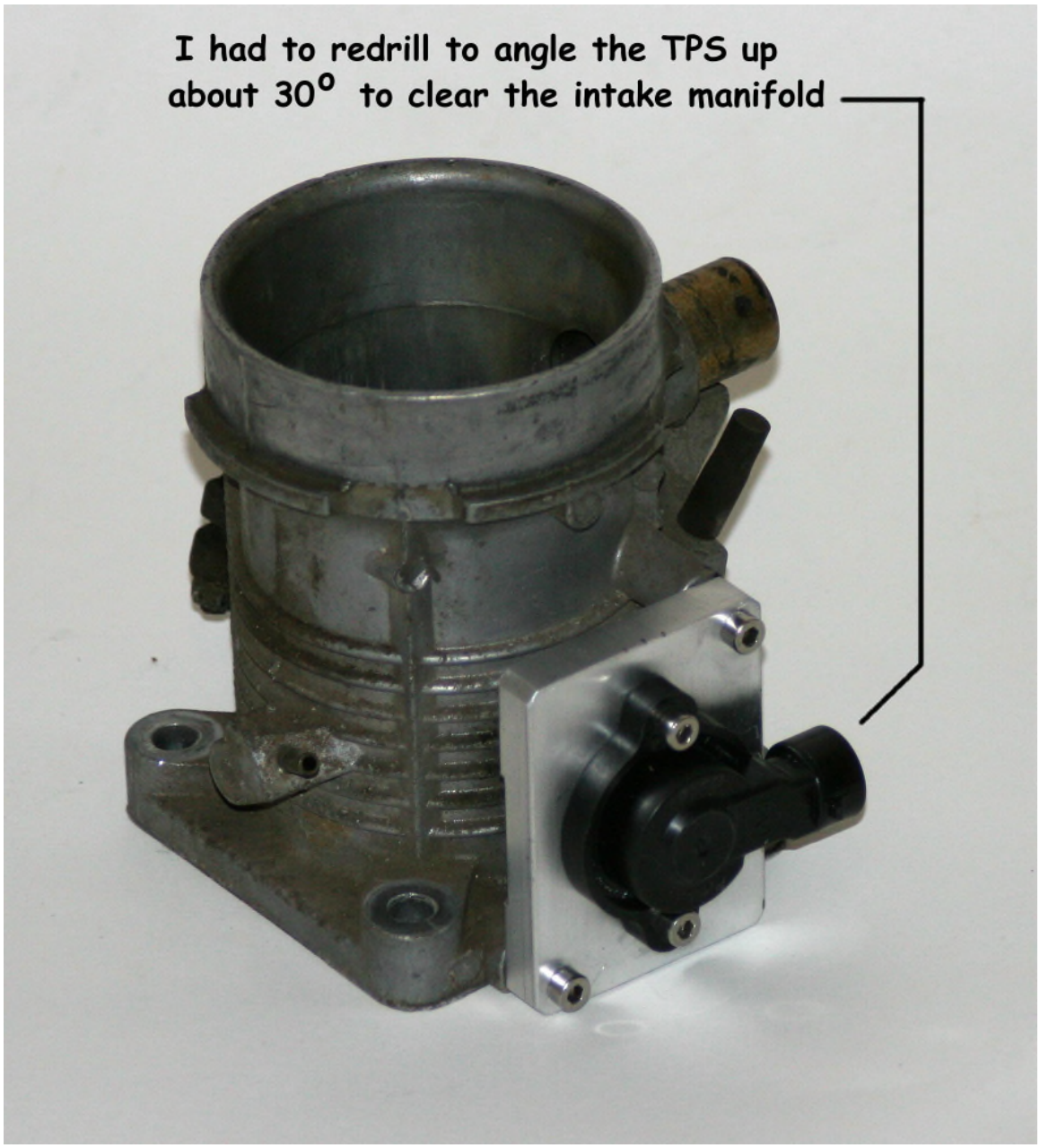
The original D-Jetronic throttle position switch won't work with the MegaSquirt ECU, it needs a more modern variable-resistance type. I chose a GM sensor more or less at random, I think it cost about 7 dollars. The shaft on the throttle body is 1mm smaller in diameter than the GM, so I used a piece of brass tubing to adapt it; and I also had to make an adapter plate to mount it to the throttle body. The exact orientation of the TPS is not critical, as long as it has enough travel to allow the throttle to go through its full range.... you will set the open and closed position settings in the software after installation.



I used a CAD program to design the adapter plate, but that's obviously a bit of overkill: I could have used a ruler and a sheet of notebook paper for this part.

