Subaru Tuning Guide

Version 1.8

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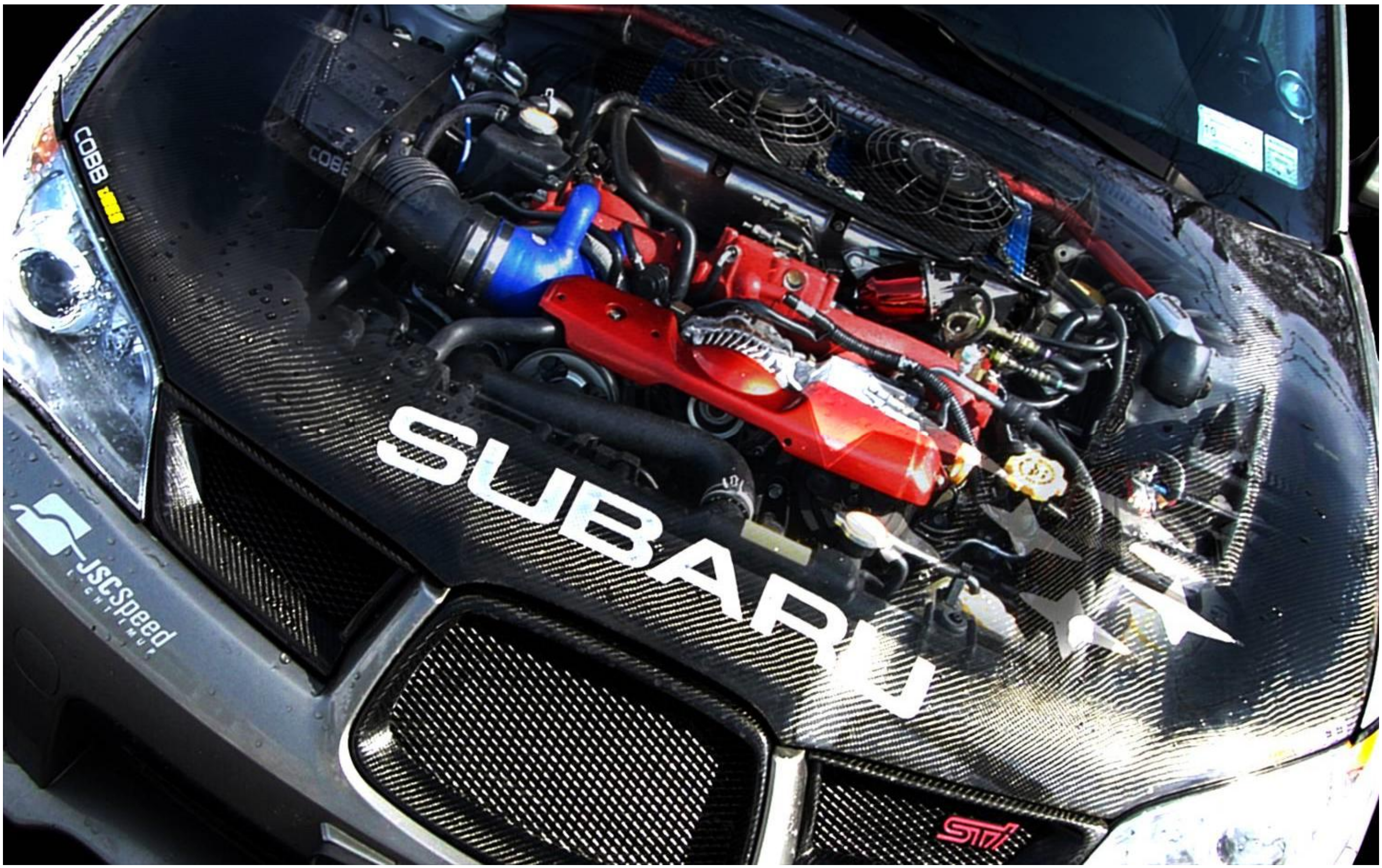
Valuable contributions and Many thanks to…
Oren, AKA **TD_D**

This procedure is mostly specific to AccessTuner Race but also references RomRaider. Further more it is specific to the GD chassis but references some GR specific instruction. Use at your own risk.



Preface

This guide is a conglomeration of confirmed methods when applying tuning knowledge to the Subaru STI and other Subaru models. This collection has been proven through personal experience and implementation however, **it is not the only way to tune** and it should be used as only a guide to learn the process. You must find your own methods and ways of implementing a tune provided the end result is the same. This guide outlines a process that is considered by most tuners to be over compensating and extreme for client/business use. This guide is meant for that person who wishes to get the absolute most out of a tune and takes the time to do it and who understands the dynamics and relationship between boost timing and fuel.

This collection combines knowledge from the community and references various sources of knowledge along with **real world experience and experimentation**.

(I.E. I destroyed 6 motors on my personal car and spent $30,000 plus to bring you this guide. Not to mention the similar acts of the for mentioned contributors and the community)

Take your time with this and be thorough. Be safe and if you can, find your self a deserted stretch of road to perform this procedure. You will need to run WOT at times and this is not safe or legal on public roads. If possible, book some time at your local track for all the Open Loop stuff. You will also need to find roads adequate enough to perform a variety of road conditions and load.

As the tuner, you must decide what needs to be performed and what can be overlooked. It may not be necessary to perform this procedure in its entirety but if it is perfection, safety and integrity you are after, I highly recommend that you perform all these steps.

Ideally you will want to adjust fuel, timing, and boost all together but for the purposes of learning and simplicity we are going to touch on each area of the tune individually. Then toward the end we will bring it all together and discuss how to go about achieving a well adjusted tune by looking at all three areas together.

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1 Workflow

1.1 Check the Vehicle.

The first thing I try to do when tuning my own or someone else's car is I will take the time to make sure the car is in a condition to be tuned. It should be understood that the tuning process can be quite taxing on a vehicle. The tune is only as good as the hardware you have to work with so heed this warning… Garbage in = garbage out. If there are any problems with the car, no matter how small, abort the tuning process and resolve these issues first.

- Check the oil level.
- If possible perform a compression test on the subject vehicle.
- Perform a Boost Leak Test of the intake system
- Check for leaks in the exhaust
- Check the coolant level
- Check the Brake and Clutch fluid level before Street Tuning.
- Run an initial check for DTC codes and resolve any sensor issues
- If not installed, Install the rear O2 sensor
- Check for proper usage of BOV's and BPV's. If using a BOV it should be properly adjusted prior to tuning.
- Check out the BOV guide on IGOTASTi.com for details.

All sensors must be plugged in and functioning prior to tuning. This includes the rear O2 sensor as well as the front O2 sensor and the Barometric sensor on the 07 and above.

1.2 Get a Baseline

For street tuning, a third party dyno software package such as VirtualDyno or AirBoys Log Interpolator spread sheet will benefit you here. You can also use the AccessPort dyno feature. It is not accurate but it will provide a baseline and a good reference point. You can use what ever solution is at your disposal.

Whenever possible you need to get a Baseline log of both closed loop and open loop conditions prior to any modifications and/or tuning. It may not be possible to get a baseline before modifications are made because you or your customer may have already installed these mods in anticipation of the tune. In this case it may be unsafe for you to perform a baseline log because the current tune may not be safe for you to go WOT.

However don't overlook the importance of this step. Here we hope to establish an estimate of expected loads and we need this information if we are to successfully define certain fuel and timing tables and other load based parameters.

If a baseline can not be performed then you will need to create an initial limp map that will allow you to obtain these calculated loads and then you can go ahead and define your fuel and timing tables based off of that result. For this you will need to continue on with this procedure and define safe and conservative initial values for your fuel map and timing map to start with. For this initial base line map you should consider making your AFRs as rich as 10.8:1 for safety sake. For the timing you should use stock level timing across the board. We are only concerned with getting our estimated max load here. As mentioned please read the fuel and timing related sections of this procedure for steps to create a base map (Sections 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.7)

1.3 Tuning and Calibrating steps

Note: Please understand that when you make adjustments to one area of the tune you may need to go back and confirm and/or adjust something you already tuned.

A. Tune for fuel. This includes fuel targets, closed loop, open loop, load compensation and tip-in enrichment.
B. Tune for Timing. This includes timing targets, defining dynamic advance and setting your knock thresholds.

C. Tune for Boost/Timing/fuel together. This includes setting your boost targets, wastegate duty cycle low and high and turbo dynamics.
D. Tune for AVCS.
E. Adjust other special areas of the tune to compensate for specific hardware such as forged pistons, light weight flywheels and pulleys, larger injectors and the use of E85
F. Finally confirm and/or adjust everything again.

2 Tuning

2.1 Fuel _*Note: Closed loop fueling will be performed via log file interpretation. Open loop will use a combination of log file interpretation and Live tuning techniques._

2.1.1 Defining Fuel Targets

I. Global and Open Loop Fueling Targets…

*Note: Please be aware that you will define these tables beyond what is listed here when it comes time to tune for power. Right now we are limiting these tables to creating a base tune only.

The first thing you need to do is define your initial fuel targets. Since every other fuel related table references primary (base) fuel targets, either directly or indirectly, it is important to define this properly. In most situations the stock fueling is adequate how ever I am of the opinion that the stock fueling is way to rich in some areas and not rich enough in others. Stock mapping also varies greatly from year to year, but for the purposes of initial calibration and safety you will want to keep these close to stock to begin with. Other than that it is necessary to adjust these tables further to better suit the fuel and/or conditions being seen and for making power or safety, whatever strategy you are tuning for.

In this section we are going to prepare the fuel tables for initial use and for calibrating other parts of the tune like MAF scaling and compensation tables. This also gives us a fairly safe starting point to go WOT when the time comes.

In the GD chassis, fuel is defined only up to a load of 2.75 and, as previously mentioned in section 1.2, this will need to be adjusted and your AFR values will need to be interpolated. In the GR chassis the defined load cells are much higher so it is not likely you will have to maintain these load values much further. Even if your actual load is observed to be higher, the fueling defined is adequate to compensate. Only when your actual observed load approaches 4.00 in a GR will I re-interpolate the table. Some smoothing of the peaks and valleys should be performed as well. However, in the GR it is probably a good idea to readjust your AFR values because the stock tables are excessively lean in some areas and could be the reason for many of the issues observed with respect to ring land failures in the GR.

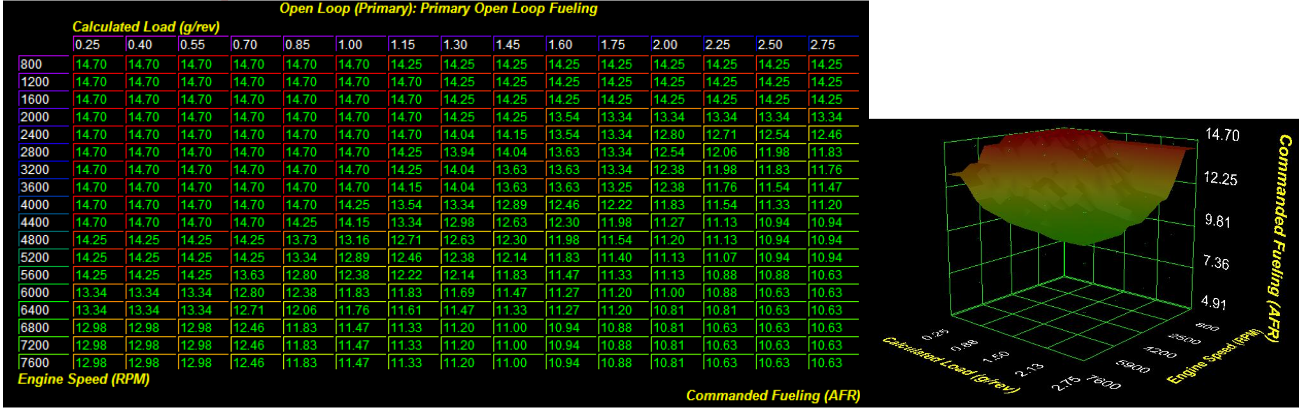
Ideal AFR's for gasoline are around 12.5:1 for making power in NA applications and 14.7:1 for ideal emissions during cruise and light to moderate throttle, however for turbo applications it should be richer for suppressing knock and for controlling Exhaust Gas Temps during WOT. You will likely want to maintain 14.7 afr in the cruise and light throttle regions of the fuel map. Then ramp down to 12.5 in the mid load cells up to something like 2.00 load and/or just before you reach working boost, but before Engine Speed of 5000rpm. Beyond that you will likely want to continue to richen the fuel mixture to control exhaust gas temperatures if you plan on running high levels of boost AND low timing. Typical starting point for this around 11.2:1 and depends also on the type of fuel you use. During the tuning process you can lean or richen the mixture to increase power and or control knock and EGT. It is important to understand the relationship between timing, fuel and boost together because the final strategy is going to define your fuel table… Essentially more timing results in less exhaust gas temps and less timing equals higher temps… Leaner fuel results in higher exhaust gas temps and rich equals less. You need to find the balance for your application and that balance will include power versus knock versus exhaust gas temps. You need to figure out how each effects power and knock and this is where tools like VirtualDyno come in.

Subsequently for a limp map, used only for acquiring a base line and estimated max load, you will want to make your WOT AFRs above load of 2.00 to be rich at first. Then as you get into the tuning process you can go back and adjust these values to suit your goal and power requirements.

For other fuels like E85, not only will you have to adjust the table for load but you will also need to adjust your AFR values throughout the entire table. For instance in the low load and RPM regions of the table you will want to lean your targets to achieve smoother closed loop operation and better economy and adversely in the higher RPM and Load regions you may wish to make your AFR targets between 11.8:1 and 11.5:1 as a good starting point for E85. Please refer to section 4.3 “Compensating for E85” for more detail.

In the following example I am showing the stock primary fuel table for the GD chassis. You will note that fuel is defined up to a load of 2.75. If we were to maintain this table and our load were to climb to 3.50 or higher, you may end up being to lean because the ECU will only adjust up to 2.75 and maintain that fuel for higher loads. Also take note of the smoothness (or lack thereof)….

(Note: The AFR’s in this example are stock values and not indicative of what I would consider good in any way. Focus on the concept only)



Open Loop (Primary): Primary Open Loop Fueling

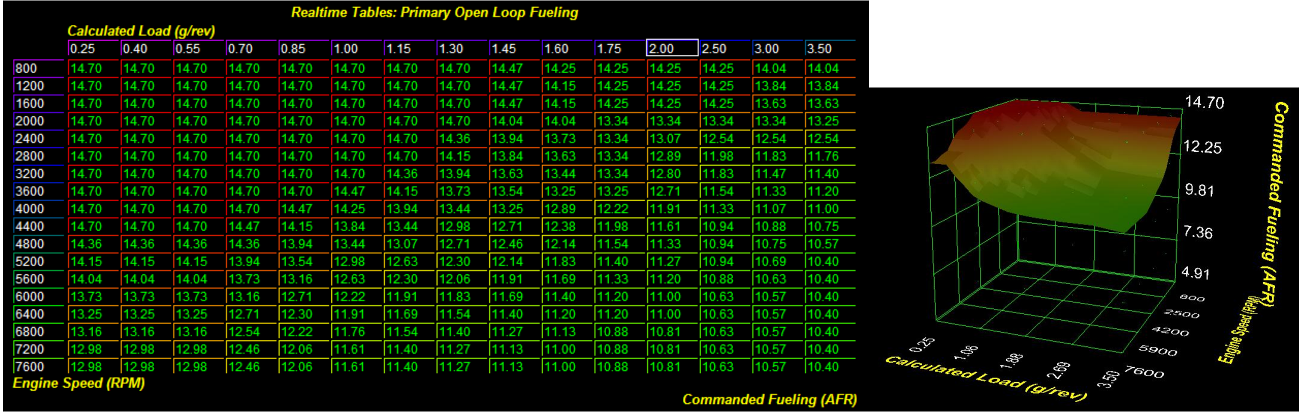
Calculated Load (g/rev)

	0.25	0.40	0.55	0.70	0.85	1.00	1.15	1.30	1.45	1.60	1.75	2.00	2.25	2.50	2.75
800	14.70	14.70	14.70	14.70	14.70	14.70	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25
1200	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25
1600	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25
2000	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.25	14.25	13.54	13.34	13.34	13.34	13.34	13.34
2400	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.04	14.15	13.54	13.34	12.80	12.71	12.54	12.46
2800	14.70	14.70	14.70	14.70	14.70	14.70	14.25	13.94	14.04	13.63	13.34	12.54	12.06	11.98	11.83
3200	14.70	14.70	14.70	14.70	14.70	14.70	14.25	14.04	13.63	13.63	13.34	12.38	11.98	11.83	11.76
3600	14.70	14.70	14.70	14.70	14.70	14.70	14.15	14.04	13.63	13.63	13.25	12.38	11.76	11.54	11.47
4000	14.70	14.70	14.70	14.70	14.70	14.25	13.54	13.34	12.89	12.46	12.22	11.83	11.54	11.33	11.20
4400	14.70	14.70	14.70	14.70	14.25	14.15	13.34	12.98	12.63	12.30	11.98	11.27	11.13	10.94	10.94
4800	14.25	14.25	14.25	14.25	13.73	13.16	12.71	12.63	12.30	11.98	11.54	11.20	11.13	10.94	10.94
5200	14.25	14.25	14.25	14.25	13.34	12.89	12.46	12.38	12.14	11.83	11.40	11.13	11.07	10.94	10.94
5600	14.25	14.25	14.25	13.63	12.80	12.38	12.22	12.14	11.83	11.47	11.33	11.13	10.88	10.88	10.63
6000	13.34	13.34	13.34	12.80	12.38	11.83	11.83	11.69	11.47	11.27	11.20	11.00	10.88	10.63	10.63
6400	13.34	13.34	13.34	12.71	12.06	11.76	11.61	11.47	11.33	11.27	11.20	10.81	10.81	10.63	10.63
6800	12.98	12.98	12.98	12.46	11.83	11.47	11.33	11.20	11.00	10.94	10.88	10.81	10.63	10.63	10.63
7200	12.98	12.98	12.98	12.46	11.83	11.47	11.33	11.20	11.00	10.94	10.88	10.81	10.63	10.63	10.63
7600	12.98	12.98	12.98	12.46	11.83	11.47	11.33	11.20	11.00	10.94	10.88	10.81	10.63	10.63	10.63

Engine Speed (RPM)

Commanded Fueling (AFR)

In this next example I am showing you a re-interpolated table with newly defined load cells for use as a base starting point. You can see how I left the stock values up to load of 2.00 (just smoothed) and then redefined the load cells higher than 2.00 and then redefined my fuel targets from that point with ever increasing rich values. This is usually my starting point for my base map…



Realtime Tables: Primary Open Loop Fueling

Calculated Load (g/rev)

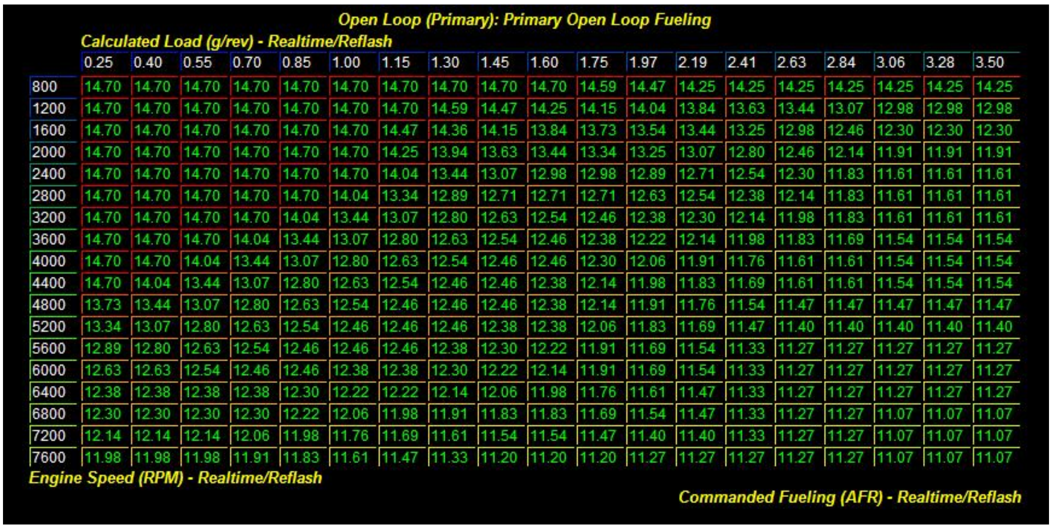
	0.25	0.40	0.55	0.70	0.85	1.00	1.15	1.30	1.45	1.60	1.75	2.00	2.50	3.00	3.50
800	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.47	14.25	14.25	14.25	14.25	14.04	14.04
1200	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.47	14.15	14.25	14.25	14.25	13.84	13.84
1600	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.47	14.15	14.25	14.25	14.25	13.63	13.63
2000	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.04	14.04	13.34	13.34	13.34	13.34	13.25
2400	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.36	13.94	13.73	13.34	13.07	12.54	12.54	12.54
2800	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.15	13.84	13.63	13.34	12.89	11.98	11.83	11.76
3200	14.70	14.70	14.70	14.70	14.70	14.70	14.36	13.94	13.63	13.44	13.34	12.80	11.83	11.47	11.40
3600	14.70	14.70	14.70	14.70	14.70	14.47	14.15	13.73	13.54	13.25	13.25	12.71	11.54	11.33	11.20
4000	14.70	14.70	14.70	14.70	14.47	14.25	13.94	13.44	13.25	12.89	12.22	11.91	11.33	11.07	11.00
4400	14.70	14.70	14.70	14.47	14.15	13.84	13.44	12.98	12.71	12.38	11.98	11.61	10.94	10.88	10.75
4800	14.36	14.36	14.36	14.36	13.94	13.44	13.07	12.71	12.46	12.14	11.54	11.33	10.94	10.75	10.57
5200	14.15	14.15	14.15	13.94	13.54	12.98	12.63	12.30	12.14	11.83	11.40	11.27	10.94	10.69	10.40
5600	14.04	14.04	14.04	13.73	13.16	12.63	12.30	12.06	11.91	11.69	11.33	11.20	10.88	10.63	10.40
6000	13.73	13.73	13.73	13.16	12.71	12.22	11.91	11.83	11.69	11.40	11.20	11.00	10.63	10.57	10.40
6400	13.25	13.25	13.25	12.71	12.30	11.91	11.69	11.54	11.40	11.20	11.20	11.00	10.63	10.57	10.40
6800	13.16	13.16	13.16	12.54	12.22	11.76	11.54	11.40	11.27	11.13	10.88	10.81	10.63	10.57	10.40
7200	12.98	12.98	12.98	12.46	12.06	11.61	11.40	11.27	11.13	11.00	10.88	10.81	10.63	10.57	10.40
7600	12.98	12.98	12.98	12.46	12.06	11.61	11.40	11.27	11.13	11.00	10.88	10.81	10.63	10.57	10.40

Engine Speed (RPM)

Commanded Fueling (AFR)

Tuned Map Examples

The following example is a Tuned fuel map designed for 93 octane gasoline. The timing was adjusted to the threshold of knock and then backed down a couple degrees. The timing was made as high as possible to control exhaust gas temperatures in this case.



Open Loop (Primary): Primary Open Loop Fueling

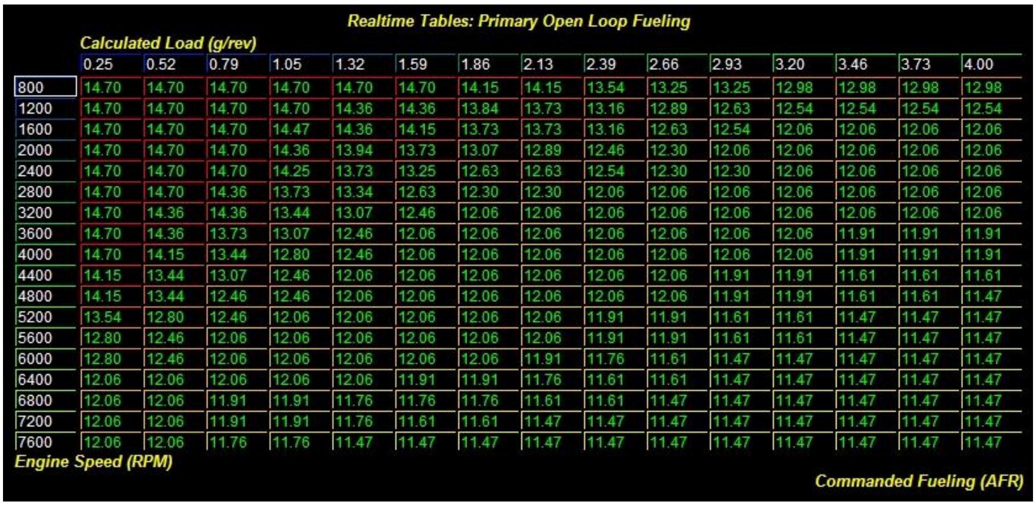
Calculated Load (g/rev) - Realtime/Reflash

	0.25	0.40	0.55	0.70	0.85	1.00	1.15	1.30	1.45	1.60	1.75	1.97	2.19	2.41	2.63	2.84	3.06	3.28	3.50
800	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.59	14.47	14.25	14.25	14.25	14.25	14.25	14.25	14.25
1200	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.59	14.47	14.25	14.15	14.04	13.84	13.63	13.44	13.07	12.98	12.98	12.98
1600	14.70	14.70	14.70	14.70	14.70	14.70	14.47	14.36	14.15	13.84	13.73	13.54	13.44	13.25	12.98	12.46	12.30	12.30	12.30
2000	14.70	14.70	14.70	14.70	14.70	14.70	14.25	13.94	13.63	13.44	13.34	13.25	13.07	12.80	12.46	12.14	11.91	11.91	11.91
2400	14.70	14.70	14.70	14.70	14.70	14.70	14.04	13.44	13.07	12.98	12.98	12.89	12.71	12.54	12.30	11.83	11.61	11.61	11.61
2800	14.70	14.70	14.70	14.70	14.70	14.04	13.34	12.89	12.71	12.71	12.71	12.63	12.54	12.38	12.14	11.83	11.61	11.61	11.61
3200	14.70	14.70	14.70	14.70	14.04	13.44	13.07	12.80	12.63	12.54	12.46	12.38	12.30	12.14	11.98	11.83	11.61	11.61	11.61
3600	14.70	14.70	14.70	14.04	13.44	13.07	12.80	12.63	12.54	12.46	12.38	12.22	12.14	11.98	11.83	11.69	11.54	11.54	11.54
4000	14.70	14.70	14.04	13.44	13.07	12.80	12.63	12.54	12.46	12.46	12.30	12.06	11.91	11.76	11.61	11.61	11.54	11.54	11.54
4400	14.70	14.04	13.44	13.07	12.80	12.63	12.54	12.46	12.46	12.38	12.14	11.98	11.83	11.69	11.61	11.61	11.54	11.54	11.54
4800	13.73	13.44	13.07	12.80	12.63	12.54	12.46	12.46	12.46	12.38	12.14	11.91	11.76	11.54	11.47	11.47	11.47	11.47	11.47
5200	13.34	13.07	12.80	12.63	12.54	12.46	12.46	12.46	12.38	12.38	12.06	11.83	11.69	11.47	11.40	11.40	11.40	11.40	11.40
5600	12.89	12.80	12.63	12.54	12.46	12.46	12.46	12.38	12.30	12.22	11.91	11.69	11.54	11.33	11.27	11.27	11.27	11.27	11.27
6000	12.63	12.63	12.54	12.46	12.46	12.38	12.38	12.30	12.22	12.14	11.91	11.69	11.54	11.33	11.27	11.27	11.27	11.27	11.27
6400	12.38	12.38	12.38	12.38	12.30	12.22	12.22	12.14	12.06	11.98	11.76	11.61	11.47	11.33	11.27	11.27	11.27	11.27	11.27
6800	12.30	12.30	12.30	12.30	12.22	12.06	11.98	11.91	11.83	11.83	11.69	11.54	11.47	11.33	11.27	11.27	11.07	11.07	11.07
7200	12.14	12.14	12.14	12.06	11.98	11.76	11.69	11.61	11.54	11.54	11.47	11.40	11.40	11.33	11.27	11.27	11.07	11.07	11.07
7600	11.98	11.98	11.98	11.91	11.83	11.61	11.47	11.33	11.20	11.20	11.20	11.27	11.27	11.27	11.27	11.27	11.07	11.07	11.07

Engine Speed (RPM) - Realtime/Reflash

Commanded Fueling (AFR) - Realtime/Reflash

The following example is even further defined because of the use of E85. In this example I modified the entire load cell range from .25 all the way up to 4.00. Since E85 generates significantly more load and thereby power, you need to redefine the entire load range to improve the over all resolution and transition from one load to the other. Essentially much of the stock values where simply re-interpolated to the left and new targets were defined for the new loads above 2.66. This example is a very conservative map for E85…



Realtime Tables: Primary Open Loop Fueling

Calculated Load (g/rev)

	0.25	0.52	0.79	1.05	1.32	1.59	1.86	2.13	2.39	2.66	2.93	3.20	3.46	3.73	4.00
800	14.70	14.70	14.70	14.70	14.70	14.70	14.15	14.15	13.54	13.25	13.25	12.98	12.98	12.98	12.98
1200	14.70	14.70	14.70	14.70	14.36	14.36	13.84	13.73	13.16	12.89	12.63	12.54	12.54	12.54	12.54
1600	14.70	14.70	14.70	14.47	14.36	14.15	13.73	13.73	13.16	12.63	12.54	12.06	12.06	12.06	12.06
2000	14.70	14.70	14.70	14.36	13.94	13.73	13.07	12.89	12.46	12.30	12.06	12.06	12.06	12.06	12.06
2400	14.70	14.70	14.70	14.25	13.73	13.25	12.63	12.63	12.54	12.30	12.30	12.06	12.06	12.06	12.06
2800	14.70	14.70	14.36	13.73	13.34	12.63	12.30	12.30	12.06	12.06	12.06	12.06	12.06	12.06	12.06
3200	14.70	14.36	14.36	13.44	13.07	12.46	12.06	12.06	12.06	12.06	12.06	12.06	12.06	12.06	12.06
3600	14.70	14.36	13.73	13.07	12.46	12.06	12.06	12.06	12.06	12.06	12.06	12.06	11.91	11.91	11.91
4000	14.70	14.15	13.44	12.80	12.46	12.06	12.06	12.06	12.06	12.06	12.06	12.06	11.91	11.91	11.91
4400	14.15	13.44	13.07	12.46	12.06	12.06	12.06	12.06	12.06	12.06	11.91	11.91	11.61	11.61	11.61
4800	14.15	13.44	12.46	12.46	12.06	12.06	12.06	12.06	12.06	12.06	11.91	11.91	11.61	11.61	11.47
5200	13.54	12.80	12.46	12.06	12.06	12.06	12.06	12.06	11.91	11.91	11.61	11.61	11.47	11.47	11.47
5600	12.80	12.46	12.06	12.06	12.06	12.06	12.06	12.06	11.91	11.91	11.61	11.61	11.47	11.47	11.47
6000	12.80	12.46	12.06	12.06	12.06	12.06	12.06	11.91	11.76	11.61	11.47	11.47	11.47	11.47	11.47
6400	12.06	12.06	12.06	12.06	12.06	11.91	11.91	11.76	11.61	11.61	11.47	11.47	11.47	11.47	11.47
6800	12.06	12.06	11.91	11.91	11.76	11.76	11.76	11.61	11.61	11.47	11.47	11.47	11.47	11.47	11.47
7200	12.06	12.06	11.91	11.91	11.76	11.61	11.61	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47
7600	12.06	12.06	11.76	11.76	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47

Engine Speed (RPM)

Commanded Fueling (AFR)

Other tables to consider

Another fuel table to consider is your Fail Safe targets. These tables should always be richer than your primary fuel targets globally I simply make these tables 5% richer in the mid and high load regions of the fuel maps.

