So you want to get into mapping cars….

I decided to write this paper to help people that want to get into the business of re-mapping cars, I say cars but it actually is relevant to any form of combustion engine and also to help myself as I want to teach people to do this. You can find details of my company at www.OBD2Equipment.com we are a company that not only supplies car diagnostic and tuning equipment but we also use it, and now teach people how to use it. We differ from other companies that offer tuning courses in that we are independent and we do not sell slave tools. Too often I found people went on a course only to think that they would not understand what they needed to do and were then “encouraged” to buy a slave tool whilst they “became more familiar with” the process. The truth is with a slave tool you cannot see what has been done and you can only buy from your “master” so all you are doing is providing them with their extra income at your expense.

If you look at these other companies you will see they do not publish what they teach, for fear of you learning their great knowledge for free? No for fear that you might read up something else and see they really do not know what they are talking about. On my website you can read my guides, I am still writing them, and then you can decide to come to me for proper tuition and ask your questions directly. We also do not do a class room of 10 as the money greedy companies do.

James

Index

1.) Where to start…..

1.1) I shall focus this paper on Turbo Diesel vehicles as these provide the easiest way to see real time results without the need for a lot of equipment. This is because the diesel engine can run “lean” without causing failure. A lean petrol engine will burn a piston, valve or turbo. Additionally the turbo allows for a percentage increase in power gains because they are from factory set to run within moderate limits. We can increase this limit safely and mildly but see big improvements.

Do not make the mistake that you can easily make a better map manufactures spend thousands of hours creating these maps, millions of pounds and engineers that have spent 6 years in universities studying all manner of maths to do this. So you’re out before you start then? Well no, the manufacturer makes a map that is a constant state, i.e.: it works in any country with any fuel quality, at any altitude above sea level and any external temperature from snow to desert. This means we can tune the map to suit our environment.

Firstly you need to understand what an ECU is, what it really does. It’s a mistake to think it just makes the engine run by adding fuel and ignition (spark in petrol, compression in diesel). An ECU has to do many jobs that you don’t even consider, however you need to have an understanding of these other features because that will affect how you tune it. On average an ECU in 2015 will have in the region of 10,000 parameters, of these around 33% will be in RAM that cannot be altered and the remaining in FLASH which can be altered so that’s about 7700 things you can change.

1.2) I’ll give you an example, an ECU will control engine temperature, too do this water is pumped around the engine and passes through a radiator to be cooled. So on start up with cold water and a cold engine the ECU has to deal with all the parts both inside and outside expanding at different rates and the exhaust gasses exiting carrying pollution. For example a piston typically an aluminium alloy expands quicker than the metal of the cylinder wall, typically a cast iron or steel. This can cause a “slap” noise and allows gasses to escape past the piston rings into the sump and out into the atmosphere if not recirculated. To counter this a cold diesel will inject a small amount of “pre” injection fuel to warm the cylinder before its main injection and firing compression thus removing noise and decreasing the pollution level in the exhaust as a higher temperature is achieved inside the cylinder. So moving on the engine is now hot, the ECU now needs to cool it down so the pumped water relies on air flowing through the radiator, simple enough as the car drives along the road, come to a stop in traffic and now we need the typically electric fan to cut in when the temperature is too hot. This is done with a simple sensor in the water system, easy all taken care of nothing much to do then… wrong the ECU will take the signal from the water temperature sensor, it will then look at the outside air temperature taken from the mass airflow sensor of if fitted an external sensor, it will also look at the ABS sensor to measure road speed, with a map created for road speed to air speed through the radiator it will decide at what temperature to switch the fan on, and what temp to switch it off. Done? No it will also then look at another map and add in a time delay for switching the fan off this is to prevent a fan from repeatedly going on, off on off which will reduce the relay that provides power to the fans life span. This is calculated from several maps and sensors. Engine speed and therefore water speed through the radiator, airflow through the radiator to calculate efficiency in degree’s per second, outside conditions, the torque map because you need to know how much heat the engine is producing….. now do you see how many things go on inside your ECU? We haven’t even got into the factors to make the engine run. On a recent remap I only changed the air conditioning pump setting so that after 30% throttle the pump dropped out until the throttle was set below 30% this saw an extra 25bhp out of the engine (Ferrari 458)

1.3) Our ECU does this by using a set of pre made set of “maps” to carry out calculations.
These maps have fixed numbers on the X and Y axis but the ECU will calculate all the steps in between these numbers. For example where it has 35mg of fuel and 40mg of fuel in the map axis the ECU will calculate the values or 36 – 37 – 38 and 39, actually it will calculate the values for 35.001, 35.002 and so on. It will then use the calculation it has made and apply it to another map, this will then give it an adjusted value based on the second map, this process then repeats for the third fourth fifth and so on until it has a final answer.
Then it takes this final answer and applies it to yet another set of maps, this next set of maps controls the output signal, the signal that the engine actually receives.

1.4) ECU sensors, the 3 catagories.
An ECU has 3 main types of sensor it has sensors that provide Commands in, for example the throttle pedal (TPS) which sends a request to the ECU. Then it has the Monitoring sensors, such as the mass air flow (MAF) which tells it the quantity of X and finally it has the Correction sensors the lambda which tell the ECU that it needs to change it calculations to make a particular problem corrected.

1.5) EEPROM vs FLASH EEPROM

I have added in this section to quickly describe the differences between eeprom and flash eeprom.
An eeprom is an acronym, that is it is a shortened word used to describe a sentence.
eeprom stands for "electrically erasable programmable read-only memory"

Flash memory uses an eeprom, but it uses a different type of eeprom
A eeprom needs to be completely erased and then reprogrammed and requires a high voltage to do this. (this where the heat comes from)
A flash eeprom uses standard computer voltages to write and can have just one part of the memory changed
i.e. If I have 1-2-3-4-5-6-7-8-9 in an eeprom and I want to have 1-2-3-4-5-6-7-8-8
I have to erase the entire chip so it will read 0-0-0-0-0-0-0-0-0
Then I send the new set of numbers to it all of them 1-2-3-4-5-6-7-8-8
If I have a flash memory chip and I want to do the same I will not erase any numbers I will only send Change 9 to 8.

One chip can have both types of data on it i.e. you see one black thing with legs sticking out but inside it are 2 eeproms one on top of the other (there can be many inside)
OR
One programming can write to 2 eeproms at the same time, one can be in the instrument cluster and the other in the radio in the boot of the car!

The main chip on a ECU, the MCU, will use flash memory stored in an eeprom, some MCU's have "on board" flash memory what this means is inside the MCU is a eeprom others use external eeprom to store the flash memory, they will also have eeproms with fixed memory.
Think of a MCU as a "suitcase" you can put what you want inside it some manufactures will put 2 shirts 2 pairs of shoes and hat in the case but then put there soap in a separate bag so as not to get their clothes contaminated should the soap leak.

The reason to put eeprom inside an MCU or not? A eeprom generates heat and it can only be used a limited amount of times. If you need 10 eeproms to store all your information you will need a fan to cool down your MCU, if you put your 10 eeproms outside then the MCU will be much cooler and the eeproms will be cooled down by the air around them.

2) What you need to know and have before you start.

You need to be able to do these following things before you can map a car.

2.1) Maths, you need to have a reasonable understanding of maths, and how to use a scientific calculator as you get more involved. By the end of this guide you will know what 14x(1-2.373 to the power of 0.263)/ A squared x (B + 460) means, now don't worry I will break this down into each part of the equation later on and it is not as complicated as you may think, that said it would help if you knew why there are parts of the equation inside ( )and what "to the power of" means

2.2)To design a map you need to understand what condition a car is in, who is driving it and for what purpose and what its mechanical problems are. A 20,000 mile car will be able to be mapped further than a 80,000 mile car, assuming they have had identical daily use, as the internal condition of the engine will be better. A car with auto transmission will want a different map from a manual one. A family man will want a different map to tow his caravan than a sales Rep in an identical car. Does this car have known gearbox issues? Increasing the torque low down will cause potential failure sooner. There are many more things to consider, these will be covered in "designing your map"

What components make up the car, not just things like how many cylinders and its total cc but you need to know is it mechanical injection, common rail, variable fuel pressure, direct injection, does it have mechanical or electrical turbo bypass, does it have EGR or DPF even down to air-conditioning, are the sensors on it voltage variable or pulse variable?

2.3) What maps are actually inside the ECU, there can be 6 or many hundreds, you need to know what map is actually the "limiting map" for example when there are 6 maps in a basic system one of those maps will be the limiting map, it usually the "torque map" but not always it may be the "fuel temperature map". So you need to know what maps you actually have and which ones limit the others before you can actually tune it correctly.

2.4) Chemistry, yes you need to be a chemist to be a high quality tuner, you will be dealing with the effect of altitude on air quality, the effect of temperature on air density, the burning of fuels and the amount of gases produced, the effect of compressing gasses and how temperature's build up from both compression and expansion. What gasses can be used to aid "gains" and what causes "losses", how we can use these things to improve our tuned map.

2.5) Use a computer, not just the basics you really need to know how to use:

In Excel you need to be able to write formulas for multiplication and division of cells, you need to be able to map cells, format numbers and set borders, text and cell colours and of course Copy and Paste functions. Why? Well you're going to start by doing maths on non-existent maps to understand the changes and calculations required to make those changes, then you're going to link one map to another map and see how changes in one affect another map.

Notepad++, this is not Notepad this is a different version that will allow you to open and convert files into different file extensions.

Hex Editor, you will need to know what "HEX" is so you can start to understand what language is inside the ECU this will help you when you have a problem, its not something you will need until much later on in this guide and by the time I introduce it you will have the basic knowledge to use it

Tuning software, from the easy to use ECM titanium to the harder WinOls. Easy to use does not mean it's what you should use. Whilst ECM is designed to be an easy to use program it really shouldn't be used beyond the training level. I will explain later why I say this.

WinRar and or 7-zip, because you'll be sending files via the internet.

Email, and additionally a file transfer program such as "We transfer" because your zip'd file will be too big to send via email or you're anti-virus will block the zip'd file as it may contain a virus!!! Well that's how viruses are transmitted by email attachments so they do not look at the file just see a zip'd file and go "oh no it's bad" and block it.

2.6) An ECU reading program, combined with an ECU reading tool. You need to connect your computer to the ECU, often via the 16 pin OBD port, however a lot of ECU's need to be removed from the vehicle and taken apart, inside there is a programming port which is just a line of gold pads about 1mm in diameter that you need to connect to. So you're going to need 2 tools, one for a OBD connection the other for a direct to ECU connection, then you'll need the software to operate each tool and you need to know how to use this software and save the file you have read from the ECU so you can work on it.

2.7) Next you need a good bench and comfortable chair, you need a good wooden toped bench, preferably with a light coloured top so you can find all the screws you have removed and as it may be necessary to remove a chip from the board to be able to read the main chip you'll need to find this afterwards. A comfy chair, it's important to be sat at the correct height for you bench and you'll be there for a few hours so if it's not the right chair you'll get neck and back pain, maybe so much so you decide to "that'll do I've had enough for today" rather than "yep that's finished"

Ok bench, chair both sorted what's next?

Well you need a magnifying glass so you can look on the ECU and read which is pin 1 and a good light source, I use a telescopic magnifier with a built in tube light, its mounted on the end of the bench and I can pull it in front of me or push it out of the way in a second so as not to have to look for it and drop what I'm holding.

Oh and its worth buying a tool called a "third hand" it's usually a metal base with a few random clips on it, this allows you to hold something still whilst holding solder in one hand and a soldering iron in the other.

Then you want a supply of 1k and 10k resistors, a handful of capacitors personally I have quad buffers, canbus transmitters and more, there is a full list in the Equipment Appendix at the end of this guide, but its about £25 for all these items and you have them so that IF you need them you don't to stop what you're doing and drive into town.

You'll need a good selection of tools, ECU's are normally well hidden requiring removal of many parts to get to them before you can remove them.

Then you'll need a proper soldering workstation that is temperature controlled with both a hot air blower and a solid tip soldering iron. You will also need a "flux pen" this needs to be "ROSIN" flux to aid any soldering you do, then you'll need a cleaner to remove old flux and old solder.

A sharp knife to scratch away any coverings, then you need a few different shaped tweezers and thin nosed pliers so you don't burn your fingers…

So now do you see that the £200 clone Kess on ebay wasn't such a cheap way into this job!

Apart from removal of the ECU (where needed when an OBD read is not possible) you will also need to be able to carry out mechanical checks before you start to even think to re map this ECU. Sensors need to be checked, cleaned or renewed, oil changed, airfilter replaced, airfilter housing modified, inlet manifold cleaned, EGR flap blanked, DPF filter removal, crankcase filter replaced and modified the list goes on and these things need to be done before any map changes are made, you can never map a car because it has a problem. Too often I see that a map has been done with a DPF delete because the car had a DPF problem. All this will do is mask the fault codes, the ECU will still be dealing with the fault and your map will not be doing its job because the ECU will have a map that over rides the actual output signals.

Additionally you will need a battery stabiliser and a bench power source.

Your bench power source will be required to power up an ECU removed from a car to allow you access to the programming pads, you need 12 or 24 volts dependant on what it has normally and I recommend a 2amp supply, in reality you need about 0.5 to 0.75 amps to power an ECU however if you use a 1amp supply it may just cause you to "brick" the ECU (the term "brick" refers to the fact that it is now only useful as a brick to stop the car rolling down the hill) this is because a 1 amp rated supply will have an efficiency rating on an cheap power supply around 10%THD that means it'll give between 0.9 and 1.1 amps in its normal operating temperature range, but hang on your in your garage and it's been 3 degree's overnight and now its 10 am, the power unit will be out of range and may only give 0.6 amps, then your ECU is cold so it now needs more power so instead of 0.75amps it needs 20% more so that's 0.9 amps and you have just shut down your ECU, if that's mid read, or worse mid write it's a brick. So why 2amps and not 5amps? Well you have an open ECU and your connecting wires to it, drop a wire with 5amps and it turns into a portable welder sparks fly and ECU is brick, at 2amps which is really 1.6amps it should survive any short circuit you do.

Right then what's a battery stabiliser? Well as your sat there car door open, ignition on the battery is losing volts, as it can take 30mins to read or write an ECU that's a lot of volts its losing drop to low and bosh ECU brick, why not use a battery charger? Well these give current, and current will damage your computer interface, never use jump leads onto another car or battery if the lead slips it'll spike the system, battery booster…no these are designed for a short sharp boost not a constant slow drain. If you have no choice a 2amp battery charger is the last result, often sold in local stores such as Argos or Halfords as "battery maintainers" these will not produce enough current to damage things, but they are not to be trusted as they will not maintain a level they will just trickle away a bit of power so as things turn on and off (you will need to turn ignition on and off several times) the voltage will be up and down, this will cause an error at the least it will give you a "wake up error" which is a no read situation.

2.8) We also need “crib” sheets, I have a set series of things to do during the entire process.

My first crib sheet includes driving the car to make sure it hasn’t got a fault, checking all the lights work, check the remote door locks work, the heated seat and more.

Mechanical condition deal with checking all the mechanical things are ok, perform a check of the sensors, you will need a generic scanner for this to read out the ECY fault codes. You must check that all the sensors on the engine are working correctly, test with the engine off, with the engine just on idle and then with it held at 3500rpm for 30 seconds.

Self-preservation sheet,
has the customer got the radio code because you will disconnect the battery, check under the seats for mobile phones or other valuables, never remove anything ask the customer to remove it. Look in the boot check what is there and make a list of items. Check the tyres, look for anything like a nail in the tread that may actually be a slow puncture, make sure the tyres are legal and check the tyre pressures, this will tell you how well he looks after the car and also if there is a slow puncture. I also check brake pads, oil level and condition, air filter etc. If anything is not correct do not proceed with the map. Fix the car first or you will have problems after the map which you will have to search for and fix before you get paid, if you did not know the condition before you started you will spend a lot of time trying to understand and undo what you’ve done.

I record all these on my crib sheets either by a tick to say I’ve checked or by writing in a number or a note, then I get the customer to sign it before I start work on his cars maps. We will also keep sheets for the changes we make, we will have one that looks at each component of the system to see who it’s made by, what’s its part number, what does it do? It’s working range so we can refer quickly to the information and make job easier.

3) What is it we have then?

Ok, so we have an ECU and inside it we have what is referred to as “maps” these maps control the engine and by altering them we can make more power, fuel economy or better emission (i.e. lower). Think of this as a triangle between these three points, an increase on will decrease the others so you cannot gain on all 3, well you can actually but only with in guidelines that do not exist. So that means you have to work out these guidelines and it will be different for every engine, even two seemingly identical engines will be different. It is true that you can make a power increase and also increase fuel economy, but only if it’s done correctly. Power is made by burning fuel, more power needs more fuel, you can calculate the bhp made from an amount of fuel with a simple formula it’s called BSFC or brake specific fuel consumption, so how do we make more power and more economy? Well we look at efficiency of the burning of the fuel we have, more efficiency gives us power and economy.

3.1) So what’s correctly then? Well I will cover this in detail in the section below. It is going to be easier to tell you what common mistakes are made by tuners who have been badly taught.

