

2010 Ultra Limited Tune Experiment

(my experience with thanks to Ed of "[The Dyno Difference](#)" in Dallas)

Preface:

I finally made the decision to replace my 2002 Ultra with a brand new 2010 Ultra Limited. My first impression was, "Oh WOW! This is certainly different from the old bike". Indeed, it appears that The Motor Company had decided to fix almost all of the nagging problems in the older motorcycles, culminating in the 2010 and 2011 model year bikes. I chose a 2010 instead of 2011 because it had the color combination I wanted, blue on black. Otherwise, the two model years are virtually identical.

My customization includes new exhaust headers, new mufflers, new air cleaner, and probably new cams. Knowing that an Electronic Control Module flash would be necessary after each of these changes (and as I decide on which components I prefer), I also chose TTS MasterTune as my gateway into the ECM. There are several manufacturers of tuning products that allow alteration of tables in the ECM, but TTS allows me to experiment and self-tune as I try the different components. After I've selected components and have done the best I can with TTS, I'll have a professional dyno tune using wide band O2 sensors in the exhaust header pipes. The process I'm going through should, as a by-product, provide a good comparison between self-tuning and professional tuning. This web page describes all of the steps and comparisons I've made.

Here it is. My first view of the new motorcycle at the dealership - - - ->

From my touring experiences with my good traveling friend where we made side by side comparisons of the pulling power of my '02 Ultra to his bone-stock 2010 limited, I knew that some work would have to be done to my new motorcycle. As with my 2002, I wanted an efficient touring motorcycle, one that would get 40 to 45 mpg and also be able to work into 30mph headwinds and long upgrades on the interstates without a problem. I plotted out a plan: New air cleaner, new exhaust, and maybe a mild cam would be in order.

I selected:

- Fuel Moto Jackpot 2:1:2 headers that have two sets of AFR sensor bungs for stock and auxillary sensors
- SuperTrapp FatShots mufflers to be easy on my ears on those long 10 - 12 hour days in the saddle
- Vance & Hines air cleaner
- TTS MasterTune, not only because it allows self-tuning, but also because it has provisions for speedometer calibration
- Cam selection has not been made yet but I'm leaning towards Screamin' Eagle 255's



Before ordering any aftermarket parts, I put a little over a thousand miles on the bike in the first couple of weeks and let the dealership do their 1,000 mile check-up. (the 1K maintenance was in the purchase agreement)

The Science Project:

I'm very lucky to have Ed at "The Dyno Difference" nearby in Dallas. Without Ed, his equipment, his experience/skills, and (most of all) his patience; this science project would not be possible. Together, we plotted out a timeline. The specific order of changes depended on when the aftermarket parts arrived. Here's how it panned out:

- Step 1:** At "[The Dyno Difference](#)", do a series of 100% Wide Open Throttle pulls to produce a bone-stock baseline dynograph
- Step 2:** Installation of the [Jackpot 2:1:2 headers](#) with the SuperTrapp mufflers. Selected 18 discs per muffler and closed end-caps.
- Step 3:** Home-tune the motor with [TTS MasterTune](#). Also make speedometer corrections (it was indicating about 3% high compared to GPS)
- Step 4:** Put the motorcycle back on Ed's dyno again and do another series of W.O.T. pulls to produce another Dynograph and make tuning comparisons

- Step 5:** Install the [Vance and Hines air cleaner](#)
- Step 6:** Back to "The Dyno Difference" for more W.O.T. pulls, data comparisons and dynographs (basic VTune and advanced VTune dynographs)
- Step 7:** Ed will do a complete "Dyno Difference" tune by hand, then comparison to the VTune tunes.
- Step 8:** Make cam selection to suit my riding style and needs and install
- Step 9:** More TTS tuning sessions to dial it in
- Step 10:** Final visit to "The Dyno Difference" for compare TTS tune to manual tuning and final WOT pull.

Each of these steps will be documented with our notes and dynographs. Our goal was to observe each individual change and what was gained (or lost) from each. Also, a side-benefit would be to observe how the TTS MasterTune with novice user on the road compares to a professional hand-tuning session on the dynamometer.

While the motorcycle was on the dynamometer for the stock baseline runs, I also recorded sound levels using my Radio Shack sound level meter. The measurements were taken 18" behind and 18" to the side of the closest muffler outlet.

Step 1: Baseline Bone-Stock Performance:

Step one included a proper warm-up and then three Wide Open Throttle pulls on the dyno to produce HP and torque curves on a graph. This would be the baseline from which all subsequent sessions and dynographs would be compared. For this pull the engine was warmed to 200 degrees and typical transmission temperatures associated with the warm-up. All subsequent pulls will be at the same ET and transmission temps.

Problem: The first pull produced HP and torque curves that were significantly better than the following two. The second showed a loss of torque and hp. The third was even worse. Something is causing this. Ed immediately said, "Sumping, when was the oil changed?" I explained that I'd just come from the dealership where they did the 1,000 mile maintenance and presumably lube changes. I usually do all of my own maintenance/modifications; but the 1K maintenance was included in the purchase price of the new motorcycle. We removed the crankcase plug and recovered 11 ounces of oil. May be sumping, indeed. The crankcase should have only contained a few ounces, preferably less than 4 oz. After removing the 11 ounces, the oil level dipstick still indicated full which affirms our suspicion that the mechanic may have over-filled.

After another proper warm-up, Ed did three more WOT pulls. Again, there was a torque dip in the same RPM regime, albeit much less than the previous pulls. Pulled the crankcase plug and drained another 6 ounces of oil. Maybe we should have, but didn't do any more WOT pulls. The oil level on the dipstick now showed slightly less than full. This will be my new fill level for the duration.

Here are the results of the bone stock sound level measurements in the dyno chamber.