II. Closed Loop Targets…

When defining your closed loop targets, one strategy is to make your closed loop targets to be the same as open loop. This will help with closed to open loop transitions and it will smooth out the overall results of your tune. To do it you want to simply zero out the closed loop targets. This table simply references the Open Loop targets and by zeroing it you effectively inherit the open loop targets for closed loop. See the following example…

Closed Loop Target: Closed Loop Fueling Target Compensation (Load)

Calculated Load (g/rev)

	0.20	0.35	0.50	0.65	0.80	0.95	1.10	1.25	1.40	1.55	1.70	1.85	2.00
800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Engine Speed (RPM)

Fueling Target Adder (AFR)

However in the GR, the ECU logic is more sensitive to these adjustments. In the past when these values are zeroed it causes the ECU to revert to Open Loop operation always. One strategy found to work is to make all the values -.001 instead of 0. Also be aware that, for the GR, there is a table for cruise and non-cruise conditions and you will need to touch them both.

You can also use this table to employ economy maps for customers wishing to increase fuel efficiency during normal and cruising driving situations. This table references the Primary Open Loop table directly and is simply an AFR adder, So if you increase a cell by .2 your resulting AFR will be what ever the primary fuel table has defined for that RPM/Load cell plus .2… So if the open loop AFR is targeted for 14.7, the closed loop target and resulting AFR will be 14.9. Positive values = leaner, Negative values = richer.

When using E85 it is good to make your closed loop targets leaner in the low load/rpm regions of the map to conserve fuel during light throttle and cruise.

2.1.2 Create your starting point

Before you continue it is best to start out with a **stock MAF housing and intake**. If there is an aftermarket unit installed, it should be removed and a stock unit should be installed temporarily. If this is not possible then reference section III below "Larger MAF Housing (Intake)".

Before you proceed any further, it is necessary to prepare your map for some of the hardware changes that were performed. Things such as larger injectors, a larger MAF housing or intake or a turbo are taken into account in this step. This will give you an initial limp tune for you to start with and allow you to continue further with the tune. Please be patient with the way the car runs at this point. It will get much better as we go. If you do it right you should have little problems with starting and running the car.

I. Defaults…

First you want to set all your default limits and thresholds.

a. Set your "Default Dynamic Advance Multiplier" or DAM (IAM) value. I usually set this to ".8" so the ECU does not have to wait for correction mode to effect a significant change in DAM (IAM). It will maintain a fairly high value from the gate and apply most of your dynamic advance immediately. You will know when the ECU has gone into correction mode by observing the DAM to increase to 1. If there is something wrong it will fall.

Another method is to simply set this to default initial value of one. This will allow 100% DAM (IAM) to be applied right away. Do this only if you are sure things are good with timing and fuel.

Others like to leave this value stock and wait till DAM effects a change to correction mode. The idea here is to wait to observe a positive change in DAM to the max of 1, and if it does not, then there is reason to believe that something is wrong and you need to figure out what is causing an issue. The other reason is to maintain minimal Dynamic Advance till you are certain conditions are right for full DAM
Note: When the time comes to log, it is necessary to drive the car for about ten minutes under varying load to allow the ECU to affect Correction Mode. You can sometimes force correction mode by reaching a mid-high load under acceleration. Once in correction mode, it is ok to log.

b. Set your "DAM (IAM) Threshold for Open Loop Fueling" (lower limit failsafe switch over point). This is set to .35 by default. IMO damage has occurred by the time your ECU reaches that value. Essentially anything other than a DAM value of 1 indicates a problem so I will set this threshold to .75. This way if DAM falls below that point, it will activate all the fail safe tables to protect your engine immediately upon a reduction in DAM.

c. Adjust your "Course Knock Learning load range" to coincide with the load values you defined in your fuel targets.

d. Adjust your "Fine Knock Learning load range" to coincide with the load values you defined in your fuel targets.

e. Set your "MAF limits". 500g/s is sufficient for most applications.

f. Set your "Load Limits". For very large turbo applications it would be prudent to set this to at least 5. For the GD there is just one table to concern your self with.

For the GR there is a second table "B" that references RPM as well. The load limit for this table is 4 and if you require more than that, then please refer to the "tips and tricks" section of the document for an advanced solution (RomRaider Only). To get your self started you can set your max load to 4 and see if that is good enough. For large turbo applications it is likely you will exceed an actual load of 4 and approach 5 or more.

For those using AccessTuner Race, you will need to perform this interim method until a proper solution can be devised. This less advanced method will have you manipulate your injector and MAF scale to fool the ECU and change the way it calculates load. However this method has an effect on many other tables and the results are not always optimal. This is why I recommend the advanced method as outlined in the Tips and Tricks section of this procedure.

The interim method: (currently the only solution for AccessTuner Race users)
To start you will need to reduce your injector scale (RomRaider) by 15% to 20% and increase your entire maf scale by the same amount. *Remember that in AccessTuner Race you will increase the number for injector scale, not reduce it.* Then you need to locate every table that has "load" as an axis and reduce the values with in the entire axis by 15% to 20% same as you did for injector scale

g. If Applicable, Set your FFS and LC defaults.

h. Set your Idle Speed

i. Set your Rev Limit. Subject to hardware being used. For instance you should maintain stock limits if you are maintaining a stock block with stock rods regardless of other valve train upgrades. Even though the valve train may handle the extra RPM, the rods won't

j. Set Vehicle Speed limit. Just put something like 300mph. If they get that high then more power to them LOL.

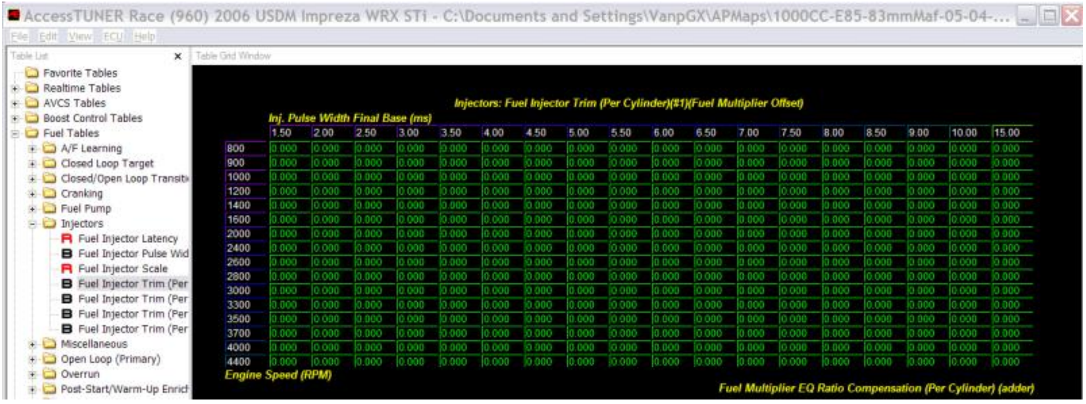
k. Set your initial timing targets and load axis. It is best to start with stock or stage 2 values and work up from there later on. You will need to rescale the load axis as you did with the primary fuel tables and re-interpolate the values to coincide.

II. ***Larger Injectors…*** **This step is not necessary if using stock injectors.**

Note: To determine if larger injectors are required you will need to log Injector Duty Cycle at WOT to determine that. Typically most tuners don't like to see IDC exceeding 85-90% for any prolonged time. If you log more than 90% IDC, I would recommend a larger injector. This doesn't mean that more than 90% is bad… It just means that you are getting close to maxing out the injectors and changes in atmosphere and temperature can have profound effects on IDC and can push these over 100% in many cases.

Note: For best results perform this step with the STOCK MAF and intake installed

a. If installing injectors larger than 740cc, the first thing you will want to do is zero out the per cylinder trims. There is no need to maintain this at this time because these tables have to be specifically defined for the injectors being used. Some will argue that this is also compensating for variations in the cylinder itself and they would be right. But the differences in the injectors far out weigh the cylinder and tuning and adjusting these tables will require the use of an exhaust temperature gauge at each cylinder. It is not very practical but if you want the ultimate perfect tune, then consider that as an alternative tuning method.



Injectors: Fuel Injector Trim (Per Cylinder)(#1)(Fuel Multiplier Offset)

Inj. Pulse Width Final Base (ms)

	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	10.00	15.00
800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
900	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3700	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Engine Speed (RPM)

Fuel Multiplier EQ Ratio Compensation (Per Cylinder) (adder)

b. Then you will set your Theoretical injector scale value and starting point. To do so you must know what the stock injectors flow for the car you are tuning. For the GD with side feed injectors I have found a stock injector size of 540cc to be the correct size, and for the GR it is 562cc (subject to verification). Now find the flow data for the new injectors and look for the measured (actual) static flow rate. For the purposes of this example I will use 1000cc injectors. In ATR go to "Injectors" and "Fuel Injector Scale" and take note of that number. For the GD STi it is 5372 (may be different for other models like the WRX). To calculate your new theoretical scale value you will take the Old Injector size and multiply it by the current scale and then divide that by the New Injector size.

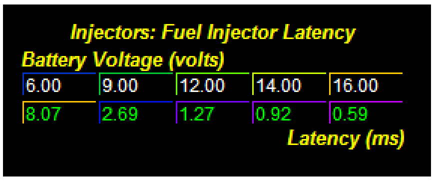
Example:
*(Old injector * Current Scale) / New Injector = New Injector Scale*

*(540 * 5372) / 1000 = 2901*

2901 will be your starting Fuel Injector Scale for this example. If using E85 then you must also multiply this value by 1.27 for a final result of 3684 as the starting point.

In RomRaider it is as simple as entering the new injector static flow rate. For E85 you will take the new injector size and multiply it by .73

c. Set your initial Injector Latency Values. If the manufacturer of the injectors did not provide this information it will be nearly impossible to get this exactly right. You will have to compensate for any discrepancies with MAF scaling. Locate the flow data sheet and populate the latency values exactly as described on the flow data sheet. You may change the voltage values in this table to coincide with the measured values in the data sheet.



Injectors: Fuel Injector Latency

Battery Voltage (volts)

6.00	9.00	12.00	14.00	16.00
8.07	2.69	1.27	0.92	0.59

Latency (ms)

If you do not have the latency values then you can find the closest match found in the AccessTuner Calibration & Tuning Guide worksheet by Cobb for either side feed or top feed injectors of respective size.

III. Larger MAF Housing (Intake) **This step is not necessary if using stock sized MAF housing.**

Note: To determine if you need a MAF housing, you need to log MAF Voltage at WOT to determine that. If, at WOT, you see the voltage approaching the maximum (4.92v), then a larger MAF is recommended. Typically I will change to a larger MAF if I start to reach 4.77v.

Note: This step is not necessary if using stock MAF housing. ***Important:*** *Please ensure that either the injectors have been scaled properly if using larger injectors, or install stock injectors and scaling for the purposes of calibrating the MAF..*

a. For the new larger intake, Physically measure the inside diameter of the area just before the MAF sensor location using either a caliper or bore gauge. It is important you know the exact size of the new housing. It may be good to also measure the old original equipment housing diameter since the initial calibration is based off of the stock housing. If the customer has already replaced the intake and the original is not available, then use 66.5mm as the stock value for the GD chassis. I am uncertain of what the stock intake size is for the GR chassis.

b. Now that you know the MAF housing sizes for stock and the new housing you need to calculate the multiplier you will apply to the entire stock MAF calibration. To do this you need to apply the following formula.

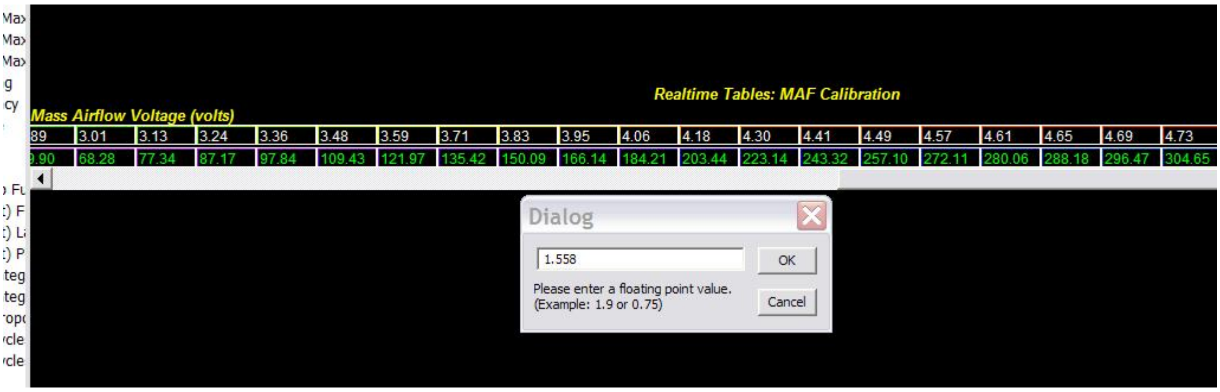
Example: *using old MAF of 66mm and new MAF of 83mm*

*(4 * 3.14159 * (New MAF / 2)) / (4 * 3.14159 * (Old MAF / 2)) = Multiplier*

*(12.56636 * 41.5) / (12.56636 * 33) = Multiplier*

521.50394 / 414.68988 = 1.26

c. You will now take the multiplier and apply it to the entire MAF scale by highlighting the entire MAF table and hitting the "M" key. Enter the multiplier and click ok to apply the multiplier.



Realtime Tables: MAF Calibration

Mass Airflow Voltage (volts)

89	3.01	3.13	3.24	3.36	3.48	3.59	3.71	3.83	3.95	4.06	4.18	4.30	4.41	4.49	4.57	4.61	4.65	4.69	4.73
9.90	68.28	77.34	87.17	97.84	109.43	121.97	135.42	150.09	166.14	184.21	203.44	223.14	243.32	257.10	272.11	280.06	288.18	296.47	304.65

1.558

Please enter a floating point value.
(Example: 1.9 or 0.75)

In RomRaider you will highlight the entire table and insert the multiplier value into the form field next to the “set” and “mul” buttons in the table and select “mul”.

This will get you close to where you need to be but further calibration will be required as discussed further on.

2.1.3 Scaling the Injectors

This should be done with the stock intake and MAF scaling installed. It will make the entire process faster. If this is not possible it is okay to continue. The results will smooth out as this procedure continues

It is now time to flash the base map and start the car for the first time. When you do this it may not run very well at all. Be patient and it should smooth out rather quickly. Before you continue with any logging or tuning you must allow the engine to reach operating temperatures. If the car does not start or it runs to bad to continue, you need to immediately observe your AFR from your wide band and your A/F Correction and A/F Learned monitors in ATR or from the AP to see what is going on. It is likely that things are way to rich or lean to start and you may need to go back and check your measurements and data assumptions and make adjustments to injector or MAF scale accordingly.

If the car does run, then you can proceed.

I. Latency and initial evaluation

***Note: You will need to download the latest version of the Trim Error Tool and the Load Comp Tool. Both can be found here, http://www.drift-ready.com/Files/TrimErrorsTool.xls and here: http://www.drift-ready.com/Files/LoadComps.xls*

I credit the folks at RomRaider for these tools. The versions I list in this link are slightly modified for preference. For the raw unmodified versions please visit the RomRaider forums to download the latest versions.

First you need to collect data to see what you need to adjust and by how much. The first thing we want to focus our attention on is Latency. If your latency is not correct you may have issues scaling the MAF properly or if the voltage in your car is not consistent you will suffer inconsistent and erratic fueling issues. Here I will show you some tools I use to derive an accurate latency and scale.

a. Set up ATR, RomRaider or the AP to datalog the following parameter. (For the GR you will want to set your throttle response to “S” versus “S#” for smoother throttle transitions.)

- A/F Correction #1
- A/F Learned #1
- A/F Sensor Ratio #1
- MAF Voltage
- Calculated Load

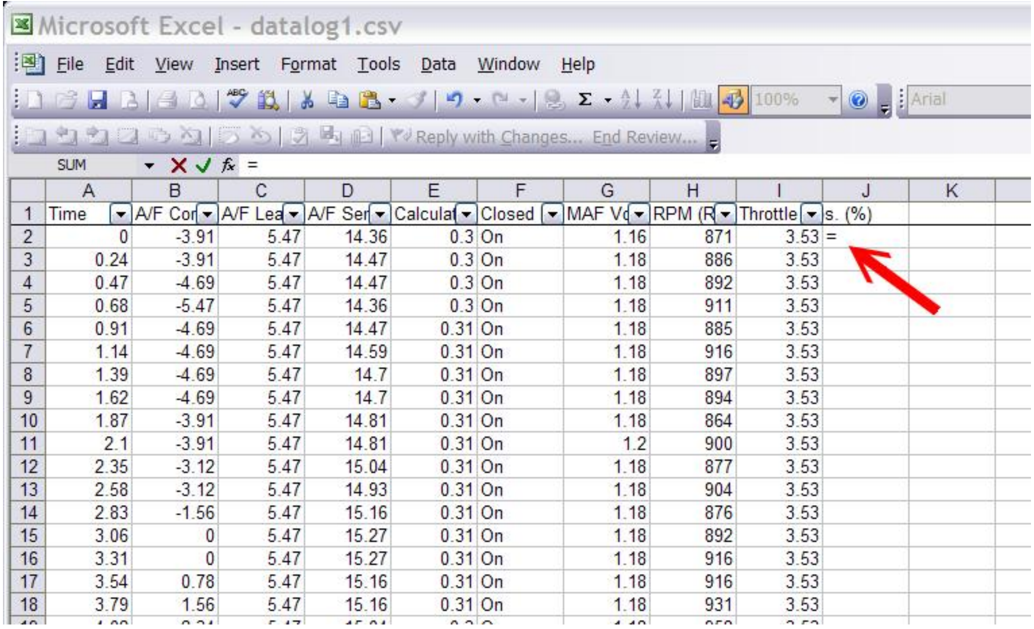
- RPM
- Close loop/Open loop Switch
- Throttle Position
- Connected AFR Gauge

b. With the car fully warmed, take it out for a 15 minute drive while logging. The whole time observing your AFR’s and fuel trims. DO NOT go WOT at this time. Please use smooth throttle inputs and try to get both town and highway driving. Try to vary the load by selecting roads with varying grades.

c. Upon your return you need to view the log and properly filter it for use using Excel’s Auto Filter feature. Essentially we ant to get rid of the following rows of data…
  1. Closed Loop/Open Loop Switch = off (“10” in RomRaider)
  2. Calculated Load < .05 AND A/F Sensor Ration < 13
  3. A/F Sensor Ratio > 16

d. After filtering the data you want to create two new columns to allow easy copy and paste into the Trim Error tool.

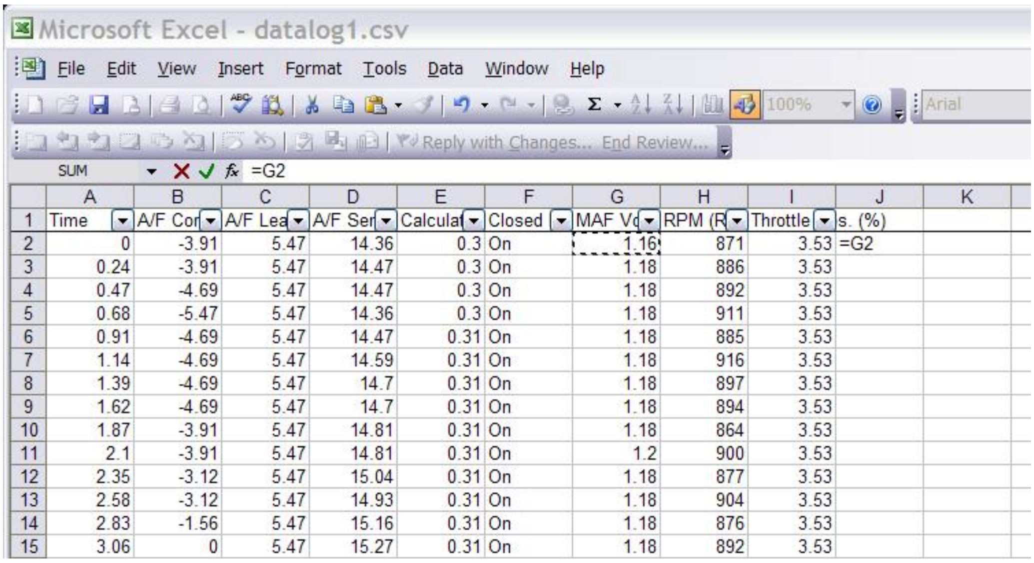
To do so click on the last cell in the first row of data and hit the “=” key.



SUM =

	A	B	C	D	E	F	G	H	I	J	K
1	Time	A/F Cor	A/F Lea	A/F Ser	Calculat	Closed	MAF Vo	RPM (R	Throttle	s. (%)	
2	0	-3.91	5.47	14.36	0.3	On	1.16	871	3.53	=	
3	0.24	-3.91	5.47	14.47	0.3	On	1.18	886	3.53		
4	0.47	-4.69	5.47	14.47	0.3	On	1.18	892	3.53		
5	0.68	-5.47	5.47	14.36	0.3	On	1.18	911	3.53		
6	0.91	-4.69	5.47	14.47	0.31	On	1.18	885	3.53		
7	1.14	-4.69	5.47	14.59	0.31	On	1.18	916	3.53		
8	1.39	-4.69	5.47	14.7	0.31	On	1.18	897	3.53		
9	1.62	-4.69	5.47	14.7	0.31	On	1.18	894	3.53		
10	1.87	-3.91	5.47	14.81	0.31	On	1.18	864	3.53		
11	2.1	-3.91	5.47	14.81	0.31	On	1.2	900	3.53		
12	2.35	-3.12	5.47	15.04	0.31	On	1.18	877	3.53		
13	2.58	-3.12	5.47	14.93	0.31	On	1.18	904	3.53		
14	2.83	-1.56	5.47	15.16	0.31	On	1.18	876	3.53		
15	3.06	0	5.47	15.27	0.31	On	1.18	892	3.53		
16	3.31	0	5.47	15.27	0.31	On	1.18	916	3.53		
17	3.54	0.78	5.47	15.16	0.31	On	1.18	916	3.53		
18	3.79	1.56	5.47	15.16	0.31	On	1.18	931	3.53		

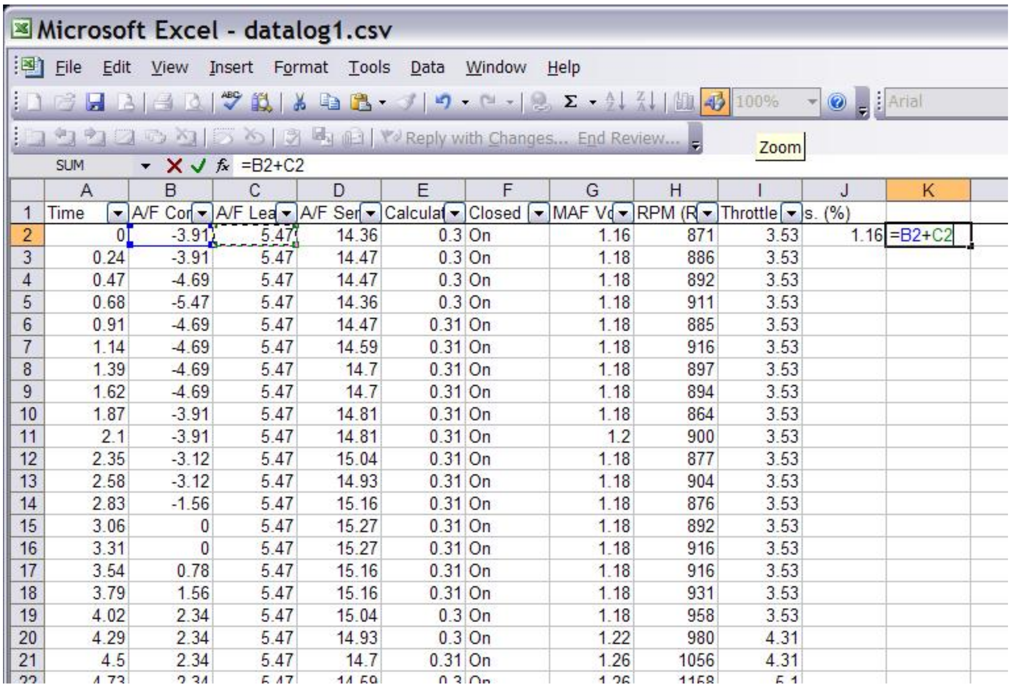
Then click on the cell in the Maf Voltage column in the same row and press enter.