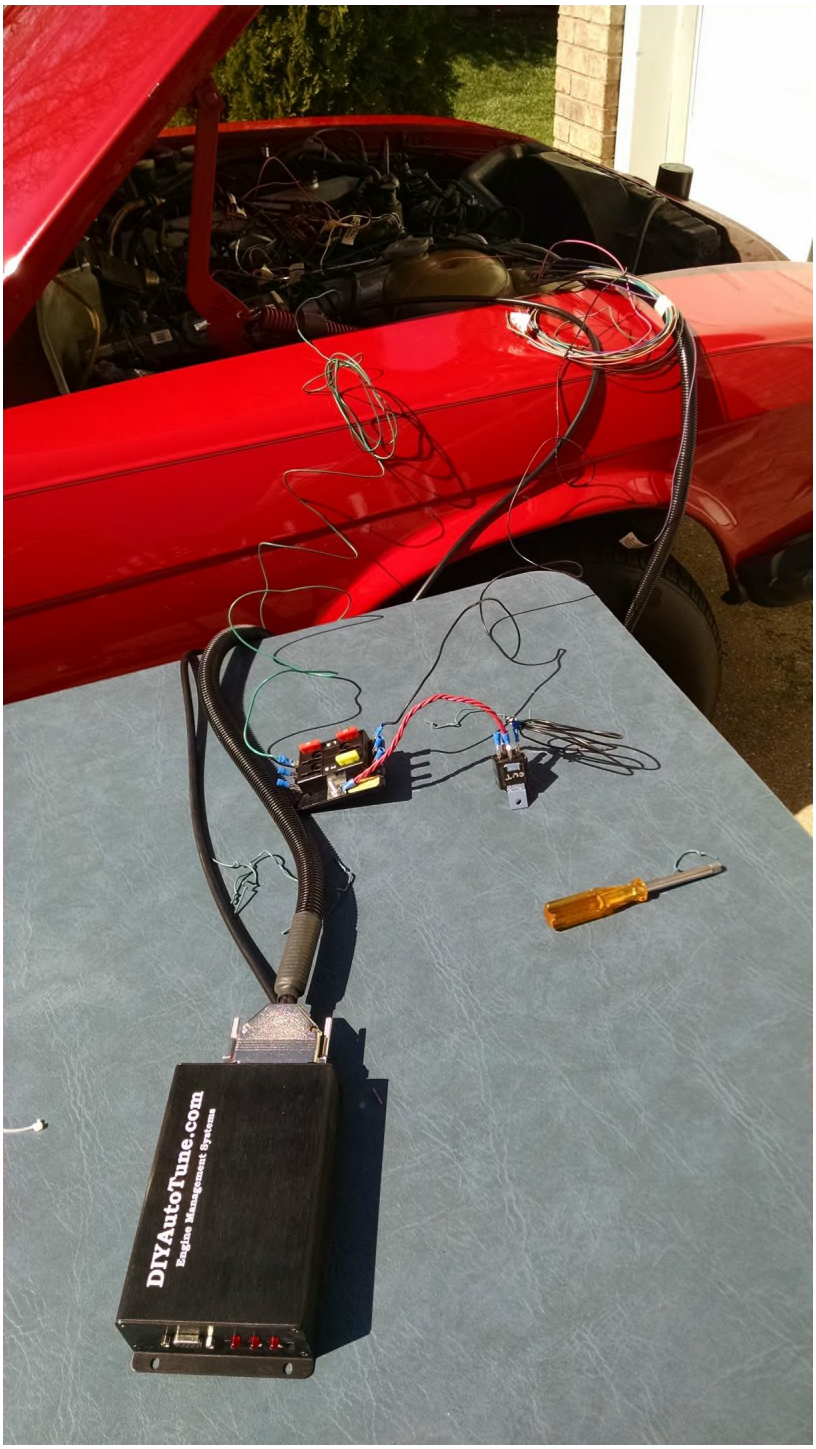


A saw and a file were all that was needed to change the shaft from 8mm to 9mm diameter with a piece of brass tubing.



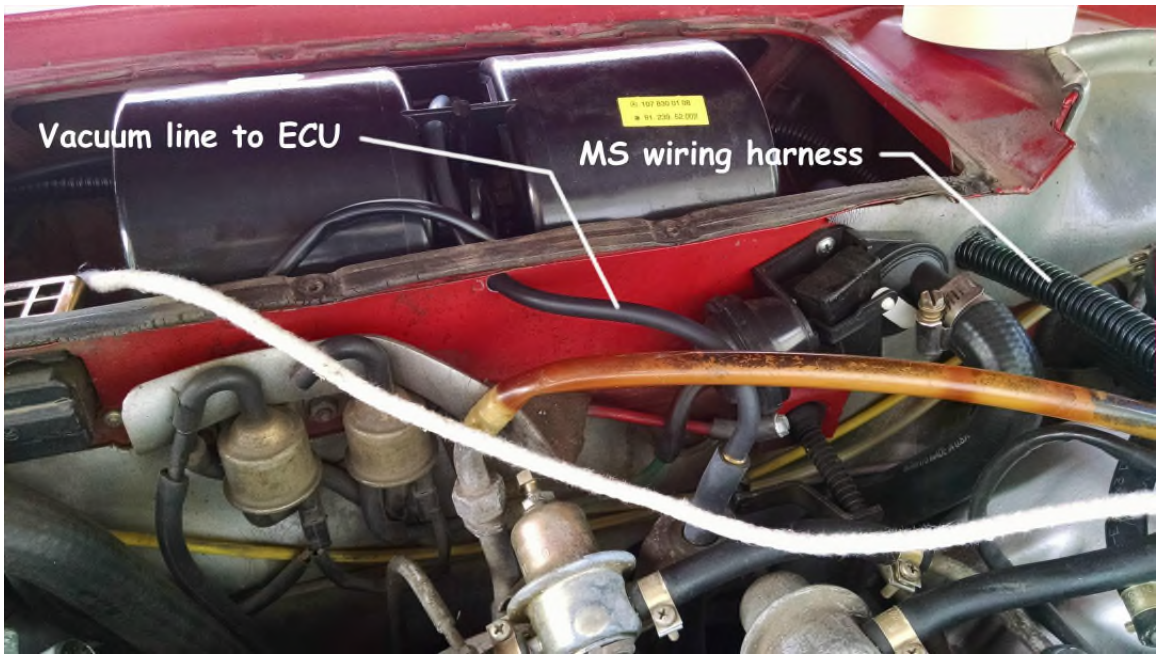
Here's the new TPS installed with its adapter plate. Unfortunately, I didn't have access to the car when I did this, and in this position the wiring harness interferes with the intake manifold runner. This TPS had extra travel in the counterclockwise direction, so all I had to do was drill another pair of holes and reposition it so that the harness connector points up at an angle.

With the TPS position corrected, the throttle body is now reinstalled on the engine.