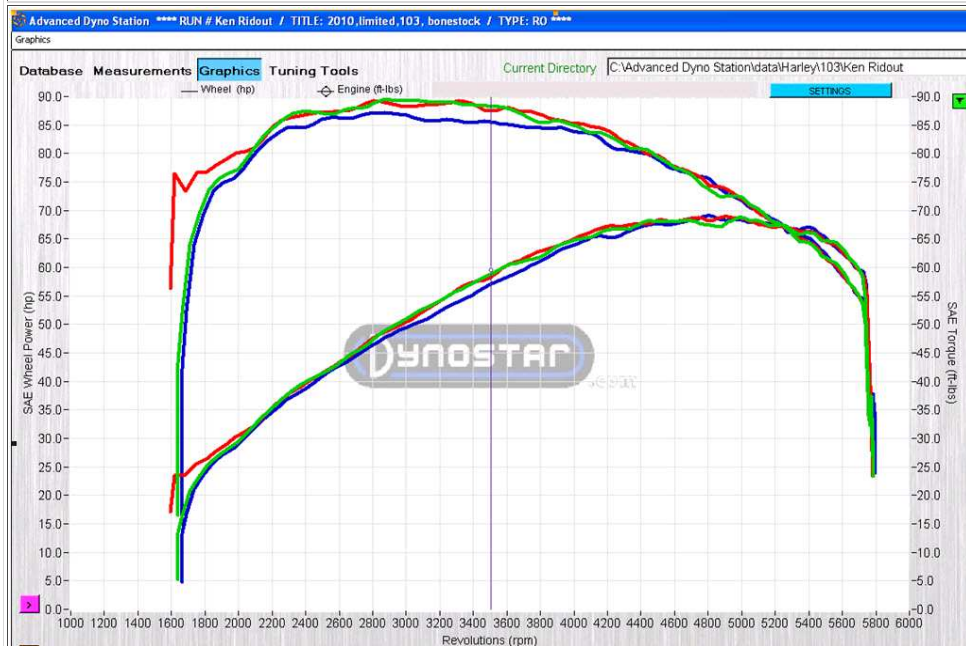
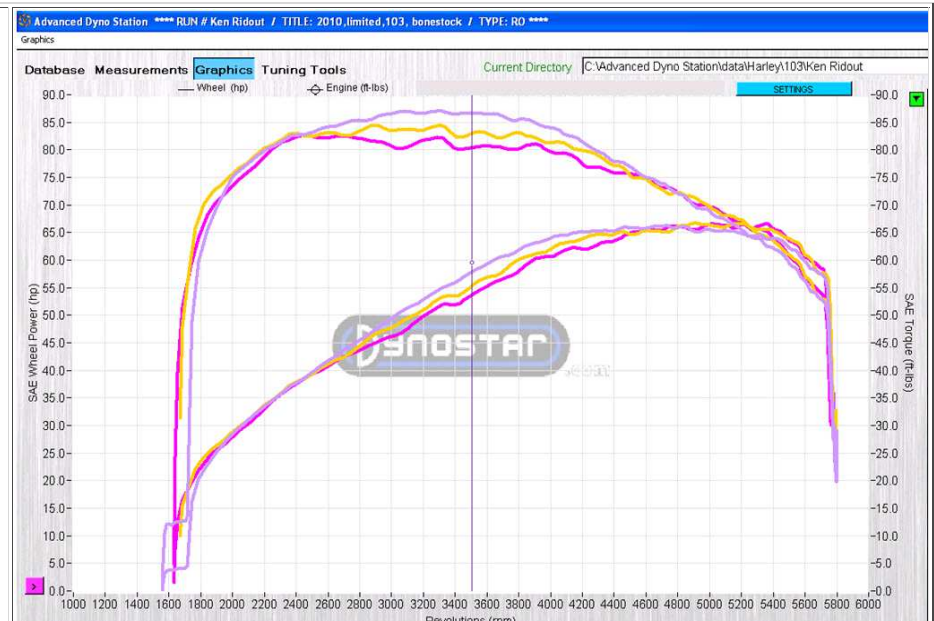
Ambient sound in the dyno chamber, motorcycle engine OFF, main exhaust fan ON	72 db
Engine ON at idle	84 db
Engine at 2,000 rpm, no load (dyno cooling fans both ON)	91 db
Engine Wide Open Throttle at approximately 3,000 rpm during WOT pulls (dyno fans ON)	110 db
Engine Wide Open Throttle at approximately 5,000 rpm during WOT pulls (dyno fans ON)	116 db

To the right are the three initial baseline WOT runs. Notice the drop in torque centered around 3,500 RPM. Ed's diagnosis appears to have been correct.

We drained the crankcase. It contained 11 ounces of oil, most of which we believe shouldn't have been there. It makes sense that if the crankshaft is sloshing in oil, that energy would be consumed. It was explained to me that it's like wading in ankle-deep water.

After removing the oil from the crankcase, we checked the oil level dipstick. The level was at the "Full" mark.

The series of runs were performed at a beginning engine temperature of 200 degrees.



To the left are the subsequent baseline runs after removing the eleven ounces of oil from the crankcase. Notice how the 1st (green) and 2nd (red) are virtually identical; but the third line (blue) has a dip in the torque curve and slightly less hp at 3,500 rpm. We suspected more sumping. Sure enough, we drained 6 more ounces of oil out of the engine crankcase after these three pulls.

In light of the situation, maybe we should have done one more series, just to confirm that the sumping issue was solved, but we didn't. When I got home, I pulled the crankcase plug one more time. Only about 2 ounces was present. And now, the oil dipstick indicates about 3/16" below the full level. I'm happy with that.

STEP 2: Engine Upgrade #1, Exhaust System:

Wanted to install the air cleaner first, but shipping was delayed. Instead, installed the FuelMoto Jackpot 2:1:2 headpipe assembly which eliminates the catalytic converter and provides auxiliary 18mm O2 sensor ports. Also installed SuperTrapp Fatshots touring mufflers with 18 discs each and closed end-caps.

The Jackpot 2:1:2 headpipe assembly was chosen because it is made of stainless steel, uses the stock exhaust shields, and has the auxiliary O2 sensors for my WEGO and for as well as for dyno tuning with wide-band sensors.

The FatShots were chosen because of the low volume, performance, and total absence of snappy - blappy sound. This motorcycle is for touring and I don't want a lot of ear-ringing noise but do enjoy the nice, deep low-frequency purr.

STEP 3: TTS MasterTune:

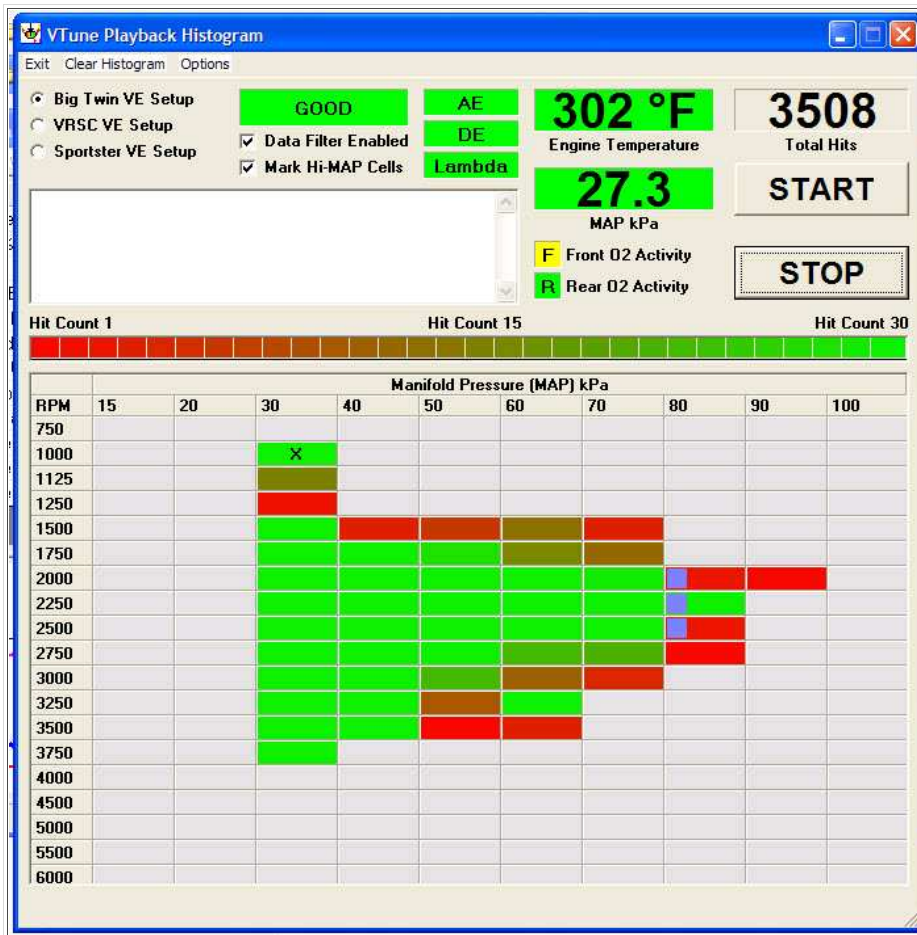
I purchased TTS MasterTune from Doc on the [HTT forum](#). I chose TTS for several reasons.

- My touring friend has it for his two motorcycles and enjoys swapping stuff and then self-tuning. He'll advise me when I ask for home-tuning help.
- Second reason was because it has provisions for calibrating the speedometer. A second gizmo for speedo calibration would have cost over \$100 alone! (I like to see my GPS and speedo match closely).
- The third reason was so I could learn more about electronic engine control, fuel injection, spark timing, etc.
- Fourth is because it is probably the best tuning software out there and give good results when used properly and fully.

Even with TTS, my final tune is going to be at The Dyno Difference where Ed can tune and measure results as he gets the ultimate performance, efficiency, and rideability from the motor. I need to know if my motor is operating at its best efficiency and performance.

I did an initial VTune ride using the MasterTune "canned" map for my 2010 '103 engine with aftermarket exhaust and stock air cleaner (DTA009-01).

My First MasterTune Experience included saving the factory ECU map in case I ever wished to return to 100% stock. After that, I needed to select a table that is similar to my motorcycle's build from the myriad of tables included. The lambda table cells for a build similar to mine needed to be changed to run "closed loop" in all areas and the Power Enrichment needed to be turned off before each tuning ride.



Collecting data is so easy that even a caveman can do it (as Dan, my touring friend told me before I started).

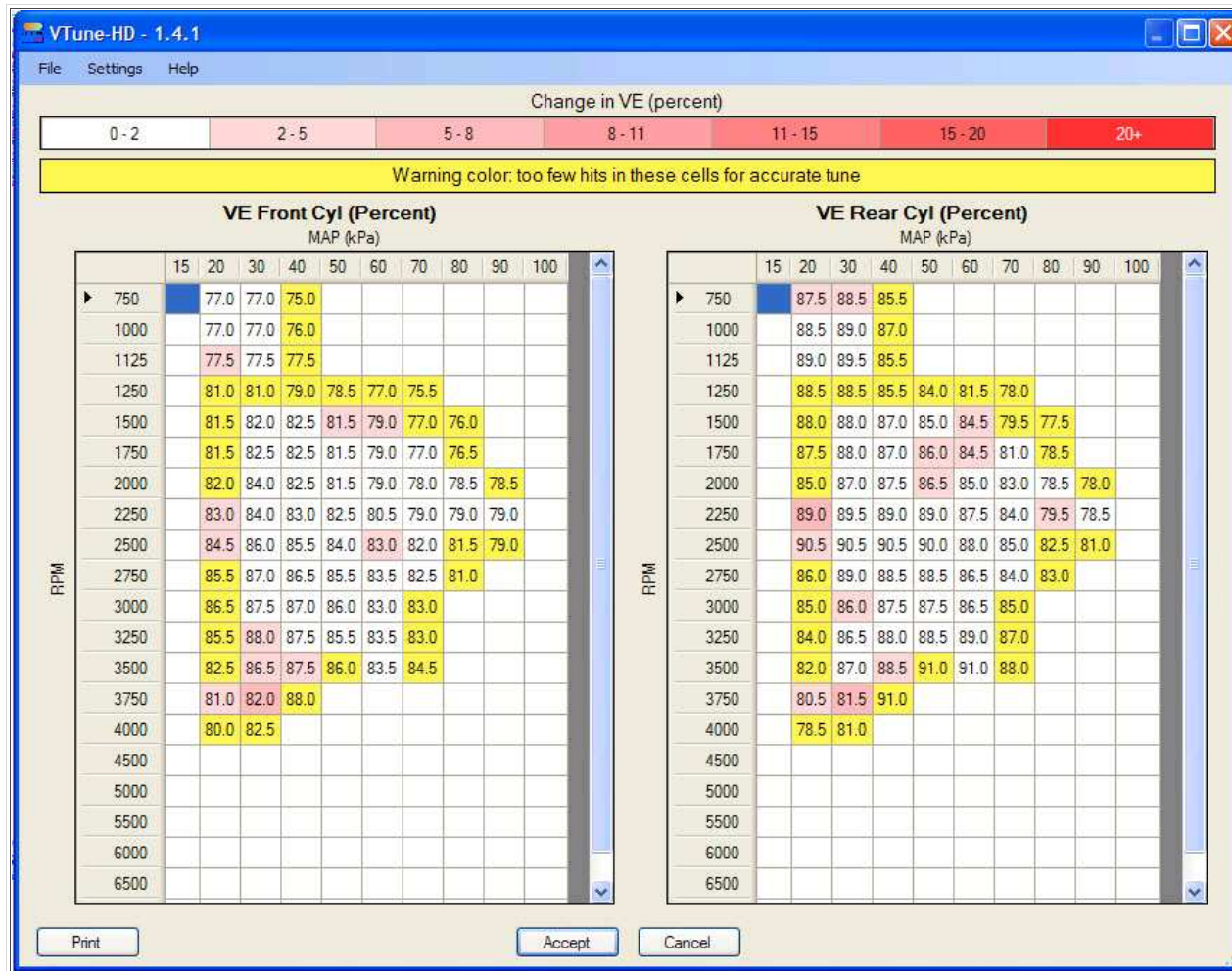
DataMaster has a provision for graphic display of the cells at each RPM range versus Manifold Pressure (MAP) spreadsheet. The cells are color-coded to show the range of "hits" from 1 to 30 or more. For me, this meant that I could look at the cells and the data contained after completing the tuning runs.