=G2

	A	B	C	D	E	F	G	H	I	J	K
1	Time	A/F Cor	A/F Lea	A/F Sen	Calculat	Closed	MAF Vo	RPM (R	Throttle	s. (%)	
2	0	-3.91	5.47	14.36	0.3	On	1.16	871	3.53	=G2	
3	0.24	-3.91	5.47	14.47	0.3	On	1.18	886	3.53		
4	0.47	-4.69	5.47	14.47	0.3	On	1.18	892	3.53		
5	0.68	-5.47	5.47	14.36	0.3	On	1.18	911	3.53		
6	0.91	-4.69	5.47	14.47	0.31	On	1.18	885	3.53		
7	1.14	-4.69	5.47	14.59	0.31	On	1.18	916	3.53		
8	1.39	-4.69	5.47	14.7	0.31	On	1.18	897	3.53		
9	1.62	-4.69	5.47	14.7	0.31	On	1.18	894	3.53		
10	1.87	-3.91	5.47	14.81	0.31	On	1.18	864	3.53		
11	2.1	-3.91	5.47	14.81	0.31	On	1.2	900	3.53		
12	2.35	-3.12	5.47	15.04	0.31	On	1.18	877	3.53		
13	2.58	-3.12	5.47	14.93	0.31	On	1.18	904	3.53		
14	2.83	-1.56	5.47	15.16	0.31	On	1.18	876	3.53		
15	3.06	0	5.47	15.27	0.31	On	1.18	892	3.53		

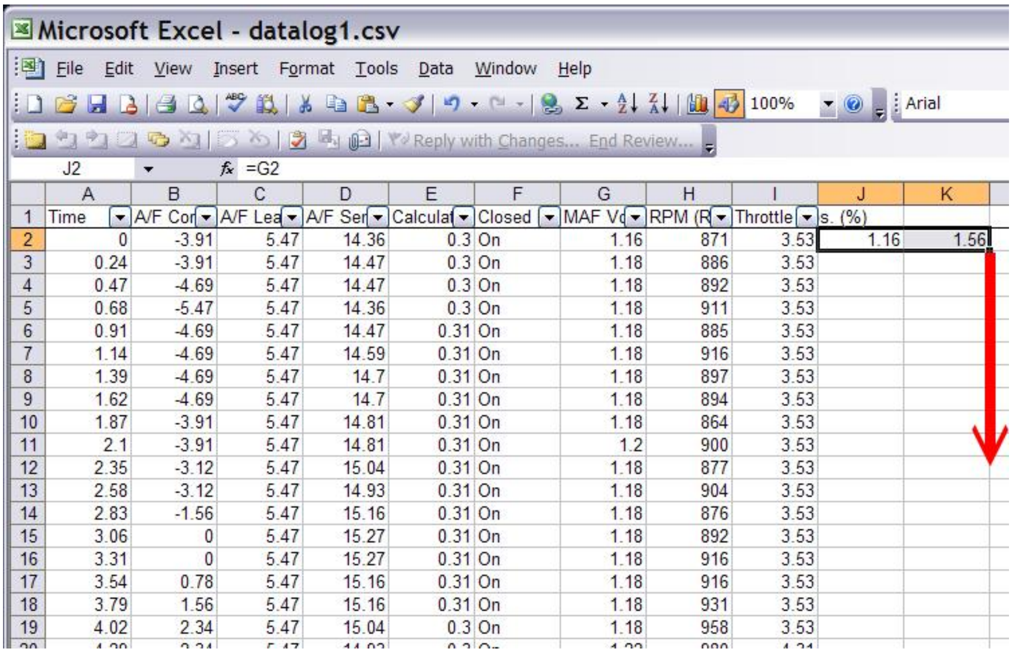
Now for the next adjacent cell you want to add A/F Correction and A/F Learned together. To do so, hit the "=" key and click on the A/F Correction cell in the same row, hit "SHIFT and +" and then click on the A/F learned cell in the same row and hit "ENTER"



=B2+C2

	A	B	C	D	E	F	G	H	I	J	K
1	Time	A/F Cor	A/F Lea	A/F Sen	Calculat	Closed	MAF Vo	RPM (R	Throttle	s. (%)	
2	0	-3.91	5.47	14.36	0.3	On	1.16	871	3.53	1.16	=B2+C2
3	0.24	-3.91	5.47	14.47	0.3	On	1.18	886	3.53		
4	0.47	-4.69	5.47	14.47	0.3	On	1.18	892	3.53		
5	0.68	-5.47	5.47	14.36	0.3	On	1.18	911	3.53		
6	0.91	-4.69	5.47	14.47	0.31	On	1.18	885	3.53		
7	1.14	-4.69	5.47	14.59	0.31	On	1.18	916	3.53		
8	1.39	-4.69	5.47	14.7	0.31	On	1.18	897	3.53		
9	1.62	-4.69	5.47	14.7	0.31	On	1.18	894	3.53		
10	1.87	-3.91	5.47	14.81	0.31	On	1.18	864	3.53		
11	2.1	-3.91	5.47	14.81	0.31	On	1.2	900	3.53		
12	2.35	-3.12	5.47	15.04	0.31	On	1.18	877	3.53		
13	2.58	-3.12	5.47	14.93	0.31	On	1.18	904	3.53		
14	2.83	-1.56	5.47	15.16	0.31	On	1.18	876	3.53		
15	3.06	0	5.47	15.27	0.31	On	1.18	892	3.53		
16	3.31	0	5.47	15.27	0.31	On	1.18	916	3.53		
17	3.54	0.78	5.47	15.16	0.31	On	1.18	916	3.53		
18	3.79	1.56	5.47	15.16	0.31	On	1.18	931	3.53		
19	4.02	2.34	5.47	15.04	0.3	On	1.18	958	3.53		
20	4.29	2.34	5.47	14.93	0.3	On	1.22	980	4.31		
21	4.5	2.34	5.47	14.7	0.31	On	1.26	1056	4.31		
22	4.73	2.34	5.47	14.59	0.3	On	1.26	1158	5.1		

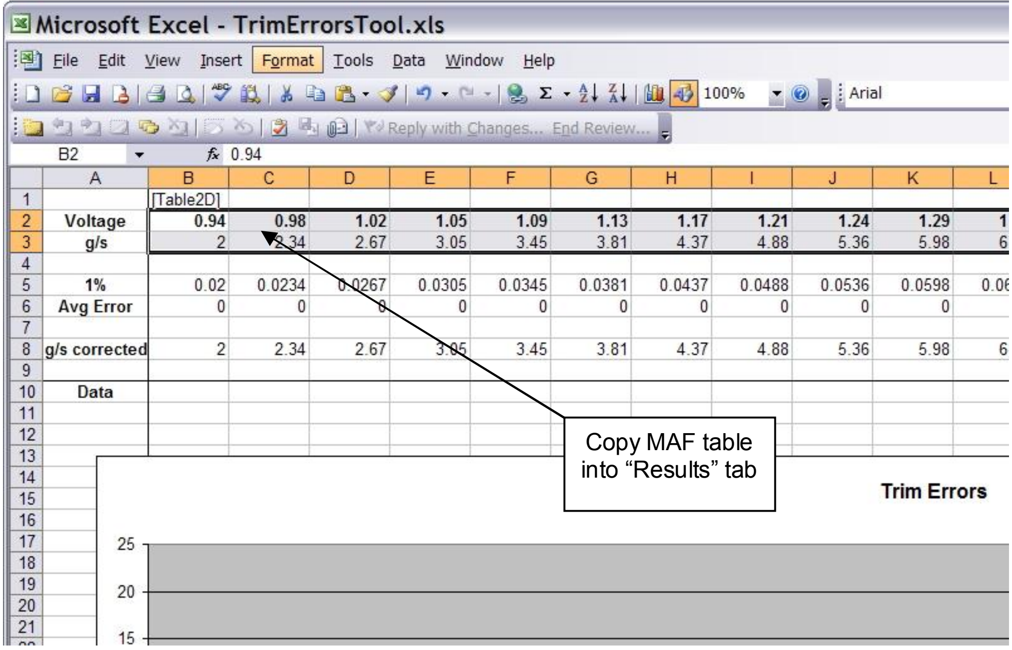
Now copy that formula down to the rest of the data by highlighting the two new cells Double click on the drag point to auto fill to the last row.



J2 =G2

	A	B	C	D	E	F	G	H	I	J	K
1	Time	A/F Cor	A/F Lea	A/F Ser	Calculat	Closed	MAF Vo	RPM (R	Throttle	s. (%)	
2	0	-3.91	5.47	14.36	0.3	On	1.16	871	3.53	1.16	1.56
3	0.24	-3.91	5.47	14.47	0.3	On	1.18	886	3.53		
4	0.47	-4.69	5.47	14.47	0.3	On	1.18	892	3.53		
5	0.68	-5.47	5.47	14.36	0.3	On	1.18	911	3.53		
6	0.91	-4.69	5.47	14.47	0.31	On	1.18	885	3.53		
7	1.14	-4.69	5.47	14.59	0.31	On	1.18	916	3.53		
8	1.39	-4.69	5.47	14.7	0.31	On	1.18	897	3.53		
9	1.62	-4.69	5.47	14.7	0.31	On	1.18	894	3.53		
10	1.87	-3.91	5.47	14.81	0.31	On	1.18	864	3.53		
11	2.1	-3.91	5.47	14.81	0.31	On	1.2	900	3.53		
12	2.35	-3.12	5.47	15.04	0.31	On	1.18	877	3.53		
13	2.58	-3.12	5.47	14.93	0.31	On	1.18	904	3.53		
14	2.83	-1.56	5.47	15.16	0.31	On	1.18	876	3.53		
15	3.06	0	5.47	15.27	0.31	On	1.18	892	3.53		
16	3.31	0	5.47	15.27	0.31	On	1.18	916	3.53		
17	3.54	0.78	5.47	15.16	0.31	On	1.18	916	3.53		
18	3.79	1.56	5.47	15.16	0.31	On	1.18	931	3.53		
19	4.02	2.34	5.47	15.04	0.3	On	1.18	958	3.53		

Now open up the Trim Error tool. Before you continue you will need to copy the current maps entire MAF table from ATR or RomRaider into the "results" tab of the tool. Always start with a fresh tool. It is good to immediately save the tool with some other descriptive file name. Something like "TrimErrors_GeorgesTune_5-5-2011_A.xls". This will help you keep track of the progress as you continue to create these files and it will also impress your customers for your thoroughness.

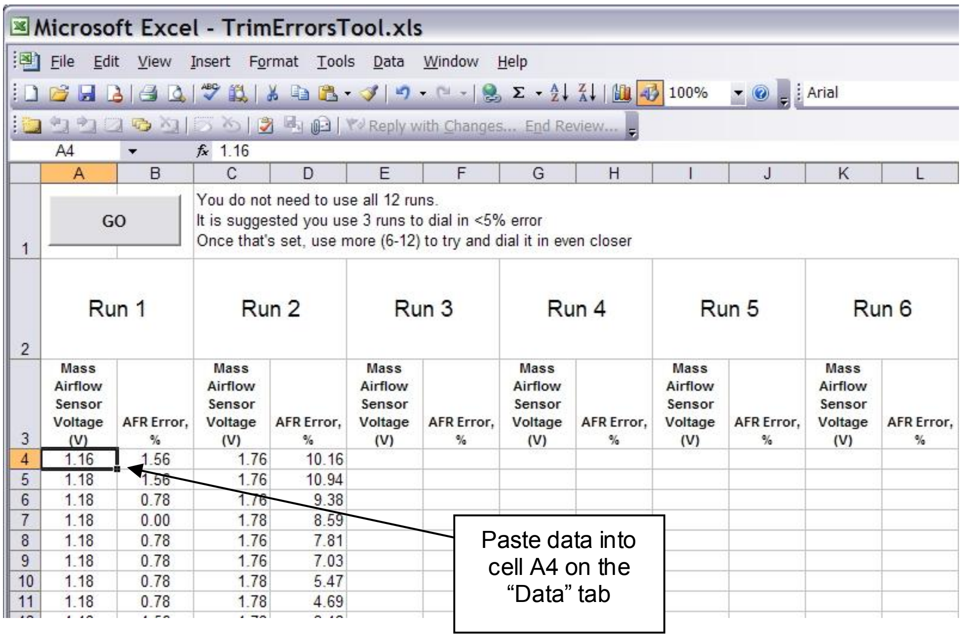


B2 0.94

	A	B	C	D	E	F	G	H	I	J	K	L
1		[Table2D]										
2	**Voltage**	**0.94**	**0.98**	**1.02**	**1.05**	**1.09**	**1.13**	**1.17**	**1.21**	**1.24**	**1.29**	**1**
3	**g/s**	2	2.34	2.67	3.05	3.45	3.81	4.37	4.88	5.36	5.98	6
4												
5	**1%**	0.02	0.0234	0.0267	0.0305	0.0345	0.0381	0.0437	0.0488	0.0536	0.0598	0.06
6	**Avg Error**	0	0	0	0	0	0	0	0	0	0	
7												
8	**g/s corrected**	2	2.34	2.67	3.05	3.45	3.81	4.37	4.88	5.36	5.98	6
9												
10	**Data**											

Copy MAF table into "Results" tab

Using the "Paste Special" option, copy and paste in the values you created in the Datalog file. It is important to know that the tool only considers the first 4000 lines of data. If your log is more than 4000 lines you will need to split the data into the subsequent runs as shown below.



You do not need to use all 12 runs.
It is suggested you use 3 runs to dial in <5% error
Once that's set, use more (6-12) to try and dial it in even closer

	Run 1		Run 2		Run 3		Run 4		Run 5		Run 6	
3	Mass Airflow Sensor Voltage (V)	AFR Error, %	Mass Airflow Sensor Voltage (V)	AFR Error, %	Mass Airflow Sensor Voltage (V)	AFR Error, %	Mass Airflow Sensor Voltage (V)	AFR Error, %	Mass Airflow Sensor Voltage (V)	AFR Error, %	Mass Airflow Sensor Voltage (V)	AFR Error, %
4	1.16	1.56	1.76	10.16								
5	1.18	1.56	1.76	10.94								
6	1.18	0.78	1.76	9.38								
7	1.18	0.00	1.78	8.59								
8	1.18	0.78	1.76	7.81								
9	1.18	0.78	1.76	7.03								
10	1.18	0.78	1.78	5.47								
11	1.18	0.78	1.78	4.69								

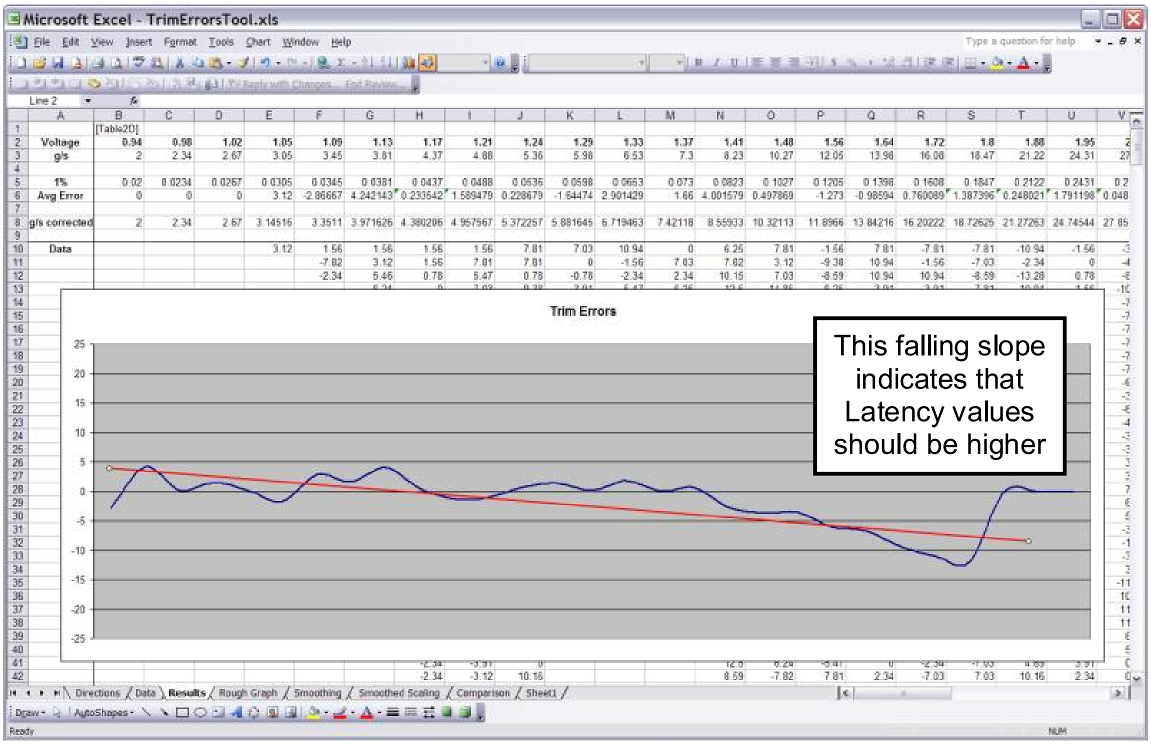
Paste data into cell A4 on the "Data" tab

Tip: TD_D

If people are brave, the Matlab or opensource version will take less than a minute on massive logs - huge time save.

In the "Data" tab you may now hit the "Go" button. The tool will begin to compile the results. It may take quite a while to complete so be patient. The longer the log the longer it will take but the more accurate the results will be. For the purposes of the initial evaluation a long log file is not necessary.

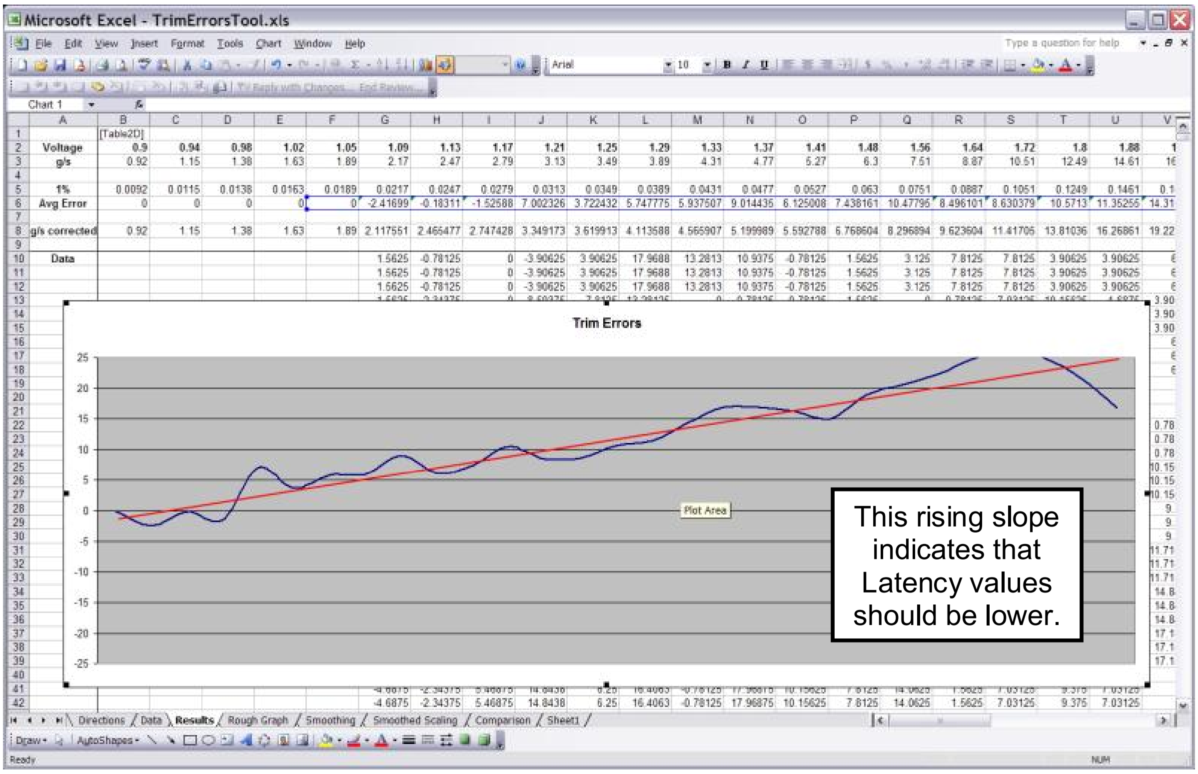
Once the tool completes, have a look at the "Results" tab. You can see that I drew a line through the average plane of the data to reveal the latency slope. Note that in the first example the slope begins around 4% trim error and ends around -4% for a total difference of 8%. Also note the slope itself as it will either rise or fall. A rising slope indicates that your latencies are too high and they need to be decreased. A falling slope indicates your latencies to be too low and they need to be increased. In other words if your idle trims are high (lean) you need more latency. If your idle trims are low (rich) you need less.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1		[Table2D]																			
2	Voltage	0.94	0.98	1.02	1.05	1.09	1.13	1.17	1.21	1.24	1.29	1.33	1.37	1.41	1.48	1.56	1.64	1.72	1.8	1.88	1.95
3	g/s	2	2.34	2.67	3.05	3.45	3.81	4.37	4.88	5.36	5.98	6.53	7.3	8.23	10.27	12.05	13.98	16.08	18.47	21.22	24.31
4																					
5	1%	0.02	0.0234	0.0267	0.0305	0.0345	0.0381	0.0437	0.0488	0.0536	0.0598	0.0653	0.073	0.0823	0.1027	0.1205	0.1398	0.1608	0.1847	0.2122	0.2431
6	Avg Error	0	0	0	3.12	-2.86667	4.242143	0.233542	1.589479	0.228679	-1.64474	2.901429	1.66	4.001579	0.497869	-1.273	-0.98594	0.760089	1.387396	0.248021	1.791198
7																					
8	g/s corrected	2	2.34	2.67	3.14516	3.3511	3.971626	4.380206	4.957567	5.372257	5.881645	6.719463	7.42118	8.55933	10.32113	11.8966	13.84216	16.20222	18.72625	21.27263	24.74544
9																					
10	Data				3.12	1.56	1.56	1.56	1.56	7.81	7.03	10.94	0	6.25	7.81	-1.56	7.81	-7.81	-7.81	-10.94	-1.56
11						-7.82	3.12	1.56	7.81	7.81	0	-1.56	7.03	7.82	3.12	-9.38	10.94	-1.56	-7.03	-2.34	0
12						-2.34	5.46	0.78	5.47	0.78	-0.78	-2.34	2.34	10.15	7.03	-8.59	10.94	10.94	-8.59	-13.28	0.78
42								-2.34	-3.12	10.16				8.59	-7.82	7.81	2.34	-7.03	7.03	10.16	2.34

This falling slope indicates that Latency values should be higher

To adjust the latency you simply apply the slope delta percentage to the entire latency table. As an example if your latency slope is 8% overall and falling, as shown above, you will apply a 1.08 multiplier to the entire latency table thereby adding 8%. If the latency slope is 8% overall and rising then you will apply a .92 multiplier to the entire latency table thereby removing 8%. The key is to get the slope to be perfectly flat. Do not concern your self with MAF or injector scale at this time. Just get the latency slope to be flat, then worry about scaling the MAF later by applying a correction to the entire MAF scale to bring it with in range.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1		[Table2D]																				
2	**Voltage**	**0.9**	**0.94**	**0.98**	**1.02**	**1.05**	**1.09**	**1.13**	**1.17**	**1.21**	**1.25**	**1.29**	**1.33**	**1.37**	**1.41**	**1.48**	**1.56**	**1.64**	**1.72**	**1.8**	**1.88**	**1**
3	**g/s**	0.92	1.15	1.38	1.63	1.89	2.17	2.47	2.79	3.13	3.49	3.89	4.31	4.77	5.27	6.3	7.51	8.87	10.51	12.49	14.61	16
4																						
5	**1%**	0.0092	0.0115	0.0138	0.0163	0.0189	0.0217	0.0247	0.0279	0.0313	0.0349	0.0389	0.0431	0.0477	0.0527	0.063	0.0751	0.0887	0.1051	0.1249	0.1461	0.1
6	**Avg Error**	0	0	0	0	0	-2.41699	-0.18311	-1.52588	7.002326	3.722432	5.747775	5.937507	9.014435	6.125008	7.438161	10.47795	8.496101	8.630379	10.5713	11.35255	14.31
7																						
8	**g/s corrected**	0.92	1.15	1.38	1.63	1.89	2.117551	2.465477	2.747428	3.349173	3.619913	4.113588	4.566907	5.199989	5.592788	6.768604	8.296894	9.623604	11.41706	13.81036	16.26861	19.22
9																						
10	**Data**						1.5625	-0.78125	0	-3.90625	3.90625	17.9688	13.2813	10.9375	-0.78125	1.5625	3.125	7.8125	7.8125	3.90625	3.90625	
11							1.5625	-0.78125	0	-3.90625	3.90625	17.9688	13.2813	10.9375	-0.78125	1.5625	3.125	7.8125	7.8125	3.90625	3.90625	
12							1.5625	-0.78125	0	-3.90625	3.90625	17.9688	13.2813	10.9375	-0.78125	1.5625	3.125	7.8125	7.8125	3.90625	3.90625	
42							-4.6875	-2.34375	5.46875	14.8438	6.25	16.4063	-0.78125	17.96875	10.15625	7.8125	14.0625	1.5625	7.03125	9.375	7.03125	

This rising slope indicates that Latency values should be lower.

In the second example above when you make adjustments to latency, please be aware that the slope will always level out to be closer to the high end of the scale. In this example if we were to make adjustments to latency then the resulting slope would level out but the over all trim errors will likely be around 20-25%. This is okay because we will fix that in the next steps.

Once you have made adjustments, repeat this procedure to either confirm they took effect or to make another adjustment.

It can be argued that the latency needs to be adjusted for each individual voltage as indicated in the top header row of the latency table. This is really only true for 14V and each adjacent cell because if the voltage is either just above or just below 14V the ECU will interpolate the latency based on the values at 14v and the adjacent cells. So the further you get away from 14V at the injector the more effect on accuracy the adjacent voltages will have if they are not correct.

However, to successfully adjust the latency for the adjacent cells you would have to operate the vehicle at those voltages and log for each of them. This is often not feasible and also represents a huge time constraint when working on a time sensitive tune for customers. Furthermore it means you will need to operate the vehicle with diminished battery capacity or force an overvoltage condition. For this reason I rely on injector manufacturer values and make adjustments to the entire table at once. Any other discrepancies can usually be compensated for with MAF scaling. Plus in most situations, the vehicles regulating circuits are sufficient and stable enough to provide consistent voltage so you will rarely have a need to be very accurate for adjacent voltages.

Subsequently, you can alternately perform this procedure for each latency voltage individually. Note that this will require you to rune the car at the specified voltage for long periods of time and that is not often feasible. One way to do this is to use an external variable voltage power source grounded to the car. The injectors are typically supplied with a common 12v source and then grounded through the ECU when activated. You can simply interrupt the common 12v source and replace it with the external power source. Then repeat the procedure listed above for each voltage.

An alternative method for adjusting latency assumes you already have a properly calibrated stock MAF housing (intake) installed. You would scale your injectors for WOT first. Then simply adjust latency at an idle till your idle trims are ideal. This method needs to be tested yet but it can save you a tremendous amount of time because you can take care of latency and scale in one process.

II. Injector Scale

Once you have successfully adjusted latency you may now move on to injector scale.

a. Set up ATR, RomRaider or the AP to datalog the following parameter.

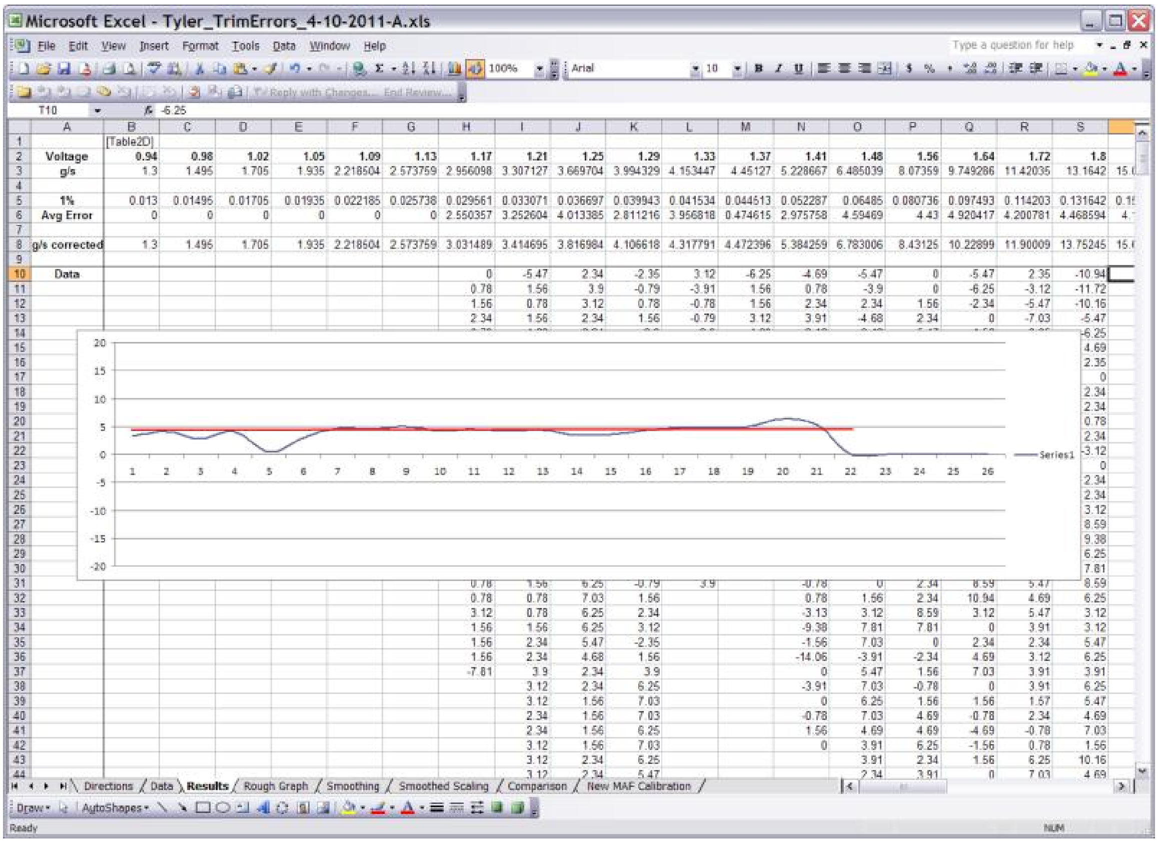
- A/F Correction #1
- A/F Learned #1
- A/F Sensor Ratio #1
- MAF Voltage
- Calculated Load
- RPM
- Close loop/Open loop Switch
- Throttle Position
- Connected AFR Gauge

b. With the car fully warmed, take it out for a 15 minute drive while logging. *(See Tips and Tricks section of this guide for resetting and when to log)* The whole time observing your AFR’s and fuel trims. DO NOT go WOT at this time. Please use smooth throttle inputs and try to get both town and highway driving. Try to vary the load by selecting roads with varying grades.

c. Upon your return you need to view the log and properly filter it for use using Excel’s Auto Filter feature. Follow the same procedure as outlined above, in section **2.1.3** for adjusting the latency subsection (I) step C, to reveal an overview of trim errors. Remember to copy your current MAF scale from your Rom into the spreadsheet.

d. In the example below of the Trim Error Tool I have drawn a line through the cruising trim region of the error graph. This line represents the global trim error and also represents the amount of correction you will apply to injector scale. It is important to focus on the data above the idle trim region from MAF voltage 1.41 and above. Idle trim will be adjusted later on through MAF scaling.