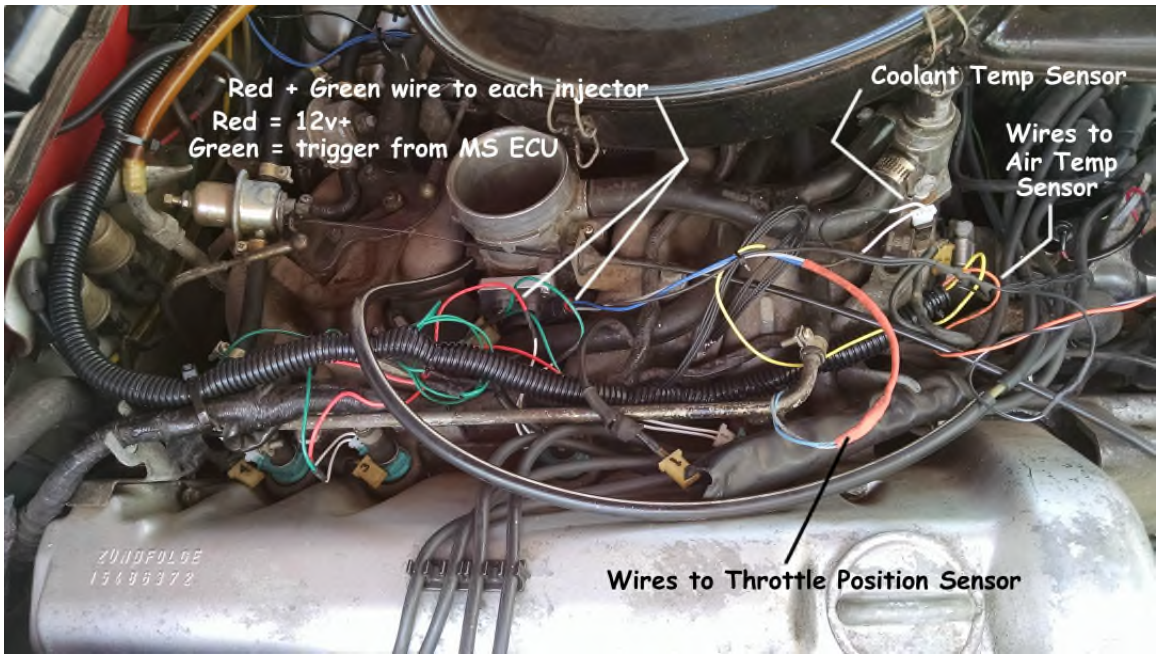


Before running the wiring harness through the car, it's a good idea to test start the engine. I set up a card table next to the car to hold the ECU, fuse block and relay and hooked up all the connections just as they would be when fully installed. The engine started and ran(!) on the first try. But it ran very rough, and it took another month before I was ready to install the system in the car. The main problem was a noisy tach signal, which I finally cleaned up by adding a 15V Zener diode in the line from the coil to the ECU (the diode goes in with the banded end toward the coil).

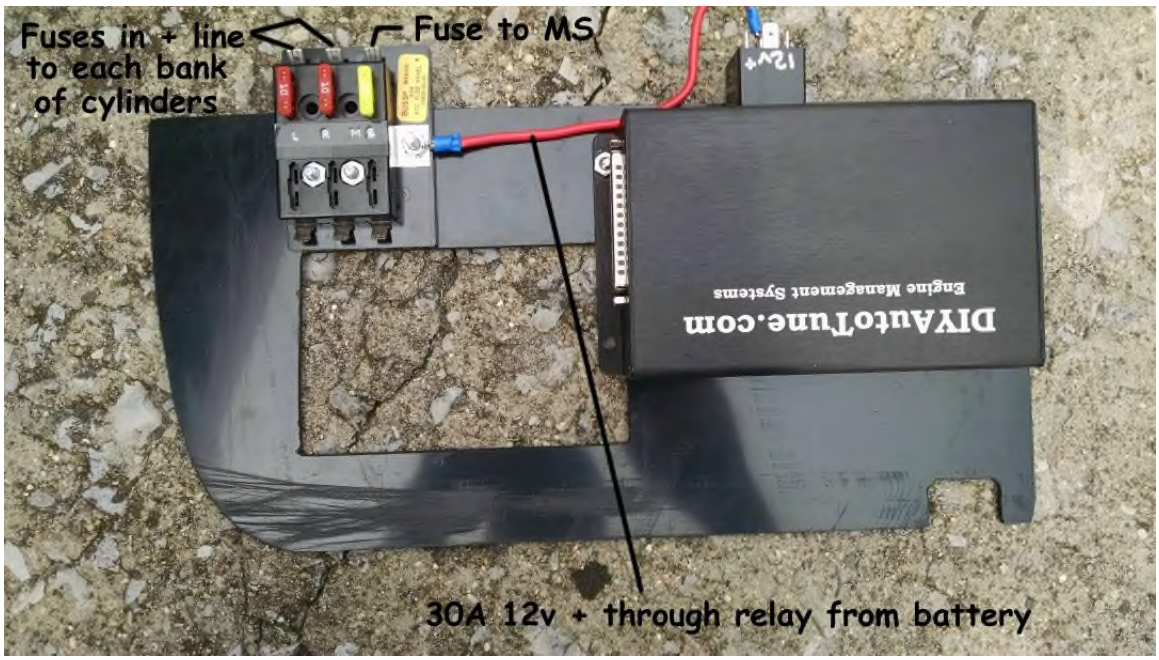
Once I was convinced that the car would run and could be tuned, it was time to install the harness. The only passage I could find for it was through the heater ducts, which luckily were pretty accessible.