3.2) First thing you need to understand and it is the most important thing you will ever come across yet more than 75% of tuners will not know what you’re talking about is something called a “stoic” value. The correct full name is “stoichiometry”, now we are into the first part of many trips into chemistry, this is the ratio of Air to Fuel the 2 elements needed to make an explosion to push the piston down. Diesel or petrol have almost identical stoic values of 14.7 and 14.6 so we do not need to worry about this difference. What that means is to burn 1gm of fuel we need 14.7gm’s of air, ok so this is true in a laboratory under perfect conditions however that is not what we have inside our engine.

3.3) Right so now we need to understand something called “efficiency”, we will be referring to efficiency in many sections of this paper and there are many types of efficiency that we will need to understand and calculate to be able to produce the ultimate maps that will make you a tuner with a reputation that see’s customers coming to find you.

So our first introduction to efficiency is in relation to our stoic calculations. In our laboratory we managed to achieve 14.7 to 1 ratio of air to fuel, we will be using the stoic value to calculate and check our new values in our “smoke map” (see the maps listing section for full description). We can’t achieve this in our engine because of efficiency issues. Our first problem that will reduce efficiency is that we have a piston going up and down, it has to stop at the top and bottom and reverse its direction, secondary our piston travels inside a cylinder and we need to seal between these two items to be able to compress the air and fuel inside to create an explosion. Next we have to allow the air in, and the burnt gasses out, via the inlet and exhaust valves again these need to create a seal between valve and its “seat”, then we have the issue of the air pressures on both the inlet and exhaust side.

3.4) So let's break this down.

We will ignore the compression ratio of a turbo in this first introduction so as to simplify what we need to explain. We have an engine that has an amount of cylinders and a total cc, for example. BMW 530TD, this is a 6 cylinder engine of 3000cc or 3 litres, each cylinder therefore is 3000/6 (the / is a divide by symbol on a computer) so we have 6 cylinders of 500cc. This means that theoretically we can get 500cc of air and fuel mixture into this cylinder. If we now apply a ratio of 14.7 to 1 we will get the following equation. 500/15.7 (14.7 plus 1) this gives us 31.85, so we will have 31.85gms of fuel and (31.85 x 14.7)= 468.15gms of air. To check this we can add 31.85 and 468.15 together and we get 500 so our maths are correct.

3.5) Getting the air in, our air travels through an air filter, which removes dirt but also slows the air down, then it travels along a network of pipes through a series of bends, again slowing the air down on the long side of the bend and speeding it up on the short side of the bend causing an aerodynamic wake (a disruption in the flow like when the wave in a sea hits a rock). Next it goes into the turbo, first the inlet housing, then the compressor wheel next onto the exit snail along another set of pipes, squeeze it through an intercooler, more pipes and bends before going through a MAF "mass airflow sensor" then into an inlet manifold which has one inlet into a large chamber to help equalise the flow and pressure before passing through a series of small outlet tubes to the cylinder head, which changes the the airflow from a horizontal plane into a vertical plane and then passes it over a valve that is opening and closing at a high speed causing another aerodynamic wake.

3.6) Getting the fuel in, well this is much more simpler as the ECU can accurately measure this by setting the time the injector is open and knowing the fuel pressure, however fuel atomisation is another factor which we will deal with later, the atomisation directly effects how well the fuel can burn

Ok next, we now have air and fuel in our cylinder and we can compress it by pushing the piston upwards, however we will get an amount of air slipping past the piston rings, this amount will vary according to mileage and also to abuse the engine has suffered. A 100,000 mile engine that has been warmed up and cooled down and then runs on a motorway at a steady state will have much less wear internally than one that has done short runs and only covered maybe as little as 20,000 miles.

3.7) Next we have to get the gasses out, again these are pushed out by the piston with the exhaust valve open, however not all will escape as the valve has to close before the piston comes to the top of the cylinder to avoid them hitting each other, so this means when the next amount of fresh unburnt air comes in there will be an amount of burnt air residue in the cylinder, burnt air has no oxygen so this will not help out stoic values.

3.8) Therefore we need to consider our "efficiency" to set our target stoic values. At this time I will not bring in the mathematics behind how we can calculate these losses, it's not hard but it is something that at this stage we don't need to do. We can use a rule of thumb figure to start out with and this figure will be good enough for us to see an increase in our cars performance and economy.

So if 14.7 to 1 is a perfect ratio what happens if we have 12 to 1, well we will see black smoke from the exhaust, that said when we start an engine from cold we may go as low as 6 to 1 but this is to do with cylinder sealing, rotational expansion, and mass acceleration. These things are not relevant to us as the sections of the maps that may contain these values we will never modify. What happens if we go to 30 to 1, well we will see higher combustion temperature's, in a diesel this is not a problem as the fuel has a greater cooling ability than petrol. This is why we start out with turbo diesel engines as we do not need to monitor the exhaust temperature's in our stage 1 tuning.

3.9) A bad tuner who actually knows what stoic is, remember most of them do not even know what this term is, will set a flat stoic value somewhere around 18 to 1. In reality you can get to 16 to 1 maybe even 15.5 to 1 under certain conditions experience is the only way you will find this value however later in this paper I will show you how to calculate the figure you can potentially achieve without causing a huge amount of black smoke. Bad tuners will just change numbers until they get smoke, then back them off a bit until the smoke reaches a level that you don't see it in your mirror as you drive down the road…..

3.10) Mapping for "power" or "economy". I am only dealing with mapping for power in this guide. Most people are looking for power and if you do it correctly by maximising efficiency then you will also get a small increase in fuel economy. To truly map for economy you must use EGR, there is a lot of discussions for and against this but I can tell you, EGR is required for economy. To get a full burn of the fuel going into the cylinder you need to have a combustion temperature, we use EGR gasses to raise the cylinder temperature pre combustion to raise the temperature of the fuel to aid the process of breaking down the molecular chain. This only is an issue in lean i.e. economy settings because in the full fuel injection the extra fuel starts to burn sooner and this raises the cylinder temperature before we get the main event of all the fuel burning.
There is a chapter at the end of this guide that deals with EGR DPF FAP etc.. in brief. I do not deal with it in detail because the correct process for these features will make for a longer guide than the one you are now reading!

Let's now look at what's involved in the Air and Fuel systems.

4) Firstly fuel.

We need to get fuel into the cylinder, there are many ways and there is an evolution over time from carburettors to metering heads to injection I will only deal with injection in this guide. Below is a basic description of how the system works, rather than discus a particular system this is a general guide, later we will look at it in more detail and discuss the different ways this process happens.

4.1) So what is "injection"? It's the method that the fuel is delivered to the cylinder and it allows us to accurately control how much fuel is delivered by opening and closing the flow. To achieve this the fuel goes through several journeys from the fuel tank to inside the engine. We need to understand each of these journeys because we are going to ask our car to provide more fuel than it did before we altered the map. Ultimately the fuel has to be "atomised" in the cylinder, the reason it is atomised is that this allows for a more controlled burn then simply having fuel pour in. Think of a garden hose when you are cleaning a car, if you simply allow the water to run out it comes in a single stream and falls to the floor in a puddle, if you place your finger over the end it now sprays out in a wide fan as a fine mist. This is what our injector is going to do, this fine mist fills the entire cylinder and has a greater contact with the air allowing for a faster and more complete burn to take place. To achieve this spray the fuel needs to be under pressure as it is forced through the tiny opening in the injector. The better the spray the better the burn, for a better spray we need more pressure so technology has evolved to increase fuel pressure. To achieve these high pressures the fuel goes through stages because we cannot simply take it from the tank and pump it up to the engine under high pressure so what we do is use a low pressure fuel pump, sometimes referred to as a "lift pump" to bring large volumes of fuel to the engine. Once we get it to the engine we are going to take small volumes of fuel and raise the pressurise pumping it to the injector, the final stage takes place inside the injector, inside the injector will be a chamber this chamber will fill up with fuel from our high pressure pump and then be compressed further by the injectors internal operation as it opens

4.2) How do we get the correct amount of fuel? This is the job of the ECU it has to open the injector and close it which is done by an electrical pulse switching on and off. The ECU will change how long the pulse lasts to change the amount of fuel that exits the injector and goes into the cylinder. The ECU must also time this pulse so that the fuel is in the cylinder at the optimum time to achieve the best explosion to force the piston down. To early and the fuel will start to burn to soon causing the piston to be forced down before it reaches the top, this will stall the piston and lower the power it produces, too late and the fuel will not burn fully as the fuel and air need to be compressed by the piston travelling upwards to generate the energy to make the resulting explosion larger. Think of a crisp packet and a carrier bag if we put one breath of air into each and then stamp on them the crisp packet will make a louder bang, this is due to the compression of the air inside it.

4.3) We need to understand the injection cycle so we can design our good map because we will need to alter this control when we start to ask for a lot more fuel, however in a stage 1 map it is most likely we will not need to change these at all, again this is our bad tuner mistake they will jump in and make changes without understanding the effects it has but before that they will make changes without actually looking at what the current map will provide. As I said before many maps control the actual signal sent out so before we change anything we need to look at what we have and decide if we need to alter it. Many times another map will actually be the limiting factor so any changes we do make have no real term gain, all it does is throw the ECU into turmoil as it calculates wrong information and then tries to correct it back to, err well back to where it was before you modified it.

4.4) There are 3 things to understand,

SOI, Start Of Injection, this is the timing of when the injector will open, it is measured in degrees of crankshaft rotation BTDC Before Top Dead Centre

Duration, as it says this is simply the time the injector stays open which is how we vary the amount of fuel that enters the cylinder, this is usually in degrees of crankshaft rotation but it can be in time. If its time its milliseconds, we will do a little math below to demonstrate the time it takes for a piston to travel up and down a cylinder.

Fuel flow rate vs engine speed. Fuel flow rate is a constant, so an injector open for 0.3 milliseconds injects 35mgs of fuel into the cylinder, it will do this at 1000rpm or 6000rpm its flow rate is static. The engine speed is not static so the time it takes for a piston to go up and down once at 1000rpm is a lot longer than it takes at 6000rpm.

Let's do a little math to see how long it takes.

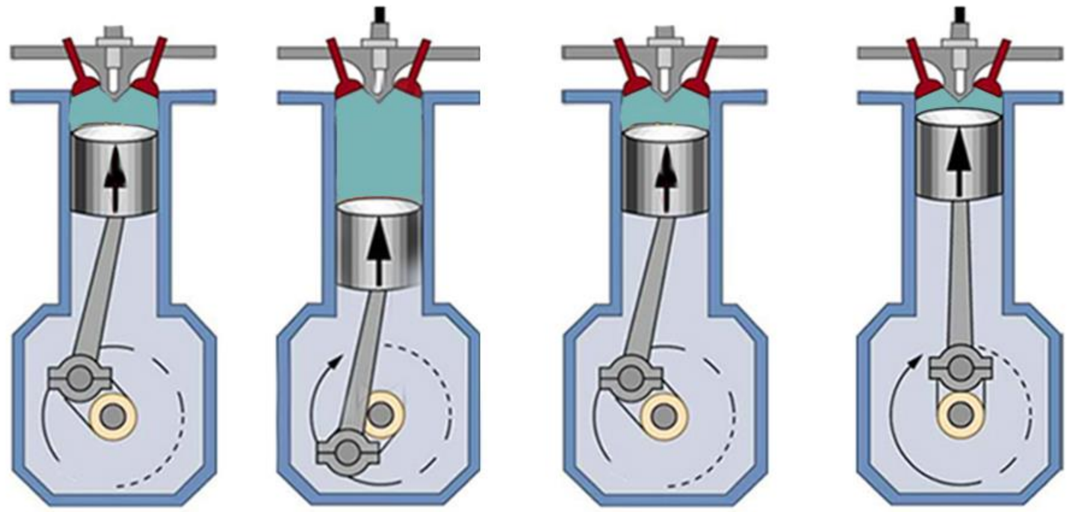
At 1000 rpm the crankshaft revolves 1000 times in every minute, therefore the piston also travels both up and down 1000 times in that minute. So how long does it take for our piston to travel up and down once? First we will work out how many times the piston goes up and down in a second. We take 1000 (the amount of times it goes up and down in a minute) divided by 60 (the amount of seconds in a minute) 1000/60 gives us 16.66. So our piston at 1000rpm travels up and down 16.66 times every second. To work out the time it takes for the piston to travel once we divide 1 second by 16.66 times we now get 0.060, lets break this number down the first 0 before the decimal point is whole seconds, the next 0 is tenths of a second, the 6 is hundredths of a second and the final 0 is thousands of a second. Our piston travels up and down in 6 hundredths of a second at 1000 rpm.

At 6000 rpm lets work it out, 6000/60 gives us 100 times per second, 1/100 gives us 0.010 which is 1 hundredth of a second. So our piston travels both up and down in 1 hundredth of a second. As we can only inject the fuel into the cylinder as the piston is travelling upwards we only have half this time so at 1000rpm we 0.060/2 which is 0.030, 3 hundredths of a second and at 6000rpm we have 0.010/2 which is 0.005 that's 5 thousands of a second.

4.5) To get the optimum fuel burn we require we have to finish the injection cycle at the exact time so the manufacturer works it out by the following math = (end time of injection take away the time of injection) this gives us the start of injection timing, however because the fuel flow is static and the engine speed is variable the time the piston travels up once becomes less this means we have to start the injection cycle sooner as the engine speed increases. This is called injection advance

4.6) To visualise this let's see how far our piston travels in the time it takes to inject the fuel. This is an example it is not factual it is just to demonstrate the principle. If at 1000 rpm our piston travels 100mm in 1 second it will travel 600mm in 1 second at 6000rpm. If it takes 1/10th of a second to inject 35mgs of fuel, remember fuel injection time is static, at 1000rpm our piston will have travelled 10mm and at 6000rpm it will have travelled 60mm. Now as we want our injection time to always finish at the same piston position we need to start putting the fuel in a lot sooner, we need to start it 50mm sooner to have the same end time. In this example I have ignored the rotational changing speeds of a piston because it has to be stationary at the top speed up to its maximum velocity as it travels up or down and then go back to stationary at the bottom of the cylinder.

4.7) The diagram below demonstrates this in the exaggerated way we have discussed it above.



Start of injection at 1000rpm | Start of injection at 6000rpm | End of injection at any rpm | Total compression at any rpm

5) So that's fuel covered now let's look at the Air.

5.1) Air has 3 ways we describe it. Flow, Pressure and Volume. We describe Flow in CFM this is cubic feet per minute and pressure in PSI which is pounds per square inch (It can be described using the metric system). Volume is given in g/L that's grams per litre, now volume of air has density that is the amount of grams of air in 1 litre, at sea level this is 1.19gms. This density changes as we get higher up a mountain, we will see maps in our ECU for differencing air density when we look at them later.

5.2) What we need to understand is that an engine requires an amount of CFM of air to flow into the cylinder, this airflow will have an amount of oxygen in it required to make our fuel burn. To get more power we need more air, specifically more oxygen, and then we can add more fuel. To achieve this we will use the turbocharger to push the air in under pressure. If we double the air pressure we will double the amount of fuel we can add and as we read earlier air/fuel is calculated as BSFC so we will get double the power less our efficiency ratio, yep here is that word efficiency again, as we force feed the engine our efficiency ratio lowers so it's not actually double. Again we have to understand that at changing engine rpm we will have to change the amount of air flow, the total CFM, but we may not want to change the pressure PSI. We want 14psi of boost at 2000rpm and we want 14psi at 4000rpm. However, unlike fuel, airflow will alter its speed of travel with engine speed so we do not have the duration issue that fuel has.

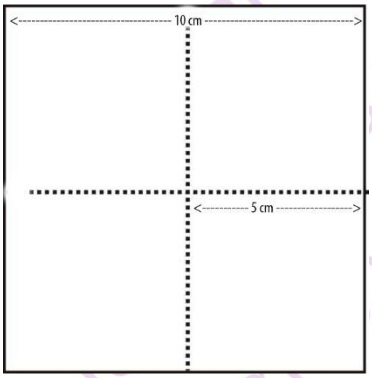
For our car engine to calculate how much fuel to inject it needs to know how much oxygen there is inside the cylinder, it does this by looking at the volume of air flowing into the engine and the pressure that it is under and the size of the cylinder it's going into. The size of the cylinder is static, in our BMW530 we know this to be 500cc, our air pressure in this example is 14psi and our flow rate of air this is measured by the MAF (mass air flow sensor) from these 3 numbers we can calculate our oxygen content and then inject the amount of fuel required.

So now we have something called flow rate, let me explain what flow rate is. To visualise this lets think of our hosepipe again we have 1 litre of water flowing through it in 1 minute, it is not under pressure because the end of the hosepipe is open. If we then connected a smaller pipe to the tap for example the pipe used to feed the windscreen washer jets we can still get the same amount of water 1 litre in 1 minute and its still not under pressure but the flow rate has gone up i.e. the water is travelling much faster. Now if we add a restriction to the end of our pipe, like a hosepipe nozzle we slow down the flow as the water tries to pass through a smaller diameter, so to get the amount of water through the nozzle in the same time we have to increase the pressure, however we have not changed our flow rate the water is still travelling at the same speed though our hosepipe only the pressure has increased. The same is true in our smaller pipe if we add a restriction our flow rate remains the same only our pressure has to be increased to maintain the same volume of water passing through the end.

5.3) Let's do some maths to demonstrate this.