In this example it is indicating that 5% more fuel is being commanded by the ECU to achieve stoich. So that means if we apply a 1.05 multiplier to injector scale, we will effectively increase global fueling by 5% and it will bring that line closer to 0. Conversely if the trims were negative you would apply a .95 multiplier to effectively remove fuel.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1		[Table2D]																	
2	**Voltage**	**0.94**	**0.98**	**1.02**	**1.05**	**1.09**	**1.13**	**1.17**	**1.21**	**1.25**	**1.29**	**1.33**	**1.37**	**1.41**	**1.48**	**1.56**	**1.64**	**1.72**	**1.8**
3	**g/s**	1.3	1.495	1.705	1.935	2.218504	2.573759	2.956098	3.307127	3.669704	3.994329	4.153447	4.45127	5.228667	6.485039	8.07359	9.749286	11.42035	13.1642
4																			
5	**1%**	0.013	0.01495	0.01705	0.01935	0.022185	0.025738	0.029561	0.033071	0.036697	0.039943	0.041534	0.044613	0.052287	0.06485	0.080736	0.097493	0.114203	0.131642
6	**Avg Error**	0	0	0	0	0	0	2.550357	3.252604	4.013385	2.811216	3.956818	0.474615	2.975758	4.59469	4.43	4.920417	4.200781	4.468594
7																			
8	**g/s corrected**	1.3	1.495	1.705	1.935	2.218504	2.573759	3.031489	3.414695	3.816984	4.106618	4.317791	4.472396	5.384259	6.783006	8.43125	10.22899	11.90009	13.75245
9																			
10	**Data**							0	-5.47	2.34	-2.35	3.12	-6.25	-4.69	-5.47	0	-5.47	2.35	-10.94
11								0.78	1.56	3.9	-0.79	-3.91	1.56	0.78	-3.9	0	-6.25	-3.12	-11.72
12								1.56	0.78	3.12	0.78	-0.78	1.56	2.34	2.34	1.56	-2.34	-5.47	-10.16
13								2.34	1.56	2.34	1.56	-0.79	3.12	3.91	-4.68	2.34	0	-7.03	-5.47
14																			-6.25
15																			4.69
16																			2.35
17																			0
18																			2.34
19																			2.34
20																			0.78
21																			2.34
22																			-3.12
23																			0
24																			2.34
25																			2.34
26																			3.12
27																			8.59
28																			9.38
29																			6.25
30																			7.81
31								0.78	1.56	6.25	-0.79	3.9		-0.78	0	2.34	8.59	5.47	8.59
32								0.78	0.78	7.03	1.56			0.78	1.56	2.34	10.94	4.69	6.25
33								3.12	0.78	6.25	2.34			-3.13	3.12	8.59	3.12	5.47	3.12
34								1.56	1.56	6.25	3.12			-9.38	7.81	7.81	0	3.91	3.12
35								1.56	2.34	5.47	-2.35			-1.56	7.03	0	2.34	2.34	5.47
36								1.56	2.34	4.68	1.56			-14.06	-3.91	-2.34	4.69	3.12	6.25
37								-7.81	3.9	2.34	3.9			0	5.47	1.56	7.03	3.91	3.91
38									3.12	2.34	6.25			-3.91	7.03	-0.78	0	3.91	6.25
39									3.12	1.56	7.03			0	6.25	1.56	1.56	1.57	5.47
40									2.34	1.56	7.03			-0.78	7.03	4.69	-0.78	2.34	4.69
41									2.34	1.56	6.25			1.56	4.69	4.69	-4.69	-0.78	7.03
42									3.12	1.56	7.03			0	3.91	6.25	-1.56	0.78	1.56
43									3.12	2.34	6.25				3.91	2.34	1.56	6.25	10.16
44									3.12	2.34	5.47				2.34	3.91	0	7.03	4.69

Now make a correction to Fuel Injector scale and repeat the process from step “a” to either confirm or make another adjustment.

2.1.4 Calibrate the MAF (Closed Loop)

In this section we will be calibrating the MAF scale for closed loop operation. We will focus on idle trims and cruising trim respectively. Though it is normally not necessary to mess with the stock MAF calibration when using the stock MAF sensor, it is recommended. I have found that the stock MAF is usually considerably more rich in the open loop region when compared to the AFR table as measured by a wide band AFR gauge.

Trims Rough and Fine Correction

a. If using a larger intake (MAF Housing) then please install it now if not already done and then please revisit section 2.1.2 and sub section III for initial MAF scale of larger than stock intakes.

b. Set up ATR, RomRaider or the AP to datalog the following parameter.

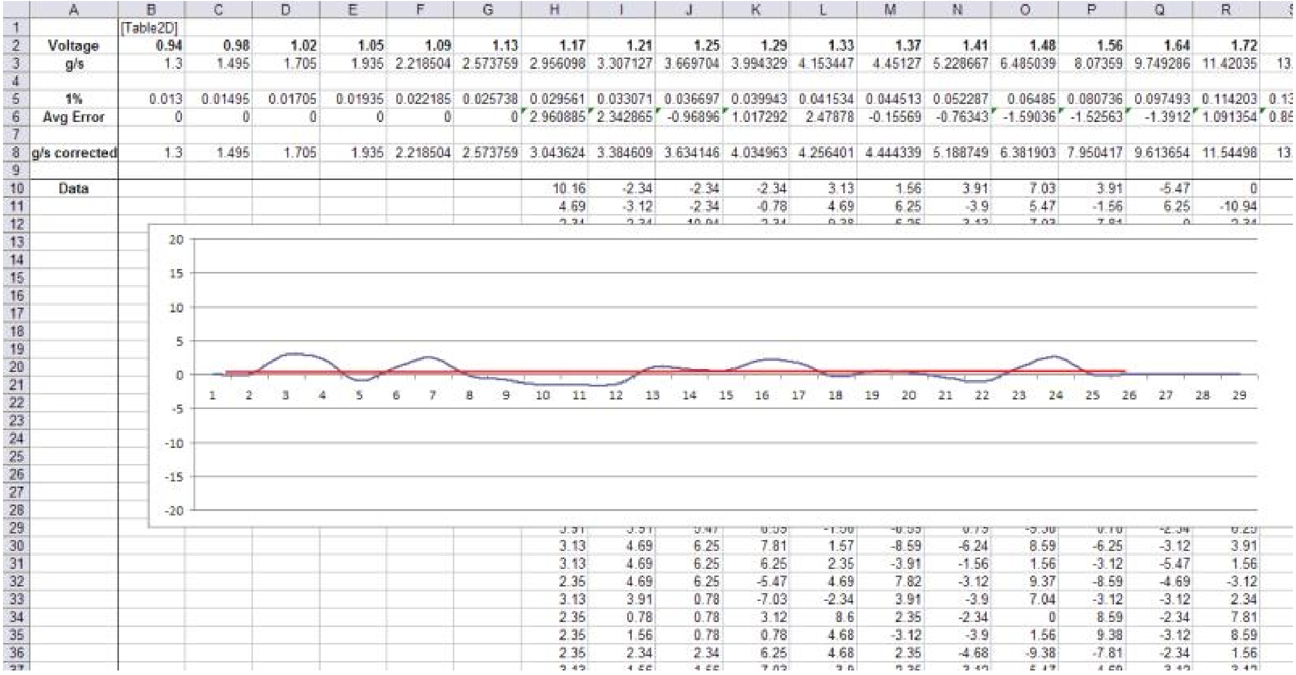
- A/F Correction #1
- A/F Learned #1
- A/F Sensor Ratio #1
- MAF Voltage
- Calculated Load
- RPM
- Close loop/Open loop Switch
- Throttle Position
- Connected AFR Gauge

c. Reset the ECU. Wait 10 seconds and turn on the ignition. Wait 5 seconds and start the car. With the car fully warmed, first allow your idle trims to stabilize and then take it out for a drive while logging. You must drive for at least 30 minutes. The whole time observing your AFR's and fuel trims. DO NOT go WOT at this time. Please use smooth throttle inputs and try to get both town and highway driving. Try to vary the load by selecting roads with varying grades.

d. Upon your return you need to view the log and properly filter it for use using Excel's Auto Filter feature. Follow the same procedure as outlined above, in section 2.1.3 for adjusting the latency subsection (I) step C, to reveal an overview of trim errors.

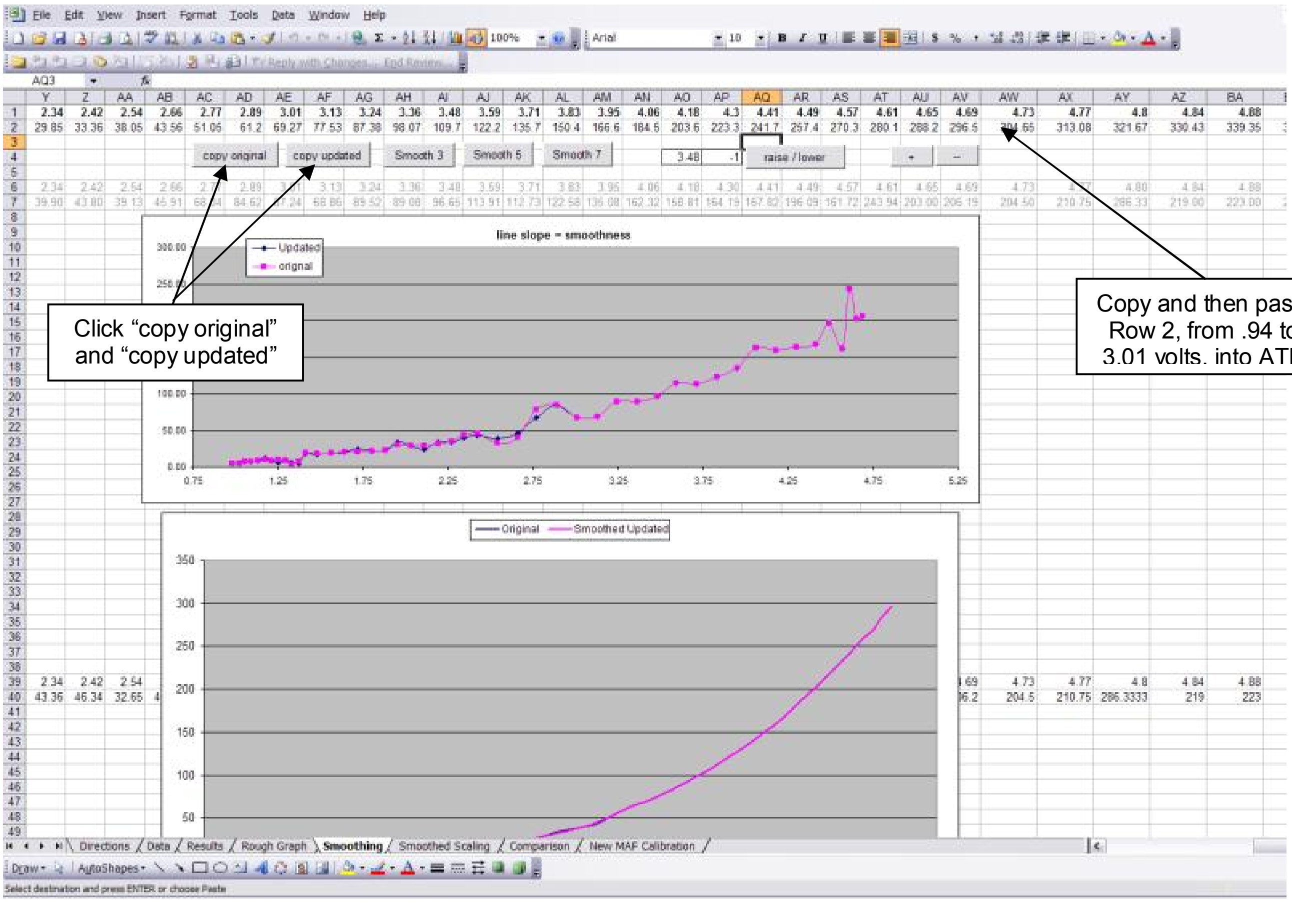
** Note: Remember to always copy your current running MAF table values from ATR or RomRaider into the Trim Error Tool "results" tab prior to every use.*

In this example the results are not that bad. Ultimately you want your cruise and idle trims to be les than +/- 5%. So it would not be uncommon to leave this as is and move on to Open Loop fueling. However, for my own sanity, there is room for some improvement and some smoothing, so adjustments will be mad.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1		[Table2D]																
2	**Voltage**	**0.94**	**0.98**	**1.02**	**1.05**	**1.09**	**1.13**	**1.17**	**1.21**	**1.25**	**1.29**	**1.33**	**1.37**	**1.41**	**1.48**	**1.56**	**1.64**	**1.72**
3	**g/s**	1.3	1.495	1.705	1.935	2.218504	2.573759	2.956098	3.307127	3.669704	3.994329	4.153447	4.45127	5.228667	6.485039	8.07359	9.749286	11.42035
4																		
5	**1%**	0.013	0.01495	0.01705	0.01935	0.022185	0.025738	0.029561	0.033071	0.036697	0.039943	0.041534	0.044513	0.052287	0.06485	0.080736	0.097493	0.114203
6	**Avg Error**	0	0	0	0	0	0	2.960885	2.342865	-0.96896	1.017292	2.47878	-0.15569	-0.76343	-1.59036	-1.52563	-1.3912	1.091354
7																		
8	**g/s corrected**	1.3	1.495	1.705	1.935	2.218504	2.573759	3.043624	3.384609	3.634146	4.034963	4.256401	4.444339	5.188749	6.381903	7.950417	9.613654	11.54498
9																		
10	**Data**							10.16	-2.34	-2.34	-2.34	3.13	1.56	3.91	7.03	3.91	-5.47	0
11								4.69	-3.12	-2.34	-0.78	4.69	6.25	-3.9	5.47	-1.56	6.25	-10.94
30								3.13	4.69	6.25	7.81	1.57	-8.59	-6.24	8.59	-6.25	-3.12	3.91
31								3.13	4.69	6.25	6.25	2.35	-3.91	-1.56	1.56	-3.12	-5.47	1.56
32								2.35	4.69	6.25	-5.47	4.69	7.82	-3.12	9.37	-8.59	-4.69	-3.12
33								3.13	3.91	0.78	-7.03	-2.34	3.91	-3.9	7.04	-3.12	-3.12	2.34
34								2.35	0.78	0.78	3.12	8.6	2.35	-2.34	0	8.59	-2.34	7.81
35								2.35	1.56	0.78	0.78	4.68	-3.12	-3.9	1.56	9.38	-3.12	8.59
36								2.35	2.34	2.34	6.25	4.68	2.35	-4.68	-9.38	-7.81	-2.34	1.56

e. Go to the "Smoothing" tab at the bottom of the tool. You will see some macro buttons at the top of the work sheet. Click the "Copy Original" button first. Then click "Copy Updated" This feature will quickly compile all the values and update Row 2 with the new value for Maf Scale.



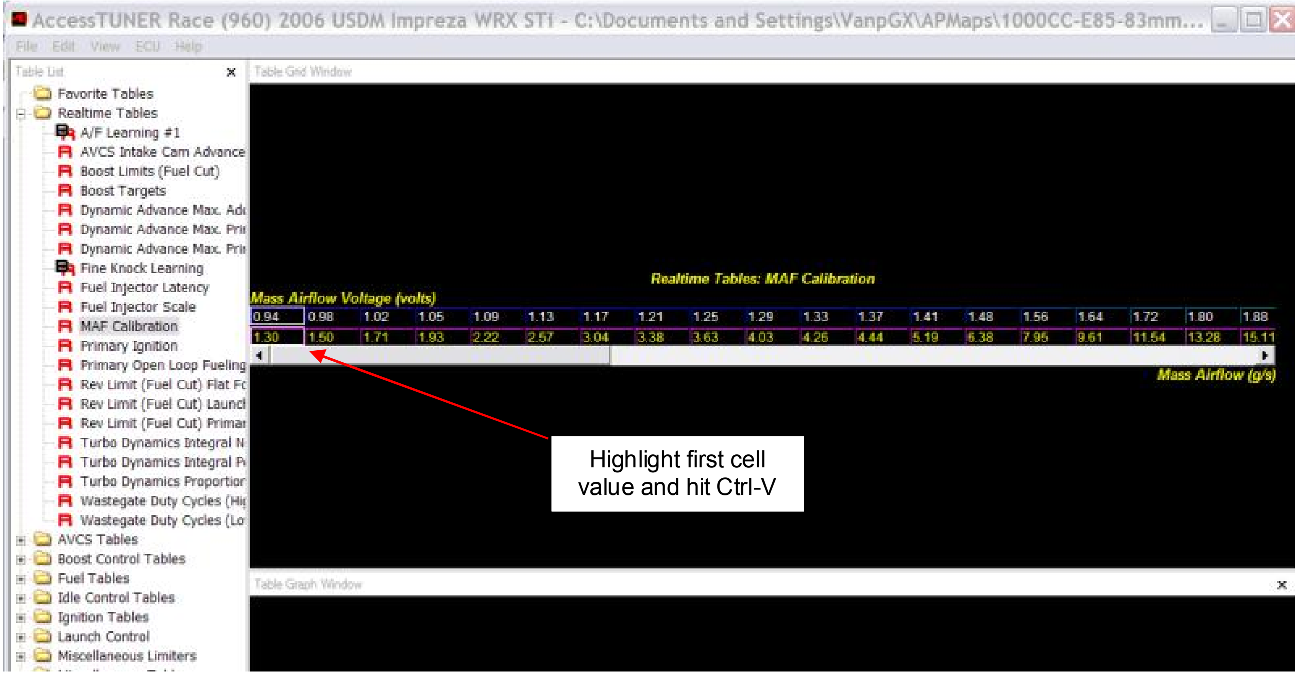
	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA
1	2.34	2.42	2.54	2.66	2.77	2.89	3.01	3.13	3.24	3.36	3.48	3.59	3.71	3.83	3.95	4.06	4.18	4.3	4.41	4.49	4.57	4.61	4.65	4.69	4.73	4.77	4.8	4.84	4.88
2	29.85	33.36	38.05	43.56	51.06	61.2	69.27	77.53	87.38	98.07	109.7	122.2	135.7	150.4	166.6	184.5	203.6	223.3	241.7	257.4	270.3	280.1	288.2	296.5	304.65	313.08	321.67	330.43	339.35
6	2.34	2.42	2.54	2.66	2.77	2.89	3.01	3.13	3.24	3.36	3.48	3.59	3.71	3.83	3.95	4.06	4.18	4.30	4.41	4.49	4.57	4.61	4.65	4.69	4.73	4.77	4.80	4.84	4.88
7	39.90	43.80	39.13	45.91	[illegible]	84.62	[illegible]	68.86	89.52	89.08	96.65	113.91	112.73	122.58	136.08	162.32	158.81	164.19	167.82	196.09	161.72	243.94	203.00	206.19	204.50	210.75	286.33	219.00	223.00

Click "copy original" and "copy updated"

Copy and then paste Row 2, from .94 to 3.01 volts. into ATR

f. Now copy the new MAF values from Row 2 to the clip board.

g. Now paste the new values into ATR/RomRaider… * *Note: Pasting into RomRaider is not that simple and will be covered in "Tip and Tricks section"*



Realtime Tables: MAF Calibration

Mass Airflow Voltage (volts)

0.94	0.98	1.02	1.05	1.09	1.13	1.17	1.21	1.25	1.29	1.33	1.37	1.41	1.48	1.56	1.64	1.72	1.80	1.88
1.30	1.50	1.71	1.93	2.22	2.57	3.04	3.38	3.63	4.03	4.26	4.44	5.19	6.38	7.95	9.61	11.54	13.28	15.11

Mass Airflow (g/s)

Highlight first cell value and hit Ctrl-V

h. Once you have updated the MAF values in ATR/RomRaider, Save the map and flash it to the vehicle.

i. **Now repeat steps "B" through "H" again,** only this time when you get to step "E" you will also select the "Smooth 3" button to apply some table smoothing to the calibration. Repeat as many times as necessary but keep in mind that you will never get it perfect. Again +/- 5% is perfectly acceptable.

j. If you are having trouble dialing in the idle trims using this method, then you can ignore idle trims for the time being. You can make adjustments to that region of the table later through live tuning in ATR or manually adjusting it in RomRaider. (More on this later) Idle trims should never be adjusted directly after an ECU reset. You should give it some driving time before you make adjustments and the vehicle should be idling steadily for 1 minute prior to making any adjustments.

2.1.5 Calibrate Load Compensations

It is necessary to perform this step if you have replaced one or any of the following items.

1. Intake
2. Turbo Inlet
3. Turbo
4. TVG Deletes
5. Intake Manifold
6. After market TMIC
7. FMIC
8. BOV
9. Cams
10. Porting and polishing of anything in the intake path including heads

This table will compensate for any load imbalances brought on by subtle changes in MAP or flow resonances created by flow profile anomalies from the use of non stock components. Typically this will manifest itself as surging, stumbling, hesitation and oscillation of rpm.

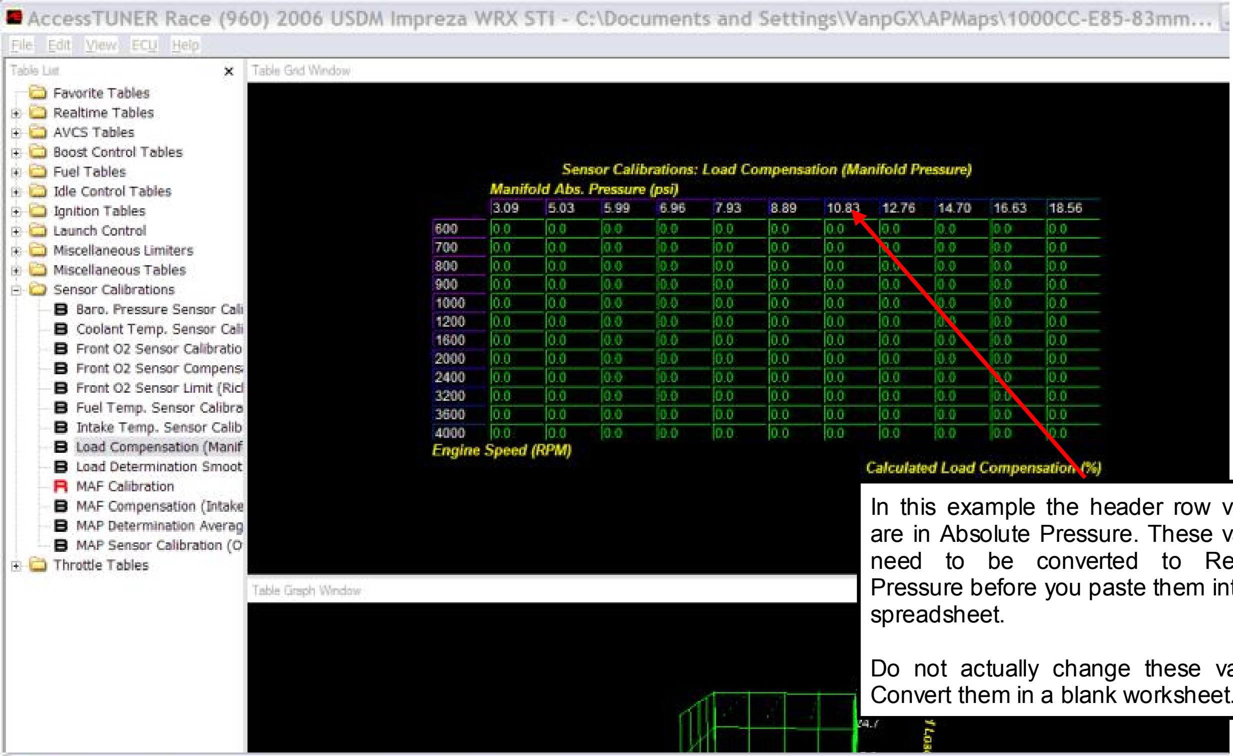
a. Set up ATR, RomRaider or the AP to datalog the following parameter.

- A/F Correction #1
- A/F Learned #1
- A/F Sensor Ratio #1
- Calculated Load
- MAF Voltage
- RPM
- Barometric Pressure
- Manifold Absolute Pressure
- Manifold Relative Pressure (Boost)
- Throttle Position

b. Reset the ECU. Wait 10 seconds and turn on the ignition. Wait 5 seconds and start the car. With the car fully warmed, first allow your idle trims to stabilize and then take it out for a drive while logging. You must drive for at least 20-30 minutes. With load comps the more data you have the better the results. The whole time observing your AFR's and fuel trims. DO NOT go WOT at this time.

c. Upon your return you may now open up the Load Compensation worksheet. You will need to prepare this file for the car being tested and to do so you need to navigate to the "ROM" tab at the bottom of the spreadsheet. Here you will be presented with a table with header rows and columns for Manifold Relative Pressure and RPM. You must copy the header rows from the current rom in ATR or RomRaider into this table.

Pleas keep in mind that the top header row must be in Relative Pressure. If the values you are copying from ATR or RomRaider are in Absolute Pressure you must convert them by subtracting 14.7 from each value.