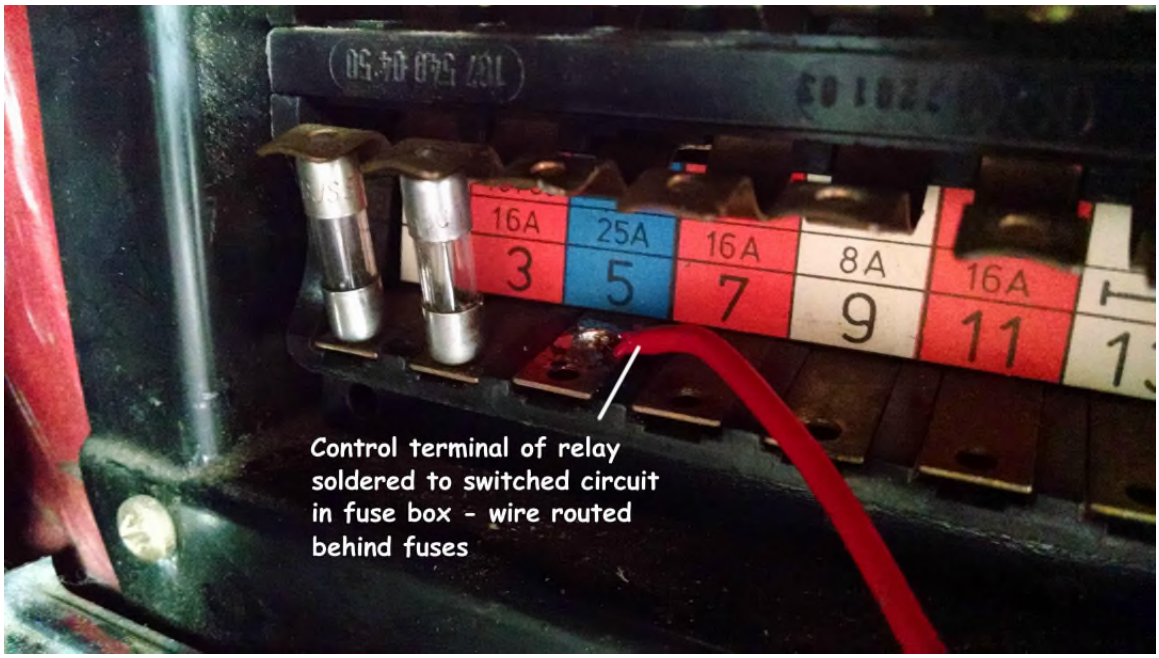
In addition to wires, there is also a vacuum line that has to be run from the engine to the ECU.



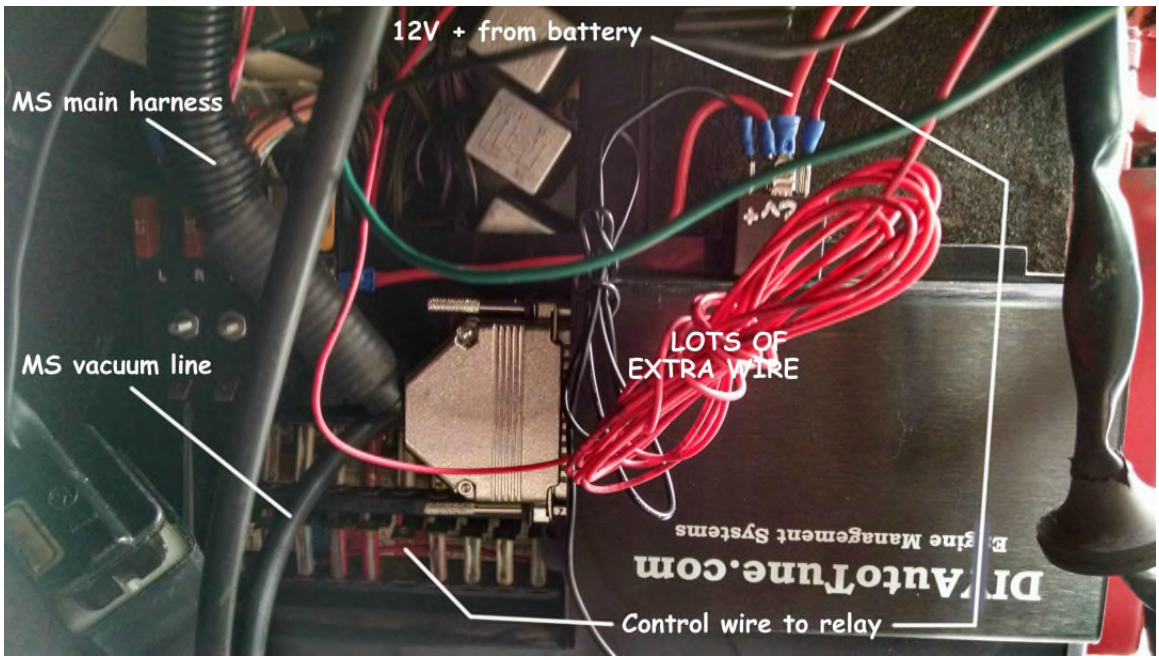
On each bank, there are 2 trigger wires and 2 power wires to the injectors. I split these off to drive 2 injectors from each pair of wires. All injectors on one bank fire together, it is not a sequential-fire system (which makes it a lot easier to tune). I bought new connectors for the injectors, you can see the old ones lying alongside the new harness. I left the original harness intact, so someone can change the whole system back to Jetronic if they want to.



I made a new kick panel to attach the ECU to, which allowed me to pre-assemble it for easier installation in the car. (the white lettering can be removed from the ECU housing with acetone - don't get it on any plastic stuff)