In the resulting VTune Histogram from my first tuning run, all of the cells in the areas in which I usually ride were filled in with green (Hit Count =30 or greater).

I had to open the throttle more than usual and drag the front brake just a little to get the 60 and 70 KPa cells 'greened-out'. I even got some hits in 80kPa and a couple in the 90 kPa region. However, I won't try to get hits in these areas in the future. It required front brake dragging while hard on the throttle, even to the point of going ABS.

All in all, the process was easy; so easy, in fact, that I doubted the results and started over. A second tuning run from scratch showed about the same results.

A caveman really *can* do it.



This VTune graphic is the result of my initial 30-minute VTune ride. It shows the difference between the previous tuning run and the one that was just completed. The software displays this data just prior to generating a new tune file for flashing the ECM.

My intention was to do a short ride to get the VE's close, create a tune, and flash the ECM so that the motor would be closer to normal AFR's for subsequent tuning runs and any riding I might do afterwards. I didn't want to be riding around with an abnormally lean or rich AFR any more than might be necessary.

What totally surprised me was the almost total lack of changes required in the areas that got acceptable data hits.

The yellow cells and the large numbers of white cells outside the yellow are those that my short tuning run didn't touch adequately or not at all during my short 30 minute run. Only a spattering of pink cells appeared.

Truly, I was expecting to see VE Table cells that were from 5 to 15 percent off as depicted in the manual. Instead, the tables from their base map closely matched those from the selected initial tables.

Even with only 30 minutes of riding around town and a few miles on the interstate, almost all of the cells in my normal riding regime were filled. Odd, though, that the canned map matched my VTune results so closely. I'd planned on more tuning before going back to The Dyno Difference, but circumstances resulted in my going back the very next day. No time for further VTune riding.

STEP 4: Dyno Testing and Comparisons:

My experiment steps include going back to The Dyno Difference for intermediate testing to see what kind of results I'm getting from the aftermarket parts and TTS. With the Jackpot 2:1:2 headers, we have the ability to insert wideband O2 sensors for data acquisition and analysis. My plan was to measure WOT pulls for improvements from installing the different components, do AFR comparisons, and also do sound level comparisons, from stock to completion. The pulls were not started until the ET was

200 degrees. Transmission temperature was not precisely measured, but assumed to be the same, run for run with other tests since the engine OFF and ON times were similar.



Here we are, back at The Dyno Difference in Dallas. Without making any changes at all to the map derived from TTS, we put the motorcycle on the dyno, did the warm-up to the same temperature as the bone-stock baseline run in Step 2, and did a series of WOT pulls.

This is what we got. The green lines are the bone-stock baseline and the blue are the results of the parts and TTS tuning.

Needless to say, I was disappointed. With the exhaust work, only (aftermarket headers and mufflers), the torque curve was virtually identical to stock. Looks like approximately 5 hp gain at the very top end, but that's it.

After we thought about it, these results should have been expected. TTS doesn't tune the 90-100 KPa regions of the map (Wide Open Throttle). They must be done by hand extrapolation. I hadn't done the extrapolation so it probably invalidated our WOT test. Interesting, nonetheless.

Target to measured Lambda

A better test would be a comparison of AFR command to the actual AFR. (or Lambda command to Lambda sensed)

We also did that comparison between the target (command) and the actual AFR resulting from my VTune session.

Using TwinScan, the target AFR command can be read directly from the J-1850 data port. Using calibrated wide-band sensors in the auxiliary O2 bungs on the headers, we measured the actual AFR, also reported by TwinScan. Ed ran the motorcycle while on the dyno in the different throttle/MAP regimes, just as if collecting data for a full tune. He has an Excel table that converts the AFR sensed values into Lambda. The results below are a comparison of the target Lambda with the measured Lambda in the exhaust.

The engine was brought up to 200 degrees ET and typical transmission temperature for this and every test.

The AFR is corrected to Lambda values for 14.68.

Examples:

- 14.27 equals a Lambda of .977
- 14.37 equals a Lambda of .984
- 14.47 equals a Lambda of .991

The table to the right is the target or command read directly from the J-1850, captured by TwinScan-II, and converted to Lambda after the initial 30-minute tuning ride.

VTuned MasterTune calibration file **DTA009-01-B2-001**

File Name: DTA009-01-B2.MT7

Application: 2010 Drive-by-Wire Touring Bikes

Configuration: 1690 A/C and factory 2:1:2 Exhaust

Components:

-- Stock Air Cleaner

-- Jackpot 2:1:2 headers

-- SuperTrapp FatShots with 18 discs each

Below is the actual AFR resulting from the target Lambda.

0.000 indicates that data was not collected for the particular cell(s).

	15	20	30	40	50	60	70	80	90	100
750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1000	0.000	0.981	0.974	0.981	0.000	0.981	0.000	0.000	0.000	0.000
1125	0.000	0.981	0.981	0.988	0.000	0.000	0.000	0.000	0.000	0.000
1250	0.000	0.981	0.988	0.988	0.000	0.000	0.000	0.000	0.000	0.000
1500	0.000	0.981	0.988	0.988	0.988	0.988	0.981	0.974	0.872	0.858
1750	0.974	0.981	0.988	0.988	0.988	0.988	0.981	0.967	0.879	0.858
2000	0.974	0.981	0.988	0.988	0.988	0.988	0.981	0.954	0.892	0.858
2250	0.974	0.000	0.988	0.988	0.988	0.988	0.981	0.974	0.892	0.858
2500	0.974	0.981	0.988	0.988	0.988	0.988	0.981	0.981	0.886	0.858
2750	0.000	0.981	0.988	0.988	0.988	0.981	0.981	0.954	0.906	0.858
3000	0.974	0.000	0.981	0.981	0.981	0.981	0.981	0.974	0.872	0.858
3250	0.000	0.974	0.981	0.981	0.981	0.981	0.981	0.974	0.865	0.858
3500	0.974	0.000	0.974	0.974	0.981	0.974	0.967	0.954	0.865	0.858
3750	0.967	0.000	0.967	0.967	0.967	0.967	0.960	0.000	0.879	0.858
4000	0.947	0.000	0.940	0.940	0.947	0.947	0.933	0.892	0.879	0.858
4500	0.926	0.000	0.926	0.906	0.906	0.906	0.000	0.886	0.000	0.858
5000	0.879	0.879	0.000	0.879	0.879	0.879	0.872	0.000	0.858	0.858
5500	0.879	0.000	0.879	0.879	0.879	0.879	0.872	0.000	0.858	0.858
6000	0.879	0.879	0.000	0.879	0.879	0.879	0.872	0.879	0.858	0.858