For example if we have a pipe of 10mm diameter and we pass 1 litre of water though it in 1 minute the water travels at a speed of 10mph this is its flow rate. If we now use a tube of 5mm diameter the water will have to travel at 20mph to pass 1 litre in 1 minute. Our pressure has not gone up, only our flow rate. Now if we take our 5mm pipe and flow the water at 10mph in 1 minute we will only get ½ litre of water through it. Returning to our 10mm pipe if we now put a 5mm nozzle on the end of it we will have our flow rate of 10mph in the main pipe but need a speed of 20mph through our nozzle to be able to get 1 litre in 1 minute. To do this we will need to put the water under pressure.

So now we need to correct what you've just read, The flow rate will not be 2 times faster it will be 4 times faster, why? The actual factor that we need to consider is the area in the pipe not the diameter of the piper, half the diameter is not half the area. To work this out in our round hosepipe we will need to use a lot of maths so we will simplify it and use a square and draw a diagram.



The actual maths we should have used is Q= V x A

(Flow rate (Q) m3/min - Speed (V) m/min - Area (A) m2)
Water in hosepipe Example:
Diameter of pipe 10mm A = 3.14 x (0.01)2 / 4 = 0.0000785 m2 = 78.5 x 10-6 m2 Q = 1 L/min = .001 m3/min
V1 = Q/A = 0.001 / 78.5 x 10(-6) = **12.74 m/min**
Diameter of pipe 5mm A = 3.14 x (0.005)2 / 4 = 0.0000195 m2 = 19.5 x 10(-6) m2
V2 = .001 / 19.5 x (10)-6 = **51.28 m/min**

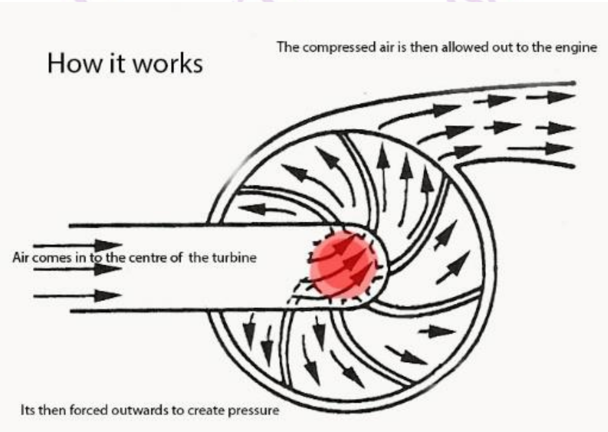
Later we will cover this subject in more detail, do not let this formula make you think you will not be able to do it. By the time you get to the end of this paper it will become easy.

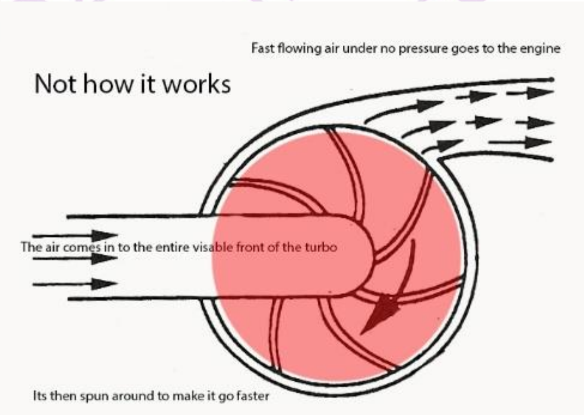
We will need to use this formula because we will need to consider our air going into our engine through the round tubes that take it from the turbocharger to the cylinder inside the engine. We will use it to calculate forwards and backwards, I.e. we will use it forwards where we know the size of our pipework and want to calculate what is going on inside the pipe, the speed of flow. Then we will work it backwards to see how big a pipe we need to increase our flow to get more air in without increasing our speed through the pipe.

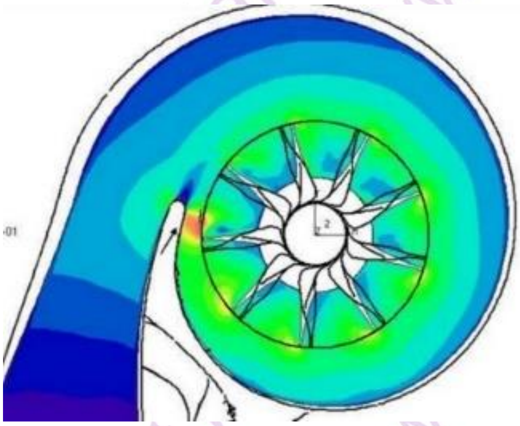
This will be relevant when we look at the size of an exhaust, intercooler and intercooler pipework.

5.4) To get more air in we are going to put our airflow under pressure and that's the job of our turbocharger. So let's now talk about turbo's and understand how they work. The turbo is going to put the air under pressure so that our air flow into the cylinder happens quicker, but as we have a fixed size of cylinder and because air speed will alter the end result is we can force more air into the cylinder.

5.5) A turbo takes fresh air in and compresses it by using a turbine. It's a common mistake to think that the outer edge of the turbine pushes the air into the engine. What actually happens is the air starts of at the point of the turbine (this is the smallest part of the turbine coloured red in the picture below) and is forced along the vanes (the channels you see) by rotating the vane at high speed it creates a centrifuge which forces the air outwards under pressure. The air is forced outwards equally all around the turbine but it is channelled away in just one place into the tubes that carry the air to the engine.







The final image shows how the turbines pressure is equal all around it, the different colours show the amount of compression, this is the centrifugal force compressing the air and forcing it outwards

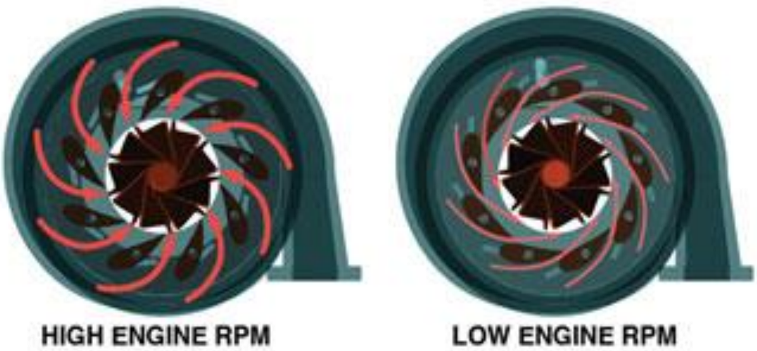
What's a centrifuge? Well we've all seen the fairground ride where you stand at the outside edge of a round cage, its then spun round and when it is at the right speed the cage is lifted up onto its side the rotational force keeps you at the outside of the cage even when its horizontal. This is centrifugal force and is exactly what the turbine in a turbo creates.

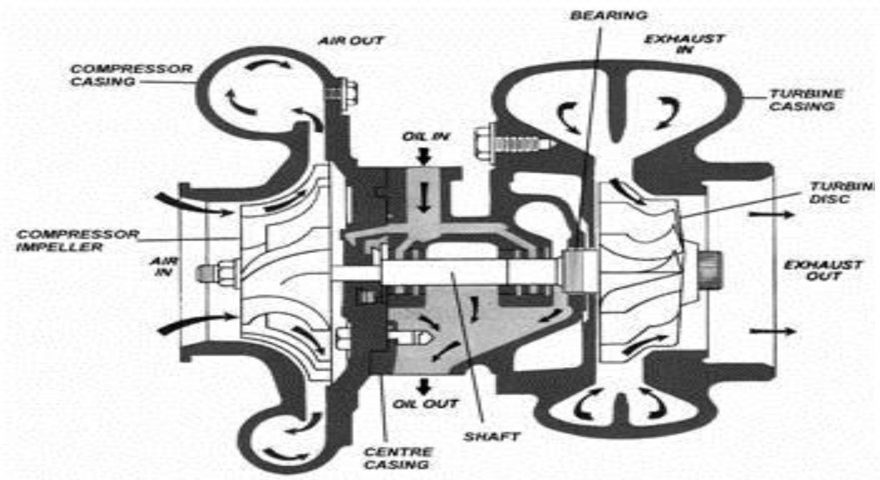
5.7) How does the turbine get its power to spin? Well it is driven by a shaft that is connected to another turbine in the exhaust, the exhaust gasses as they come out of the engine are very hot and as they escape they cool this causes the gasses to expand and so there flow rate, i.e. the speed it travels down the exhaust has to increase. This is the driving force for the turbine in the exhaust.

5.8) What we need to understand is that this turbine in the exhaust causes a restriction, much like the nozzle on our hose pipe, however this brings in a bad thing it is called back pressure. Back pressure means the burnt gasses escaping from the cylinder via the exhaust valve now have to force their way past the turbo. Without going into a lot of explanation at this time the end result we need to know is that it causes a small amount of the burnt gasses not to escape the cylinder so on our next intake of fresh air we will have an amount of burnt gasses left behind so our mass of air inside is the same but our amount of oxygen is lower so we cannot get as much fuel in, here we are back to that word "efficiency" again.

5.9) The turbine has a working speed, the speed is actually relatively static at any engine speed. The turbo needs to spin within its operating range typically this will be between 95,000 rpm and 115,000 rpm in order to do this it has one of two methods to control the pressure it will force into the engine. The two turbo types we will talk about are a fixed vane and a variable vane called a VGT (variable geometry turbine) the first the fixed vane will produce more airflow the faster it spins, the second the variable vane will change the angle of the turbine vanes to make it more or less efficient (there's that word efficiency again) this will keep its speed static but change the amount of air it can force into the engine. When our fixed vane turbo has too much airflow a mechanical valve must open to allow this excess air to escape. If it is not allowed to escape it will do two things, the first is it will cause an increase in pressure beyond the amount we need potentially causing the engine to fail from "over boost" the second is this build-up of air will cause the turbine to slow down causing what's referred to as "turbine stall". When we then want more airflow the turbo will have to speed up which takes time and causes a period of time when we have reduced power from the engine, this is called "turbo lag".

A variable vane turbo will change its shape according to engine RPM





This is the side view of a fixed vane turbo.

Here we can see how the "impellor" that is going to compress our air is connected to the exhaust "fan" which is going to providing the force to spin the shaft that connects the two.

6) POWER, but what is power?

6.1) Before we move onto maps we will discuss Torque NM (newton meters) and BHP (brake horse power) PS or KW are also used they all describe the same thing but in a different method. Though it's still commonly used by carmakers, PS or Pferdestärke (horse-strength in German) was actually replaced by kW as the EU's 'legal' measurement of engine power in 1992, its the metric system.

Horsepower vs Brake Horespower

6.2) Horsepower refers to an engine's total output, Brake Horse Power only looks at the amount of energy left once other parts like the gearbox, alternator and water pump have all been powered. It's measured at the road wheels, not at the flywheel. This can be called WHP wheel horsepower.

6.3) Torque refers to the amount of pulling power an engine delivers when working at different speeds. The more torque an engine has, the more pull (or acceleration) it offers at lower revs.

To explain this Horsepower = Speed, Torque = Acceleration, for a fast 0-60 you need more torque, to top 200mph you need more BHP.

6.4) Another thing to consider is the cars gearbox, the torque the engine is applied to the road and is multiplied by the gearbox, the BHP an engine makes is the same in any gear. The maths! 50nm torques with a gear ratio of 3 to 1 will give us 150nm torque at the wheel. 100bhp with a 3 to 1 gear ratio will still give us 100bhp at the wheel.

6.5) As fuel has a BSFC that is 1mg of fuel can only make a set amount of power, we will be able to calculate our engine new BHP from the fuel we have put in, and we will be able to calculate the torque we have. We use the basic formula HP= Torque x RPM/5252. As we have our HP and our RPM and 5252 is a static number we can re arrange the formula to TORQUE = HP x 5252 ÷ RPM.

Later we will make a power calculator, this will automatically calculate our BHP and torque. We will then build a table in Excel and link it to our maps so that as we make a change to a map we will be able to see a live change to the cars actual output at any given RPM. This will then demonstrate that when we change one map we will see an increase but then this increase will stop, why? Well it will stop because another map will be preventing any further increase. Our maps provide a "limit" to the engine, that is we may ask for 100% power by pressing the throttle but our ECU will look at everything and go, no you can have 65% power because that is what is safe in my "limits" We need to find what is actually the "limiting map" so we can make a real power increase. This is the common mistake in bad map writing because bad map writer's will increase the wrong map because they do not understand which is the correct map.

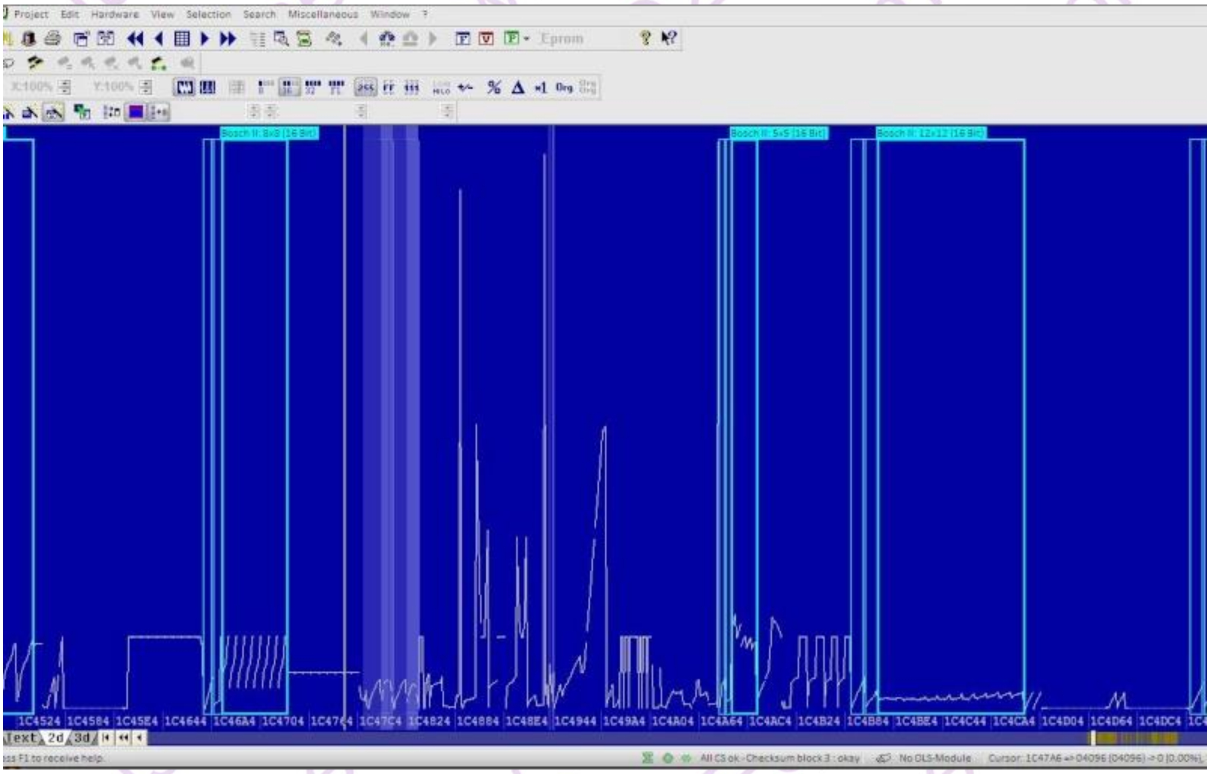
7) Quick bit about how we view a map

We are in the next chapter going to look at maps so I will give you a quick guide to how we view maps, that said at this stage you do not need to understand how to view them, or where to get the information in them from. In this guide we will use a table to view the information and this table will have an X and a Y axis with a series of numbers in them. Changing a number will change what the map does, what you will learn is what these changes do and how to calculate what numbers to use.

The maps in an ECU can be viewed in 2d 3d HEX or tabular (in a table) whichever way you view it the information in it is exactly the same. A table map is going to be our easiest introduction.