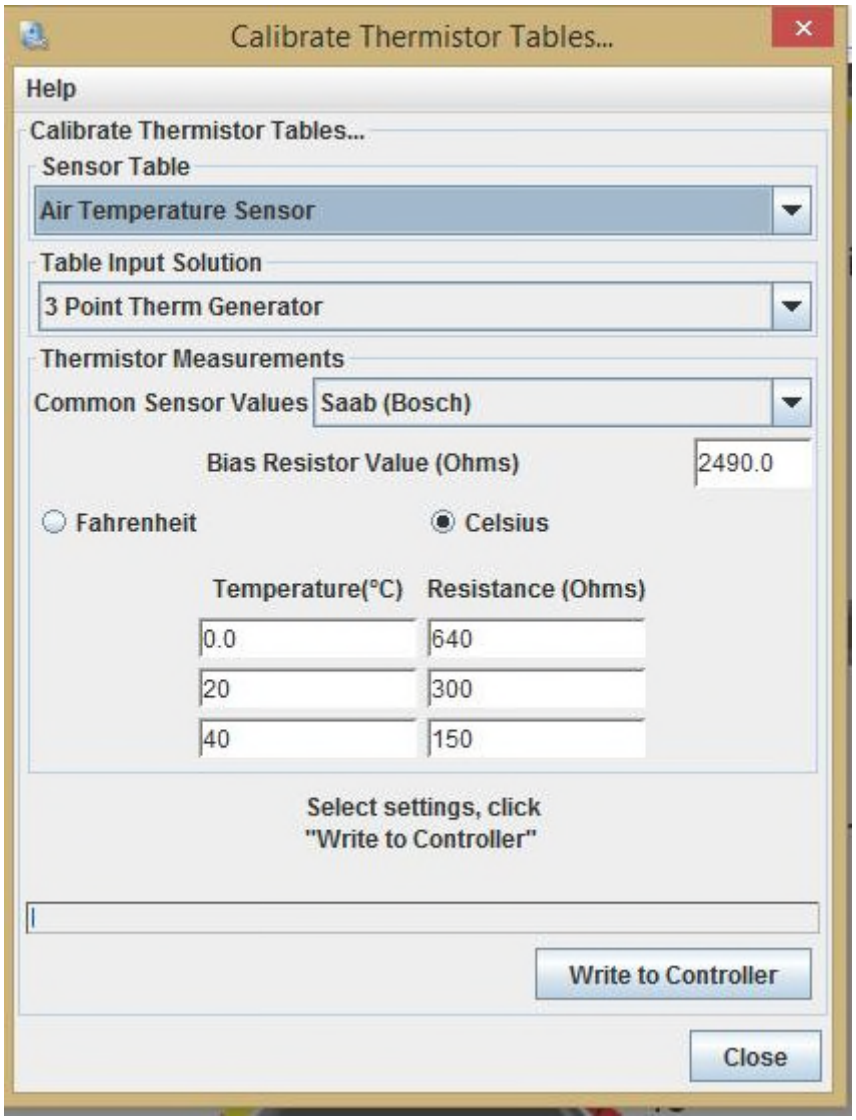
The ECU is powered through a relay (which you have to provide); for the control side of the relay I found a fused circuit that was switched through the ignition switch and had plenty of spare power available. I think this one was for the rear window defroster. I soldered the wire to the downstream fuse terminal in a position where I could run the wire behind the fuses to the end of the box. You can see this wire behind the fuses in the photo below.



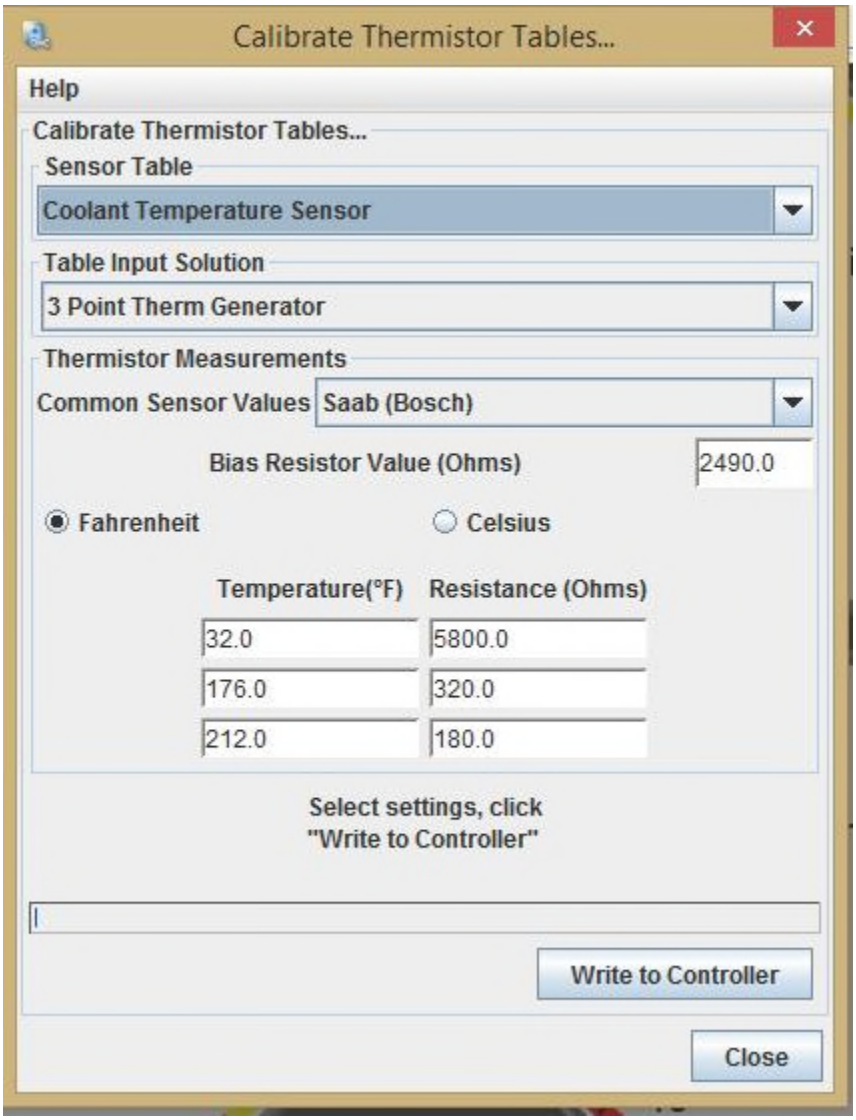
This shows how the ECU is mounted and basically where the wiring goes. This was the first fitting, all of the wads of spare wire were trimmed out later.

This is how it looks after the interior fascia is put back in (I did have to cut away a little of the lower dash fascia to clear the ECU... it intrudes slightly into the air duct that feeds into the front edge of the door). The 3 red indicator LEDs (injectors firing, warm-up enrichment, and acceleration enrichment) face toward the passenger toward the upper end of the ECU; below them is the D9 connector to hook up a laptop for tuning. I've put a waterproof cap on that connector. Also, not shown, I conformal coated the circuit boards after I was sure everything was working right, to protect the system from weather. I also did my best to seal the seams of the ECU enclosure on the top side, leaving some gaps at the bottom to allow moisture to vent in case any finds its way in.