	15	20	30	40	50	60	70	80	90	100
To the right is the AFR reported by the WEGO-II, converted to Lambda for comparison to the target command from the ECM above.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
The calibrated O2 sensors were installed in the auxiliary bungs in the headers, data was recorded as Ed went through a typical data collection process as if during a complete typical dyno tune.	0.000	0.980	0.991	1.008	0.000	1.015	0.000	0.000	0.000	0.000
Lt Green = Measured within .005 of target	0.000	0.993	0.984	0.960	0.000	0.000	0.000	0.000	0.000	0.000
Red = Measured was >.006 higher measured versus target	0.000	0.989	1.001	0.976	0.000	0.000	0.000	0.000	0.000	0.000
Blue = Measured was <.006 lower measured versus target	0.000	0.987	1.002	1.001	0.995	0.995	0.984	0.985	0.901	0.932
White = Target and measured were both 0.000, data not collected	0.989	0.973	1.007	0.999	1.011	1.003	0.987	0.979	0.915	0.918
The difference between target and measured appears to be significant, although this is only with one tuning run and ECM flash. The higher MPA cells have not been extrapolated.	0.979	0.991	1.022	1.001	1.003	0.994	0.997	0.978	0.938	0.944
	0.979	0.000	0.984	0.989	0.989	0.984	0.985	0.976	0.908	0.948
	1.012	0.988	1.010	1.002	0.999	0.996	0.986	0.995	0.911	0.941
	0.000	1.001	1.001	0.998	0.985	1.000	0.980	0.974	0.918	0.955
	0.906	0.000	0.998	0.992	0.992	0.993	0.991	0.966	0.911	0.941
	0.000	0.995	0.999	0.987	0.996	0.984	0.981	0.981	0.862	0.919
	1.069	0.000	0.980	0.979	0.981	0.967	0.976	0.909	0.855	0.883
	0.906	0.000	0.955	0.974	0.979	0.969	0.967	0.000	0.861	0.884
	1.141	0.000	0.911	0.946	0.960	0.948	0.957	0.896	0.886	0.905
	0.875	0.000	0.899	0.911	0.943	0.951	0.000	0.922	0.000	0.928
	0.928	0.831	0.000	0.920	0.936	0.956	0.942	0.000	0.924	0.956
	0.906	0.000	0.879	0.912	0.928	0.947	0.934	0.000	0.909	0.929
	0.925	0.882	0.000	0.897	0.916	0.858	0.898	1.172	0.869	0.884

Sound Levels measured in the Dyno chamber (Jackpot 2:1:2 w/SuperTrapp Fatshots, 18 discs per muffler):

Ambient sound in the dyno chamber, motorcycle engine OFF, main exhaust fan ON	78db
Engine ON at idle	84db
Engine at 2,000 rpm, no load	91db
Engine Wide Open Throttle at approximately 3,000 rpm during WOT pulls	98db
Engine Wide Open Throttle at approximately 5,000 rpm during WOT pulls	116db

As the data shows, this exhaust system produced nominally the same noise level as stock. Unlike stock, though, the sound was much more pleasing for long-duration riding. SuperTrapp claims 10% greater HP and torque. I didn't get it, though; not even close.

We're not seeing it so far, but one must remember, this is without hand-extrapolation of the VEs where my tuning runs didn't affect.

Step 5: Installation of the V&H Air Cleaner and VTuning:

After replacing the stock air cleaner with the new Vance and Hines air cleaner with the DRAK cover, I did some rather extensive VTuning. Sessions were each about an hour long. The first was an in-town ride around to get the tables close. The next four were combination city and highway riding. Pushed hard up hills and even dragged the front brake a bit to get hits in the nether-regions. I rode at steady throttle settings in 3rd, 4th, 5th, and 6th gear at speeds between 40 and 80 mph. I wanted to fill as

many cells as possible; but without a display to watch as the cells fill, it's a guessing game. I ride and hope that good data is being recorded in all the cells.

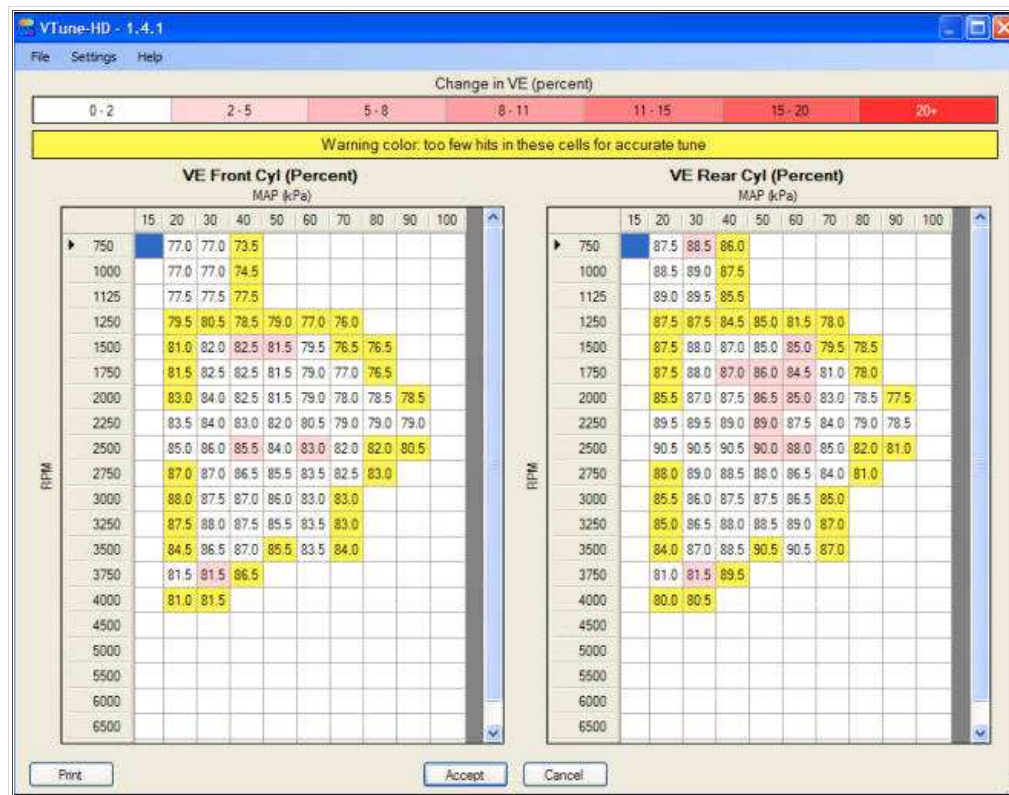
To anyone that is considering TTS and home-tuning, it's really important to get the laptop set up before going out for tuning rides. Otherwise, it'll be going to standby, going to sleep, turning itself off, running out of battery, etc. leaving you with incomplete data.