Sensor Calibrations: Load Compensation (Manifold Pressure)

Manifold Abs. Pressure (psi)

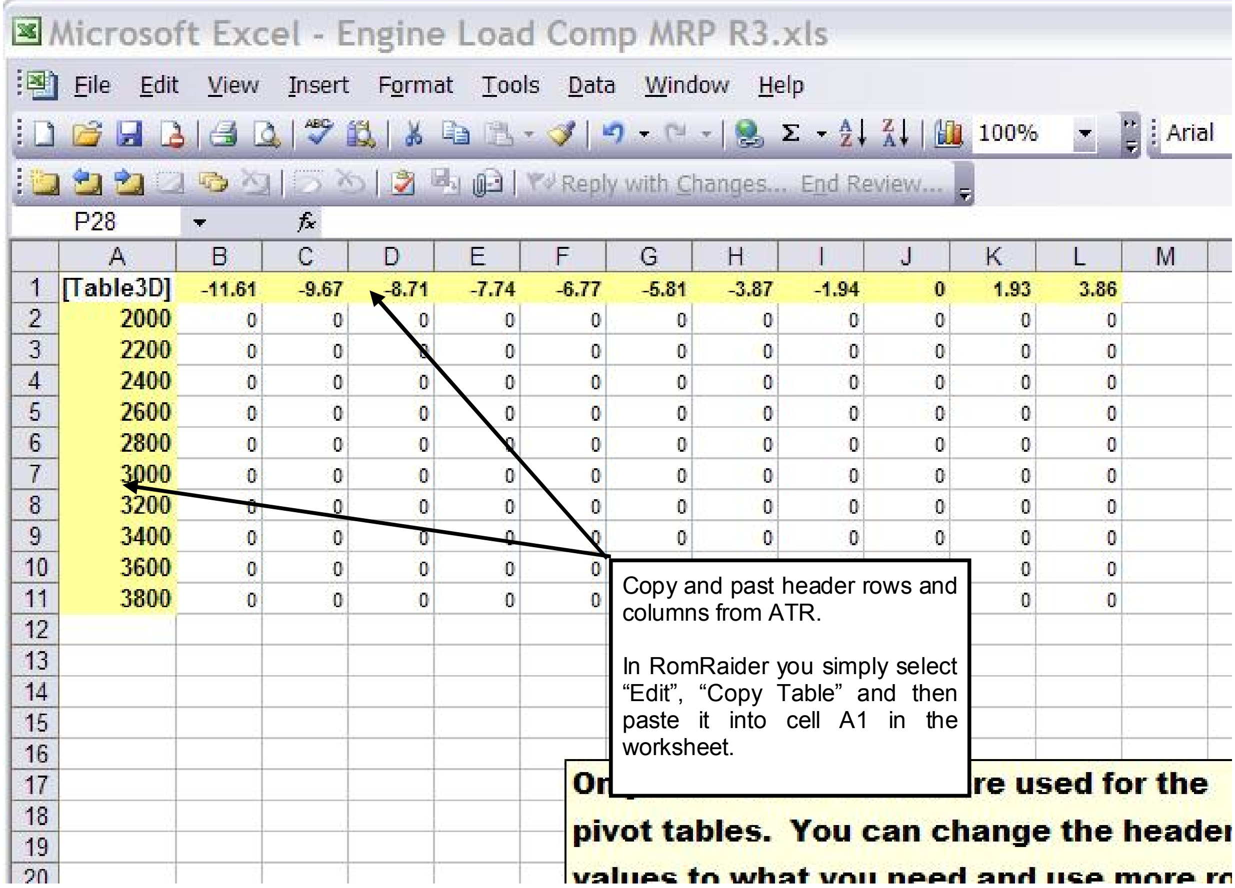
	3.09	5.03	5.99	6.96	7.93	8.89	10.83	12.76	14.70	16.63	18.56
600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Engine Speed (RPM)

Calculated Load Compensation (%)

In this example the header row values are in Absolute Pressure. These values need to be converted to Relative Pressure before you paste them into the spreadsheet.

Do not actually change these values. Convert them in a blank worksheet.



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	[Table3D]	-11.61	-9.67	-8.71	-7.74	-6.77	-5.81	-3.87	-1.94	0	1.93	3.86	
2	2000	0	0	0	0	0	0	0	0	0	0	0	
3	2200	0	0	0	0	0	0	0	0	0	0	0	
4	2400	0	0	0	0	0	0	0	0	0	0	0	
5	2600	0	0	0	0	0	0	0	0	0	0	0	
6	2800	0	0	0	0	0	0	0	0	0	0	0	
7	3000	0	0	0	0	0	0	0	0	0	0	0	
8	3200	0	0	0	0	0	0	0	0	0	0	0	
9	3400	0	0	0	0	0	0	0	0	0	0	0	
10	3600	0	0	0	0	0					0	0	
11	3800	0	0	0	0	0					0	0	
12													
13													
14													
15													
16													
17													
18													
19													
20													

Or **re used for the**
pivot tables. You can change the header
values to what you need and use more ro

Copy and past header rows and columns from ATR.

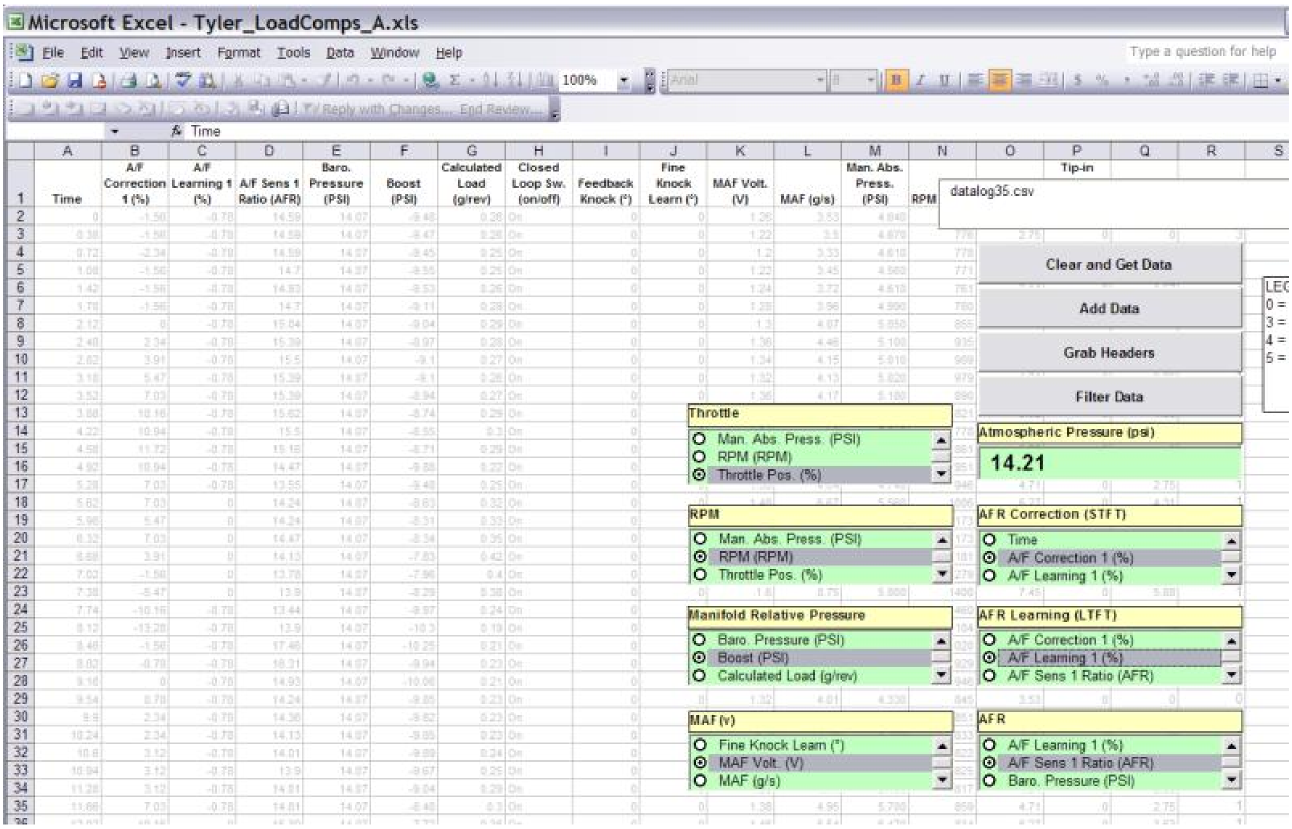
In RomRaider you simply select “Edit”, “Copy Table” and then paste it into cell A1 in the worksheet.

d. Please be aware that for the GD, there is only one load compensation table to worry about. But for the GR there is one for cruise and one for acceleration. Please bear in mind that you will need to perform this procedure once for each table individually. Meaning twice.

**Note: For the GR, when adjusting for load compensations, you need to be aware of the AVCS tables for cruise and non-cruise. These tables should always be set to the non-cruise values.*

> Tip: TD_D, This is experimental, but the logic is sound. In opensource, you can now log the cruise / non cruise parameter (0 or 1). You can use this to further refine the cruise vs. non cruise tables accurately.

e. Now navigate to the input tab. Select the "Clear and Get Data" button. You will be prompted to browse for the relevant log file . You may wish to append other files to the data and to do so you will select the "Add Data" button at this time. Once you have loaded all the log data, you must match each of the parameters with the proper header by selecting the appropriate radio button. Now you may select "Filter Data".



datalog35.csv

Throttle
- ○ Man. Abs. Press. (PSI)
- ○ RPM (RPM)
- ● Throttle Pos. (%)

RPM
- ○ Man. Abs. Press. (PSI)
- ● RPM (RPM)
- ○ Throttle Pos. (%)

Manifold Relative Pressure
- ○ Baro. Pressure (PSI)
- ● Boost (PSI)
- ○ Calculated Load (g/rev)

MAF (v)
- ○ Fine Knock Learn (°)
- ● MAF Volt. (V)
- ○ MAF (g/s)

Atmospheric Pressure (psi)
14.21

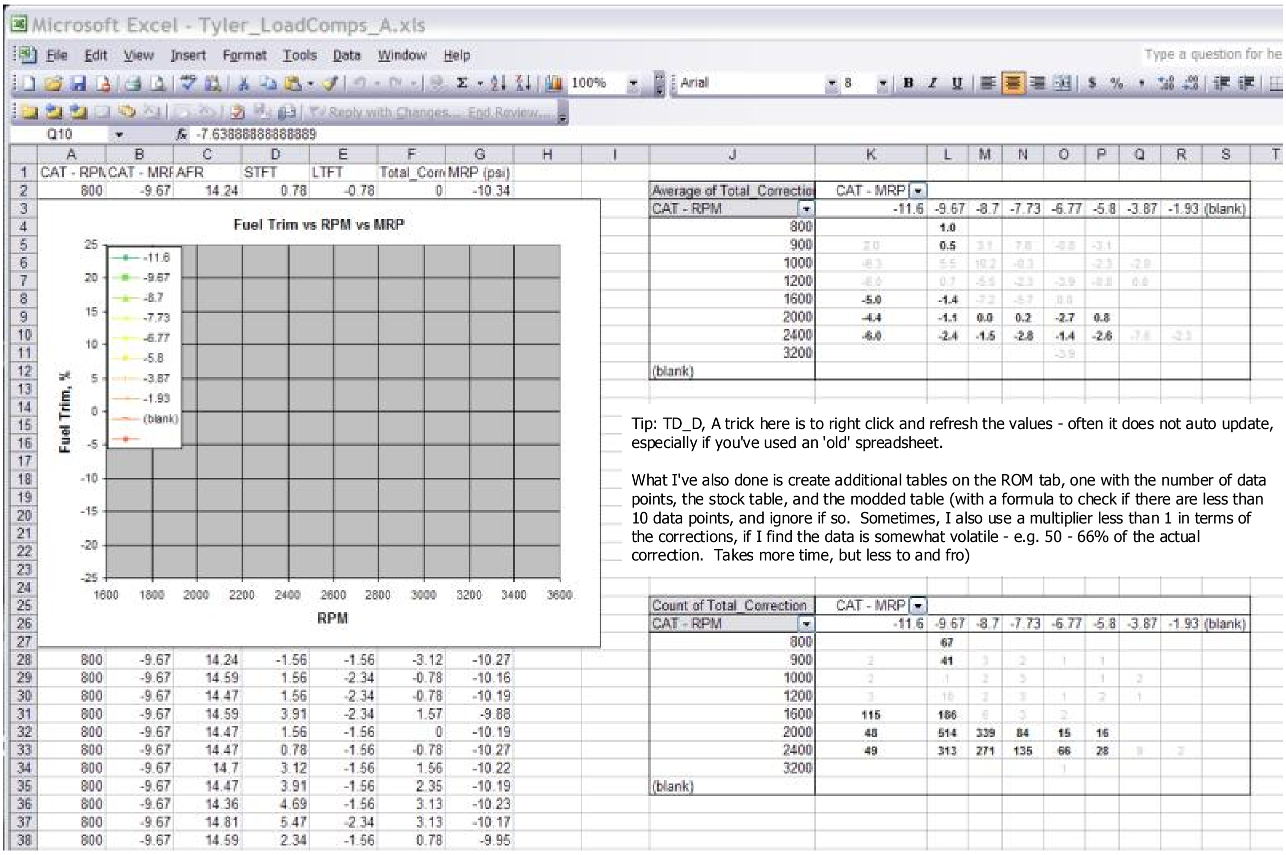
AFR Correction (STFT)
- ○ Time
- ● A/F Correction 1 (%)
- ○ A/F Learning 1 (%)

AFR Learning (LTFT)
- ○ A/F Correction 1 (%)
- ● A/F Learning 1 (%)
- ○ A/F Sens 1 Ratio (AFR)

AFR
- ○ A/F Learning 1 (%)
- ● A/F Sens 1 Ratio (AFR)
- ○ Baro. Pressure (PSI)

f. Once the spreadsheet has finished compiling the results you may now select the "EL Comp" tab at the bottom of the spread sheet. You will note two pivot tables are shown. You will concern yourself with the top table labeled "Average Total Correction". You will also only concern yourself with the values shown in black. Gray indicated that not enough data was compiled to warrant a viable change and these values are not reliable.

g. Copy and paste these values into ATR and into the relevant cells for RPM versus load as shown in the example below.



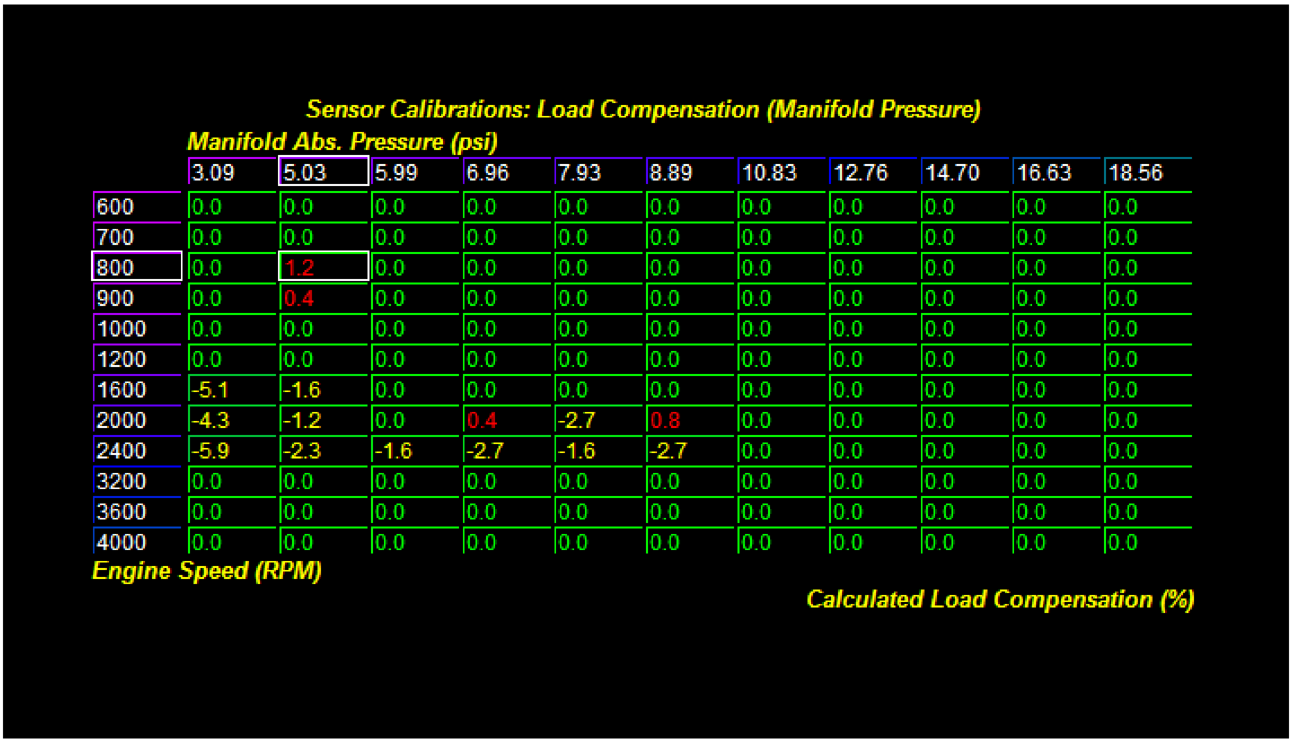
	A	B	C	D	E	F	G
1	CAT - RP	CAT - MR	AFR	STFT	LTFT	Total_Corr	MRP (psi)
2	800	-9.67	14.24	0.78	-0.78	0	-10.34
28	800	-9.67	14.24	-1.56	-1.56	-3.12	-10.27
29	800	-9.67	14.59	1.56	-2.34	-0.78	-10.16
30	800	-9.67	14.47	1.56	-2.34	-0.78	-10.19
31	800	-9.67	14.59	3.91	-2.34	1.57	-9.88
32	800	-9.67	14.47	1.56	-1.56	0	-10.19
33	800	-9.67	14.47	0.78	-1.56	-0.78	-10.27
34	800	-9.67	14.7	3.12	-1.56	1.56	-10.22
35	800	-9.67	14.47	3.91	-1.56	2.35	-10.19
36	800	-9.67	14.36	4.69	-1.56	3.13	-10.23
37	800	-9.67	14.81	5.47	-2.34	3.13	-10.17
38	800	-9.67	14.59	2.34	-1.56	0.78	-9.95

Average of Total_Correctio	CAT - MRP								
CAT - RPM	-11.6	-9.67	-8.7	-7.73	-6.77	-5.8	-3.87	-1.93	(blank)
800		1.0							
900	2.0	0.5	3.1	7.8	-0.8	-3.1			
1000	-8.3	5.5	10.2	-0.3		-2.3	-2.8		
1200	-6.0	0.7	-5.5	-2.3	-3.9	-0.8	0.0		
1600	-5.0	-1.4	-7.2	-5.7	0.8				
2000	-4.4	-1.1	0.0	0.2	-2.7	0.8			
2400	-6.0	-2.4	-1.5	-2.8	-1.4	-2.6	-7.8	-2.3	
3200					-3.9				
(blank)									

Tip: TD_D, A trick here is to right click and refresh the values - often it does not auto update, especially if you've used an 'old' spreadsheet.

What I've also done is create additional tables on the ROM tab, one with the number of data points, the stock table, and the modded table (with a formula to check if there are less than 10 data points, and ignore if so. Sometimes, I also use a multiplier less than 1 in terms of the corrections, if I find the data is somewhat volatile - e.g. 50 - 66% of the actual correction. Takes more time, but less to and fro)

Count of Total_Correction	CAT - MRP								
CAT - RPM	-11.6	-9.67	-8.7	-7.73	-6.77	-5.8	-3.87	-1.93	(blank)
800		67							
900	2	41	3	2	1	1			
1000	2	1	2	3		1	2		
1200	3	16	2	3	1	2	1		
1600	115	186	6	3	2				
2000	48	514	339	84	15	16			
2400	49	313	271	135	66	28	8	2	
3200					1				
(blank)									



Sensor Calibrations: Load Compensation (Manifold Pressure)

Manifold Abs. Pressure (psi)

	3.09	5.03	5.99	6.96	7.93	8.89	10.83	12.76	14.70	16.63	18.56
600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1600	-5.1	-1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	-4.3	-1.2	0.0	0.4	-2.7	0.8	0.0	0.0	0.0	0.0	0.0
2400	-5.9	-2.3	-1.6	-2.7	-1.6	-2.7	0.0	0.0	0.0	0.0	0.0
3200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Engine Speed (RPM)

Calculated Load Compensation (%)

h. Now apply these setting to the vehicle and repeat.

2.1.6 Calibrate Tip-in Enrichment.

Tip-in enrichment is an important feature of the ECU that allows extra fuel to be instantly delivered to the engine when large or sudden positive deltas in throttle plate angles are observed. This concept goes back to carbureted engines. If you have ever peered down the barrel of a carburetor while moving the throttle, I'm sure you have observed fuel being pumped into the barrels from the accelerator pump nozzles at the top. You would also observe that this stream to become more intense when the throttle is abruptly moved. In the Subaru, tip-in is the very same concept.

If tip-in is not correct you will notice this performance issue during the onset of throttle and would usually manifest it self as hesitation or a brief loss of power. If to rich, you will flog the engine with fuel. If to lean you risk knock during the onset of throttle.

a. Begin by logging the following. Keep the parameters listed below only to allow maximum data resolution.

  - Throttle Position
  - Throttle Delta
  - A/F correction 1
  - A/F Sensor 1 Ratio

b. When you drive, you want to exaggerate throttle input. Try to change your input from small deltas to large deltas. You want to try to obtain data for deltas ranging from 1%, 5%, 10%, 20%, and 30%.

   You will basically see two different scenarios when driving that apply to tip-in. The first is when coasting in gear and then applying throttle. The other is when cruising in gear and applying throttle. Keep these in mind and try to maintain driving conditions for both scenarios.

c. Open up the log and filter the data for Throttle Delta =/> 0.

d. Now look at the data and graph Throttle Position, A/F Correction 1 and the A/F Sensor 1 Ratio.

e. Now observe the curve for A/F Sensor 1 and look for spikes in AFR either positive or negative. Now look for corresponding spikes in A/F correction 1. As you see AFR go positive you should observe A/F correction to respond in kind by adding fuel. This should confirm a tip in event and will indicate that a correction should be made for that corresponding % of delta applied.

f. Average the A/F correction values for the duration of the tip-in event and apply the % correction to the tip-in table for that corresponding % delta.

g. Repeat as many times as needed till tip-in events are minimized and AFR's are smooth during throttle transitions.

2.1.7 Calibrate the MAF (Open Loop)

When tuning for open loop driving, it is necessary to calibrate the MAF scale to coincide with targeted fuel as defined in the Open Loop Primary Fuel Table plus any compensations. In closed loop the ECU references the O2 sensor to derive fuel and reach target. In Open loop the fuel is based on look up values as defined in the primary fuel table and MAF scaling but it never receives feed back from the O2 sensor so the ECU never really knows whether it has reached target or not. In this section we will hope to achieve a final AFR to coincide with commanded fuel final +/- 1-2%. Essentially this step ensures that the AFR at the tail pipe matches what is defined in the AFR table plus any other compensations (Final Commanded Fuel)

a. Begin by logging the following. It is best to log using RomRaider logger and the Tactrix OpenPort2 for this part of the tune. To get as much data as possible you will want the FastPoll feature in RomRaider. Log…

- MAF Voltage
- Throttle Position
- Commanded fuel Final (or Primary Enrichment Final in RomRaider)
- Wide Band AFR (Gauge)
- IDC (Injector Duty Cycle)
- Manifold Relative Pressure
- MAF Voltage
- FBKC
- FLKC

b. Before you continue please refer to section 1 of this procedure. This portion of the tune is very taxing on the vehicle and damage can occur if the vehicle is not up to the task. It is also recommended you start this process while using the stock timing values to ensure a level of safety during the run.

c. First do a WOT run in 3rd gear to gauge how the car is running. Compare the reading on the wide band AFR gauge with commanded fuel final (Final Fueling Base parameter in RomRaider). Take note of where 100% throttle begins and were boost begins. Compare that with MAF voltage and make a rough correction to MAF scale within that region and all the way up to 5 (4.92) volts…

To do a rough correction you want to apply the over all % of error between the AFR Gauge and Commanded Fuel Final. Divide AFR Gauge reading plus 1 by Commanded Fuel Final plus 1. Then subtract 1 from the result. Then times that by 100. This is the rough correction value you will initially apply to the entire WOT region of the MAF scale.

Example:
Error = ((AFR Gauge + 1) / (Commanded Fuel Final + 1) - 1) * 100
Error = ((11.2+1) / (12+1) - 1) * 100
Error = -6.154%
Multiplier = (100-6.154)/100) = .93842

Your AFR's should be good enough to continue safely from this point but always keep an eye out for extremes and cut the throttle at the first sign of a problem.

d. Now start a fresh log and perform the following runs…

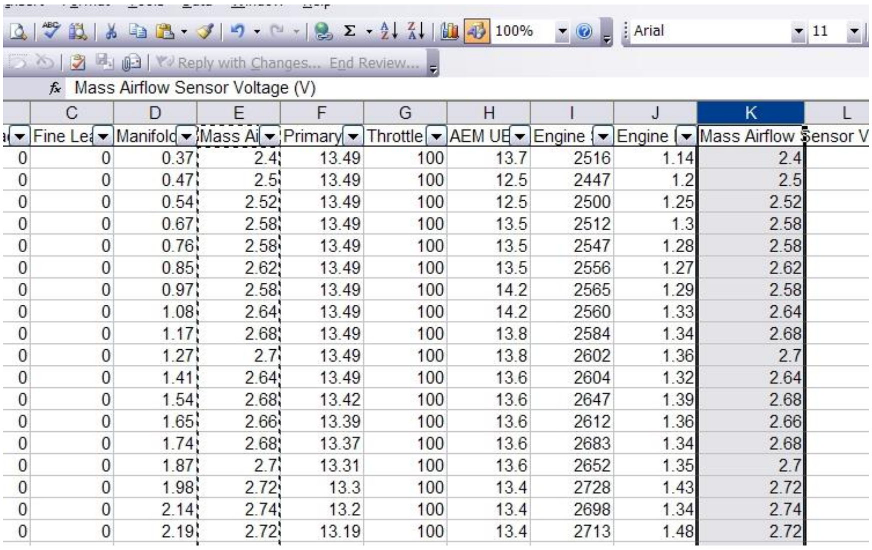
- 1 rolling first gear from 1000 rpm to redline
- 1 rolling second gear from 1000 rpm to redline
- 2 rolling third gear from 2000 rpm to redline
- 3 rolling fourth gear from 2400 rpm to redline
- 1 WOT run from 1st to 4th gear

e. Upon your return open the log for viewing. Fist check the IDC to be below 95% Ideally you want IDC to be <85% but 95% is acceptable. If your IDC's are >95% then it is recommended you use larger injectors for this particular application.

f. Now apply the following filters…

- Remove Throttle Position < 100
- Remove Manifold Relative Pressure (Boost) < 1 psi

g. Copy the MAF Voltage column into a new column.