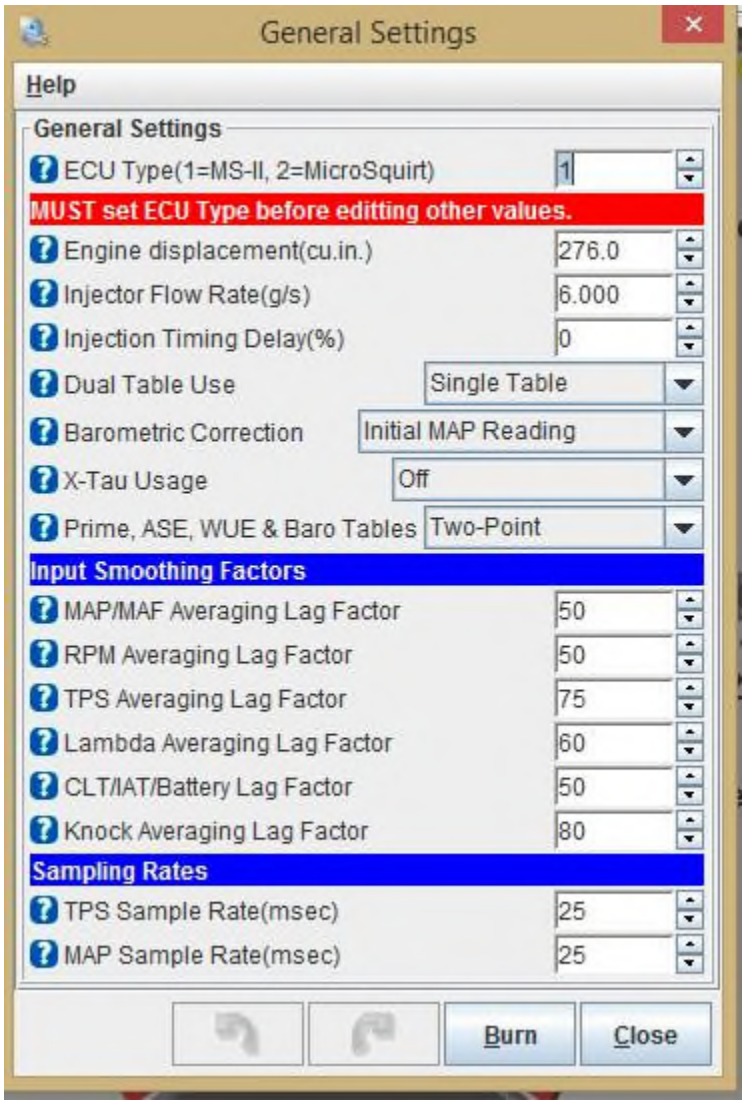
Configuration and Tuning



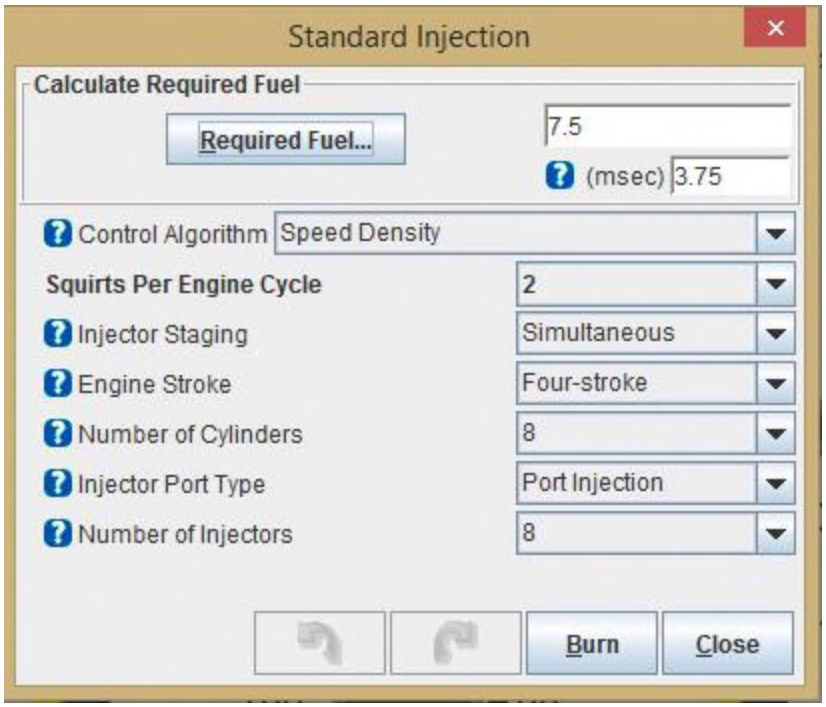
These are the settings to use for the Air Temperature Sensor, if you're keeping the original sensor from your D-Jetronic system.



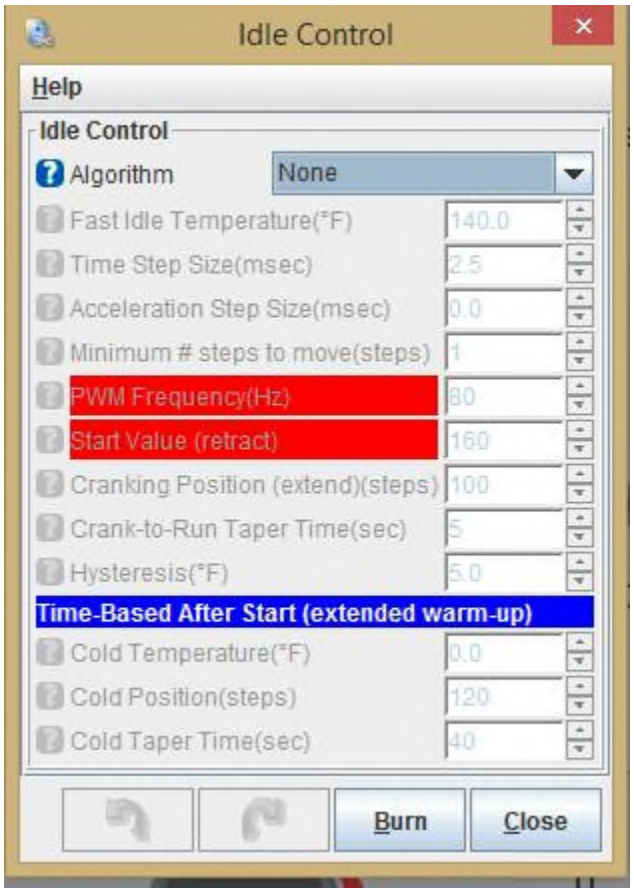
And likewise, these are the Coolant Temperature Sensor settings for the original equipment Bosch sensor on the 450SL engine.