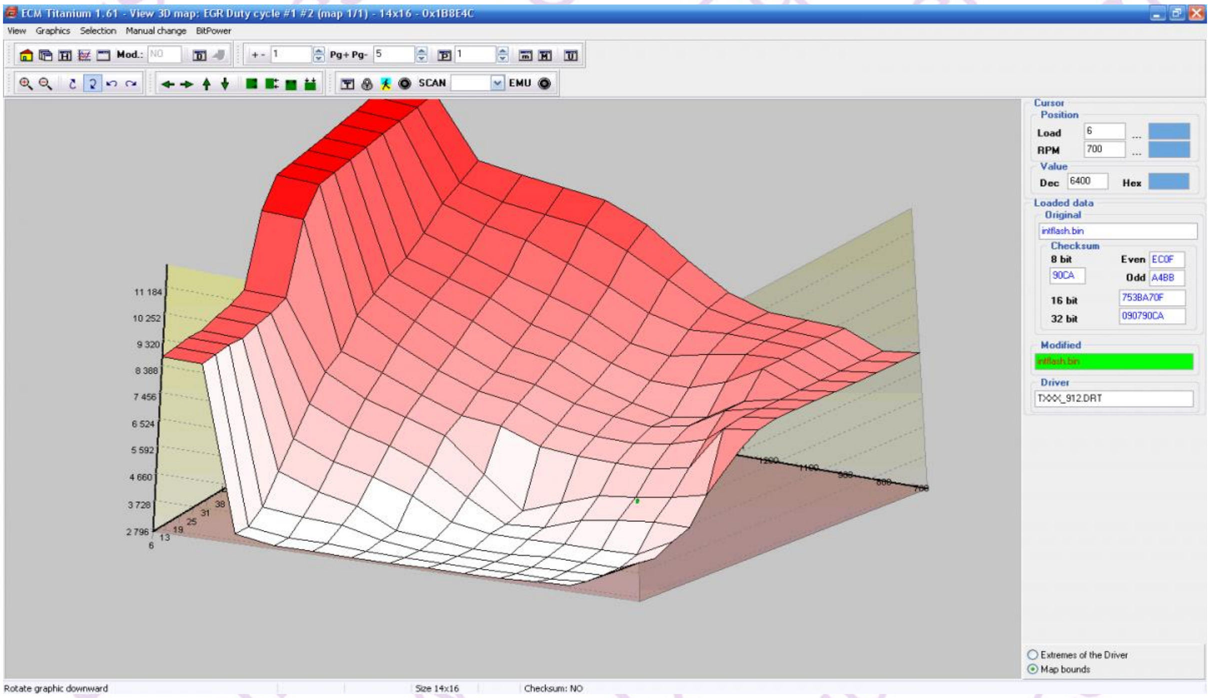
7.1) 2d MAP view

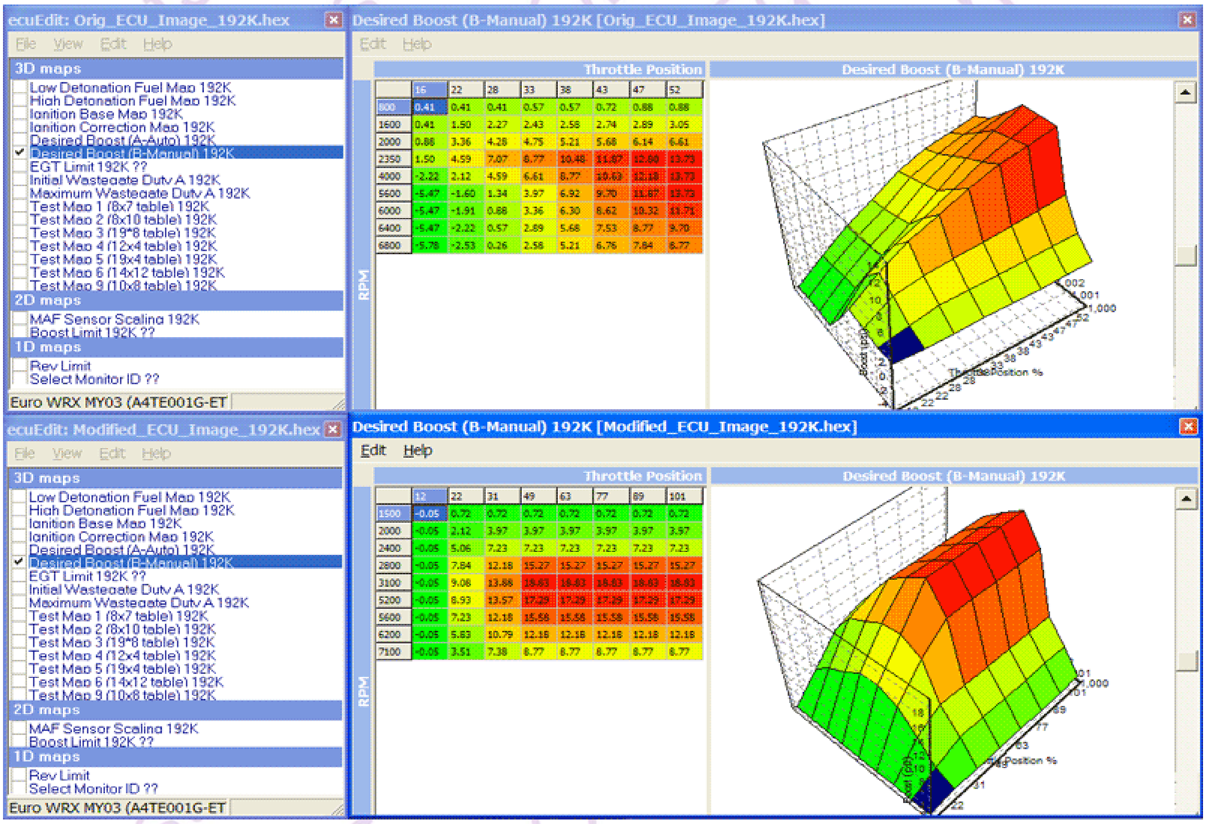
This is a 2d map, only after time will you view it and read it, however you may never need to read it. I say this because as map programming software evolves the 2D map is needed less, you may one day need to read it to find a feature. At this time you will understand it because you will understand it from knowing the end and working backwards because you will know what information is in each of the tables you will be able to analyse the section of a 2d map to see if it has the correct amount of information in it. By that time you will be a long way into your new career as a map writer.



7.2) 3d Map view

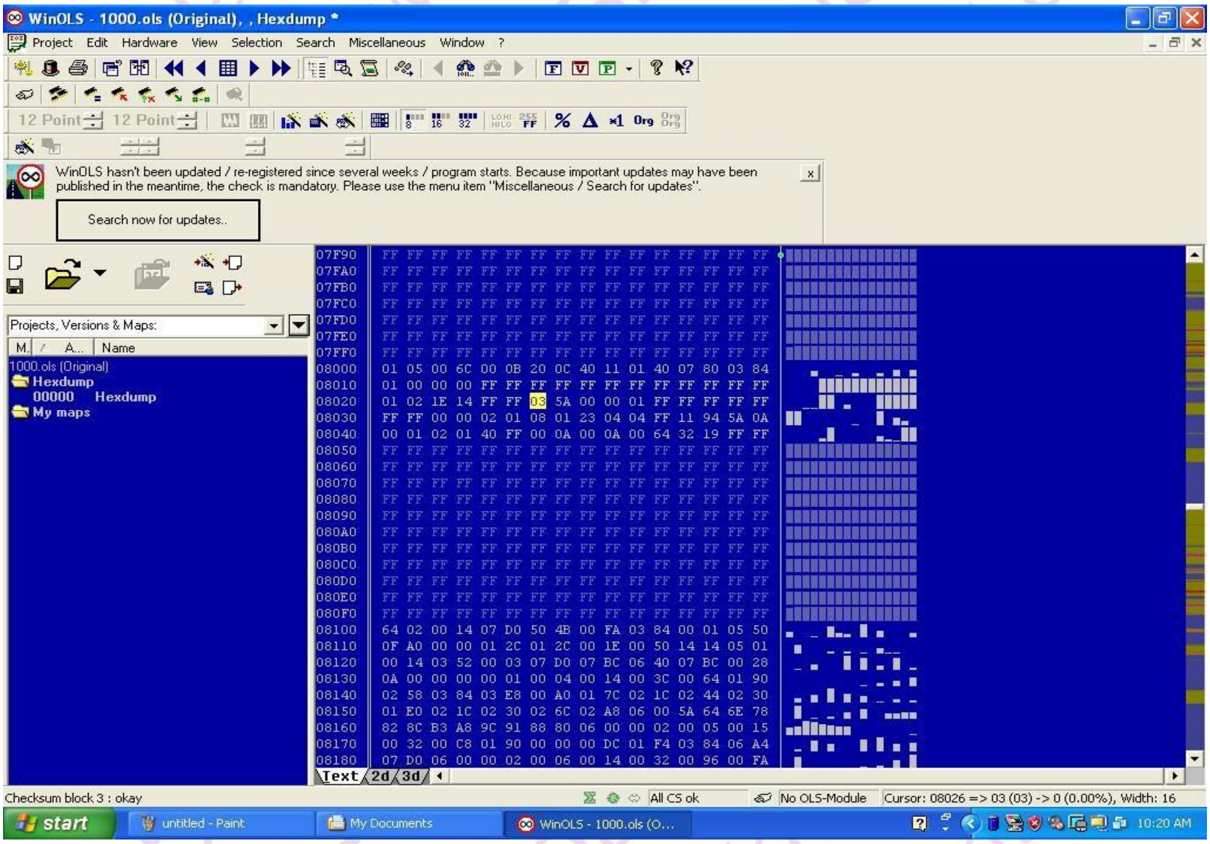
This is a3d map, now this looks like something we can understand if we see a standard one and a modified one overlayed it makes even more sense. Although it has little meaning to us in this form now without the overlay after we have the basic knowledge from looking at the tables view we will suddenly understand the 3D view, like a light turning on!





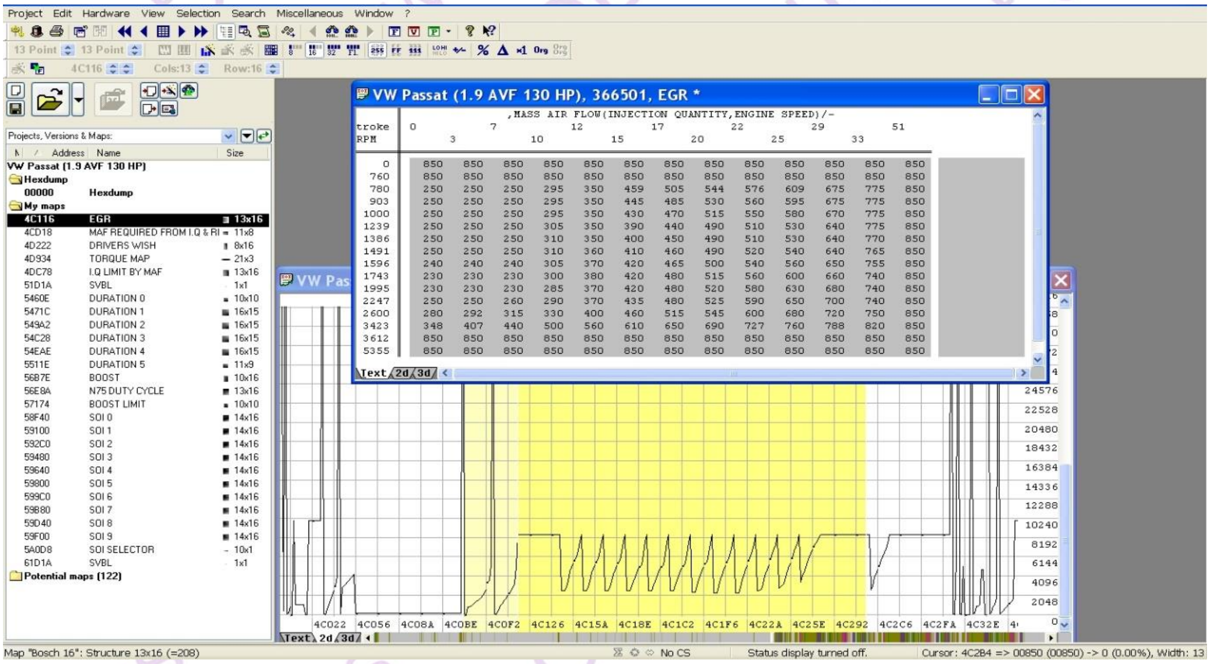
7.3) HEX map view

This is HEX, it is the purest form of code and is who programming languages developed, again `at this stage in our learning curve we do not need to know about it, we only need to know it exists.



7.4) Tabular Map view

This is a tabular map, we have a series of numbers, these we can understand far more easily and explain the changes with simple math.



8) Mapping, our first introduction.

We are only going to look at the maps that deal with fuel and air in this first journey into the "map" and we are only going to discuss the using the table type of map view.

Right, we have covered how many things an ECU has to do, how fuel gets into the engine and how air gets in, how a turbo works and touched on a few basic principles so now we will look at maps the things that actually control the power. We will look at 3 different vehicle examples in this paper but for now we will deal with a basic system.

We are going to use the VW 1.9 tdi engine specifically the 130pdi fitted to a VW Passat from 2004. The reason for this is that it only has a few maps to cope with we will only look at 7 and after this we will understand how maps work, when later we look at a car with 50 maps we will be able to focus only on the ones we need to and not be overwhelmed by how many there is. Additionally there is an excellent series of video's on youtube by "vagecumap" and I will use these videos as our guide explaining what is done, and why it's done, along with what mistakes are made and why these mistakes are made.

8.1) Before we look at each map I will explain the ECU's process to inject fuel into a cylinder. It will look at many maps and filter the information from the different maps, after it has filtered the information it will send the signal out to the engine. Why so many filter processes? Well each map has only an X and a Y axis, that is it only has 2 parts of information with one answer and the engine needs several parts of information so it looks at one map, gets an answer, looks at another map gets another answer and repeats the process through all the maps, at the end of this is does the maths on all the separate answers and has a final figure to actually send to the engine.

8.2) In our VW 1.9 TDi 130pdi the maps we are going to look at are:

1)Drivers wish. 2) Smoke map. 3)Torque map. 4)Boost map. 5)Boost limiting map.

6)SVBL (single value boost limit). 7)Start of injection. 8)Duration of injection.

We are only going to look at the maps that relate to the car at correct working temperature.
An ECU will have a different set of maps to deal with when the engine is cold, i.e. you have just started it up, and there will be maps for as it warms up. As cars get newer more maps levels are added in. Because we want performance we only need to alter the "at working temp" maps.

8.3) Before we move onto the next section there is one more thing to consider. Map Style, this is the way YOU not anyone else writes a map, or series of maps to make a full tune. Each map we look at you will develop a style as to how you want to change it. Some of these changes are governed by maths with maximum and minimum values you can use, some of these changes will need to be considered by what conditions the car is going to be used. Is it towing a caravan and taking the kids to school, is it a sales rep on motorways all day long. We also need to consider the cars condition but after we look at all these fixed factors we will personally make a choice as to how we modify a map. You will develop your own style, in the introduction below I will give you examples of what we need to consider in our mapping and I will tell you how and why I modify the map as I have done. I will also show examples of our "bad tuner" and discuss what he did, why he did it and why we do not.

Another thing to understand is although the map has numbers across all of it, which ones can be left alone because the engine will never see this. For example our boost map has figures in it for 0% to 100% accelerator position at 21rpm, we will never see this condition so we do not need to change it. We will ignore a lot of numbers because we will only modify the desired "operating range"

9) THE EXAMPLE MAPS BELOW ARE NOT HOW YOU WOULD SEE THEM IF YOU TOOK THE INFORMATION DIRECTLY FROM THE ECU. I HAVE CHANGED THEM TO REMOVE 0'S AND THEN I HAVE ADDED IN DECIMAL POINTS. IN A MAP WE WOULD HAVE 05310 THIS IS ACTUALLY 53.1mg OF FUEL. I HAVE DONE THIS TO MAKE OUR INTIAL VIEW EASIER TO EXPLAIN. THE NUMBERS IN RED SHOW YOU THE MAXIMUM AMOUNTS CALLED FOR IN EACH MAP

9.1) Drivers wish --- this map deals with the fuel going into the engine

This map is actually TPS, that's Throttle Position Switch (or Sensor) it is simply how hard you are pressing the accelerator pedal, that's why it's called drivers wish, this is how much fuel the driver wishes to inject into the cylinder.

% Accelerator								
rpm	1	4	10	25	37	56	80	100
0	18.7	41.9	46.0	54.0	61.7	68.9	70.0	70.0
399	7.7	27.9	33.3	41.2	49.5	62.7	70.0	70.0
609	0.0	19.6	25.8	34.7	43.6	59.1	70.0	70.0
693	0.0	16.0	22.7	32.0	41.4	57.6	70.0	70.0
798	0.0	11.4	19.0	28.2	37.6	56.3	70.0	70.0
903	0.0	6.6	14.5	24.6	33.9	54.7	70.0	70.0
1008	0.0	4.9	9.0	19.0	30.3	53.1	70.0	70.0
1113	0.0	3.8	7.0	15.0	27.2	53.1	69.0	70.0
1218	0.0	2.8	5.8	13.0	24.6	49.6	68.0	70.0
1491	0.0	1.5	3.5	9.3	19.0	45.3	66.0	70.0
1995	0.0	0.8	2.1	5.5	15.5	40.3	62.0	70.0
2499	0.0	0.7	2.0	4.5	13.5	36.3	59.5	70.0
3003	0.0	0.5	1.5	3.5	12.0	33.0	57.3	67.8
3990	0.0	0.0	1.0	2.0	9.9	29.9	52.8	64.4
4998	0.0	0.0	0.0	1.1	7.4	26.7	45.8	60.0
5355	0.0	0.0	0.0	0.5	1.1	20.5	29.5	45.5

We have an X and Y axis which has 0 – 100 referring to how much we press the pedal in percentage of travel, and it has RPM on the other. It will use this table to decide how much fuel to inject at any given RPM for any given amount of accelerator pedal pressure. This table is the amount to inject in just one revolution it is not how much fuel in time, the increase in fuel at the same RPM for more pedal pressure is to generate more torque from the engine

9.2) Smoke Map --- this deals with the fuel going into the engine

The smoke map has on its X and Y axis amount of AIR and the RPM, this map is going to limit the amount of fuel we can actually have by looking at the amount of air we have going into the engine, it will take its reading from the MAF (mass air sensor). The ECU process is, driver wish is asking for 70mg of fuel, but we only have enough air for 50mg of fuel so you get 50mg of fuel.