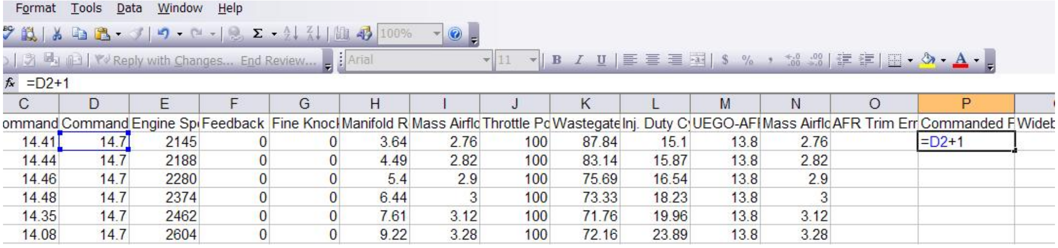


Mass Airflow Sensor Voltage (V)

	C	D	E	F	G	H	I	J	K	L
	Fine Le	Manifold	Mass Ai	Primary	Throttle	AEM UE	Engine	Engine	Mass Airflow Sensor V	
0	0	0.37	2.4	13.49	100	13.7	2516	1.14	2.4	
0	0	0.47	2.5	13.49	100	12.5	2447	1.2	2.5	
0	0	0.54	2.52	13.49	100	12.5	2500	1.25	2.52	
0	0	0.67	2.58	13.49	100	13.5	2512	1.3	2.58	
0	0	0.76	2.58	13.49	100	13.5	2547	1.28	2.58	
0	0	0.85	2.62	13.49	100	13.5	2556	1.27	2.62	
0	0	0.97	2.58	13.49	100	14.2	2565	1.29	2.58	
0	0	1.08	2.64	13.49	100	14.2	2560	1.33	2.64	
0	0	1.17	2.68	13.49	100	13.8	2584	1.34	2.68	
0	0	1.27	2.7	13.49	100	13.8	2602	1.36	2.7	
0	0	1.41	2.64	13.49	100	13.6	2604	1.32	2.64	
0	0	1.54	2.68	13.42	100	13.6	2647	1.39	2.68	
0	0	1.65	2.66	13.39	100	13.6	2612	1.36	2.66	
0	0	1.74	2.68	13.37	100	13.6	2683	1.34	2.68	
0	0	1.87	2.7	13.31	100	13.6	2652	1.35	2.7	
0	0	1.98	2.72	13.3	100	13.4	2728	1.43	2.72	
0	0	2.14	2.74	13.2	100	13.4	2698	1.34	2.74	
0	0	2.19	2.72	13.19	100	13.4	2713	1.48	2.72	

h. Create three new columns for **AFR Trim Errors**, **Commanded Fuel Final Corrected** and **Wideband Corrected**. Create the following formulas…

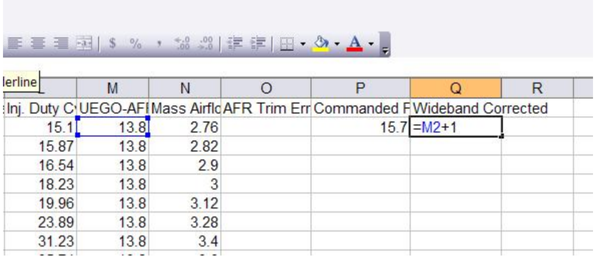
Commanded Fuel Final Corrected column: (Comanded Fuel Final +1)



=D2+1

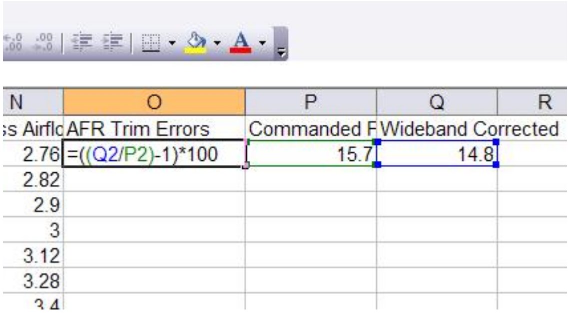
C	D	E	F	G	H	I	J	K	L	M	N	O	P	
ommand	Command	Engine Sp	Feedback	Fine Knoc	Manifold R	Mass Airflc	Throttle Pc	Wastegate	Inj. Duty C	UEGO-AFI	Mass Airflc	AFR Trim Err	Commanded F	Wideb
14.41	14.7	2145	0	0	3.64	2.76	100	87.84	15.1	13.8	2.76		=D2+1	
14.44	14.7	2188	0	0	4.49	2.82	100	83.14	15.87	13.8	2.82			
14.46	14.7	2280	0	0	5.4	2.9	100	75.69	16.54	13.8	2.9			
14.48	14.7	2374	0	0	6.44	3	100	73.33	18.23	13.8	3			
14.35	14.7	2462	0	0	7.61	3.12	100	71.76	19.96	13.8	3.12			
14.08	14.7	2604	0	0	9.22	3.28	100	72.16	23.89	13.8	3.28			

Wideband Corrected column: (Wideband +1)



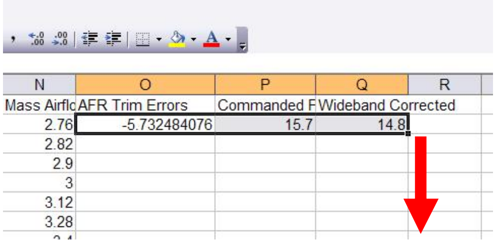
	M	N	O	P	Q	R
Inj. Duty C	UEGO-AFI	Mass Airflc	AFR Trim Err	Commanded F	Wideband Corrected	
15.1	13.8	2.76		15.7	=M2+1	
15.87	13.8	2.82				
16.54	13.8	2.9				
18.23	13.8	3				
19.96	13.8	3.12				
23.89	13.8	3.28				
31.23	13.8	3.4				

AFR Trims errors: ((Wideband Corrected + 1) / (Commanded Fuel Final Corrected + 1) - 1) * 100



N	O	P	Q	R
ss Airflc	AFR Trim Errors	Commanded F	Wideband Corrected	
2.76	=((Q2/P2)-1)*100	15.7	14.8	
2.82				
2.9				
3				
3.12				
3.28				

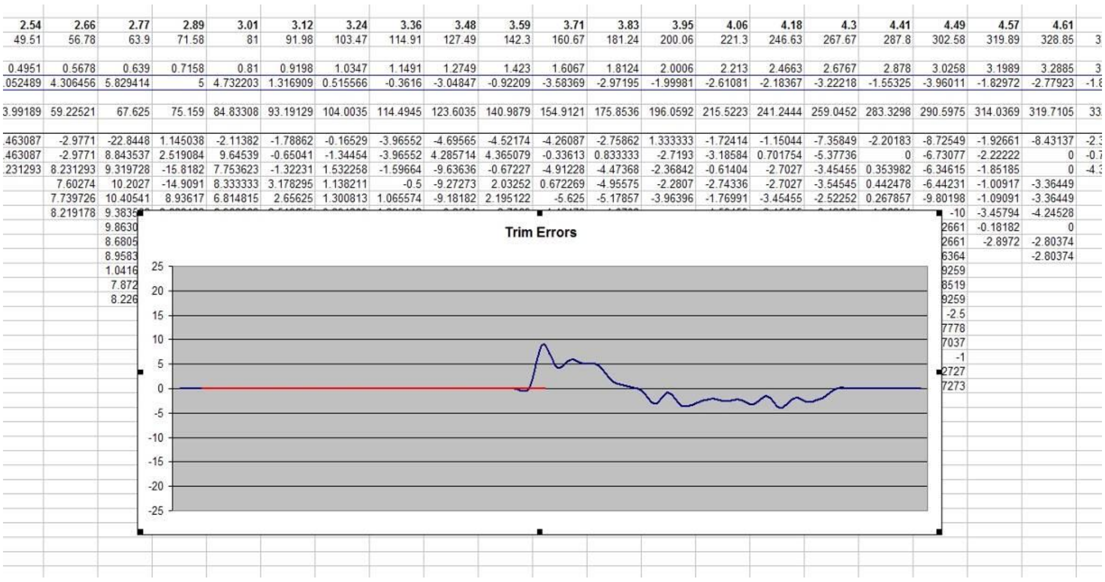
Now copy the three rows to the end of the data



N	O	P	Q	R
Mass Airflo	AFR Trim Errors	Commanded F	Wideband Corrected	
2.76	-5.732484076	15.7	14.8	
2.82				
2.9				
3				
3.12				
3.28				

i. Highlight and copy the final results from Mass Air Flow column and AFR Trim Errors column into a fresh copy of the Trim Error tool. **Before you process the Trim Errors you need to remember to copy your latest MAF scale to the "results" tab.** When you are ready select "GO" on the "data" tab to begin compiling the errors.

Take note of where, in the MAF scale, the data starts. You will only be working with the region of the MAF from that point all the way up to 5 (4.92) volts. There needs to be a fair amount of data for each MAF voltage that was observed by the log so take note of the values in the first and last column where data begins and ends. If there is less than 5 data points shown then the data should be considered unreliable and should be deleted unless the average error is a smooth transition from the adjacent cell.



2.54	2.66	2.77	2.89	3.01	3.12	3.24	3.36	3.48	3.59	3.71	3.83	3.95	4.06	4.18	4.3	4.41	4.49	4.57	4.61
49.51	56.78	63.9	71.58	81	91.98	103.47	114.91	127.49	142.3	160.67	181.24	200.06	221.3	246.63	267.67	287.8	302.58	319.89	328.85
0.4951	0.5678	0.639	0.7158	0.81	0.9198	1.0347	1.1491	1.2749	1.423	1.6067	1.8124	2.0006	2.213	2.4663	2.6767	2.878	3.0258	3.1989	3.2885
.052489	4.306456	5.829414	5	4.732203	1.316909	0.515566	-0.3616	-3.04847	-0.92209	-3.58369	-2.97195	-1.99981	-2.61081	-2.18367	-3.22218	-1.55325	-3.96011	-1.82972	-2.77923
3.99189	59.22521	67.625	75.159	84.83308	93.19129	104.0035	114.4945	123.6035	140.9879	154.9121	175.8536	196.0592	215.5223	241.2444	259.0452	283.3298	290.5975	314.0369	319.7105
.463087	-2.9771	-22.8448	1.145038	-2.11382	-1.78862	-0.16529	-3.96552	-4.69565	-4.52174	-4.26087	-2.75862	1.333333	-1.72414	-1.15044	-7.35849	-2.20183	-8.72549	-1.92661	-8.43137
.463087	-2.9771	8.843537	2.519084	9.64539	-0.65041	-1.34454	-3.96552	4.285714	4.365079	-0.33613	0.833333	-2.7193	-3.18584	0.701754	-5.37736	0	-6.73077	-2.22222	0
.231293	8.231293	9.319728	-15.8182	7.753623	-1.32231	1.532258	-1.59664	-9.63636	-0.67227	-4.91228	-4.47368	-2.36842	-0.61404	-2.7027	-3.45455	0.353982	-6.34615	-1.85185	0
	7.60274	10.2027	-14.9091	8.333333	3.178295	1.138211	-0.5	-9.27273	2.03252	0.672269	-4.95575	-2.2807	-2.74336	-2.7027	-3.54545	0.442478	-6.44231	-1.00917	-3.36449
	7.739726	10.40541	8.93617	6.814815	2.65625	1.300813	1.065574	-9.18182	2.195122	-5.625	-5.17857	-3.96396	-1.76991	-3.45455	-2.52252	0.267857	-9.80198	-1.09091	-3.36449
	8.219178	9.3835															-10	-3.45794	-4.24528
		9.8630															2661	-0.18182	0
		8.6805															2661	-2.8972	-2.80374
		8.9583															6364		-2.80374
		1.0416															9259		
		7.872															8519		
		8.226															9259		
																	-2.5		
																	7778		
																	7037		
																	-1		
																	2727		
																	7273		

j. When the tool has completed go to the "Smoothing" tab and select "copy original" and then "copy updated". Now select "Smooth 3". Observe the resulting curve to be smooth. Some lumps in the curve are acceptable and perfectly fine but ideally you would like to see a smooth transition from one cell to another if at all possible.

k. For the higher range voltages it is likely that there is no data to correspond with these values. You can simply apply a rough correction to this region of the table. So if the average correction of the adjusted cells is 3% then you will apply a 3% correction to the higher unadjusted cells in row 2 of the smoothing tab.

l. Take note of the values in Row 2. These are the new MAF values that you will copy to your MAP in ATR/Rom Raider. **Since you do not want to apply the resulting smoothing to the closed loop portion of the MAF scale, it is best to copy just the relevant WOT data from the MAF voltage where the data starts as noted in step "i" above.**

m. Repeat as needed until resulting AFR's are with in +/- 1-2% or better of commanded Final.

Now you should be completed with calibrating the maf for WOT and can continue with the rest of the tune. It is recommended that you take one final log to verify both Closed and Open loop functionality and general drivability.

2.2 Timing

There are many ways to derive the best timing tables for your tune. Some of them are completely wrong because they circumvent the built in safety of the stock strategy. Here I will show you how to incorporate those safeties and even strengthen their function. The following is the procedure I have settled into and has shown itself to work best for me. You may find that other methods work best for you. You need to experiment with them all to gauge the effects each one has over the other. This procedure covers adjustments base on a goal that your car will be driven on the street. Race and Drag style tunes may require different ways of thinking

2.2.1 Primary (Base) Ignition Table

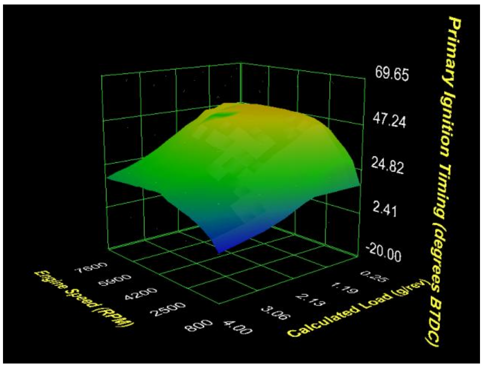
You must understand that base timing is not your final timing and you should not use the primary timing table to tune from except to remove timing in troubled areas. The idea is to derive your base timing for all failsafe conditions and worst case scenarios and then use the dynamic advance tables to increase timing as needed. So you will tune from the Dynamic Advance tables. As a good starting point I never exceed total timing to be more than 13° during peak boost and no more than 20° at peak RPM and load. Then once I get into the tuning process, this will likely increase but could decrease based on many variations.

To make things simple and to make things go faster I would recommend that you simply start with a COBB stage two table for the appropriate fuel being tuned. Beyond that there is no real rocket science behind this but there is a lot of intuition needed. To just recap… As a rule of thumb as the RPM increases, the timing will increase. Adversely, as the load increases the timing will decrease.

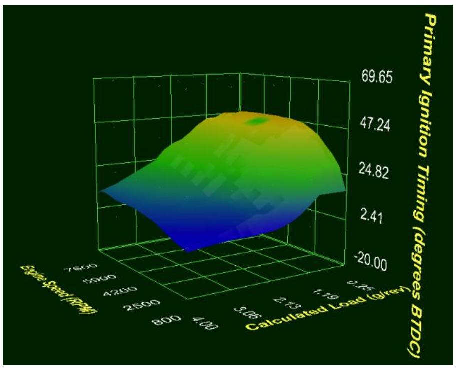
Also the timing can be defined differently for different fuel and the mean best timing from one to the other is different. Subsequently the timing for 93 is not going to be the same for 91 obviously, but the timing for meth or E85 are going to be drastically different.

In the following examples you can see the timing from 93 octane stage two and E85 stage two. Note the convex shape of the E85 tune as compared to the concave shape of the 93 table. This is because the dynamic effects of the fuel allow for a considerable increase in mean best timing for E85 in the lower and mid to upper mid Load/RPMs and a marginal increase in mean best timing in the high load/RPM range versus gasoline which has a lower mean best timing over all.

E85



93



It is also important to understand that because you observe knock it may not be a timing issue. It may be a lean condition either due to a poorly defined fuel table or some other problem. Subsequently too much fuel can also produce knock. It could also be bad gas so make sure you are using a high quality gas for the tune. If you have made adjustments to AVCS this could have a profound effect on timing and knock.

a. First Zero out your Dynamic Advance Tables (Ignition Advance). This will help you to establish a known good primary ignition setup. Once you have established your primary ignition table you can then increase timing using the Dynamic Advance tables. This allows the ECU to determine if it is safe to add timing or remove it if the situation becomes necessary.

b. Then begin logging the following. Drive in a variety of conditions with varying load. Do multiple WOT runs in all gears. Drive in heavy traffic and use spirited throttle input at times.

- Commanded Fuel Final (Primary Enrichment Final)
- Wide Band AFR Gauge
- Calculated Load (Engine Load)
- Boost (Man Relative Press)
- Dynamic Advance (Knock Correction Advance)
- RPM (Engine Speed)
- Feedback Knock Correction
- Fine Learned Knock Correction
- Primary Ignition Timing
- Intake Air Temp
- Throttle Position

c. Log for a long time and monitor your Feedback Knock Correction. If at any point during WOT you observe any knock activity, Stop immediately and return to home base. Analyze the log to see where and when the knock occurred.

✓ First filter the log to observe only the data points that show knock activity.
✓ Check the Wide Band reading for that data point and determine if the AFR is appropriate for the RPM and Load. Adjustment may need to be made to the primary fuel table.
✓ Compare the Wide Band reading with the Commanded Fuel Final and determine if there is a reasonable error between them. If the error is great then you need to investigate as to why.
✓ Check Tip-in conditions by observing when the knock occurs in conjunction with the initial onset of throttle. If the knock occurs during this transition and you observe a lean condition then it is likely due to a poorly adjusted Tip-in table and you should revisit that portion of the tune. Don’t confuse this with knock during the onset of boost. Tip-in knock only occurs during the instance when a positive change in throttle delta is observed.
✓ If your fuel is good then you can make an adjustment to the region of the Primary Ignition Table where the knock occurs. Compare RPM and Load to determine where to make your adjustments.
✓ Once done making adjustments, resume logging.

d. Once logging is complete you would want to filter only the interesting data. You want to show only activity in the Fine Learned Knock Correction column and the Feedback Knock Correction column.

e. As done in step “c” you want to determine if the knock is due to a lean fuel condition or not. Make the appropriate adjustments to the Primary Ignition table.

Suggestion: *One strategy would be, once you have made your final adjustments to the specific areas of the MAP, reduce timing by a couple of degrees globally throughout the entire table. You will be increasing timing in the next section for Dynamic Advance. This will guaranty a safe starting point when the ECU applies initial timing.*

Suggestion: *Once you have defined your Primary Ignition table, apply some smoothing to the table. You want a smooth transition from one cell to the adjacent cell. To do this in ATR you simply highlight three columns and hit <Ctrl-Alt-H>. This will average the center column to the two adjacent columns. Shift over one column and repeat till you reach the end of the table.*

f. Verify the adjustment took hold by driving.

If you are encountering stubborn or random knock events, please keep in mind that these could be cause by internal engine noise or a loose components or brackets. It is common to observe random knock caused by newly installed forged components or pistons that are fit loosely and are experiencing piston slap. Check all your exhaust hangers and brackets.

It is also common to see knock during low load and rpm situations. This to me is not interesting knock. If you see knock of -1.4 to -2 here and there it can probably be ignored. But if you see a continuous stream of knock then you probably have an interesting event.
Also look for knock that starts out at one value but then increases. This means that the ECU heard knock and made a correction, but then still heard more and made another correction. This event should definitely be looked into. Additionally, all knock that occurs under a positive boost condition should always warrant your attention.

So to summarize, you have created a base map by sampling all driving conditions and making adjustments to the map as needed. Then you reduce timing by a couple of degrees across the entire map to build in some failsafe.

2.2.2 Dynamic Advance Tables

Here we can use Dynamic Advance (Knock Correction Advance) tables to derive our final timing (Or actually tune the timing). The strategy here is to achieve as much HP without knocking. It is also important to remember that just because it is not knocking dose not mean you should increase timing. It is all about how much timing should you run to achieve the most HP (Mean Best Timing). For this reason you will need the help of VirtualDyno software to help you gauge your results. The procedure to do this is as follows.

**Note: AirBoys spreadsheet is also a good dyno solution.*

a. Log the previous parameters and take a log separately for both a 3rd gear and 4th gear run
b. Plot the data in VirtualDyno and use these as your base runs
c. Begin to add timing to the Dynamic Advance tables from load cells starting at about 1.5 and up. Start by populating the tab with about 4° of timing all around.
d. Flash the ROM and go out for another run. Remember you must drive around for a while before correction mode kicks in and starts to apply the Advance tables, so observe the "Dynamic Advance Multiplier (Ignition Advance Multiplier)" parameter to be "1" to determine when it is being applied. Then it is safe to continue with your runs.
e. Plot the data in VirtualDyno and compare the results. If the results are good then you can continue to add timing. If they are not then you know you have to remove timing. If the results are staggered and they are poor in one area and good in another then you need to add or remove timing in the appropriate areas. To determine where to adjust you can mouse over a portion of the plot in VirtualDyno and it will tell you what RPM point it is referencing. You can then locate that RPM point in the log and determine the RPM/Load cells to adjust. Also note that if you observe knock in any portion of the log, whether it corresponds to an improvement in power or not, you must remove some timing.
f. Keep repeating until you can not produce anymore power.

2.2.3 Compensating for a noisy engine.

There are situations that will warrant knock control to be suppressed to prevent it from having adverse affects on Ignition Advance. Generally the use of forged internal components is the primary cause. Most typical is the use of forged pistons. Since these expand and contract more than cast pistons they tend to be quite noisy and could be picked up by the knock sensor and interpreted as real knock by the ECU. Other causes can be a loose engine or exhaust brackets.

You must understand that you are effectively shutting off the ECU's ability to compensate for knock whether it is real or not. By making these adjustments you are fully responsible for any damage that may occur as a result of poor judgment. Before you commit to these adjustments you need to have exhausted every other method for determining whether knock events are real or not. Here we will discuss some ways to determine if the knock is false and then make adjustments to Knock Thresholds so that it has no effect on Dynamic (Ignition) Advance.

a. Determining a real knock event

1. First log the following

   - FLKC
   - FBKC
   - Primary Ignition Timing
   - Dynamic Advance
   - (Total) Ignition Timing
   - AF Senor #1 Ratio
   - AF Correction #1
   - AF Learned #1
   - Boost (Manifold Relative Pressure)
   - Intake Air Temp
   - Calculated Load
   - RPM
   - Throttle Position

2. Observe the log for knock. Look for a stream of knock in one area of the Load/RPM range. Generally these events will occur between 2000 and 3000 rpm and between .50 and 1.2 load. This is generally an indication of noisy forged pistons. If it is a loose bracket that is making noise, these events can occur anywhere in the rpm/load range. Also look for inconsistent values, values that are climbing and falling and then climbing again are generally false indicators. A stream of knock that climbs consistently or climbs to a plato and then falls are usually indicators of real knock.

3. Make an adjustment to the primary ignition (base timing) table in the load and rpm region that is exhibiting the knock. For example if the ECU is correcting timing by removing 6* of timing at a specific load and rpm range, then you remove that much plus 1* of timing from the table in that load and rpm range.

4. Then log again and observe the results. If there is no knock or a significant improvement then it is likely a real knock event and you need to determine why. If there is no observable improvement then it is likely false knock.

5. Now to confirm this theory you need to check that fuel is not the issue. *This step does not apply to E85 users*. To rule out the fuel we need to boost its octane level significantly. To do that you purchase three gallons of toluene and put it in the gas tank and fill the rest of the tank with high quality premium grade fuel. This will boost your over all octane to roughly 96-97 octane. Alternatively you may drain the tank and fill up with Cam2 race fuel if available in your area or 100 octane aviation fuel.

6. Log once more and observe the existence of knock in the same area as previously observed. If it is present then the knock is false. If it is gone then the knock is real and should be addressed.

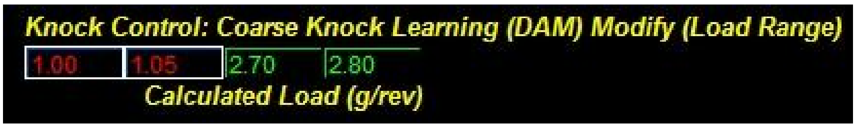
b. Adjusting for false knock

1. In AccessTuner Race, locate the following tables under "Knock Control"

   - Course Knock Learning (DAM) Modify (Load Range)
   - Course Knock Learning (DAM) Modify (RPM Range)
   - Feedback Knock Retard Activation (Min Load)

- Feedback Knock Retard Activation (RPM Range)
- Fine Knock Learning Modify (Load Range)
- Fine Knock Learning Modify (RPM Range)

2. Okay now let's assume my log is showing false knock between 2000 and 2300 rpm and between .70 and .97 load. We want to take the highest result from each category and apply that to the tables, as shown in the following examples, to allow you to affect when knock control is active. Note that the first value in each table represents when knock control is disabled below that point and the second value represents when knock control is activated above that point. So we want our first number to be just above our observed values. For instance our knock events occurred at the highest RPM of 2300 and our highest load of .97. So we will make our starting point in our tables at 2400 rpm and 1.00 load. There should be some gap between the disable value and the enable value. See the following examples…



Knock Control: Coarse Knock Learning (DAM) Modify (Load Range)

1.00	1.05	2.70	2.80

Calculated Load (g/rev)

Knock Control: Coarse Knock Learning (DAM) Modify (RPM Range)

2400	2500	5700	5800

Engine Speed (RPM)

Knock Control: Feedback Knock Retard Activation (Min. Load)

1.00	1.05

Calculated Load (g/rev)

Knock Control: Feedback Knock Retard Activation (RPM Range)

2400	2500	6900	7000

Engine Speed (RPM)

Knock Control: Fine Knock Learning Modify (Load Range)

1.00	1.05	2.70	2.80

Calculated Load (g/rev)

Knock Control: Fine Knock Learning Modify (RPM Range)

2400	2500	6400	6500

Engine Speed (RPM)

2.3 AVCS (Active Valve Control System)

WARNING: Damage can occur if you do not take precautions. On stock STi's it is relatively safe to advance your valve timing as much as 30° but in many non stock applications, this kind of advance can cause physical damage to your motor. If you are not aware of the clearances between valves and pistons you risk interference of these components. For many high lift, high duration cams, advancing these beyond 22° is not recommended and for larger valves in combination with high duration and lift cams it is not recommended you go beyond 15°.

In the Subaru, depending on whether you have a GD or a GR chassis, there are either two or four tables available for adjustment. They are the left and right intake valve advance and the left and right exhaust valve advance. Depending on your strategy you may need to adjust both intake and exhaust together.

Keep in mind that there are many reasons for adjusting AVCS and not all of them are geared toward making power. For instance you can adjust your valve timing to improve turbo spool but you may not necessarily be improving overall power because you may reduce your torque to the point where it negates having good spool characteristics. Unfortunately for this case, torque is what is going to get you going and yet at the same time turbo spool is important also. This is why I choose to tune AVCS for torque and use other strategies like Wastegate Duty, turbo dynamics, timing and AFR for improving turbo spool. It is a matter of finding balance and not getting caught up in focusing on one thing such as spool. Subsequently, the manufacturer employs emissions related techniques by creating an EGR effect and manipulating AVCS to overlap the exhaust valve with the intake valve.

Tip: TD_D, The "bubble" in intake degrees in the very low ranges is for emissions, and removing it (and replacing with adjacent values) pretty much always improves driveability.

Here we will attempt tc io software or AirBoy's spreadsheet to compare results. You can also observe the "Engine Load' parameter in your log to determine if you are making progress. The idea here is to achieve the greatest torque values for each of the Load/RPM ranges in the low and mid regions of the map and concentrate on HP for the higher regions. Observing your Calculated Load parameter is a good indicator of torque and you will reference VirtualDyno for both torque and HP.

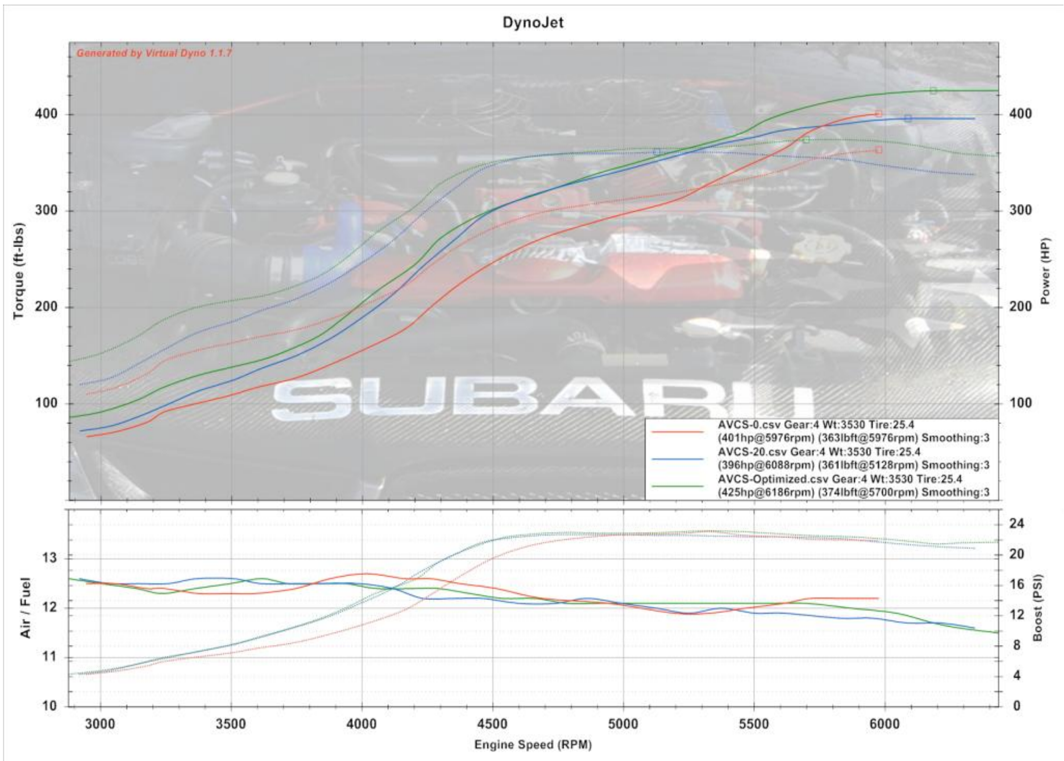
Additionally as you make adjustments to AVCS you need to observe your knock parameters. AVCS and Timing should be considered together and adjusted accordingly. You also need to understand the relationship between the two together by understanding what effects both have on horse power and torque. The procedure for performing these adjustments is as follows. (There are two methods for doing this)

Method A

a. Begin with the Intake AVCS. Start out using stock AVCS values.
b. Log using the same parameters as outlined in the section above for Timing (2.2.1 item b) only this time add AVCS parameters. Take a 3rd gear and 4th gear run individually
c. Plot them in VD and then determine what load/rpm cells are being referenced by interpolating the log with corresponding cells in ATR or RR. To do this I copy the table into Excel and shade the cells that are relevant. This will give us a good idea where and what to adjust.
d. Start to add some advance in those load cells. Take small steps here because you can cause potential damage if you go too far.
e. Flash the ROM and log again in 3rd and 4th.
f. Plot the results in VD and observe the difference in torque from these runs to the original *(See Next Step also*). Make adjustments accordingly for the rpm and load being referenced. Also observe knock and AFR. If there are any knock events that occur, you may need to either reduce AVCS advance or reduce ignition timing or adjust fuel to compensate. You need to determine if you should sacrifice HP for torque or visa versa by seeing where, on the plot, the knock corresponds to. If it is in the low load cells it would probably be a better bet to reduce timing since torque is most important in the low and mid load cells. If it occurs in the high load cells it would probably be prudent to compensate with AVCS advance because HP is most important in the high load cells. Before you make adjustments to ignition timing, keep in mind that this can greatly effect the dyno results you just plotted so you may want deal with a little knock and continue to see what effects the AVCS adjustment had on power/torque and then make an adjustment to ignition timing to see how that effects power/torque.
g. Also be aware that changing AVCS changes VE and in turn will affect your AFR so you may need to make adjustments to fuel before you make a comparison in VD. If there is any knock please be aware that this may be caused by inappropriate fuel and not ignition timing. Your AFR's should match what is defined in the Primary Fuel table. Make adjustments to your MAF to compensate. Ideally for the purposes of optimizing AVCS, as much as 3% difference in fuel as defined by the Primary Fuel table is acceptable.
h. Rinse and repeat. From step b.