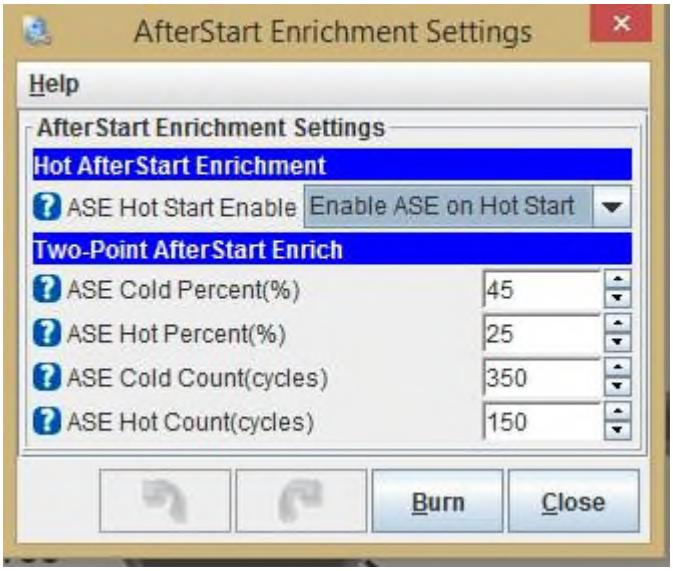
These are the General settings for fuel set-up. The fuel flow rating of these old Bosch injectors is very high compared to most later ones - they can move enough fuel to feed 800 horsepower.



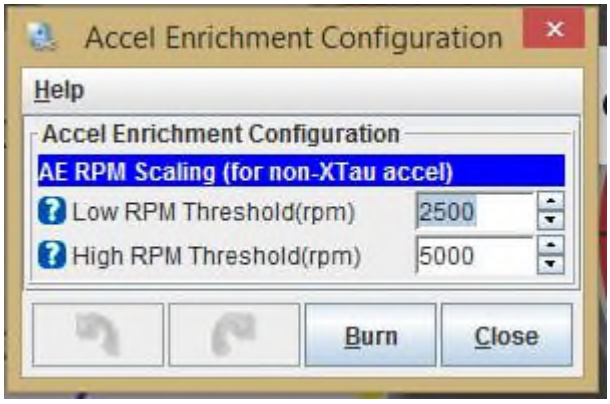
These are the Injector Control settings.



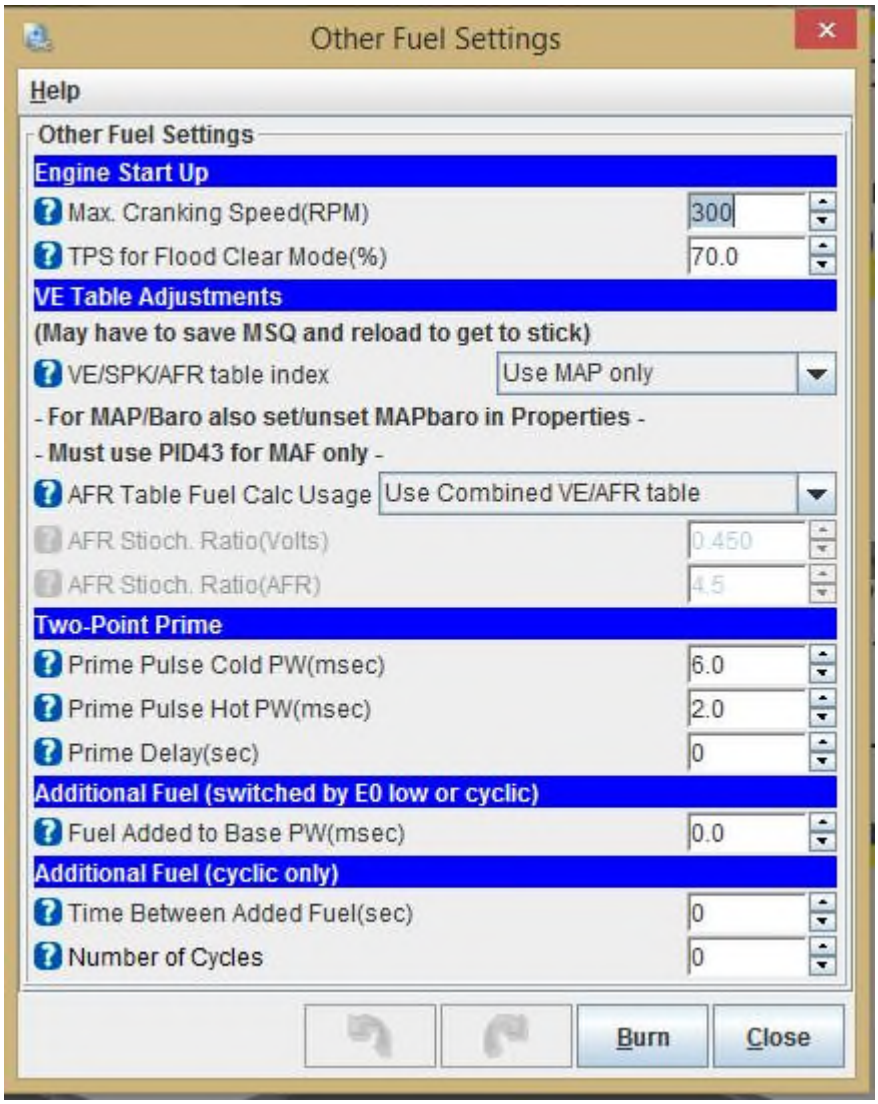
I did not use Idle Control through MegaSquirt, as the engine has a mechanical fast idle control system built into it that works well.



These are the Warm-up Enrichment settings that I used (it may be slightly on the rich side but I haven't had reason to change it so far).



And these are the Acceleration Enrichment settings (they seem to be just fine as they are).