Mass Air Flow													
rpm	3000	3500	4000	4500	5030	5500	6000	6500	7000	7500	8500	9250	10500
00861	21.1	22.9	24.6	26.4	28.3	30.0	30.5	30.5	30.5	30.5	30.5	30.5	30.5
01000	21.7	23.6	25.4	27.2	29.3	32.0	34.0	36.5	37.0	37.0	37.0	37.0	37.0
01100	21.6	23.5	25.4	27.3	29.7	32.4	35.2	37.8	40.3	42.0	42.0	42.0	42.0
01200	20.5	22.6	24.8	26.7	29.6	32.3	35.3	38.7	41.3	43.7	47.0	47.0	47.0
01300	19.4	21.4	23.6	25.9	28.8	31.6	34.6	38.3	41.4	44.6	48.0	50.1	50.1
01400	18.3	20.3	22.6	24.9	27.7	30.6	33.3	37.1	40.5	44.6	48.6	52.5	52.6
01500	18.3	20.0	22.0	24.0	26.4	29.1	32.0	35.2	38.7	43.1	48.4	52.8	54.7
01600	18.1	19.7	21.8	23.5	25.5	27.9	30.9	34.2	37.4	41.2	47.2	52.7	56.5
01750	18.0	19.5	21.4	23.1	25.2	27.5	30.6	33.8	36.9	40.4	45.1	51.1	57.9
02001	18.0	19.4	21.3	22.9	25.0	27.4	30.4	33.5	36.8	40.0	44.6	49.9	58.0
02250	18.0	19.4	21.2	22.8	24.9	27.2	30.3	33.4	36.8	40.0	44.6	49.8	57.8
02500	18.0	19.4	21.2	22.8	24.9	27.2	30.2	33.4	36.8	40.0	44.6	49.9	57.4
03007	18.1	19.6	21.2	22.8	24.9	27.2	30.2	33.4	36.8	40.0	44.6	49.7	56.0
03500	18.2	19.8	21.3	22.8	24.8	27.2	30.3	33.4	36.8	40.0	44.6	49.5	54.9
04100	18.1	19.7	21.2	22.8	24.6	26.7	29.9	32.9	36.4	39.7	44.2	49.3	53.8
05355	15.5	16.5	17.8	19.3	21.1	23.1	26.1	29.1	32.8	36.1	39.6	44.8	49.3

9.3) Torque Map --- this deals with the fuel going into the engine

The torque map has on its X and Y axis engine RPM and Outside Air Pressure. This is the air pressure around us not inside the engine. This air pressure will be less the higher above sea level we go, it is why our ears pop as we go up in a plane or drive up a big hill. The torque map will have been developed by the manufacture and they will have set limits of how much torque you can have so that things like the gearbox, differential, driveshafts and CV joints do not fail. Again we can increase this because they have set safe limits to cope with bad drivers and to make the parts mentioned above last longer than the 3 year warranty they supply! It also prevents wheelspin and a thing called “torque steer” on front wheel drive cars.

Engine rpm													
Air Pre	0	550	551	1000	1250	1500	1750	1900	2016	2247	2499	2750	3000
600	0.0	0.0	30.0	30.0	39.6	48.0	51.0	**52.0**	**52.0**	**52.0**	51.0	50.3	49.5
800	0.0	0.0	30.5	30.5	40.0	48.0	51.0	**52.0**	**52.0**	**52.0**	**52.0**	51.5	51.0
1000	0.0	0.0	30.5	30.5	40.0	48.0	51.0	**52.0**	**52.0**	**52.0**	**52.0**	51.5	51.0

This map continues past 3000rpm to 5200rpm for the ease of viewing it I have cut it off at this point.

Now the ECU’s process is Driver wants 70mg of fuel, smoke says we can only have 50mg of fuel torque map says 45mg of fuel because 50mg of fuel will break X component

9.4) Boost Map --- this map deals with the air going into the engine.

The boost map has on its X and Y axis RPM and Injected quantity (ie how many mg of fuel). Inside the table the numbers we have are Mbar of air

	Injected Quantity									
rpm	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	45.0	50.0
0	198	198	198	198	198	198	198	198	198	198
21	1002	1502	1102	1158	1195	1265	1350	1350	1350	1350
1008	1002	1058	1106	1153	1199	1265	1350	1350	1350	1350
1260	1002	1060	1119	1171	1225	1281	1373	1500	1710	1710
1500	1002	1090	1155	1225	1305	1380	1495	1650	1900	1950
1750	1002	1115	1195	1280	1365	1475	1610	1800	2050	2170
1900	1002	1130	1210	1310	1395	1515	1660	1860	2115	2250
2000	1002	1140	1220	1320	1415	1535	1685	1880	2155	2275
2247	1012	1160	1240	1340	1440	1565	1705	1915	2205	2325
2499	1021	1180	1260	1360	1460	1585	1725	1925	2210	**2350**
3500	1060	1225	1320	1425	1525	1645	1775	1965	2235	**2350**
3750	1080	1225	1330	1435	1530	1645	1780	1970	2235	**2350**
3990	1100	1225	1330	1445	1540	1650	1780	1970	2215	2320
4250	1120	1225	1330	1445	1540	1650	1780	1980	2170	2260
4494	1149	1225	1328	1445	1540	1645	1780	1965	2070	2140
4746	1200	1225	1325	1429	1530	1655	1772	1900	1950	1950

9.5) Boost Limiting Map --- this map deals with air going into the engine.

As its description says this “limits” the amount of boost we can have on its X and Y axis we have Air Pressure and RPM and in the table we have actual boost in Mbar of air.

	Engine rpm									
Air Pre:	1500	1750	1900	2250	2500	3000	3500	4000	4300	4700
600	1600	1825	1950	1965	1955	1915	1715	1505	1365	1305
650	1650	1875	2000	2015	2015	1985	1790	1595	1460	1390
700	1700	1925	2040	2055	2055	2035	1855	1670	1555	1495
750	1750	1975	2100	2125	2125	2105	2020	1835	1720	1590
800	1800	2025	2150	2175	2175	2175	2110	1930	1815	1675
850	1850	2075	2200	2225	2225	2225	2195	2080	1970	1810
900	1900	2125	2250	2300	2300	2300	2280	2205	2110	1940
950	1950	2175	2325	2375	2375	2375	2355	2300	2215	2075
980	2000	2225	2350	2400	2400	2400	2400	**2350**	2275	2160
1100	2000	2225	2350	2400	2400	2400	2400	**2350**	2275	2160

9.6) SVBL or single boost value --- this deals with the air going into the engine.

This is not a map, this is a single number and it is the maximum boost you can have, if the boost goes over this limit then the engine will go into “limp mode” or it may cut out and stop altogether. This number is set by the manufacturer and we can increase it, again it is set to provide a safe guard to protect the entire car in any country in any conditions. We will find out how to calculate a new number, this number is needed so that we can alter the Boost and Boost Limit maps.

9.7) Start of Injection --- this map deals with the fuel going into the engine

The start of injection map we talk about previously, it is the timing of when we will inject the fuel into the cylinder. On its X and Y axis are RPM and Injected Quantity (i.e. mg’s of fuel). The figures in the table are degrees of crank rotation. As a crankshaft is a circle it has 360 degree’s in it, the engine will use a sensor the crankshaft timing sensor or TDC sensor so that it knows where in the rotation the crankshaft is and then it can inject the fuel at the correct time.

	Start of Injection													
	0.0	5.0	7.5	10.0	15.0	20.0	22.5	25.0	30.0	35.0	40.0	45.0	50.0	55.0
100	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99
400	0.00	0.00	0.00	0.00	1.99	5.49	9.00	12.00	13.99	15.00	15.00	15.00	15.00	15.00
800	0.00	0.00	0.00	0.00	1.99	5.49	9.00	12.00	13.99	15.00	15.00	15.00	15.00	15.00
1000	0.00	0.00	0.00	0.00	1.99	5.49	9.00	12.00	13.99	15.00	15.00	15.00	15.00	15.00
1250	0.70	0.70	0.70	0.70	1.99	5.49	9.00	12.00	13.48	15.00	15.00	15.00	15.00	15.00
1500	1.71	1.71	1.71	1.71	2.39	4.64	6.14	7.60	10.01	12.31	13.01	13.01	13.01	13.01
1750	2.42	2.42	2.42	2.42	3.21	4.85	6.17	7.29	8.51	10.67	11.51	11.51	11.51	11.51
2000	2.95	2.95	2.95	2.95	3.68	5.04	6.24	7.29	8.51	10.50	12.00	12.00	12.00	12.00
2250	3.75	3.75	3.75	3.75	4.43	5.88	7.03	7.99	9.10	11.04	13.24	13.24	13.24	13.24
2500	5.51	5.51	5.51	5.51	6.21	7.15	8.16	9.31	10.60	12.00	14.60	14.60	14.60	14.60
2750	7.57	7.57	7.57	8.32	9.24	10.24	11.37	12.21	13.20	14.13	16.01	16.48	16.48	16.48
3000	9.33	9.33	9.33	10.95	12.28	13.24	14.20	15.02	15.77	16.57	17.72	18.42	18.42	18.42
3500	12.26	12.26	12.26	14.44	16.55	17.39	18.07	19.01	19.88	20.42	21.19	22.24	22.24	22.24
4000	15.00	15.00	15.00	17.25	19.99	21.00	21.59	22.01	22.50	23.06	23.51	24.00	24.00	24.00
4250	15.94	15.94	15.94	17.95	20.81	21.47	21.99	22.43	23.02	23.51	23.98	24.45	24.45	24.45
5000	17.35	17.35	17.35	19.17	21.75	22.52	22.99	23.42	24.09	24.56	25.03	25.50	25.50	25.50

9.8) Duration of Injection --- this map deals with the fuel going into the engine

Our last map in this series to look at is the duration of injection, quiet simply it is the amount of time the injector needs to be open. On its x and Y axis are Injected quantity (mg's of fuel) and RPM. In the table the numbers again refer to degrees of crankshaft rotation.

	100	200	600	800	1000	1250	1500	1750	2000	2500	3000	3500	3800	4000	4500	5000
0.50	8.09	7.97	7.12	6.23	5.37	4.83	3.94	3.23	2.25	0.26	-1.66	-2.86	-3.47	-3.87	-4.05	-4.41
2.00	9.12	9.00	8.20	7.15	6.28	5.88	5.44	4.76	3.77	2.04	0.28	-1.50	-2.41	-2.65	-3.35	-3.77
5.00	10.52	10.36	9.09	8.09	7.05	6.59	6.30	5.70	5.02	3.47	1.65	0.12	-0.89	-1.41	-2.39	-2.84
7.00	11.18	11.06	9.80	8.91	7.71	7.24	6.82	6.40	5.67	4.31	2.93	1.48	0.40	-0.28	-1.45	-1.92
10.00	11.67	11.55	10.45	9.68	8.51	7.76	7.45	7.27	6.59	5.32	4.20	2.98	1.83	1.05	-0.37	-0.84
15.00	12.19	11.98	11.02	10.27	9.47	9.52	9.21	8.58	8.41	7.69	6.82	6.70	5.32	4.41	2.93	1.76
20.00	12.66	12.42	11.53	10.92	10.27	10.38	10.34	9.84	10.38	9.91	9.21	9.75	9.28	8.79	7.12	5.02
25.00	13.20	12.96	12.23	11.72	11.25	11.60	11.72	11.53	11.81	12.45	12.35	12.42	12.14	12.21	11.53	10.29
30.00	13.92	13.69	12.96	12.59	12.26	12.94	13.31	13.22	13.80	14.32	14.69	15.35	14.93	14.95	14.60	14.09
35.00	14.60	14.37	13.66	13.34	13.55	14.32	15.02	15.42	15.66	16.34	16.94	17.84	18.07	18.00	17.48	17.16
40.00	15.35	15.12	14.27	14.41	15.07	15.56	16.62	17.11	17.37	18.16	19.15	19.97	20.37	20.48	20.79	20.79
45.00	15.87	15.52	14.81	15.02	16.12	16.80	17.98	18.54	19.34	20.60	21.80	22.38	23.02	23.39	24.02	24.00
50.00	16.45	16.17	15.37	15.70	16.90	17.88	19.05	19.87	20.84	22.96	23.86	24.54	25.41	25.59	26.18	26.32
55.00	17.37	17.02	16.10	16.50	17.62	19.17	20.32	21.49	22.62	24.16	25.83	26.58	27.28	27.42	28.01	28.17
60.00	17.93	17.58	16.92	17.46	18.70	20.39	21.56	22.78	24.00	25.55	27.28	28.24	28.97	29.18	29.58	29.81

Why is this map in duration and not time? Surely time would be a better number to use time as we know that it takes a fixed amount of time to inject a fixed amount of fuel. Well it is done in degrees of crankshaft rotation because we "time" the engine in degrees of rotation so if we know use time the ECU will have to do a long calculation changing time into degrees.

9.9) These last 2 maps are very important in our "what not to do bad tuners guide". To often I see big changes done to these 2 maps without consideration for what we already have available. Rather than make the correct changes and find the limiting factor people will change these 2 to override what another map is doing.

The problem with this is whilst you can do a quick guess of about what it should be the reality is you need to consider many things and calculate many variants depending on speeds inside the engine, to do this you need to look at the bore (diameter of the cylinder) and the stroke (its top to bottom measurement) and the diameter of the crankshaft journal.

We need this last figure because a piston changes its speed from stationary at the bottom to maximum speed when it is halfway up the cylinder to stationary at the top. Its speed is constantly changing as it accelerates and decelerates and we need to know this speed at each point in the cylinders stroke so that we can finish our injection at the most efficient time. As we need more fuel in the injection period becomes longer so the starting point of our injection occurs in a point where the piston is travelling faster therefore we need to start even sooner to compensate for this extra piston speed.

If you want to find out how good another tuner is ask him how the piston velocity affects the SOI, watch as he stands there glazed over and come back with? or see if he comes back with what you have just read!

1 Hour map services, why they cannot actually exist.

A 1 hour map service cannot exist, they just send you back a modified map they send to anyone with the same or similar vehicle. These maps come from a map bureau, this is where you can send your maps into and every time it's downloaded you get paid for it. It is not possible to actually make all the changes you need to make in 1 hour, nor do these companies ask, how many miles has the car done? how old is the driver? what does he do for a living? Will he be towing a caravan?

10) Making Map Changes.

We need to change the maps to make more power. Firstly we will look at each map one by one and understand it and understand the potential effect on the engine it will make, I say potential because after we have looked at each map by itself we need to look at how this map interacts with the other maps. It is this interaction that is often misunderstood bad tuners, or perhaps I should say badly taught tuners, do not appreciate that making changes can have no effect because another map has actually cancelled out what you are doing, or and this is something I see a lot our bad tuner will ask for something that is not possible to achieve.

10.1) A map as we now know in a table format has an X and Y axis, on these axis are number that set the tables format, inside the table is the numbers that are used by the ECU to calculate what to do. So what happens if we want more than a table has on its axis, for example, the boost map has on the Y axis injected quantity, that's the amount of fuel, it's maximum number is 50mg. Our drivers wish has 70mg of fuel as its maximum figure but this number does not exist in our boost map. We cannot add another column to the table, an ECU will only look for the amount of columns and rows it already has in the table. To add in this new figure we will have to change the Y axis injected quantity numbers, we need to delete one column for example the 25mg so our map now goes 20mg then 30mg, now we have space to add our 70mg column.

10.2) As the table was originally

	Injected Quantity									
rpm	**0.0**	**5.0**	**10.0**	**15.0**	**20.0**	**25.0**	**30.0**	**35.0**	**45.0**	**50.0**
0	198	198	198	198	198	198	198	198	198	198
21	1002	1502	1102	1158	1195	1265	1350	1350	1350	1350
1008	1002	1058	1106	1153	1199	1265	1350	1350	1350	1350
1260	1002	1060	1119	1171	1225	1281	1373	1500	1710	1710
1500	1002	1090	1155	1225	1305	1380	1495	1650	1900	1950
1750	1002	1115	1195	1280	1365	1475	1610	1800	2050	2170
1900	1002	1130	1210	1310	1395	1515	1660	1860	2115	2250
2000	1002	1140	1220	1320	1415	1535	1685	1880	2155	2275
2247	1012	1160	1240	1340	1440	1565	1705	1915	2205	2325
2499	1021	1180	1260	1360	1460	1585	1725	1925	2210	**2350**
3500	1060	1225	1320	1425	1525	1645	1775	1965	2235	**2350**
3750	1080	1225	1330	1435	1530	1645	1780	1970	2235	**2350**
3990	1100	1225	1330	1445	1540	1650	1780	1970	2215	2320
4250	1120	1225	1330	1445	1540	1650	1780	1980	2170	2260
4494	1149	1225	1328	1445	1540	1645	1780	1965	2070	2140
4746	1200	1225	1325	1429	1530	1655	1772	1900	1950	1950

10.3) As the table is changed to allow the 70mg column

	Injected Quantity									
rpm	**0.0**	**5.0**	**10.0**	**15.0**	**20.0**	**30.0**	**35.0**	**45.0**	**50.0**	**70.0**
0	198	198	198	198	198	198	198	198	198	
21	1002	1502	1102	1158	1195	1350	1350	1350	1350	
1008	1002	1058	1106	1153	1199	1350	1350	1350	1350	
1260	1002	1060	1119	1171	1225	1373	1500	1710	1710	
1500	1002	1090	1155	1225	1305	1495	1650	1900	1950	
1750	1002	1115	1195	1280	1365	1610	1800	2050	2170	
1900	1002	1130	1210	1310	1395	1660	1860	2115	2250	
2000	1002	1140	1220	1320	1415	1685	1880	2155	2275	
2247	1012	1160	1240	1340	1440	1705	1915	2205	2325	
2499	1021	1180	1260	1360	1460	1725	1925	2210	**2350**	
3500	1060	1225	1320	1425	1525	1775	1965	2235	**2350**	
3750	1080	1225	1330	1435	1530	1780	1970	2235	**2350**	
3990	1100	1225	1330	1445	1540	1780	1970	2215	2320	
4250	1120	1225	1330	1445	1540	1780	1980	2170	2260	
4494	1149	1225	1328	1445	1540	1780	1965	2070	2140	
4746	1200	1225	1325	1429	1530	1772	1900	1950	1950	

11) Map change 1 The Drivers Wish

11.1) Changes to this map make no change to the actual fuel going into the engine. What is really does is only change how much fuel we are asking the ECU to consider injecting into the engine.