Method B.

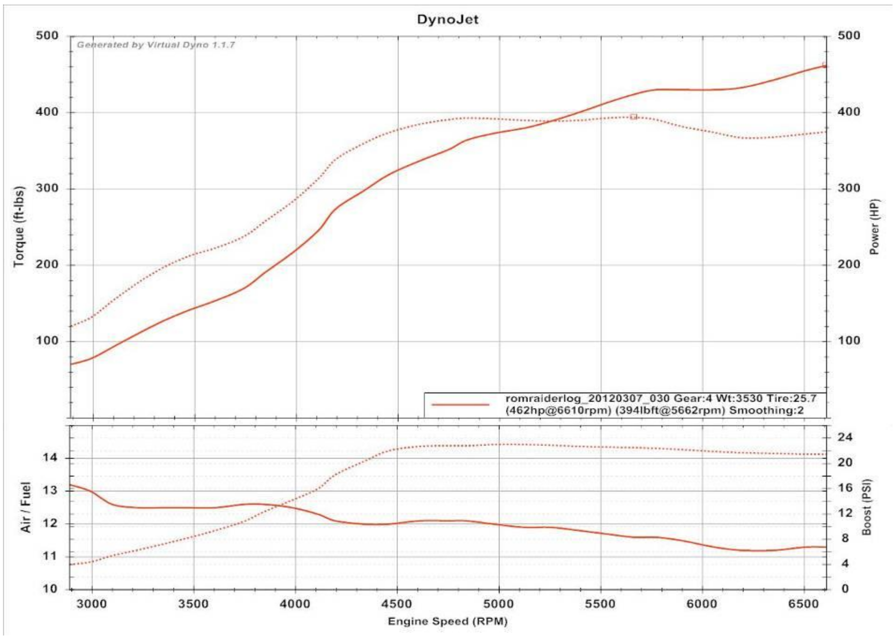
a. Beginning with the Intake AVCS, start by adjusting your entire AVCS tables to zero. Take a run in 4th gear WOT from 2400-6500 rpm.
b. Observe AFR and make adjustments to MAF scale and make your run again.
c. Plot the resulting log in VD.
d. Now adjust your entire AVCS table to 25º. *(less if you have after market cams and larger valves.)* Take a run in 4th gear from 2400-6500 rpm.
e. Observe AFR and make adjustments to MAF scale and make your run again.
f. Plot the resulting log in VD and compare to the previous run. See where, on the graph, the car is making power with each. Just extrapolate the results and populate your table accordingly. Also you can see how these runs affect spool from the example below. Note that the plot in green is a hybrid of the two runs and the AVCS table was populated with the best values from each result in the corresponding areas of the map as it relates to load and RPM. Also take note of the difference in spool.



g. Rinse and repeat. From step b.

For the exhaust AVCS the concept is largely the same but I would not go any further than 20º. I have not personally experimented with any more than that so any more is at your discretion. Further more the Exhaust AVCS is in Degrees retarded. Not advance like Intake AVCS.

Here is the final result of that AVCS optimization. Take note of the flat torque curve from 4500 rpm through to red line



2.4 Boost (Pump It Up)

Now it is finally time to start adding boost. This is where most of your gains will come and everything we did prior to this point has set us up to adjust this final yet most important of parameters. In this section we will not only tune for boost but we will also attempt to improve turbo characteristics like spool-up. We will also explain how you can adjust integral and proportional gains to minimize the effects of spike and/or over boosting in high load situations. We will also touch on what boost creep is and how to fix that.

At this point it is important to understand that boost is going to have a profound effect on how much timing you can run so revisiting timing is going to be necessary. Again for the purpose of understanding, I have separated these two functions but they really have to be adjusted together

It is important to understand that the turbo's output is determined ultimately by load on the engine. You will note that the 3D tables referenced are missing this vital component and reference only rpm and throttle position. So based on that we are limited as to what we can do in the wastegate tables alone. This is the reason I tend to focus mostly on 3rd and 4th gear tuning with respect to wastegate and then use the integral and proportional table to compensate for higher load situations. It is common not to reach your targets in the low load gears such as 1st and 2nd and it is possible to overshoot your target in the higher load gears such as 5th and 6th gear. However it is possible to smooth out these effects across the gear range

a. First you need to zero out your Wastegate Duty Cycle tables High and Low if not already done. They should look like this right now…

Wastegate Duty: Wastegate Duty Cycles (High)

Throttle Position (%)

	0.0	11.9	23.8	35.7	59.5	71.4	83.3	95.2
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Engine Speed (RPM)

Wastegate Duty Cycle (%)

Wastegate Duty: Wastegate Duty Cycles (Low)

Throttle Position (%)

	0.0	11.9	23.8	35.7	59.5	71.4	83.3	95.2
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Engine Speed (RPM)

Wastegate Duty Cycle (%)

The reason for this is to get a feel for the latency mechanical characteristics of the turbo and then start to add a bit of duty cycle till we get the desired result.

b. Next you need to set your boost limit and fuel cut. First determine your initial target boost and please make this reasonable. You should determine this by matching your target with the turbo you are using and what ever other supporting mods you have. For a stock turbo I would not be making your target more than 19psi. Though the stock turbo can support more than that it won't last very long at those levels. The larger the turbo the higher the target can be… but again you should determine if more is good. Another example would be a 20G. I would set this to be no more that 23 or 24 psi but typically I run these at 22 just to stay well with in its efficiency range. In many instances just because your turbo is capable of boosting, your MAF may not support it, which brings me to a key point…

Know the turbo you have selected. You should become familiar with its compressor map and exhaust housing and compressor housing sizes to determine the capabilities of the turbo and how best to take advantage of it. You should understand what effects each of these has on the spool characteristics of the turbo. Only then can you fully understand the process of making your turbo perform.

As a starting point I set my limits by selecting the Boost Limits table and apply a multiplier to the entire table till the value in the last cell (Barometric Pressure @ 14.7) is 2 or 3 psi more than my desired target at sea level. In this example I made the boost limit 25psi because my target is expected to be 23psi. Also be aware that your limits and targets are directly related to your elevation as indicated by the barometric pressure so you should make your target appropriate for the elevation you are at. In ATR the limit values are in Manifold Pressure Relative. So the numbers you define here are what you would see at the gauge and are a 1:1 relationship of indicated/actual. In RomRaider the values are in Manifold Pressure Absolute. So the numbers you define here are gauge pressure plus atmosphere. In other words to define 25psi boost limit for the 14.7 column you need to apply 14.7psi atmosphere plus 25psi relative for a total of 39.7psi absolute.

Boost Limiters: Boost Limits (Fuel Cut)

Barometric Pressure (psi)

8.51	9.75	10.98	12.22	13.46	14.70
12.68	15.26	17.81	20.34	22.91	25.06

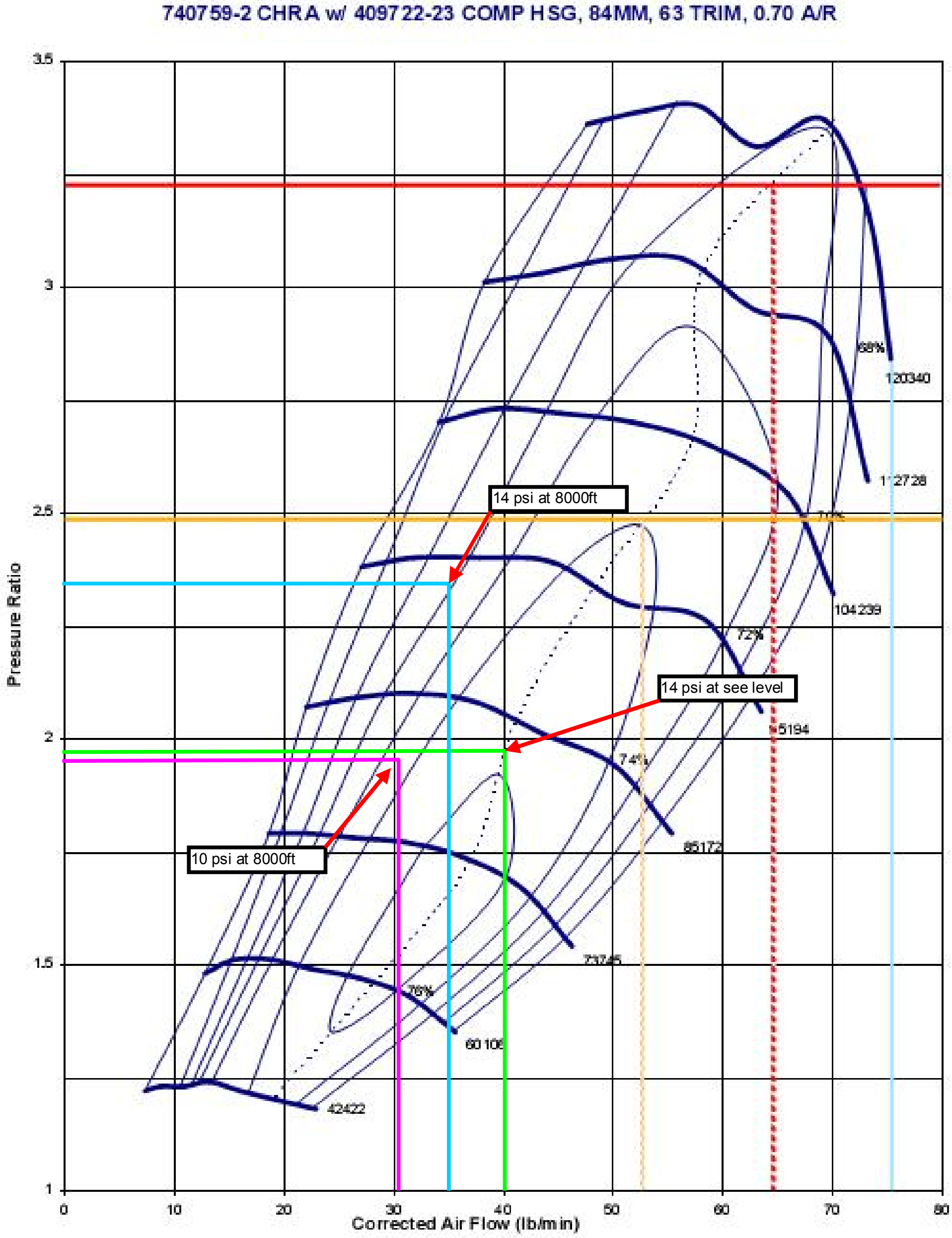
Manifold Rel. Pressure (sea level) (psi)

You may be asking yourself "Why do the limit values go down as you increase your elevation?", "Wouldn't it be prudent to keep the same relative pressure limits throughout the range?" No, simply resetting your relative pressure limit to 25 psi through out all atmospheric conditions is not the correct way to compensate. You have to realize why the numbers are less the higher you go in elevation and this is where getting intimate with your turbo compressor maps pays off. Because the air is much thinner and the turbo has to work harder and faster to achieve the same results, the efficiency of the turbo is greatly affected at different elevations. So the turbo speed will be exponentially faster at the same boost level as if you were at sea level and its efficiency is not the same. Ideally you need to adjust this table to coincide with the compressor map and the efficiency of your turbo versus different pressure ratios. If you maintain the same relative pressure through out, the turbo may become a hair dryer at +5000 feet and you will be affecting a negative impact to overall power and risk knock

To explain, 14 PSIR, at sea level makes 28.7 PSIA while at 6K altitude it makes only 26.6. So the pressure out versus pressure in (pressure ratio) gets higher at higher elevations:

28.6/14.6 = 1.958 PR
26.6/12.6 = 2.111 PR

The process to defining your limits and targets is to first evaluate the compressor map for your turbo to determine its efficiency and to understand were the turbo's output is optimized for certain pressure ratios. In the following example we will determine this by looking at the compressor map below.



First take note of the colored lines as they relate to both the pressure ratio and flow axis and the efficiency islands. Also note the dotted line through the center of the islands that represents the highest efficiency relative to pressure ratio and flow. Ideally this is where we want to be as we spool and maintain boost and you can see how increasing the pressure ratio (changing the elevation) can affect the efficiency of the turbo. Although this is ideal it is rare to achieve this because you may not be able to achieve the flow necessary to achieve the exact range you are targeting. In this instance you may consider a different turbo choice.

Let’s break down the map starting with the corrected flow axis. This axis can be related to your MAF readings but to understand that lets first convert it to g/s instead of lbs/min. To do that we take the value in lbs/min and times it by 453.5924 then divide by 60. So 30lbs/min becomes 226.7962 g/s. That seems reasonable right?

Now let’s look at the pressure ratio axis. This is the ratio between input pressure and output pressure. To understand this lets assume a constant manifold relative pressure of 14psi (actual boost) and then calculate the expected pressure ratio based on different elevations or atmospheric pressures. Let’s start at sea level and an atmosphere of 1 or 14.7psi. The calculation is 14psi relative + 14.7psi atmosphere = 28.7psi absolute. Then divide Absolute by Atmosphere to get the ratio which is 1.95:1.

PSIr + PSIat = PSIa (14+14.7=28.7)
PSIa/PSIat (28.7/14.7=1.95)

Now lets do the same relative pressure but at 8000 feet.

14+10.9=24.9
24.9/10.9=2.28

Now look at the map and make an estimate of how much your MAF will flow based on manifold relative pressure at the relevant elevation or atmospheric pressure. You should have a pretty good idea of this by now. If not then you will need to find out by running the turbo at the target boost and determine MAF flow. Once you know the flow rate you can compare this to the compressor map and look at the intersections where flows versus pressure ratio meet. In the example I am assuming 302g/s for 14psir at sea level. If you take a look at the map you will see that we are well with in ideal efficiency for this turbo… However look at what happens when we go to 8000 feet. If we leave relative boost pressure at 14psi, our reading at the MAF is decreased because of less atmosphere and our efficiency is affected greatly because the pressure ratio is higher and this puts us closer to where we don’t want to be. Now let’s stay at 8000 feet and reduce our boost to only 10psi. Our MAF reading reduced but also our pressure ratio reduced as well and this put us closer to where we want to be with in the turbo efficiency range.

Now that you are educated about compressor maps you can make better decisions regarding target boost and boost limits.

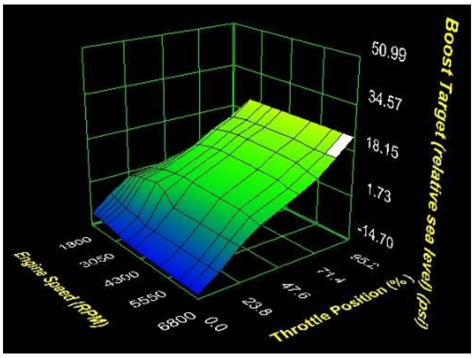
c. Now you need to set your target boost. The ECU will look at this table to try to achieve the boost levels that are defined here. The most important columns to consider in this table are the last four columns. The first three can be left at stock levels or adjusted as you see fit. Beginning at column 95.2, set your desired target from 2600rpm on up. Make the transition to decreasing values from cells 2600rpm and lower and make their transition smooth as outline in the example below.
    1. Beginning at column 95.2, set your desired target from 2600rpm on up. Make the transition to decreasing values from cells 2600rpm and lower and make there transition smooth as outline in the example below.
    2. Continue to define target in columns 83.3, 71.4 and 59.5. You will make the transition from one column to the other as smooth as possible till the graph shows a smooth linear slope as indicated in the example below.
    3. Note in the lower columns that the upper RPM cells have decreasing values. This is because increasing values under these conditions are unrealistic

Boost Targets: Boost Targets

Throttle Position (%)

Engine Speed (RPM)	0.0	11.9	23.8	35.7	59.5	71.4	83.3	95.2
1800	-10.54	-4.64	0.23	1.41	2.94	5.26	6.21	8.02
2000	-10.54	-5.12	1.01	2.40	5.47	8.62	10.44	12.45
2200	-10.54	-5.90	1.97	2.96	7.77	11.68	13.38	16.24
2400	-10.54	-6.57	2.28	3.44	9.46	13.77	16.88	20.26
2600	-11.06	-6.96	2.32	4.14	10.07	14.37	17.62	23.28
3200	-11.99	-7.54	3.67	5.03	11.31	15.49	18.49	23.28
3600	-12.82	-8.89	1.84	5.45	11.70	15.74	18.49	23.28
4000	-13.25	-8.89	-2.32	5.10	11.49	15.66	18.49	23.28
5200	-13.25	-8.89	-2.32	4.54	10.94	15.28	18.49	23.28
6000	-13.67	-8.89	-2.42	4.31	10.48	14.73	17.62	23.28
6400	-13.67	-8.89	-2.42	3.44	9.26	13.27	17.62	23.28
6800	-13.67	-8.89	-2.42	2.36	8.74	12.18	17.62	23.28

Boost Target (relative sea level) (psi)



d. Now you can begin to define your wastegate duty cycle table. You will begin by applying some percentage to the last column of both the High and Low tables (In RomRaider this is usually Max WGDC and WGDC High/Low KCA). Start out with small increments because we don’t know the characteristics of the turbo quite yet. Always remember that the Low table should always be about 8-10% less than the High/Max table as outlined in the following illustrations. This is because the ECU starts out by applying the values in the Low table and then applies compensations to WGDC based on Turbo Dynamics up to the Max values outlined in the Max table.

Wastegate Duty: Wastegate Duty Cycles (High)

Throttle Position (%)

	0.0	11.9	23.8	35.7	59.5	71.4	83.3	95.2
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
2200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
2400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
3200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
3600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
5600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
6400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00

Engine Speed (RPM)

Wastegate Duty Cycle (%)

Wastegate Duty: Wastegate Duty Cycles (Low)

Throttle Position (%)

	0.0	11.9	23.8	35.7	59.5	71.4	83.3	95.2
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
1800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
2200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
2400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
2600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
3200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
3600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
4800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
5200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
5600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40
6800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40

Engine Speed (RPM)

Wastegate Duty Cycle (%)

e. Now you are ready to see what effect that made. You may now flash your ROM and take the car out for a run while logging the following.

- ✓ Throttle Position
- ✓ MAF Voltage
- ✓ RPM
- ✓ Load
- ✓ Boost
- ✓ Turbo Dynamics (Boost Error)
- ✓ Turbo Dynamics Integral (not sure what this is in RR)
- ✓ Turbo Dynamics Proportional (not sure what this is in RR)
- ✓ WGDC
- ✓ AFR Gauge
- ✓ Commanded Fuel Final (Primary Enrichment)
- ✓ FLKC
- ✓ FBKC

Log a 4th gear run at WOT. When done, observe your log and look first for knock. If any knock is observed then you must deal with that before you continue. Then observe your fuel. Look at the AFR gauge reading compared to the commanded fuel final as outlined in the AFR tables and compensations. These need to track within 1% of each other. If they do not, then make adjustments to MAF scaling in the appropriate areas. If the fuel is good and there is no knock observed but you have not yet reached your desired boost target, then increase the values in the last column of your wastgate duty cycle tables and repeat your run. Continue to repeat this process till your resulting boost in 4th gear has reached target.

To adjust the lower columns you perform the same procedure for each of the targeted throttle positions. For all intents and purposes it is best to maintain stock level values below 35.7% throttle position. You can always refine these later if you so desire.

You also want to observe your logs to see what WGDC values are being used to achieve target boost. Ideally you want to achieve boost with the initial WGDC tables and not the Max. This will give room for Turbo Dynamics to work and will also allow you to refine things later should you experience spike or hunting.

f. Once you have defined your Wastgate duty cycle values you can now refine them to allow for better spool. Note that the below examples were defined for use with a very laggy turbo. Your values may be different and you should always start out with smaller values. In the following examples you will see that I have redefined the Duty Cycle cells from 2000 rpm to 2400 rpm and increased them to 95% in most cases. This was done as a measure to combat the laggy characteristics of the turbo by insuring the wastgate remain closed under low rpm/high load situations when boost is being called for. Typically from 2000 to 2400 rpm's is where the turbo begins to build spool and this strategy helps that process. Again, here you will need to experiment and find the values that work for you if at all. In many cases with faster spooling turbos this strategy will cause your turbo to spike and that is not a desired effect. In some cases you may need to decrease these values further.

Wastegate Duty: Wastegate Duty Cycles (High)

Throttle Position (%)

Engine Speed (RPM)	0.0	11.9	23.8	35.7	59.5	71.4	83.3	95.2
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00
2200	0.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00
2400	0.00	15.00	15.00	15.00	75.00	75.00	90.00	90.00
3200	0.00	0.00	15.00	15.00	27.00	40.00	53.00	53.00
3600	0.00	0.00	15.00	15.00	27.00	40.00	53.00	53.00
5600	0.00	0.00	15.00	15.00	27.00	40.00	53.00	53.00
6400	0.00	0.00	15.00	15.00	27.00	40.00	53.00	53.00

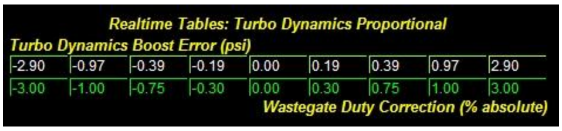
Wastegate Duty Cycle (%)

Tip: TD_D, The newly found per gear requested torque tables can markedly improve hitting targets in lower gears.

g. In this step I will show what tables control errors you may be experiencing such as boost spike, hunting or over shooting your targets in higher load situations and we can even use these tables to refine your targets in lower and higher gears. It is possible to achieve target boost in 2nd gear and maintain target in 5th and 6th. Turbo dynamics is a closed loop system and will react IAW boost error to make corrections to final waste gate duty and characteristics.

In your log you need to isolate RPM, Throttle Position, Boost, Turbo Dynamics (Boost Error) and TD Integral and Proportional. This will give you a really good idea as to what is going on and it will, in turn, give you a pretty good idea what to adjust to achieve your desired result. In the log, try to isolate the area that is giving you problems and adjust the following table to achieve the desired results.

1. <u>Turbo Dynamics Proportional:</u> This makes an immediate adjustment to waste gate duty based on boost error. This table corresponds to both positive and negative errors. Typically used allow you to reach target boost initially. If boost hunting occurs, consider smaller numbers here. Typically when tuning, these numbers are adjusted to the point where boost begins to oscillate as boost target is reached. Negative errors correspond to higher load situations that cause over boosting to occur. Positive errors correspond to lower load situations where under boosting occurs. Experiment and adjust these tables to achieve the desired result.



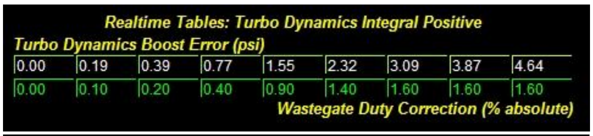
Realtime Tables: Turbo Dynamics Proportional

Turbo Dynamics Boost Error (psi)

-2.90	-0.97	-0.39	-0.19	0.00	0.19	0.39	0.97	2.90
-3.00	-1.00	-0.75	-0.30	0.00	0.30	0.75	1.00	3.00

Wastegate Duty Correction (% absolute)

2. <u>Turbo Dynamics Integral Positive:</u> This makes an long term adjustment to waste gate duty based on boost error. Use this table in conjunction with corresponding positive errors in your log. Positive errors indicate an under boost condition. This table can be used when boost is not reaching or maintaining target provided the turbo itself is not the limiting factor. Experiment with this table to achieve the desired results. Increasing these numbers will increase your final WGDC when positive errors are observed in your logs.



Realtime Tables: Turbo Dynamics Integral Positive

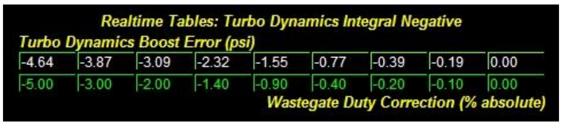
Turbo Dynamics Boost Error (psi)

0.00	0.19	0.39	0.77	1.55	2.32	3.09	3.87	4.64
0.00	0.10	0.20	0.40	0.90	1.40	1.60	1.60	1.60

Wastegate Duty Correction (% absolute)

3. <u>Turbo Dynamics Integral Negative:</u> This makes an long term adjustment to waste gate duty based on boost error. Use this table in conjunction with corresponding Negative errors in your log. Negative errors indicate an over boost condition. Typically used to correct for boost Spikes and for reaching and maintaining target provided the turbo itself is not the limiting factor. Experiment with this table to

achieve the desired results. Decreasing these values will decrease your final WGDC when negative errors are observed in your logs



Realtime Tables: Turbo Dynamics Integral Negative

Turbo Dynamics Boost Error (psi)

-4.64	-3.87	-3.09	-2.32	-1.55	-0.77	-0.39	-0.19	0.00
-5.00	-3.00	-2.00	-1.40	-0.90	-0.40	-0.20	-0.10	0.00

Wastegate Duty Correction (% absolute)

h. One other thing to consider is the use of a three port electronic boost control solenoid or EBCS. This type of solenoid will offer better, faster and more concise control of your waste gate profile and really compliment the factory boost control system very well. Please refer to Cobb’s Tuning Guide for details on how to configure these. The tuning process is the same but the resulting values will not be the same. Typically the use of these devices yields much lower WGDC’s than the stock unit primarily due to the increase control and lack of a in line pill

i. What is boost creep and how can I fix it? This is a good question and so often people run into this situation. This condition is caused by changes to hardware… more specifically exhaust. Boost creep is brought on when increased exhaust gas flow is generated due to the upgrade of exhaust components such as downpipe, headers and up-pipe. What actually occurs is the internal waste gate is not adequately large enough to pass the extra flow of gases, so pressure begins to build behind the waste gate and the gases exit through the turbine instead. This causes a run away effect where the turbo just keeps on building boost to spite the waste gate being open.

   One method for compensating for this is to port the internal waste gate by smoothing the sharp edges of the orifice. Depending on the amount of pressure is building up behind the waste gate, this method may not yield any good results. This is why I always just recommend the second method…

   The second method would be to install an External Waste Gate assembly which generally consists of an up pipe, a waste gate and a dump tube. Again refer to Cobb’s Tuning Guide for details on how to configure this set up.

j. Other alternative methods for improving spool would be to manipulate timing and fuel both during the onset of boost and while the turbo is building boost.

   The first strategy would be to reduce timing and fuel in the areas of the map where the turbo begins to build boost and all the way through till it has reached useable boost. The idea here is that by reducing timing and fuel you are increasing exhaust temperature. The temperature increase helps the turbine spin because of the increase in gas velocity and pressure as a result of expansion. I have seen this method produce great results but at the expense of some drivability due to the lack of timing in some cases. This is called Lean Spool and is regarded as unsafe by many tuners.

   The second method would have you increase timing and fuel during the onset and building of boost. The idea here is to allow timing to build power and then increase fuel to allow for a greater exhaust load. To spite what is widely circulated as truth it is not heat directly that spins a turbo. It is exhaust gas velocity. The velocity is nothing more than the result of super heated gases as they expand. Thus the misconception that heat is what spins a turbo. If you increase the volume of gas, you increase its velocity through a conduit… Simple as that. So by increasing fuel you are doing two things. You are controlling knock brought on by higher timing and you are increasing the volume of exhaust by adding molecules. However you need to be careful how much fuel you add. You need to be able to burn all of the fuel entering the engine if this method is to be successful. The result here can be quicker spool and great drivability. This method lends itself very well to the use of E85. Add on top of volume created by richer fuel mixtures, the use of E85 increases that even more and the results can be explosive!

   Yet a third method is the same as above only you would reduce timing during the onset of boost to allow greater exhaust gas temperatures and expansion of the gas thereby increasing volume further.