My final VTune session produced this VTune histogram:



In the resulting DataMaster histogram, all of the cells in the areas in which I usually ride were filled in with green (Hit Count =30 or greater). Some of the cells reported hit counts nearing 200!

I had to ride in higher gears than I like, open the throttle more than usual, and drag the front brake a little to get the 60 and 70 KPa cells 'greened-out'. I elected to take these steps only in the lower RPM regimes to avoid abnormal brake rotor and pad wear. You can easily see that I didn't collect as much data in the 60 - 80 kPa above 3,000 RPM and none at all in the 5,000 to 6,000 RPM range.



I actually made four data collection runs over a week's time; creating a tune file and flashing the ECM after each. This graphic is the result of the final tuning run with the V&H air cleaner and the previously-installed exhaust system. These displays are created by VTune, just before it creates a new map for flashing into the ECM, allowing the user to accept or reject the tune file before it is generated.

Each of the sessions resulted in different cells that required slight change from the previous data collection. It appears that all that required changes were in the 2% to 5% range.

I didn't save the graphics from tuning run to run. If I had, it would have shown the progression. With so many files saved being generated and saved, it became confusing to me. Unfortunately, the program doesn't allow changing the description without re-saving as a new entire file (which creates a new file creation date).

At this point, my motorcycle has been tuned to the limits that I put on myself regarding stresses on the engine and brakes during the tuning rides. The graphics looked very similar to those presented in the manual, so I stopped. I've done all the home-tuning that I'm going to do. I did not extrapolate the VE tables out because I didn't totally understand what I would be doing. The manual could be a little more instructive in this area for unskilled customers like me.

It's now time to take the motorcycle back to The Dyno Difference for more comparisons and a final tune by Ed.

Step 6: More Dyno Comparisons:

Back to the Dyno Difference. We have four goals for this trip:

1. WOT runs to see what improvements the addition of the new air cleaner made
2. Extend the VE's into the MAP regions that weren't tuned by TTS and make comparison WOT dyno runs
3. Full Dyno Difference tune using the auxiliary wide band O2 sensors for VE's, Lambda targets, ignition tables, enrichment, etc. with comparison to the final TTS tune
4. Comparison of the narrow band sensor O2 to the auxiliary wide band sensors

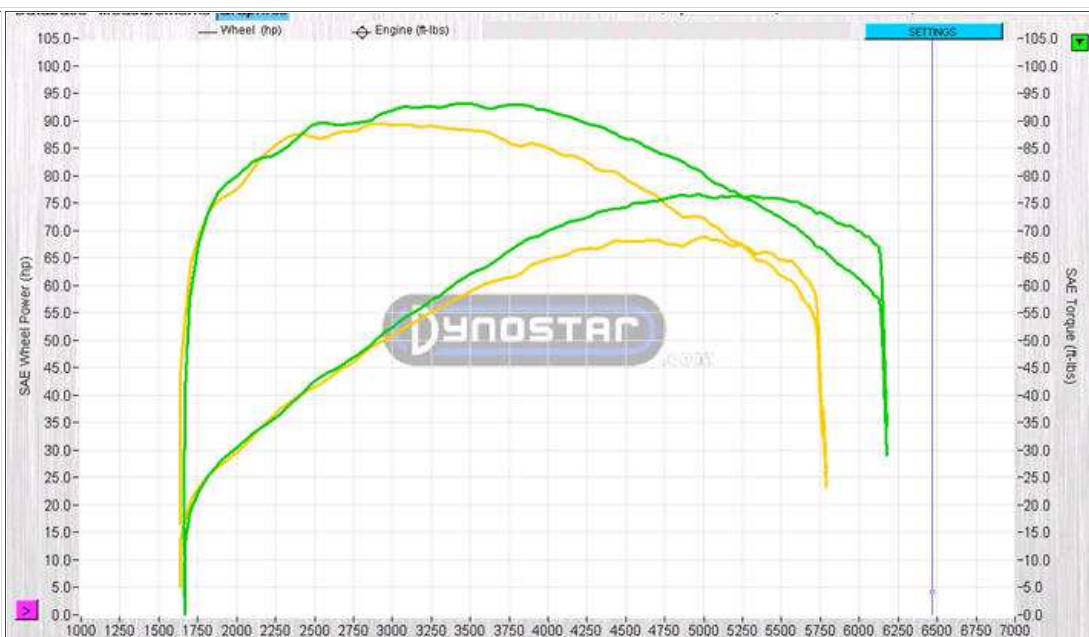
After arriving, removing the saddlebags and left-hand side cover, we rolled the motorcycle onto the dyno, strapped it down, prepared it with O2 sensors, spark plug sensor, etc.. Preparation takes about a half hour or more. It was time to see what the addition of the air cleaner and my home tuning did for the WOT performance.

The results were gratifying.

This dynograph displays the shows baseline factory-stock torque and horsepower to the torque and horsepower graph resulting from the FuelMoto head pipe, SuperTrapp mufflers with 18 disks each, and the Vance and Hines K&N air filter assembly. VTUNED with TTS.

The torque and horsepower gains above 4,000 RPM were significant with almost 10 ft lbs torque gain at 5,000 RPM and 10 hp gains at the rear wheel.

The lack of torque gains in the 3,000 RPM and below was bewildering. But we still wanted to do the VE table extrapolation. Maybe it would make a difference.



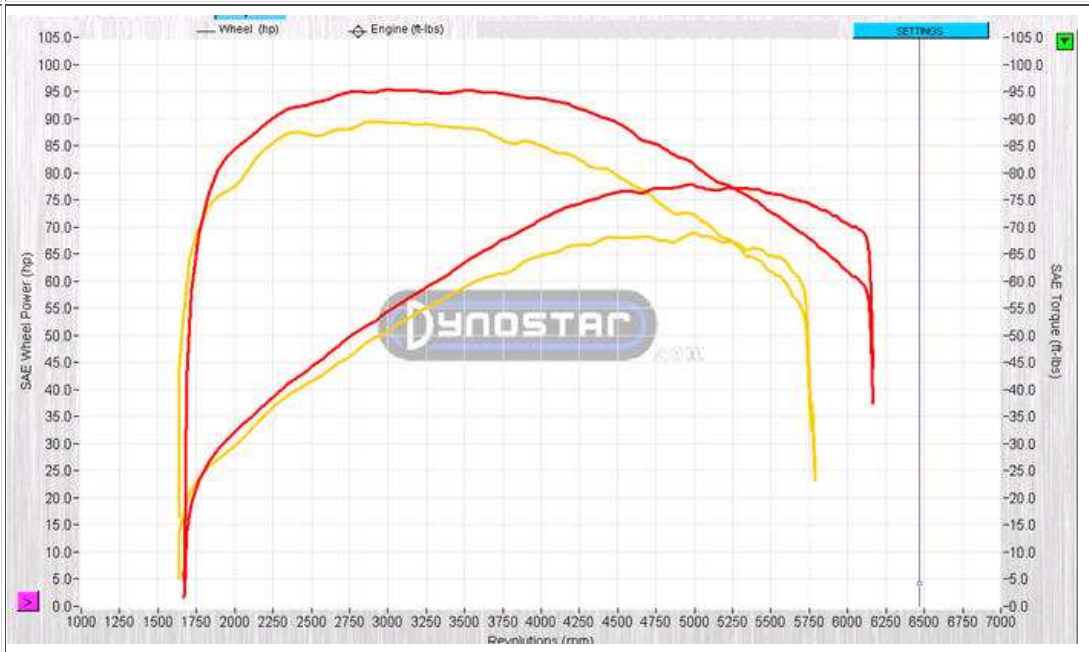
We extrapolated the 80, 90, and 100 kPa cells of the VE tables using the data derived from the green cells produced in the latest DataMaster histogram as described in the manual. We filled the higher MAP kPa VE cells for each rpm regime with whatever the average VE from last green cell in the histogram. We also looked at adjacent rpm regimes to see a normal progression. In a few cells, we fudged the VE slightly to make smooth transitions from adjacent cells. This was done for both cylinders.