So why will we change it? Changes to this map will make the car feel more responsive. You can make any changes you want to this map and it will have no potential damage causing alterations to what actually happens in the cylinder of the engine.

In you very first map write to an ECU we will only change this map, then go and drive the car and feel how it has changed. It's very safe and will be the most apparent change you will see from any map modification.

11.2) Oddly there is 2 things we can achieve in this map without changing anything else.

Firstly we can fool the car owner into thinking his car is much faster. If we make the map so that our 100% throttle settings are at 50% throttle we will have changed what is called "throttle response" What you need to consider is not many people actually put their foot flat down on the throttle, and if they do it is for a very short period of time. Make it so that it happens at only 50% and the car will respond quicker, the brain will think the car is faster because it is used to how far we press the pedal and how much acceleration we feel. Additionally when we do accelerate in our standard car we are used to the acceleration feeling falling away the faster we go, our driver will not be able to separate these 2 known pre-existing feelings (i.e. before we changed the throttle settings) because our brain learns over time how to alter pressure on our foot and the feedback it gets.

Secondly, and this takes a bit more knowledge of how an engine works today, we will see improved fuel economy. How? How can we possibly get more fuel economy just by changes to the drivers wish after all we haven't actually changed anything the ECU sends to the cylinder in the engine.

This is why, the modern engine when you release the accelerator pedal actually cuts the fuel to the cylinder completely. In the old days of carburettors when you took your foot of the pedal an amount of fuel continued to flow into the engine, it was pulled into the engine by vacuum. In this era drivers were taught to take the car out of gear and allow it to roll to a stop at a traffic light. Move on to injection and what now happens is when we take our foot off the accelerator pedal no fuel is sent (you can see this in our drivers wish map) the engine is kept rotating by inertia I.e. the fact the car is moving and the wheels are connected to the gearbox which is connected to the engine. If we now take our car out of gear and roll to the traffic lights our ECU has to inject fuel to keep the engine running as it cannot use the inertia of the cars movement.

So how does this make for fuel economy? Well our driver as he goes along the road at 30mph keeps a steady pressure on the accelerator pedal and uses a steady amount of fuel, if he has to take his foot of the pedal, because it responds quicker the engine gets no fuel, the argument between steady state fuel consumption and the inject - no inject - inject - no inject state is a long and complex argument but it's safe to say that this actually happens, its effect is small mind you and in the real world it is so small it may not actually be measurable.

We are now going to look a series of tables for the drivers wish, an original as it comes from the ECU, our modified view one so we have the information in an easier to read format, next our condensed version so we have 100% signal at 50% movement, then a "considered map" I say considered because there is no formula for a good map if there was then that would make everyone's map the same and as I said before we need to consider our drivers use and the cars condition. Finally we will look at the bad map, we will see how it was made and examine the mistakes.

11.3) Driver wish as it comes directly from the ECU, see how the table is formatted with 5 digits in each cell. 5 digits would give us the potential for 99999rpm that's 1rpm of ten thousand rpm! As we mentioned before the ECU has to see the data in this format so you will modify this table when you are actually making changes. Whilst we are learning I will change all the tables we look at into a format that is easier for me to explain and fro you to "see" the numbers.

	% Accelerator							
rpm	**00100**	**00400**	**01000**	**02500**	**03700**	**05600**	**08000**	**10000**
00000	01870	04190	04600	05400	06170	06890	07000	07000
00399	00770	02788	03334	04120	04950	06270	07000	07000
00609	00000	01962	02580	03470	04360	05910	07000	07000
00693	00000	01600	02270	03200	04140	05760	07000	07000
00798	00000	01140	01900	02820	03760	05630	07000	07000
00903	00000	00660	01450	02460	03390	05470	07000	07000
01008	00000	00490	00900	01900	03030	05310	07000	07000
01113	00000	00380	00700	01500	02720	05312	06900	07000
01218	00000	00280	00575	01300	02460	04960	06800	07000
01491	00000	00150	00350	00925	01900	04530	06600	07000
01995	00000	00080	00210	00550	01550	04032	06200	07000
02499	00000	00070	00200	00450	01350	03632	05950	07000
03003	00000	0050	00150	00350	01200	03300	05728	06784
03990	00000	00000	00100	00200	00990	02988	05278	06440
04998	00000	00000	00000	00112	00738	02666	04578	05996
05355	00000	00000	00000	00050	00110	02050	02950	04546

11.4) So let's change this to make it easier to view.

	% Accelerator							
rpm	**1**	**4**	**10**	**25**	**37**	**56**	**80**	**100**
0	18.7	41.9	46.0	54.0	61.7	68.9	70.0	70.0
399	7.7	27.9	33.3	41.2	49.5	62.7	70.0	70.0
609	0.0	19.6	25.8	34.7	43.6	59.1	70.0	70.0
693	0.0	16.0	22.7	32.0	41.4	57.6	70.0	70.0
798	0.0	11.4	19.0	28.2	37.6	56.3	70.0	70.0
903	0.0	6.6	14.5	24.6	33.9	54.7	70.0	70.0
1008	0.0	4.9	9.0	19.0	30.3	53.1	70.0	70.0
1113	0.0	3.8	7.0	15.0	27.2	53.1	69.0	70.0
1218	0.0	2.8	5.8	13.0	24.6	49.6	68.0	70.0
1491	0.0	1.5	3.5	9.3	19.0	45.3	66.0	70.0
1995	0.0	0.8	2.1	5.5	15.5	40.3	62.0	70.0
2499	0.0	0.7	2.0	4.5	13.5	36.3	59.5	70.0
3003	0.0	0.5	1.5	3.5	12.0	33.0	57.3	67.8
3990	0.0	0.0	1.0	2.0	9.9	29.9	52.8	64.4
4998	0.0	0.0	0.0	1.1	7.4	26.7	45.8	60.0
5355	0.0	0.0	0.0	0.5	1.1	20.5	29.5	45.5

Now we have it formatted to be a round number and a single decimal point. The numbers in RED are our maximum mg's of fuel requested by the accelerator pedal.

11.5) The map below is our “copy and paste”, now we have full throttle at 56% of actual movement. We have copied the columns 25 – 37 – 56 – 80 – 100 and moved them across so that our original 25 column is now on our 4 column, which means we will now see the 25% TPS request at only 4%. Our 56 – 80 – 100 columns are the same so anything over half throttle will make no signal change.

% Accelerator								
rpm	**1**	**4**	**10**	**25**	**37**	**56**	**80**	**100**
0	18.7	54.0	61.7	68.9	**70.0**	**70.0**	**70.0**	**70.0**
399	7.7	41.2	49.5	62.7	**70.0**	**70.0**	**70.0**	**70.0**
609	0.0	34.7	43.6	59.1	**70.0**	**70.0**	**70.0**	**70.0**
693	0.0	32.0	41.4	57.6	**70.0**	**70.0**	**70.0**	**70.0**
798	0.0	28.2	37.6	56.3	**70.0**	**70.0**	**70.0**	**70.0**
903	0.0	24.6	33.9	54.7	**70.0**	**70.0**	**70.0**	**70.0**
1008	0.0	19.0	30.3	53.1	**70.0**	**70.0**	**70.0**	**70.0**
1113	0.0	15.0	27.2	53.1	69.0	**70.0**	**70.0**	**70.0**
1218	0.0	13.0	24.6	49.6	68.0	**70.0**	**70.0**	**70.0**
1491	0.0	9.3	19.0	45.3	66.0	**70.0**	**70.0**	**70.0**
1995	0.0	5.5	15.5	40.3	62.0	**70.0**	**70.0**	**70.0**
2499	0.0	4.5	13.5	36.3	59.5	**70.0**	**70.0**	**70.0**
3003	0.0	3.5	12.0	33.0	57.3	67.8	67.8	67.8
3990	0.0	2.0	9.9	29.9	52.8	64.4	64.4	64.4
4998	0.0	1.1	7.4	26.7	45.8	60.0	60.0	60.0
5355	0.0	0.5	1.1	20.5	29.5	45.5	45.5	45.5

This map we can write to our ECU and try it, as we are only changing the response to the accelerator pedal we can do no damage to the engine. We will never use this method to change maps although our “bad tuner” will copy and paste almost all of his map changes.

11.6) What will be a bad result from this map is if the car has cruise control, the cruise control will have its own map to control the way the actuator responds i.e. its map will say we are losing speed going up this hill I need to add 5mm of travel to the accelerator pedal, because we have altered this map the cruise will now become very jerky in it operation. The cruise control cannot see how we have altered the drivers wish so it calls for 5mm based on its map, this map before we changed anything meant that 5mm at 2500rpm gave an increase from 24mg to 33mg which it got from the original drivers wish map, now it will get an increase from 24mg to 41mg so it will accelerate a lot harder and increase the speed in a short burst, it will then see an over-speed coming back from the speedo and have to cut the throttle to 0 whilst it slows down, and so the circle repeats…………..

11.7) Next we are going to look at the considered map, there will follow a lot of discussion about this map so I have coloured in all the area's I want to discuss in different colours for both the numbers and the background to enable me to show 2 factors.

We have the yellow band, we will never make any changes here because we will never see them. The green band, this is the peak operating range of the diesel engine, changes here will see the most "feel" the light amber range, well here the manufacture is tailing off performance to make you change gear to protect all the cars components as we previously discussed horsepower is speed and that comes at higher rpm so we will change this section to improve that area of performance, with the dark amber section we now have to start thinking about preventing the driver from hitting the Vmax of an engine so we will start to take away what he can have. The final red band, we leave this as is to prevent engine destruction.

	% Accelerator							
rpm	1	4	10	25	37	56	80	100
0	18.7	41.9	46.0	54.0	61.7	68.9	70.0	70.0
399	7.7	27.9	33.3	41.2	49.5	62.7	70.0	70.0
609	0.0	19.6	25.8	34.7	43.6	59.1	70.0	70.0
693	0.0	16.0	22.7	32.0	41.4	57.6	70.0	70.0
798	0.0	11.4	19.0	28.2	37.6	56.3	70.0	70.0
903	0.0	6.6	14.5	24.6	33.9	54.7	70.0	70.0
1008	0.0	4.9	9.0	19.0	30.3	53.1	70.0	70.0
1113	0.0	3.8	7.0	15.0	27.2	53.1	69.0	70.0
1218	0.0	2.8	5.8	13.0	24.6	49.6	68.0	70.0
1491	0.0	1.5	3.5	9.3	19.0	45.3	66.0	70.0
1995	0.0	0.8	2.1	5.5	15.5	40.3	62.0	70.0
2499	0.0	0.7	2.0	4.5	13.5	36.3	59.5	70.0
3003	0.0	0.5	1.5	3.5	12.0	33.0	57.3	67.8
3990	0.0	0.0	1.0	2.0	9.9	29.9	52.8	64.4
4998	0.0	0.0	0.0	1.1	7.4	26.7	45.8	60.0
5355	0.0	0.0	0.0	0.5	1.1	20.5	29.5	45.5

The numbers in blue are the ones I would change, these numbers generally have the biggest jump from one column to the next and increasing them as well as making these jumps smaller will see the best improvement. The numbers in Black are the original ones we will not change them, the numbers in Red show what was the original maximums, The numbers in Blue are the ones we will alter to see the best increase, White numbers need a small change to make the map smooth (we do not want to go from 13.o to 40 in one jump we will get a jerky response from the engine) and finally the last 2 numbers in green we will decrease, decrease you say why when we want more power and are making more power? Quite simply we will decrease these numbers because our now faster car is going to make our driver push it further so we need to protect our engine more at this very high point, if we don't we won't have a ten second car we will have a 10 second engine.

% Accelerator								
rpm	1	4	10	25	37	56	80	100
0	18.7	41.9	46.0	54.0	61.7	68.9	70.0	70.0
399	7.7	27.9	33.3	41.2	49.5	62.7	70.0	70.0
609	0.0	19.6	25.8	34.7	43.6	59.1	70.0	70.0
693	0.0	16.0	22.7	32.0	41.4	57.6	70.0	70.0
798	0.0	11.4	19.0	28.2	37.6	56.3	70.0	70.0
903	0.0	6.6	14.5	24.6	33.9	54.7	70.0	70.0
1008	0.0	4.9	9.0	19.0	30.3	53.1	70.0	70.0
1113	0.0	3.8	7.0	15.0	27.2	53.1	69.0	70.0
1218	0.0	2.8	7.2	21.2	31.5	49.6	68.0	70.0
1491	0.0	4.5	9.5	25.6	36.5	48.2	70.0	75.0
1995	0.0	4.8	14.4	28.9	34.1	40.3	62.0	77.0
2499	0.0	7.3	17.2	32.8	46.5	53.3	72.0	80.0
3003	0.0	4.9	15.1	29.0	38.6	55.4	65.0	77.0
3990	0.0	4.8	11.0	22.2	35.6	48.9	60.8	70.0
4998	0.0	0.0	7.8	15.0	22.5	38.3	50.7	60.0
5355	0.0	0.0	0.0	0.5	1.1	20.5	25.5	38.3

In the map above I have decided where I want to have more useable power and more torque, I haven't actually calculated these numbers using maths at this point as they are only to demonstrate the changes I think we should make. We have increased the mid-range power and torque considerably then added a small change to the low down torque to aid acceleration, our additions in the higher rpm range will improve our potential top speed. We have then changed the white numbers so smooth out our map preventing a sudden change. Overall we have a considered map.

11.8) Let's now look at our "bad tuners" map

% Accelerator								
rpm	1	4	10	25	37	56	80	100
0	20.6	46.1	50.6	59.4	67.9	75.8	77.0	77.0
399	8.5	30.7	36.7	45.3	54.5	69.0	77.0	77.0
609	0.0	21.6	28.4	38.2	48.0	65.0	77.0	77.0
693	0.0	17.6	25.0	35.2	45.5	63.4	77.0	77.0
798	0.0	12.5	20.9	31.0	41.4	61.9	77.0	77.0
903	0.0	7.3	16.0	27.1	37.3	60.2	77.0	77.0
1008	0.0	5.4	9.9	20.9	33.3	58.4	77.0	77.0
1113	0.0	4.2	7.7	16.5	29.9	58.4	75.9	77.0
1218	0.0	3.1	6.3	14.3	27.1	54.6	74.8	77.0
1491	0.0	1.7	3.9	10.2	20.9	49.8	72.6	77.0
1995	0.0	0.9	2.3	6.1	17.1	44.4	68.2	77.0
2499	0.0	0.8	2.2	5.0	14.9	40.0	65.5	77.0
3003	0.0	0.6	1.7	3.9	13.2	36.3	63.0	74.6
3990	0.0	0.0	1.1	2.2	10.9	32.9	58.1	70.8
4998	0.0	0.0	0.0	1.2	8.1	29.3	50.4	66.0
5355	0.0	0.0	0.0	0.6	1.2	22.6	32.5	50.0

Our guy has simply added 10% to everything from start up to flat out.

11.9) Why did our “bad tuner” make a 10% change to our map, and why is it so bad?

The percentage increase, how was it done and why is it wrong.

How was it done? One of the mapping software systems you can buy will show you the tables we are looking at, you can select each map table one at a time. With the map selected you can then highlight and area and using a built in “button” at the top increase this selected area just by using the up and down arrows on your keyboard, or by typing a number into the box next to the button. If our tuner was using another software then he would copy the table to Microsoft Excel and using Excel’s built in facilities created a simple formula to increase the numbers by a percentage. The formula used is =A3*1.1 this will give a 10% increase to one number, you can then copy this formula to all the other numbers and Excel will auto update the formula for you. After we have looked at all the maps I will do a chapter on using Excel, we do not need to know how it works to understand the maps and the changes we will want to make to them.

11.10) Firstly a percentage increase has not been calculated it’s just been guessed at.

Secondly 10% of 0 is 0 so where we have small numbers the increase we have is also very small which means we have not smoothed out our map, in my modified map I have changed in the 1218/25 cell the original number from 13 to 21, a 10% increase would have seen 13 changed to 14.3.

Thirdly, we want a smooth accelerating car at the end of our remap, our percentage increase method now means that we go from 0 to 14.3 over a long gap but to 54 in a short space, so we go from a nice slope up a hill to suddenly the side of a mountain with a near vertical rock face.

Now we need to look at sections of the map to understand why our “bad tuner” is so bad.