3 Making Power (Suggestion only)

Tuning method

This is simple in concept but difficult to do successfully if you don't understand the relationship between fuel timing and boost. To recap on what was covered, adding timing increases power. Leaning fuel (to a degree) makes power. Adding boost makes power, but to find the balance is key and to fully understand why you choose to adjust one or the other is imperative. In just about all turbo application most people choose to run with richer AFRs to control knock and/or exhaust temps and focus more on adjusting boost and timing. It is almost nearly impossible to run NA level fuel in a turbo application because you simply won't be able to achieve the optimal boost level without knocking. You need to maintain a fair level of fuel to run safely. You need to run a fair amount of timing to achieve a consistent dyno curve. And you have to adjust both to control exhaust gas temperatures

The use of virtual dyno software is what I use to do the actual tuning. What we have done up to this point is really calibrate everything but really haven't actually tuned anything other than boost. I also HIGHLY recommend the use of an exhaust temp gauge to monitor exhaust gasses. I start getting uncomfortable when temps either go below 1100 or above 1600 degees F. Low exhaust gas temps mean either your fuel is to rich or timing is to high or a combination of both. To high a temperature and you are to lean and/or your timing is to low. Monitor knock and adjust accordingly. So…

- Fist I will decide on a timing/boost strategy as listed below for the application I am working with.

- Then I like to set my target boost level first and then tune everything else around it for making power, and then adjusting boost again if needed.

- Once boost is initially set I will optimize my fuel tables by making adjustment and comparing that with multiple runs in VD. Conceptually you want to adjust your fuel till you have achieved as much power as possible. However, I stop just before I make the most power and move on to timing.

- Timing is done the same way fuel was done and I compare VD result each time to achieve the best timing with out knocking. To adjust timing I will be doing this with the dynamic advance tables only. This is because it offers me a level of safety, and if IAM falls so will your tuned timing drop accordingly. If you tune using the primary map, the timing defined there may not be appropriate for high knock situations. (see "Fuel and Timing Strategies" below)

- Finally I will go back and adjust fuel and timing again and repeating as many times until no more power can be achieved safely

Timing and Boost Straegies

There are two camps when it comes to making power. The first will have you reduce timing and build your power with boost. The other will have you increase timing to build power and reduce boost. There is no wrong way to do it, and you need to find your best method. However more importantly you need to know what to adjust in each scenario to not only make power but how to do it safely.

Regardless, this section deals mostly with WOT scenarios and much of your daily driving strategies should include a reasonable amount of timing regardless of the method you choose for making power. Great smooth and consistent response is generally achieved through the use of timing and appropriate fuel mixtures. Let's tackle each of these methods individually…

A. Making power with timing: Here the idea is to build much of your power with timing. But to do this you will need to make compromises in other areas to compensate for knock. The method tends to lend itself better to small turbo applications where boost is relatively low. Subsequently higher timing can be used to increase HP in the high RPM range to increase HP as the turbo begins to taper off. Be careful here though.

   - First you will not be able to utilize high levels of boost because your cylinder pressures will be too great for the timing you are commanding and a higher propensity for knock exists under these conditions.

   - Second you will need to increase fuel to control knock.

B. Making power with boost: Here the idea is to increase boost thereby increasing cylinder pressure. This tends to be the more popular method. This method tends to lend itself better to large turbo applications where higher boost levels can be achieved.

   - First you need to reduce timing to control knock but you need to monitor exhaust gas temperatures while you do this. As you remove timing you are increasing exhaust temperature.

- Second you may need to increase fuel to control exhaust gas temperatures

<u>Fuel and Timing Strategies</u>

For the purpose of making power you may decide to further refine your fuel targets. Typically to make power you will want to lean your mixture. But keep in mind that doing so will increase your exhaust temperatures and it is recommended you use a quality EGT gauge to monitor your Exhaust Gas Temperatures. Ideal AFR's for making power are between 12.3:1 and 12.5:1. However this is not feasible in turbo applications because you have to compensate for high exhaust temps brought on by the effect of boost and the very high cylinder pressures it creates. In the case of our cars you will want to maintain a level of richness to control EGT's at high RPM's and/or for controlling knock. Also adjusting your fuel could have a profound affect on how much timing you can run and how much knock you will see. My method for dealing with this situation is I will begin with stock level timing for a given load and RPM cell and slowly increase my AFR till optimum power can be achieved. The whole time I will observe knock and if I see any, I will decrease timing more, but only if power is increasing as a result of the AFR changes I am making. If there is no knock and once I have adjusted AFR to optimum levels, I will then add timing to the threshold of knock and then back off a few degrees. Ultimately I end up right around 11.3 – 11.5 to 1 on a turbo application

4 <u>Tips and Tricks and Other Compensations</u>

4.1 <u>Installing new injectors and MAF?</u> If you are installing larger injectors and a larger MAF housing/intake, install just one and scale it off the other stock unit first. Then go ahead and install the other. For instance you can install your injectors first and scale them till fuel trims are ideal because we already know that stock MAF scaling is good. You might choose to install the MAF first and scale that to known good stock injectors also. It is your choice.

4.2 <u>Resetting the ECU and logging.</u> When resetting the ECU it could take some time before you start to monitor accurate data. This is because the ECU is running routines and learning data. It is fair to say that the ECU is in a state suitable for logging data when it has reached correction mode. In this mode the ECU is correcting fuel based on input from all of its sensors and it has activated dynamic advance and knock routines.

It is for this reason it is important to give the car some driving time after a reset and before you start logging. At least 15 minutes of normal around town driving is necessary to complete this process

4.3 <u>Leaks</u> in the intake system are the most common cause of bad fuel trims and will really mess with the tuning process. If your fuel trims are high across the RPM/Load range, you most likely have a leak between the MAF and Turbo. If you have positive fuel trims at idle and cruise but negative fuel trims while boosting then you most likely have a leak after the turbo.

4.4 E85 Compensations

When using E85 we have to compensate for its use because it has a smaller energy potential per volume then gasoline. As a result we have to use more of it to achieve the same result. Here I will show you some important tables to adjust. Tuning for E85 is the same basic procedure for tuning with gasoline. The only difference is the amount of fuel we need to command.

When compensating for E85, we throw out the notion that E85 is different than gasoline because it references the AFR table in its existing form as defined for gasoline. This is because the Value for Lambda is 1 when stoich and the AFR tables are really in lambda. For the purpose of convenience the AFR table is displayed as AFR. As such, since the AFR table is displayed in a scale suited for Gasoline, We will tune for E85 as if we are tuning for Gasoline. With this in mind we simply manipulate the injector scaling to trick the ECU into thinking it is using smaller injectors than is actually being used. By doing this we increase the pulse width to the injector and it squirts more fuel. The advantage to this is you maintain the AFR fuel table as it is so there is no chance of getting that wrong. The other advantage is there is less thought involved during tuning because you are referencing the same AFR's as if you were using gasoline so it is business as usual.

Over all this method yields about 25 to 30% more fuel. Remember those numbers because this will be more common then you think throughout tuning process.

1. Correcting fuel

   a. Start out with pure gasoline in the tank and with a known good tune for gasoline and verify the idle trims are close to zero and stable. If not, then make adjustments.

   b. Then make the switch over to E85. It is highly recommended that you fully drain the tank of all gasoline prior to switching.

   c. Then you need to manipulate your injector scale. In AccessTuner Race you need to open the table for "Fuel Injector Scale". Take the existing number and apply a multiplier of 1.30. So assuming the existing value 2523, you need multiply that number by 1.30 for a 30% increase to 3280. In RomRaider you need to decrease the value since it is showing actual injector size. For that you want to take the existing value and apply a multiplier of .70.

   d. Now save your map as your starting point for E85 and flash it to the vehicle. Start the car and allow a few minutes to allow the idle trims to stabilize. Once the fuel trims have stabilized, observe your trims at idle.

   e. If you are connected to the ECU live with AccessTuner Race then go ahead and apply changes to injector scale till your fuel trims are at or close to zero. Once adjusted, save the map to ATR and the AP and flash the adjusted map to the vehicle.

   f. If you are making adjustments off line then observe the trims average over time and apply that difference to injector scale in ATR. So if you observe the "A/F Correction #1" plus "A/F Learned #1" parameter to be showing an average of +5%, then you will need to increase fuel by 5% in kind. For this you simply apply another multiplier to injector scale with a value of 1.05. In RomRaider you will apply a .95 multiplier. Subsequently if the fuel trims are negative you need to take away fuel.

Save the map and flash it to the vehicle. Start the car and allow fuel trims to stabilize. Continue to make adjustments till you achieve the desired results.

2. Correcting Tip-In

   a. Start out by leaving tip-in values alone and test through proper logging as outlined in section 2.1.6.

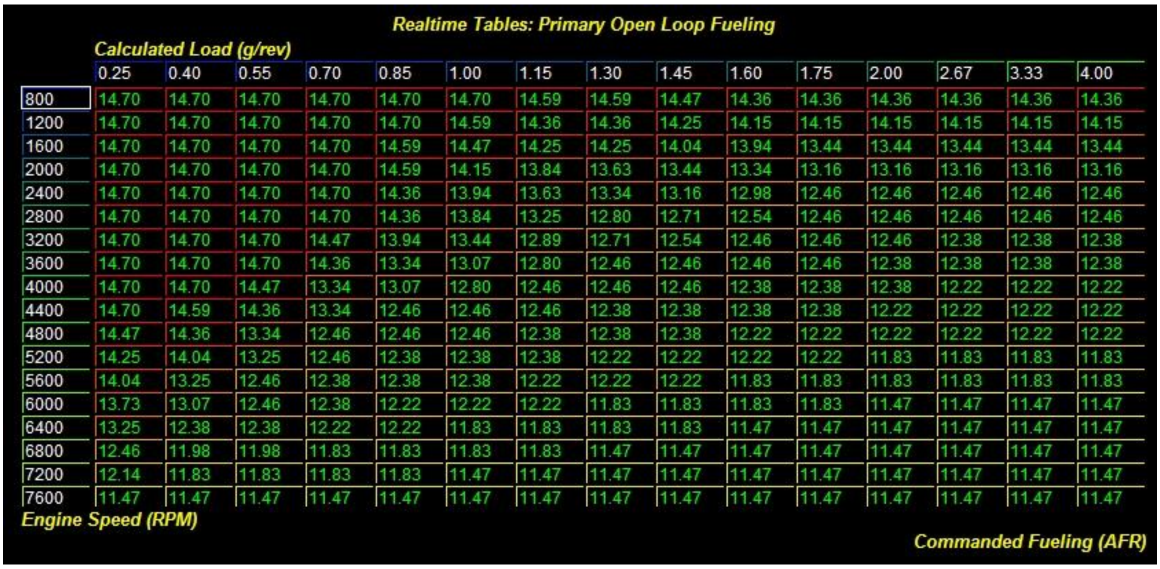
   b. If tip-in adjustments are required, perform the procedure referenced in section 2.1.6 of this guide for fine tuning Tip-in Enrichment.

3. Redefine your fuel tables

   Since E85 has different characteristics than gasoline you can make modifications to the fuel tables to take advantage of these differences.

   E85 has a greater octane level than pump gas and it also results in a cooler cylinder temperature. To take advantage of this we can lean out the mixture. I have seen AFR's defined as lean as 12.5:1 but I have found that the tuner is ignoring EGTs. My experience has shown that only a few points leaner is necessary and that significant boost and timing can be used if you maintain mixtures close to that which you would use for gasoline. Typically I like to be around 11.8 to 11.5 in the peak power range

   As such I like to redefine my fuel table accordingly. The standard rules apply hear when defining fuel in the very high load and RPM regions of the table. You still need to richen the mixture to maintain a level of safety when considering knock and exhaust temperature. Please refer to section 2.1.1 of this guide for defining fuel targets.



Realtime Tables: Primary Open Loop Fueling

Calculated Load (g/rev)

	0.25	0.40	0.55	0.70	0.85	1.00	1.15	1.30	1.45	1.60	1.75	2.00	2.67	3.33	4.00
800	14.70	14.70	14.70	14.70	14.70	14.70	14.59	14.59	14.47	14.36	14.36	14.36	14.36	14.36	14.36
1200	14.70	14.70	14.70	14.70	14.70	14.59	14.36	14.36	14.25	14.15	14.15	14.15	14.15	14.15	14.15
1600	14.70	14.70	14.70	14.70	14.59	14.47	14.25	14.25	14.04	13.94	13.44	13.44	13.44	13.44	13.44
2000	14.70	14.70	14.70	14.70	14.59	14.15	13.84	13.63	13.44	13.34	13.16	13.16	13.16	13.16	13.16
2400	14.70	14.70	14.70	14.70	14.36	13.94	13.63	13.34	13.16	12.98	12.46	12.46	12.46	12.46	12.46
2800	14.70	14.70	14.70	14.70	14.36	13.84	13.25	12.80	12.71	12.54	12.46	12.46	12.46	12.46	12.46
3200	14.70	14.70	14.70	14.47	13.94	13.44	12.89	12.71	12.54	12.46	12.46	12.46	12.38	12.38	12.38
3600	14.70	14.70	14.70	14.36	13.34	13.07	12.80	12.46	12.46	12.46	12.46	12.38	12.38	12.38	12.38
4000	14.70	14.70	14.47	13.34	13.07	12.80	12.46	12.46	12.46	12.38	12.38	12.38	12.22	12.22	12.22
4400	14.70	14.59	14.36	13.34	12.46	12.46	12.46	12.38	12.38	12.38	12.38	12.22	12.22	12.22	12.22
4800	14.47	14.36	13.34	12.46	12.46	12.46	12.38	12.38	12.38	12.22	12.22	12.22	12.22	12.22	12.22
5200	14.25	14.04	13.25	12.46	12.38	12.38	12.38	12.22	12.22	12.22	12.22	11.83	11.83	11.83	11.83
5600	14.04	13.25	12.46	12.38	12.38	12.38	12.22	12.22	12.22	11.83	11.83	11.83	11.83	11.83	11.83
6000	13.73	13.07	12.46	12.38	12.22	12.22	12.22	11.83	11.83	11.83	11.83	11.47	11.47	11.47	11.47
6400	13.25	12.38	12.38	12.22	12.22	11.83	11.83	11.83	11.83	11.47	11.47	11.47	11.47	11.47	11.47
6800	12.46	11.98	11.98	11.83	11.83	11.83	11.83	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47
7200	12.14	11.83	11.83	11.83	11.83	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47
7600	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47	11.47

Engine Speed (RPM)

Commanded Fueling (AFR)

4. Redefine your Timing (Optional)

   Since E85 has different characteristics than gasoline you can make modifications to the timing tables to take advantage of these differences.

   Since E85 has a significant resistance to knock you can increase timing globally, but you should do this with caution. Take small steps here. Typically you can significantly increase timing in the low to mid load regions but in the higher load regions, the increases should only be marginal. Please refer to section 2.2 of this guide for tuning timing.

5. Redefine your boost (Optional)

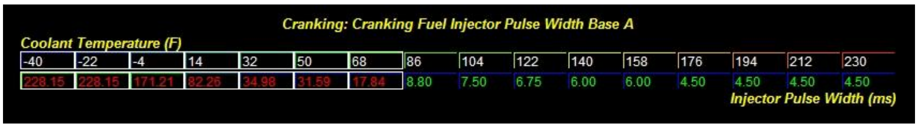
Again because of the differences in characteristics, E85 will allow you to significantly increase boost. Do this at your own risk. If using the stock block, damage can occur.

Refer to section 2.4 for adjusting boost. Standard turbo dynamics apply here. Maintain the proper boost according to the efficiency range of the turbo being used.

6. Cold Start and Warm-up

a. Cranking

In ATR locate the tables "Cranking Fuel Injector Pulse Width Base A, B, C and D". Highlight all cells from 68* and below and apply a multiplier of 1.30.



Cranking: Cranking Fuel Injector Pulse Width Base A

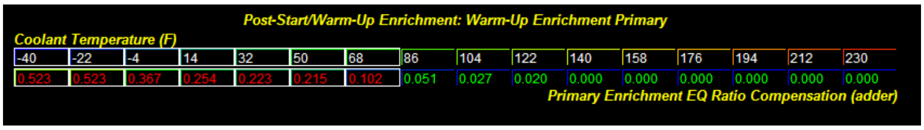
Coolant Temperature (F)

-40	-22	-4	14	32	50	68	86	104	122	140	158	176	194	212	230
228.15	228.15	171.21	82.26	34.98	31.59	17.84	8.80	7.50	6.75	6.00	6.00	4.50	4.50	4.50	4.50

Injector Pulse Width (ms)

b. Warm-up

In ATR locate the tables "Warm-Up Enrichment Primary". Highlight all cells from 68* and below and apply a multiplier of 1.30.



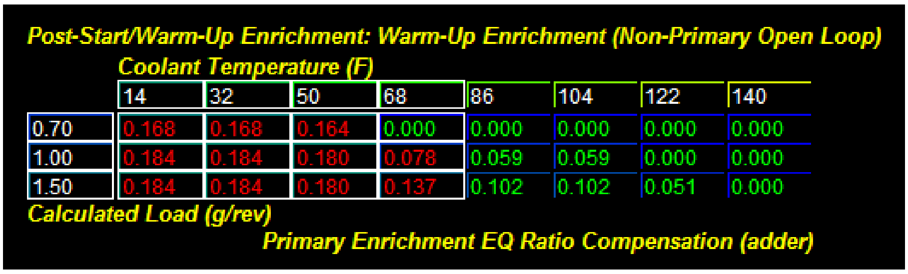
Post-Start/Warm-Up Enrichment: Warm-Up Enrichment Primary

Coolant Temperature (F)

-40	-22	-4	14	32	50	68	86	104	122	140	158	176	194	212	230
0.523	0.523	0.367	0.254	0.223	0.215	0.102	0.051	0.027	0.020	0.000	0.000	0.000	0.000	0.000	0.000

Primary Enrichment EQ Ratio Compensation (adder)

Now locate the table "Warm-Up Enrichment (Non-Primary Open Loop)". Highlight all cells from 68* and below and apply a multiplier of 1.30.



Post-Start/Warm-Up Enrichment: Warm-Up Enrichment (Non-Primary Open Loop)

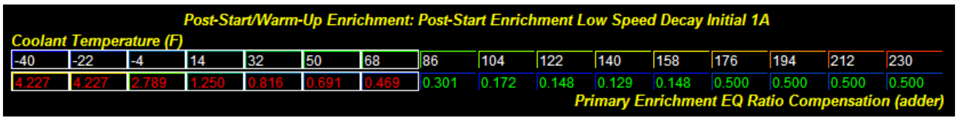
Coolant Temperature (F)

	14	32	50	68	86	104	122	140
0.70	0.168	0.168	0.164	0.000	0.000	0.000	0.000	0.000
1.00	0.184	0.184	0.180	0.078	0.059	0.059	0.000	0.000
1.50	0.184	0.184	0.180	0.137	0.102	0.102	0.051	0.000

Calculated Load (g/rev)

Primary Enrichment EQ Ratio Compensation (adder)

Now locate tables "Post Start Enrichment Low Speed Decay Initial 1A, 1B, 2A and 2B". Highlight all cells from 68* and below and apply a multiplier of 1.30.



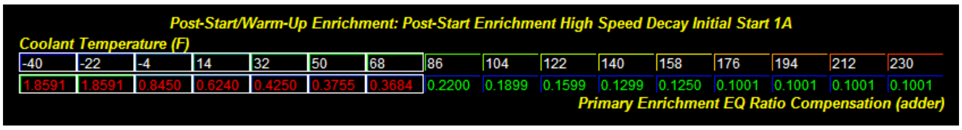
Post-Start/Warm-Up Enrichment: Post-Start Enrichment Low Speed Decay Initial 1A

Coolant Temperature (F)

-40	-22	-4	14	32	50	68	86	104	122	140	158	176	194	212	230
4.227	4.227	2.789	1.250	0.816	0.691	0.469	0.301	0.172	0.148	0.129	0.148	0.500	0.500	0.500	0.500

Primary Enrichment EQ Ratio Compensation (adder)

Now locate tables "Post Start Enrichment High Speed Decay Initial Start 1A, 1B, 2A and 2B". Highlight all cells from 68* and below and apply a multiplier of 1.30.



Post-Start/Warm-Up Enrichment: Post-Start Enrichment High Speed Decay Initial Start 1A

Coolant Temperature (F)

-40	-22	-4	14	32	50	68	86	104	122	140	158	176	194	212	230
1.8591	1.8591	0.8450	0.6240	0.4250	0.3755	0.3684	0.2200	0.1899	0.1599	0.1299	0.1250	0.1001	0.1001	0.1001	0.1001

Primary Enrichment EQ Ratio Compensation (adder)

4.5 Compensating for Pulleys and Flywheels.

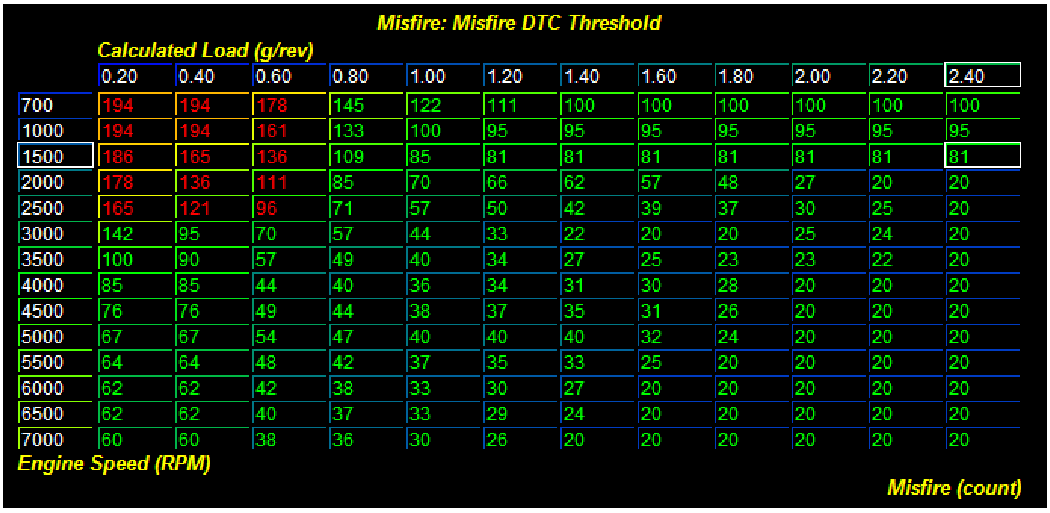
Perform this change only after you have installed a light weight component and are now experiencing misfire codes.

When you install a light weight pulley and/or flywheel, this may not come with out some consequence. Often the introduction of these items can have an adverse effect on the crank position sensor and how the ECU interprets the signals. Typically the ECU detects misfires by observing the crank speed. It looks for either positive or negative spikes in engine speed. When you add a light weight component such as a pulley or flywheel, you change these characteristics.
The OEM fly wheel is designed to be heavy enough to allow smooth rotational motion of the crank. The rotational mass of the flywheel or pulley has a significant dampening effect on the speed of the engine and smoothes it out and makes it consistent. When using a light weight flywheel, you are decreasing this dampening effect and the ECU sometime interprets this as a misfire.

To correct this you need to locate the table "Misfire DTC Threshold". You need to try to determine when the misfires are occurring and were. To do this you need to log the following…

- Roughness Cyl. #1, 2, 3, 4
- RPM
- Load

Observe the log for any misfire counts and note what RMP and Load the event occurs at. Then make adjustments to the table in those observed areas. For Example, if you see that you have 10 misfire counts at 2500rpm and load of .60, then you adjust that area of the map and every cell below that point by increasing the value by 10 +1.



Misfire: Misfire DTC Threshold

Calculated Load (g/rev)

	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40
700	194	194	178	145	122	111	100	100	100	100	100	100
1000	194	194	161	133	100	95	95	95	95	95	95	95
1500	186	165	136	109	85	81	81	81	81	81	81	81
2000	178	136	111	85	70	66	62	57	48	27	20	20
2500	165	121	96	71	57	50	42	39	37	30	25	20
3000	142	95	70	57	44	33	22	20	20	25	24	20
3500	100	90	57	49	40	34	27	25	23	23	22	20
4000	85	85	44	40	36	34	31	30	28	20	20	20
4500	76	76	49	44	38	37	35	31	26	20	20	20
5000	67	67	54	47	40	40	40	32	24	20	20	20
5500	64	64	48	42	37	35	33	25	20	20	20	20
6000	62	62	42	38	33	30	27	20	20	20	20	20
6500	62	62	40	37	33	29	24	20	20	20	20	20
7000	60	60	38	36	30	26	20	20	20	20	20	20

Engine Speed (RPM)

Misfire (count)

4.6 GR load limit constraint addressed. (Advanced, RomRaider Only solution) By TD_D

Here is an example as performed on a 2009 Subaru STi. For RomRaider, you would have to edit the following in ecu_defs.xml. Search for 32BITBASE - this will take you to the section that defines all the tables for the 32bit ECUs. You will recognize all the sections as they would show in RomRaider.

Scroll down quite a bit until you find Engine Load Limit B Maximum (RPM). you will see that there is also one that just says Engine Load Limit B (Maximum) - that's not the one you want to edit (this one is for ECUs that have this value as a float, which means it can be any value, like in the GD rom). Replace the whole of Engine Load Limit B Maximum (RPM) right down to description and the "[/table]" after it with the following:

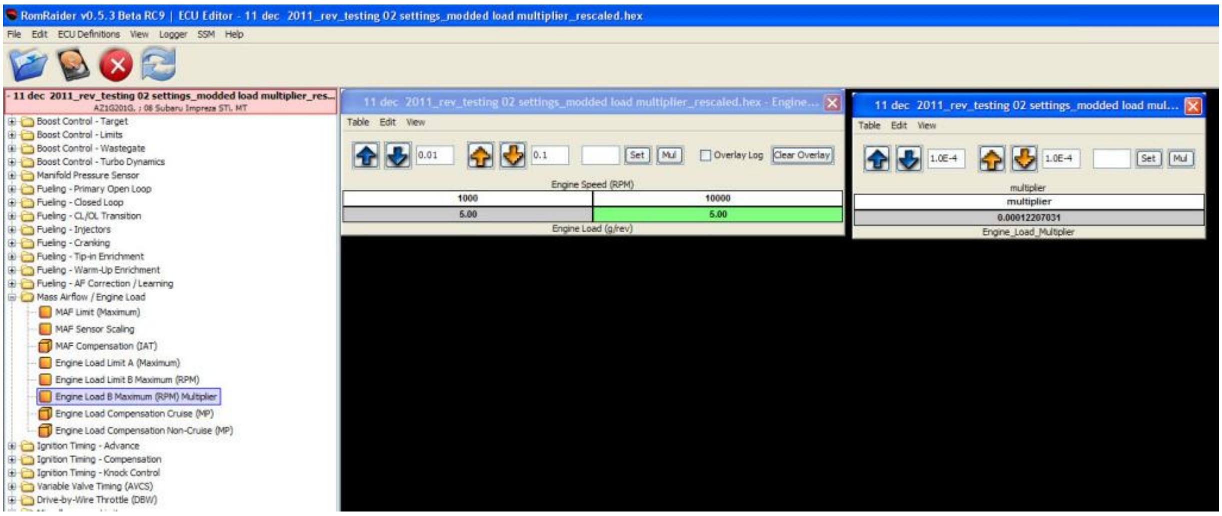
Code:

```
<table type="2D" name="Engine Load Limit B Maximum (RPM)" category="Mass Airflow / Engine Load" storagetype="uint16" endian="big" sizey="2"
userlevel="4">
   <scaling units="Engine Load (g/rev)" expression="x*0.0001220703125" to_byte="x/0.0001220703125" format="0.00" fineincrement=".01"
coarseincrement=".1" />
   <table type="Y Axis" name="Engine Speed" storagetype="float" endian="little" logparam="P8">
    <scaling units="RPM" expression="x" to_byte="x" format="#" fineincrement="50" coarseincrement="100" />
   </table>
   <description>This is the maximum allowable engine load. Engine load will be capped at this limit regardless of actual engine load. "Engine Load
Limit A (Maximum)" must also be changed as it also impacts the max engine load.</description>
  </table>
    <table type="2D" name="Engine Load B Maximum (RPM) Multiplier" category="Mass Airflow / Engine Load" storagetype="float" endian="big" sizey="1"
userlevel="4">
   <scaling units="Engine_Load_Multiplier" expression="x" to_byte="x" format="#0.00000000000" fineincrement="0.0001" coarseincrement="0.0001" />
   <table type="Static Y Axis" name="multiplier" sizey="1">
    <data>multiplier</data>
   </table>
   <description>Multiplier to overcome load = 4 limitation on 08 GRs onwards</description>
  </table>
```

```
<table name="Engine Load B Maximum (RPM) Multiplier" storageaddress="0x97974">  </table>
```

All that would have to be done for other roms is to find the right address, and replace the above with it. Note that you have now hardcoded the doubled multiplier into the table.

Go into Romraider, and you will now have a new table under the Mass Airflow section right after the load limit B table. Change the multiplier in there to 0.0001220703125



Engine Speed (RPM)

1000	10000
5.00	5.00

Engine Load (g/rev)

multiplier

multiplier
0.00012207031

Engine_Load_Multiplier

::END::