We applied our best guesstimates as the data was extrapolated. I'll be quite honest in saying that a lot of performance change was not expected; extrapolating the VEs seemed like a guessing game.

Then, after warming the engine ET back up to 200 degrees, Ed did another series of three pulls. All three produced nominally the same HP and torque curves. We were surprised.

- Bone Stock is in yellow
- Our TTS result with extrapolated VE's is in red.

NOTE: The Dynostar smoothing is set to ZERO, no smoothing.



We could have stopped at this point. The motor has gained 5 ft lbs of torque at 3,000 RPM, 10 ft lbs of torque at 5,000 RPM, and 12 horsepower at 5,500 RPM. The torque curve is smooth, the motor starts and runs well, and a typical home-tuner would probably be relatively satisfied with the results. It appears that TTS has lived up to its promises. Without WOT dyno runs, a home-tuner would not know this; but our runs bear this out. Could a home-tuner get a better tune? Probably, with a lot of practice, better data for extrapolation, and a knowledge of spark advance and how to tune it. But unfortunately it seems that without a dyno run, one would never know.

We had one more test to do before completion. It was time for Ed's professional tune and comparison to my best TTS effort.

Step 7: Professional "Dyno Difference" Tune and Comparison:

Ed prepared a completely new initial tune file for his dyno tune. It included turning spark knock sensing OFF, PE OFF, and setting the VE's and Lambda tables to comfortable starting point. Then he ran the motor through different RPM and throttle settings while TwinScan gathered data. I don't totally understand all that is required for a custom tune, but the process was lengthy. He gathered data, adjusted VEs, ran the motor on the dyno some more, gathered more data, adjusted VEs again, ran the motor even more, until he was satisfied with the VE tables.

Ed ran the bike on the dyno and watch the TwinScan reported live AFR data versus the AFR Command or Target. Until these values for both Front Cylinder and Rear Cylinder overlay as closely as possible the tune is not complete. More partial throttle running and data collection is done and adjustments are made as necessary. We keep running this test until the overlay of Live data and Target data is as close as possible. Indeed, watching the TwinScan program, the AFR Measured matched the AFR Command under every running condition that I watched as he tested.

I watched again as he dialed the Dynostar's cursor to hold the engine at RPM ranging from 2,000 to 3,500 while he slowly went from light throttle to full throttle at each setting and listened for pinging. With TwinScan, he could also display the recorded data for knock sensor to confirm what he heard or didn't hear. Take a little timing out at the rpm ranges that produced knock and run through the process again; he did this several times before showing satisfaction.

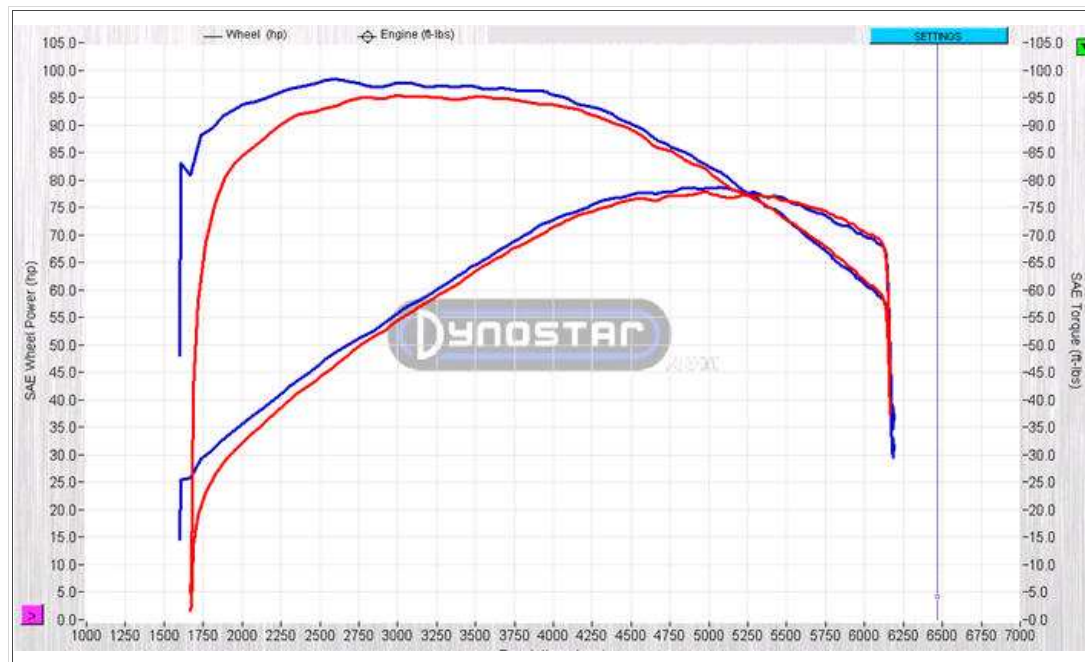
Then, Ed did yet another series of WOT pulls to confirm that the timing changes didn't cause changes in AFR command. This whole tuning process took about 3 hours. I lost track of time because of the boredom of watching the same processes over and over. My job was to turn the dyno chamber ventilation ON and OFF as required for each test. It's really noisy in there with all the fans running, even with the motorcycle OFF.

The final test is to put the bike back in closed loop operation in the cruise area and compare what the live AFR values from the bike are now doing as compared to the AFR Command or Target. This test is nice, as he can compare what my motorcycle's NB sensors are seeing versus what the bike is actually doing. This verifies correct operation of the OEM NB sensors as they should match the tuning sensors exactly. Once satisfied that these values overlay as close as possible it is time for a test ride out on the street. The test ride is verification of smooth starting (cold and warm), smooth acceleration, absence of pinging, and deceleration without exhaust popping.