Everything below 1008 rpm has been changed, but we know that we will never use this part of the map during actual driving, this section of the map deals with the cars start up and its idle (when we just leave it running for example stopped at traffic lights) Our cars manufacture will have spent a lot of time developing this area for the following reasons.

1).The car idles smoothly from a cold start up to extreme heat when the engine also needs to power air-conditioning pumps, electric fans (the cause the alternator to work hard).

2).The engine uses as little fuel as possible to maximise economy, the recent introduction oof “stop start” technology where the engine switches of when the car is stationary is said to save 30% fuel.

3).When going from stationary to selecting first gear and pulling away we want a smooth acceleration, or even almost no acceleration when we are just crawling in traffic.

Moving into the 1113 to 1491 section we see no increase at the under 25% TPS but massive increases in the 37% to 80% range, the 100% increase range has an additional error our 100% TPS is asking for 77mg’s of fuel our problem is that our injection system cannot supply 77mg of fuel. We will discuss this later and explain why, and how to calculate what we can ask for. We will see this issue a lot in our “bad tuner” maps where he will ask for things you can’t actually produce.

Another thing to consider in the 1113 to 1491 range is that from driving diesel cars we already know that they make their power from about 1750 to 2500rpm, they have a “narrow band” when they make the most usable power. I say usable because whilst they do make more power at higher rev’s diesel engines to not like to “rev fast” they like to “pull hard”

1995 to 2499, as we have already discussed this is a diesels usable power band, if we look at he figures in the 25% to 80% TPS they are lower than the figures in the 1113 to 1491 range so he's asking the engine to make less power in its best range…………..

From 3003 to 4990 our "bad tuner" has the same problems as above, but he has failed also to realise that this part of the rev range is actually going to be dealing with BHP not torque so we actually need to modify how we calculate these figures. Think back to our BHP vs Torque chapter, we need torque to accelerate and BHP to make top speed.

Finally 5355 rpm. This is where the engine cannot increase its rpm, diesels have a much lower rpm range than petrol's. Our "bad tuner" has still increased these numbers this will mean the engine is still getting fuel, and a reasonable amount of fuel, so it will still try to increase its rpm and our driver will still be getting power so he will keep his foot full pressed on the accelerator pedal. The manufactures map has the power dropping away from 2500rpm, to make our driver change gear sooner, keeping economy and protecting the engine. In my map I have actually lowered these numbers at the top end from the ones the manufacture set. My reason for this is having increased the numbers to make more power further up the RPM range I now need the power drop off to be stronger so that you get a sudden drop off and change gear. This is to make the driver change gear before this happens and stop the inertia of the rotating engine from causing a situation where you accelerate hard up to 4950rpm press down the clutch pedal and have the engine spin up faster for a split second. This will cause damage to the engine.

Let's review what we have learnt move onto the next map.

Our drivers wish only changes the "feel" we have but we have discussed the changes we want to make and why. These changes and the reasons for them apply to every map we will deal with, we are after a better map for our end user so we need to consider what we are doing.

We have looked at making a percentage increase and why it is a bad thing to do, we need a smooth map to make a nice to drive car and we also need to think about protecting the engine MORE than the original manufacture did because we want to make MORE power.

We've looked at my map and why I changed it in the areas I have changed it to increase torque for more acceleration and also to increase top speed and then using our "bad tuner" looked at why we do not change numbers is specific areas.

We will discuss maths after we have looked at each map at this point the numbers do not matter we just need to understand the "reason" and the "direction" that we want to make changes.

Later we will work out the maths so you know what numbers you can use, I say can because remember maths is just numbers, numbers do not know the cars condition nor its end user's needs. This is where "style" comes into, this is where you take the maths and decide what number you actually will use by taking "maths number" minus "I think that's all we should allow". This allow ratio will have parts where we do use maths, we will perhaps decide that we will take our calculated numbers and because the engine has 100,000 miles on it we will use a factor of 85% to decrease our number, if it was a 20,000 mile engine we would use 93% as our factor. After we have applied our factors we might then go, "this driver, he's a bit of an idiot" so I will take away another 5% or maybe rather than a percentage we will, from the experience we now have, decide to take a 2 from the number. This is so we protect ourselves, give an idiot too much power and he breaks something and he will blame you and try to get you to pay for the damage. I've seen claims for broken iPhones made because you moved the seat back to access the OBD port and the phone was under the seat.

12) Map change 2 The Smoke Map.

For our smoke map we need to venture into chemistry and mathematics, so I am not going to discuss the reasons to make changes in different areas, this is because the reasons we have used above on our Driver's Wish are basically the reasons we apply to the Smoke map.

12.1) The smoke map is so called because it is the amount of black smoke we see coming out of the exhaust pipe, this smoke is unburnt fuel. We read in chapter (XXXXXXXXXXXX) a little about "stoic" values, now we need to apply this to our maths in our smoke map.

12.2) First up, the smoke map unmodified from the ECU, I have taken away all the 0's and gone straight to our map with decimal points in it as we saw in the very first 2 diagrams in the Drivers Wish section.

						Mass Air Flow							
rpm	3000	3500	4000	4500	5030	5500	6000	6500	7000	7500	8500	9250	10500
00861	21.1	22.9	24.6	26.4	28.3	30.0	30.5	30.5	30.5	30.5	30.5	30.5	30.5
01000	21.7	23.6	25.4	27.2	29.3	32.0	34.0	36.5	37.0	37.0	37.0	37.0	37.0
01100	21.6	23.5	25.4	27.3	29.7	32.4	35.2	37.8	40.3	42.0	42.0	42.0	42.0
01200	20.5	22.6	24.8	26.7	29.6	32.3	35.3	38.7	41.3	43.7	47.0	47.0	47.0
01300	19.4	21.4	23.6	25.9	28.8	31.6	34.6	38.3	41.4	44.6	48.0	50.1	50.1
01400	18.3	20.3	22.6	24.9	27.7	30.6	33.3	37.1	40.5	44.6	48.6	52.5	52.6
01500	18.3	20.0	22.0	24.0	26.4	29.1	32.0	35.2	38.7	43.1	48.4	52.8	54.7
01600	18.1	19.7	21.8	23.5	25.5	27.9	30.9	34.2	37.4	41.2	47.2	52.7	56.5
01750	18.0	19.5	21.4	23.1	25.2	27.5	30.6	33.8	36.9	40.4	45.1	51.1	57.9
02001	18.0	19.4	21.3	22.9	25.0	27.4	30.4	33.5	36.8	40.0	44.6	49.9	58.0
02250	18.0	19.4	21.2	22.8	24.9	27.2	30.3	33.4	36.8	40.0	44.6	49.8	57.8
02500	18.0	19.4	21.2	22.8	24.9	27.2	30.2	33.4	36.8	40.0	44.6	49.9	57.4
03007	18.1	19.6	21.2	22.8	24.9	27.2	30.2	33.4	36.8	40.0	44.6	49.7	56.0
03500	18.2	19.8	21.3	22.8	24.8	27.2	30.3	33.4	36.8	40.0	44.6	49.5	54.9
04100	18.1	19.7	21.2	22.8	24.6	26.7	29.9	32.9	36.4	39.7	44.2	49.3	53.8
05355	15.5	16.5	17.8	19.3	21.1	23.1	26.1	29.1	32.8	36.1	39.6	44.8	49.3

12.3) We have on our X axis RPM on our Y axis MAF (mass air flow) in the table we have mg of fuel.

If we look on this map the largest number we see is 58, so that's 58mg of fuel going into the engine, but wait a minute in our Drivers Wish we wanted 70mg of fuel before we changed it. This is starting to highlight our "bad tuner" he has asked for 77mg of fuel but this map says we can only have 58mg of fuel at 2001rpm and 1050 of airflow so all those numbers he has put in have made no change because the ECU has limited our requested 77mg to 58mg in this map.

Moving onto what these numbers mean, it is the relationship between an amount of air and an amount of fuel, this is the stoic value. It is easy to calculate we take the amount of air and divide it by the amount of fuel to get our stoic value, for example at 1750rpm we have 700mg of air and 36.9mg of fuel 700/36.9 = 18.97 so our stoic value is 18.97. Now we learnt before that our perfect stoic value in a laboratory testing facility is 14.7, but we also know that we cannot achieve this in our engine. We have to have a stoic value that allows for these "efficiency" losses.

12.4) Using Microsoft Excel we can make a new table to convert all our figures in the smoke map to stoic values. We use the formula =A1/A3 where A1 is Y axis figures (i.e.300) and A3 is 21.7(1000rpm).

Mass Air Flow													
rpm	3000	3500	4000	4500	5030	5500	6000	6500	7000	7500	8500	9250	10500
00861	14.2	15.3	16.3	17.1	17.8	18.3	19.7	21.3	23.0	24.6	27.9	30.3	34.4
01000	13.8	14.8	15.7	16.6	17.2	17.2	17.6	17.8	18.9	20.3	23.0	25.0	28.4
01100	13.9	14.9	15.8	16.5	16.9	17.0	17.1	17.2	17.4	17.9	20.2	22.0	25.0
01200	14.6	15.5	16.2	16.9	17.0	17.0	17.0	16.8	17.0	17.2	18.1	19.7	22.3
01300	15.5	16.4	16.9	17.4	17.5	17.4	17.3	17.0	16.9	16.8	17.7	18.5	21.0
01400	16.4	17.2	17.7	18.1	18.2	18.0	18.0	17.5	17.3	16.8	17.5	17.6	20.0
01500	16.4	17.5	18.2	18.8	19.1	18.9	18.8	18.5	18.1	17.4	17.6	17.5	19.2
01600	16.6	17.8	18.3	19.1	19.7	19.7	19.4	19.0	18.7	18.2	18.0	17.6	18.6
0175	16.7	17.9	18.7	19.5	20.0	20.0	19.6	19.3	19.0	18.6	18.9	18.1	18.2
02001	16.7	18.0	18.8	19.7	20.1	20.1	19.8	19.4	19.0	18.8	19.1	18.5	18.1
02250	16.7	18.0	18.9	19.7	20.2	20.2	19.8	19.5	19.0	18.8	19.1	18.6	18.2
02500	16.7	18.0	18.9	19.7	20.2	20.2	19.9	19.5	19.0	18.8	19.1	18.6	18.3
03007	16.6	17.9	18.9	19.7	20.2	20.2	19.9	19.5	19.0	18.8	19.1	18.6	18.8
03500	16.5	17.7	18.8	19.7	20.3	20.3	19.8	19.5	19.0	18.8	19.1	18.7	19.1
04100	16.6	17.8	18.9	19.7	20.5	20.6	20.1	19.8	19.2	18.9	19.2	18.8	19.5
05355	19.4	21.2	22.5	23.4	23.9	23.9	23.0	22.3	21.3	20.8	21.5	20.7	21.3

These numbers are now our stoic values.

12.5) From this table we can see that our manufacture has the bulk of its "power" range, i.e. 1750rpm to 2500rpm with stoics around the 19 to 20 mark.

In the start-up phase I.e. 300mg of air and below 1100 rpm we have a stoic of less than 14.7. This is to aid our cold engine as it starts up by a process of sealing the piston rings using the excess fuel, this excess fuel will form a small bond between the piston ring and the cylinder bore, the excess also acts as a lubricant, when an engine first starts there is no oil being pumped around so it helps with this too. Once the engine is running it will never see this combination of airflow and rpm so it will not access it once the engine is running because whilst we may only have 861rpm our airflow will be over 300mg, 300mg only occurs as the stationary engine starts to turn with the electric starter motor before idle and inertia keep it running.

In the ranges outside of our "power" range we can see values from 20 to as high as 34, this is how we get economy and also how we protect the engine, 20 -24 gives us economy 24 up prevents the engine from making power and makes you change gear.

12.6) Now we come to "free power".

Free power is where we can make changes to get more power without the need for lots of changes. Let's look at 2250 rpm and 850mg of air, we have 44.6mg of fuel being injected and a stoic value of 19.1. This means we have air that is not being burnt, we know that for more power we need more fuel and we know this fuel needs air to burn, so in this cell (that's what we call a single number in a table) we have air that is not being used. We can calculate what this number can be by reversing the formula MAF/mg of fuel = stoic to MAF/Stoic = mg of fuel therefore 850/14.7 = 57.8mg of fuel.

BSFC gives us an equation that an amount of fuel makes an amount of Horse Power. We now have more fuel for the same amount of air going into our engine so our engine will make more power, both BHP and torque.

This is the “freepower” we already had that much air in our cylinder and some of it was not being used, now all of this air is being used we have made our engine more “efficient” Efficiency brings both power and economy.

If we had 44.6mg and now we have 57.8mg we have 29% more power at 2250rpm, factors mean we cannot achieve this as we know we cannot get to 14.7. If we take a stoic ratio of 17.5, we should be ok as a guess to our efficiency issues, we would have 48.6mg of fuel, this would give us 10% more power and no issues of black smoke out of the exhaust and we haven’t changed any other map in the ECU, leave the Drivers Wish alone, leave the Turbo map alone no need to use the turbo to put more air in because we have spare air not being used.

Can we use the stoic value to calculate all our numbers? No we can’t, stoic is directly related to airflow and fuel and it does not change with engine rpm. If we look at our stoic table above we can see how the manufacture has altered it at different rpm, if we set our stoics at 17.5 in the 800mg column we would have 48.6mg of fuel at any engine rpm.

How do we use this information to calculate our new injected fuel quantities then?

12.7) A good starting point is to look at the information we have, the information that a manufacture and a team of university trained people with rolling roads, laboratories, years of time and millions of pounds to develop. If we look at the stoic table we can see a relationship between the numbers, that is we can see 1400rpm and 925mg of air has a 17.6 stoic ratio and at 1050mg of air a stoic of 20.0. If we take the 2 numbers and divide 20 by 17.6 we get 13.6 so it’s a stoic increase of 13.6%, which in turn is a decrease in fuel being injected. Remember to lower a stoic we need more fuel therefore to raise the stoic we need less fuel.

If we look at the entire map we can calculate all the relationships between each row (the left to right) and we can use this to adjust our stoic values accordingly. We can set out target values for example 17.5 in the cells we want to see our NEW “power” range then we can apply the percentage rule to all the surrounding cells so that we have a good “considered” map where we see a smooth increase in power. We have just used a rolling road to calculate this without even owning one.

We can use Excel to calculate all of these things for us. If we make a table in Excel with a formula that takes information from each part of the map we can write very long formula’s to give us a mathematical answer. OMG how am I going to do this, it’s going to take a lot of time how can I ever make any money from this when J blogs down the road does it for £150…… wrong here is the thing these tables we build will be usable on every new job we do. We will make a table that will take information from the map apply our formula to it and give us answers in a new table. So we will have 3 tables, our incoming map table, our formula table and our outgoing map table. All we need to do is copy the standard map into our first table, in our second table set our stoic target numbers in our desired “power” range and then allowing Excel to calculate the surrounding stoics based on our manufactures standard map cell relationship. Excel will use this to give us a new table of our new mg’s of fuel. We can now just copy this back to our ECU and hey presto we have a mapped car giving us more power and more economy and we’ve not changed the 6 other maps.

Our “bad tuner” will do the same as before he will make a percentage change over all or some of the numbers and then drive the car, if he see’s black smoke in the mirror he has gone too far and will change the numbers again. No thought for smoothness, economy nor for safety

12.8) Our new Smoke Map.

First up here is our stoic table

rpm	3000	3500	4000	4500	5030	5500	6000	6500	7000	7500	8500	9250	10500
00861	12.9	13.9	14.8	15.5	16.2	16.7	17.9	19.4	20.9	22.4	25.3	27.6	31.3
01000	12.6	13.5	14.3	15.1	15.6	15.6	16.0	16.2	17.2	18.4	20.9	22.7	25.8
01100	12.7	13.6	14.3	15.0	15.4	15.5	15.5	15.7	15.8	16.2	18.4	20.0	22.7
01200	13.3	14.1	14.7	15.3	15.4	15.5	15.5	15.3	15.4	15.6	16.4	17.9	20.3
01300	14.1	17.0	17.0	17.0	17.0	15.8	15.8	15.4	15.4	15.3	16.1	16.8	19.1
01400	14.9	17.0	17.0	17.0	17.0	16.3	16.4	15.9	15.7	15.3	15.9	16.0	18.2
01500	14.9	17.0	17.0	17.0	17.0	17.0	17.0	16.8	16.4	15.8	16.0	15.9	17.5
01600	15.1	17.0	17.0	17.0	17.0	17.0	17.0	17.3	17.0	16.5	16.4	16.0	16.9
0175	15.2	16.3	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.2	16.5	16.5
02001	15.2	16.4	17.1	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.3	16.9	16.5
02250	15.2	16.4	17.2	17.9	18.4	18.4	17.0	17.0	17.0	17.0	17.3	16.9	16.5
02500	15.2	16.4	17.2	17.9	18.4	18.4	17.0	17.0	17.0	17.0	17.3	16.9	16.6
03007	15.1	16.2	17.2	17.9	18.4	18.4	18.1	17.7	17.3	17.0	17.3	16.9	17.0
03500	15.0	16.1	17.1	17.9	18.5	18.4	18.0	17.7	17.3	17.0	17.3	17.0	17.4
04100	15.1	16.2	17.2	17.9	18.6	18.7	18.2	18.0	17.5	17.2	17.5	17.1	17.8
05355	17.6	19.3	20.5	21.3	21.7	21.7	20.9	20.3	19.4	18.9	19.5	18.8	19.4

The figures in RED are the ones I have manually set as my target numbers in my target ranges.