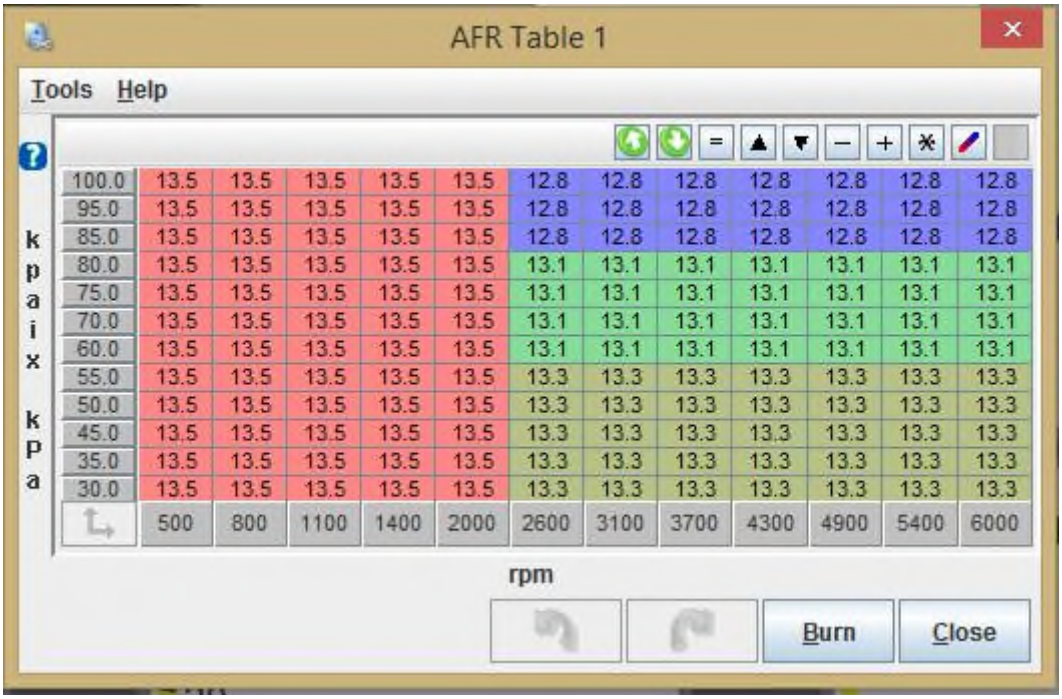


The Flood Clear feature is one of the great features of MegaSquirt. Set this up, and if you get too much fuel into the engine you can clear it out just by restarting with the throttle floored. It works great, and gives you a bit of extra tuning flexibility in the rich direction.

One other setting that I don't show here is the **Throttle Position Sensor calibration**. That is a very simple and exact process: You click on the "closed throttle" button with your foot off of the accelerator, and you click on the "open throttle" button with the accelerator floored. The program locks in these values, and that's all there is to it.

(now the tuning.....)

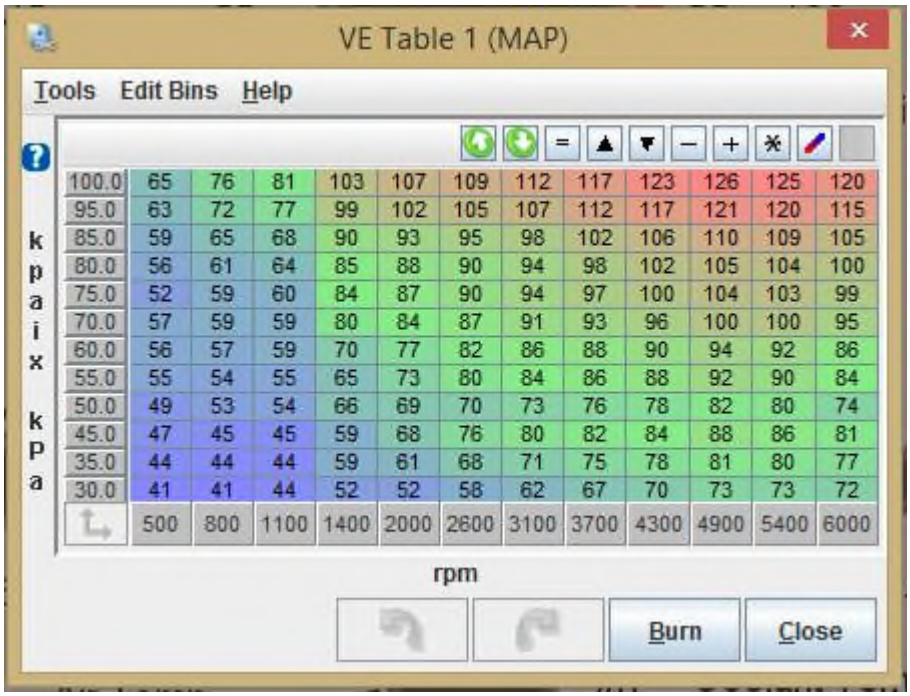
The steps above can (must) all be done before you try to start the engine, they define the basic characteristics of the hardware that the ECU is dealing with. For the actual tuning, I managed to find a local shop that had a dyno and was familiar with MegaSquirt. I highly recommend this approach if you can do it, it not only saves much time and trouble but is safer than having to road test every time you make a change.



This is the table of Air-Fuel Ratio settings that were used to set up my engine. This is the result of a fair amount of time on the dyno, and it works very well in my 450.

The axes of this table are manifold pressure (vertical, as a percentage of atmospheric pressure) and RPM. You can adjust the mixture separately in each cell, or in groups of cells.

I DO NOT have closed loop operation with an O_2 sensor in the exhaust. The original D-Jetronic system didn't have an O_2 sensor, and adding one to the system seemed to be making the tuning more difficult rather than easier in this case.... so although I had bought one and had it installed, I took it back out.



This is the VE table that corresponds to the AFR table above for my engine.

It is possible for me to plug my laptop computer into the ECU and adjust any of these mixture settings. So far (about 1 year back on the road now), I have not done so.

I hope you find all this useful if you're planning a similar project.

Good Luck & Best Wishes!