It should also be noted that exhaust noise after the tuning were nominally the same as before. Tuning had virtually no effect on noise.

RESULTS COMPARISON TIME!

It's time to compare Ed's Dyno Difference tune to my best TTS MasterTune.



This is the comparison of Ed's tune to my best TTS tune!

To recap, this is with air cleaner and exhaust work, only; no cams or head work.

The blue lines are the result of Ed's manual tuning using TTS and Twinscan.

The Red lines are the result of my best TTS MasterTun (including VE table data extrapolation)

The missing torque improvements at the lower RPM have been found! The torque and HP gains from TTS versus Ed's tune have stayed the same from about 4,500 RPM and higher, but large torque gains in the lower RPM regime are now evident.

Oddly, the lower torque curve below 3,000 RPM was in the range where DataMaster showed the most hits and I felt most confident in the VE table extrapolations. I wonder how one would know if the motor has more potential than I achieved without a dyno comparison.

FINAL TUNING COMPARISON TO BONE-STOCK BASELINE

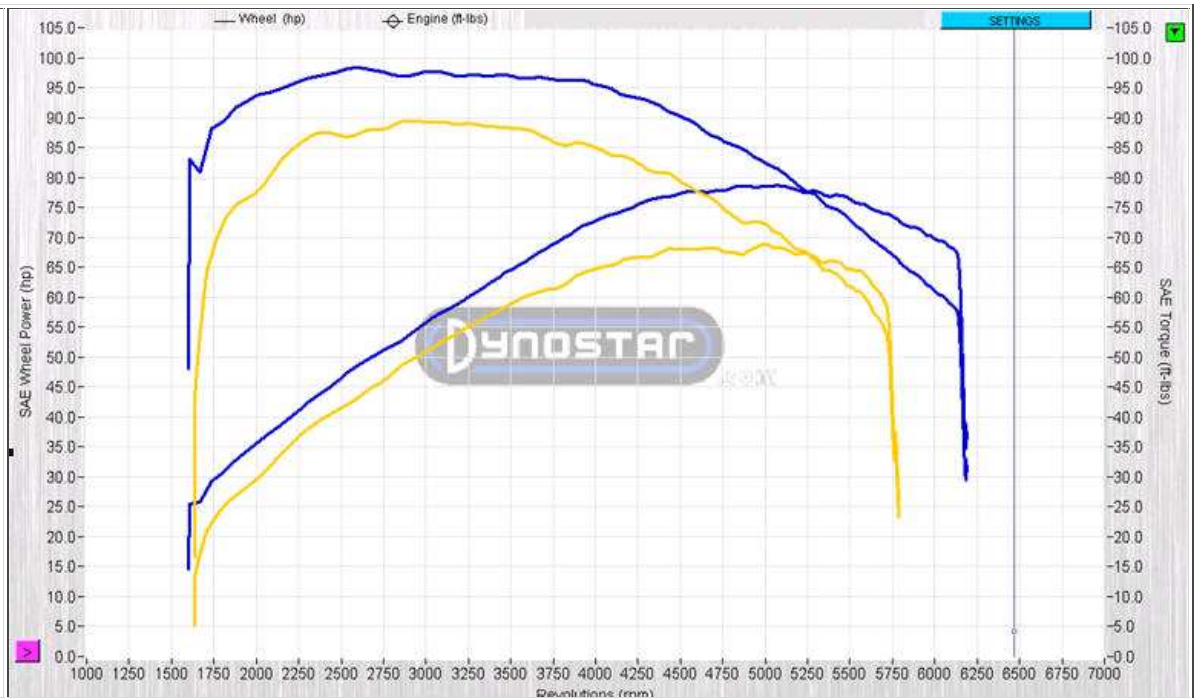
The adjacent graphic is the comparison between the baseline bone-stock WOT pull and the final Dyno difference-tuned WOT pull. As with all our testing, the engine temperature was at 200 degrees with transmission temperature approximately the same as all previous runs.

To recap:

Yellow Lines: 2010 Ultra Limited, bone stock

Blue Lines: Same motorcycle with V&H Draco air filter, Jackpot 2:1:2 headers, and SuperTrapp mufflers with 18 discs each.

Both pulls depicted here were done at a 200-degree ET with similar transmission temperatures.



There was a large torque gain between 2,500 and 3,000 RPM, but I would have liked to have seen the torque curve continue to rise past 2,600 RPM to peak at about 3,200 before slowly dropping off. Instead, it kind of flattened out.

However, the engine's performance may be enough to suit my requirements for an efficient touring motorcycle for cross country travel as well as parking lot exercises without the downside effects of a finicky aftermarket cam. Instead of rushing to change cams, I will wait a while and carefully make my cam decision. I'd like to go on at least one long-distance trip before changing cams to see how the motor copes with wind and hills at highway speeds. I keep thinking that the SE 255 cams would be a good choice (I bought a new set a few weeks ago). But then I keep reading about warm start problems due to the intake closing degrees that cause very high CCP. With the SE255-s, though, I'm sure that the torque curve would exceed 105 ft lbs in the 2,500 to 3,200 RPM range (where my motor spends the vast majority of its time).

Also before choosing cams (should I decide to), I will also do a few of my famous gas mileage runs. I usually do 75 to 80 miles out and back (150 to 160 miles total) on Interstate 30 on selected calm-wind days with precise fuel fills before and after. Bone stock on a trip to the Texas Hill Country a few weeks ago yielded mileages of 38 to 40 miles per gallon. It would seem that with the increased efficiency of the engine, that mileage would increase.

Conclusions So Far:

TTS MasterTune does exactly what it's billed to do. I am an unskilled customer, probably typical for TTS's customer base. I worked my way through the initial learning curve to calibrate the speedometer and eventually get a reasonable tune file flashed into the ECM. With Ed's help, the VEs were extrapolated in the areas in which I could not reach on the road, resulting in an even better tune file.

But after spending over one thousand dollars in aftermarket components and \$400+ for TTS, I needed to know what the motor's potential was; and did I get close with my home tune.

Ed has spent hours of his own time as well as time on his dyno to meticulously test each of my experiment stages before performing the final tune. Without a dyno final run and then comparison tune, I would really never know what the gains of my engine and home-tune might have been. I'm also happy to make all of our work public so that others might benefit from my experience and Ed's patience and time.

When I make my cams decision, I'll do more VTuning before taking the motorcycle back to Ed for another final tune.

In the meantime, it might be fun to do a tuning run on the current Dyno Difference ECM flash and see what changes TTS thinks needs to be made. Of course, I won't be re-flashing afterwards, no matter what the comparison might show. Ed's tune is the final one for this build.