All the other numbers I have used the calculation method to produce.

You will see that I went with 17.0 as my target and if you study the map will see figures as low as 15.3. The lower numbers occur in a section of the map that the engine will only use in rare conditions because this car has a single injection per stroke I am using the added fuel to preheat the cylinder. With the latest injection methods we have 3 injections per stroke, the first a small amount causes the cylinder to warm up before the main injection takes place then after the combustion has occurred we will have our third injection this is to control the exhaust gasses. Think of this first injection like starting a BBQ we put on a few coals to start the fire then add more once it's going if we put them all on at the beginning then the fire goes out.

12.9) Taking my new stoic table I can use the figures in it to calculate my new Smoke map.

rpm	300	350	400	450	503	550	600	650	700	750	850	925	1050
00861	23.2	25.2	27.0	29.0	31.1	33.0	33.6	33.6	33.6	33.6	33.6	33.6	33.6
01000	23.9	25.9	27.9	29.9	32.2	35.1	37.4	40.2	40.7	40.7	40.7	40.7	40.7
01100	23.7	25.8	27.9	30.0	32.7	35.6	38.7	41.5	44.3	46.2	46.2	46.2	46.2
01200	22.6	24.8	27.2	29.4	32.6	35.5	38.8	42.6	45.4	48.0	51.7	51.7	51.7
01300	21.3	20.6	23.5	26.5	29.6	34.8	38.1	42.1	45.5	49.0	52.8	55.1	55.1
01400	20.1	20.6	23.5	26.5	29.6	33.7	36.6	40.8	44.6	49.1	53.4	57.8	57.8
01500	20.1	20.6	23.5	26.5	29.6	32.4	35.3	38.7	42.6	47.4	53.2	58.0	60.1
01600	19.9	20.6	23.5	26.5	29.6	32.4	35.3	37.6	41.1	45.3	51.9	58.0	62.2
01750	19.8	21.5	23.5	26.5	29.6	32.4	35.3	38.2	41.2	44.1	49.6	56.2	63.6
02001	19.8	21.3	23.4	26.5	29.6	32.4	35.3	38.2	41.2	44.1	49.1	54.9	63.8
02250	19.8	21.3	23.3	25.1	27.4	29.9	35.3	38.2	41.2	44.1	49.1	54.8	63.6
02500	19.8	21.3	23.3	25.1	27.4	29.9	35.3	38.2	41.2	44.1	49.1	54.8	63.1
03007	19.9	21.6	23.3	25.1	27.4	29.9	33.2	36.7	40.5	44.0	49.1	54.7	61.6
03500	20.0	21.7	23.4	25.1	27.2	29.9	33.3	36.7	40.5	44.0	49.0	54.5	60.4
04100	19.9	21.6	23.3	25.1	27.0	29.4	32.9	36.1	40.0	43.7	48.6	54.2	59.1
05355	17.1	18.2	19.5	21.2	23.2	25.4	28.7	32.0	36.1	39.7	43.6	49.2	54.2

In this new Smoke map all of the numbers have been calculated I have not manually input any number. Our "bad tuner" will have manually input every number and then changed them until he cannot see smoke in the rear view mirror.

12.10) Introducing EGT's

Before we finish the section there is another factor we need to consider. EGT's exhaust gas temperatures are important they tell us what going on in the engine and they also control the harmful emissions coming out of the exhaust. The more "lean" the engine runs i.e. the more air to fuel, the higher the stoic number we have, the higher the internal engine temperatures will be, too high we will melt pistons and destroy turbochargers.

When we are mapping cars on a rolling road we monitor EGT's and when we are mapping a petrol engine car we have to use the EGT's to calculate our smoke map because a petrol engine car will suffer internal damage sooner than a diesel, additionally with a petrol engine we do not get to see the black smoke that a diesel will produce.

EGT's the things we need to know.

In a turbocharged engine the gas coming out of the cylinder passes via the exhaust valve into the exhaust manifold and then past the turbos fan and on into the exhaust system. The gasses as they escape from the cylinder expand and this expansion is the force that turns the turbos fan. By controlling the EGT we can control the turbochargers incoming air flow i.e. the amount of fresh air going into the engine and therefore the amount of fuel we can add and so the amount of "power" we can have from the engine. We need to understand EGT's to maximise our engine efficiency and get the most amount of power from the engine we can. In our stage 1 mapping we do not need to look at this as we will not be looking at turbo compressor maps, this is the graph that the turbo maker has produced to show us what turbos operating range is, this is not a map that we find in the ECU for control of the turbo. Additionally in our stage 1 map we will gain enough "power" increase that we will not push map numbers into the range where we are going to cause significant changes to the EGT's. We get our main gains from "efficiency" not from "bad tuning"

We have all seen on modern cars the "shift light" this is the little indicator on the dashboard that lights up when we should change gear, either up or down. This light is controlled by the ECU, it gets its information from the EGT's. Our ECU will have maps to control this light, yes that's right it has a set of maps to control this light. One map will look at which gear is selected and what speed the car is travelling at, another map will look at our accelerator TPS position and the air flowing into the engine. It will use all this information and look at the EGT and then decide if we need to change up or down a gear for best fuel "efficiency" simply by looking at the temperature of the exhaust gasses and the loading the engine is under…… clever hey.

There is a lot more we need to know about EGT's and how we can use them to help us, in the stage 1 mapping we are doing we only need to know of their existence. When we look at EGR, DPF FAP removal, i.e. when we want to remove these systems we will discuss EGT's in great detail.

14) Map change 3 The Torque Map

14.1) This map is best described as a "limiting map" our first 2 maps dealt with how much fuel we want to inject and how much fuel we can inject for a given amount of air. This map is designed to safe guard the entire car from the engine to the tyres. It will safeguard us by "limiting" the amount of fuel we can have at a given RPM range.

If we do not change this map our overall improvements and gains in "power" will not actually be beneficial to us they will be limited by this map. Making changes to it is necessary and the maths to calculate it can be complex for us to get the last few percent out of our usable "power". We do not have to get the last few percentage in our stage 1 map, when I say last few I mean the difference between 33% increase and 33.5% for example.

14.2) If we want the last few percentage we will look at the tyres fitted to the car, on the sidewall there is a set of numbers and letters. These letters and numbers give us a way to calculate the "traction" capabilities of the tyres. We will look at the gearbox and the gear ratios because as we learnt earlier torque will change by the gear ratio (50nm torques and a 3 to 1 gear ratio gives us 150nm torques) we then have to take our gear ratio and multiply it by our diff ratio (the differential will have a single fixed value typically in the 3.5 to 1 to 4.39 to 1 range). We also need to look at the tyre size, a 15 inch tyre will apply a different torque to the amount of rubber in contact to the road then the same car equipped with a 14 inch tyre. When we look at the next series of maps taken from a 2015 VW Golf we will actually have torque maps for every gear, even reverse. We will cover this in detail in another section, I don't want you to be overloaded with information you just need to understand what the manufacture will have looked at when they calculated the numbers you see in this map.

14.3) This map differs from all the other maps in that it only has 3 rows, the X axis. The X axis only has air pressure in Mbar, this is the air pressure outside of the engine before it is taken in through the air filter. This is what we feel when we go up a steep hill, our ears pop as we equalise the pressure that is inside out eardrum with the pressure outside. We are all familiar with this, it is a change in air density, we have all experienced the affect and just before our ears pop we will notice that our hearing has changed, things have gone quiet, well the truth is we don't notice that's its gone quiet as the air pressure change is gradual we slowly have less "volume" in our hearing, when our ears pop suddenly everything just got louder this is because of the sudden change in pressure. Our air pressure is referred to as "above sea level" that is at sea level we have the best air pressure and density. As we get higher above sea level it reduces.

Our torque map has 3 rows for three different "above sea level" air pressure changes. If we look carefully at the figures in the 3 rows for a given RPM we can see that the differences are small. So if they are so small no need to have 3 rows? no need in our modified map for there to be any differences then? Well our "bad tuner" will just do one line and copy it to the other 2 lines. Why should we not do this? Simple the original set of maps are built as a system not a single map, the manufacture had sufficient room in its smoke map (they had spare stoic value) to allow for only a small change in the torque map X axis. Because we have changed the smoke map to make it more "efficient" we now have a situation where we will risk making smoke as we climb up a hill. We do not have the amount of spare stoic before we get to a figure too low. Thankfully it is not difficult to work out the new numbers we need in the 2 lines because the change in air is a given amount. We need to work out our full power line this is the 1000mbar line then we can alter the other 2 lines by a simple equation.

14.4) Here is our torque map as it comes from the ECU, again have removed the 0's and then added in the decimal point so that it looks the same as our first 2 maps. I have had to split it into 2 parts so that it is readable in this paper.

Engine rpm																					
Air Pre:	**0**	**550**	**551**	**1000**	**1250**	**1500**	**1750**	**1900**	**2016**	**2247**	**2499**	**2750**	**3000**	**2350**	**3500**	**3750**	**4000**	**4250**	**4500**	**4800**	**5200**
600	0.0	0.0	30.0	30.0	39.6	48.0	51.0	**52.0**	**52.0**	**52.0**	51.0	50.3	49.5	48.5	47.8	46.5	45.5	43.0	38.5	32.0	0.0
800	0.0	0.0	30.5	30.5	40.0	48.0	51.0	**52.0**	**52.0**	**52.0**	**52.0**	51.5	51.0	50.0	49.0	48.0	47.0	44.0	39.0	32.0	0.0
1000	0.0	0.0	30.5	30.5	40.0	48.0	51.0	**52.0**	**52.0**	**52.0**	**52.0**	51.5	51.0	50.0	49.0	48.0	47.0	44.0	39.0	32.0	0.0

14.5) We can assume our "bad tuner" will do one of 2 things now, he will keep to form and do his 10% (or whatever percentage he chooses) change to all the numbers or just a section of them or he will just change all the numbers to 77 the number he made in his "drivers wish" in the main section and then try to guess what numbers to put in the other columns.

14.6) For our changes the reasons (the theory) behind what we change and by how much we change them are the same reasons we have applied to our "drivers wish" because we are not going to be modify this car to far we can reasonably apply logic to our changes from our knowledge of cars. We know if this was a Peugeot 206 HDI that they suffer with gearbox issues so we would "consider" this and make our changes accordingly. In our scenario with the VW Passat we can find that the gearbox is also used in the VW van range where they are under much more strain so we can reasonably assume it will take 30% more torque. Remember BHP is speed so BHP does not apply more "load" to the cars drivetrain. Now that we have done our research on our car and decided what we think is a "considered" amount more peak torque we can also change the figures in the RPM Y axis to make a bigger increase relative to the original figure used, we just do not want to exceed our 30% increase on the maximum.

14.7) Lest do the math 52mg + 30% = 67.6mg, now hang on a minute what was our drivers wish maximum from the manufacturer? It was 70mg, if we add in the offset for "efficiency" for example 95% we would get 70x95% = 66.5. Is that coincidence or have we just hit the magic "safe" number.

Now you start to see that good mapping is not that hard, as we work out what we think we should be doing we discover that our workings are close to what we have seen in other sections of other maps. This is not just a coincidence on this set of maps, we will see similar in for example a set of maps from a BMW 530td. You might now think, well heck if that number in the drivers wish was so near why did we do all this maths? The answer is = simples because I'm a right bastard and wanted you to sweat… oh no sorry had to put that in!!! The answer is we need to look at all the other things we have to consider. If this car was in Cyprus not in the UK we need to think about road surface, Cyprus has a lot of semi gravel roads so we could not have 30% increase because we would just be spinning wheels all the time. Remember our factory original map has to be a "worldwide" map.

14.8) The revised Torque Map.

Engine rpm										
Air Pre:	0	550	551	1000	1250	1500	1750	1900	2016	2247
600	0.0	0.0	27.2	29.9	40.2	46.4	50.9	55.3	60.7	60.7
800	0.0	0.0	29.4	32.3	43.4	50.2	55.0	59.8	65.6	65.6
1000	0.0	0.0	30.5	33.5	45.0	52.0	57.0	62.0	68.0	68.0

	2499	2750	3000	2350	3500	3750	4000	4250	4500	4800	5200
600	60.7	60.7	60.7	60.7	60.7	58.9	50.9	46.4	34.8	28.6	3.6
800	65.6	65.6	65.6	65.6	65.6	63.7	55.0	50.2	37.6	30.9	3.9
1000	68.0	68.0	68.0	68.0	68.0	66.0	57.0	52.0	39.0	32.0	4.0

14.9) In our new torque map we have made a lot of changes so let’s discuss these changes.

0 to 551rpm we make no changes from 1000 to 1500rpm we have increased our figures in an increasing slope, we want more torque here to aid “in town” driving and aid fuel economy, now at 1500rpm we have the same amount of torque as we had at 1900rpm.

1750rpm on our new map we have a good usable increase of 12% this should be a safe increase that will not harm the transmission or cause “torque steer” in our front wheel drive cars. You will know if this is wrong when you road test the car, if when accelerating you here a low droning noise and feel a vibration in the car then you have gone too far. This noise, which is from the vibration, is the gearbox internally putting pressure on the bearings that hold the revolving parts.

1900rpm on our factory original map was the max torque figure we now have 19% more torque. We have not got our new max figure here because we do not want to damage things. By producing more torque higher up the RPM range the “load” on the cars transmission is less.

2016rpm we now have our max torque, we carry this through to 3750, with just a small drop between 3500 and 3750, our original map only took it to 2500rpm when drop takes place. Now we have carried the torque through to this much higher RPM what we actually have is a big increase in BHP, think back BHP is Torque x RPM/5252 BHP is what we need for more top speed.

4000rpm to 4500rpm in this area we have gone from our new numbers to the factory original numbers. We have done this to slowly take power away and make our driver change gear in a diesel there is no good power at higher RPM unlike a petrol where you can go to 20,000rpm.

5200rpm now we have a slight increase from the factory 0, where the original map injected no fuel, we have 4.0mg. Why have we done this? This is my personal choice and I do it so that when the ECU does the maths on all the maps it has a figure here that it uses to calculate a small number instead of nothing at all this will smooth all our other maps in the upper regions, it also has an effect on the EGT’s and engine lubrication but we will discuss this when we discuss DPF EGR etc.. removal.

With all these changes it has been necessary to alter the 800 and 600mbar rows, as we are pushing for more “efficiency” using the spare air we have to consider this air pressure drop more. We can calculate this drop from standard figures plus our car knowledge figures (its mileage and condition) Air density is also affected by air temperature, we do not need to consider the temperature in our calculations as our air has come via a turbocharger and an intercooler and monitored by the MAF.

15) Map change 4 The Boost Map.

This is the point our "bad tuner" goes horribly wrong.

15.1) We will need to look at the "boost control system" this is the Boost map, Boost Limiting map and the SVBL (single value boost limit) we have to make our changes to all of these and calculate new figures accordingly. However in our stage 1 map we may not need to make any real changes what we will do next is start by looking at the Boost map and make the changes our "bad tuner" makes, we will use good maths to calculate our new numbers so you understand how we would make the changes correctly then we will talk about why we may not need to do any of this how we can change 1 number in the entire map and have something that is far better than our "bad tuner"

15.2) Before we look at the map we need to look at the numbers in it. Our X axis has RPM and our Y axis has our Injected quantity (mg's of fuel) in our table the numbers relate to mbar of boost pressure. To understand boost pressure we need to know about ambient air pressure, air that is all around has air pressure at sea level this is 14.7psi this can be referred to as 1 bar (technically it is 1.01bar). Turbo pressure can be spoken about in 2 ways, we can quote the turbos pressure called boost pressure (technically called "gauge" pressure) or we can quote our actual cylinder pressure i.e. what is inside the engine, tis is called "absolute" pressure. Turbo pressure is the amount of "extra" pressure as we always have our ambient pressure of 14.7psi with no boost at all we have 14.7psi inside the cylinder. If our turbo produces 10psi we now have 24.7psi inside the cylinder to convert this to Mbar as seen in our "Boost" map we need to multiply it by 68. This number has a long calculation behind it and will vary under a wide range of conditions but for our purposes we do not need to understand this using 68 is not going to cause us any problems.

Ambient pressure 14.7psi - Gauge pressure 10psi Absolute pressure 24.7psi - Turbo map 1679.6mbar

15.3) Here is our Boost map, as before I have changed the numbers you see below removing the 0's, no need for a decimal point as the numbers we are dealing with relate to air in mbar and are in the 1000mbar to 2350mbar range. We get 2350mbar as our stock 130pdi will produce 1.32bar of boost, the maths is (1.32x14.7)+14.7 = 34.1psi of absolute pressure 34.1x68 = 2318mbar

	Injected Quantity									
rpm	**0.0**	**5.0**	**10.0**	**15.0**	**20.0**	**25.0**	**30.0**	**35.0**	**45.0**	**50.0**
0	198	198	198	198	198	198	198	198	198	198
21	1002	1502	1102	1158	1195	1265	1350	1350	1350	1350
1008	1002	1058	1106	1153	1199	1265	1350	1350	1350	1350
1260	1002	1060	1119	1171	1225	1281	1373	1500	1710	1710
1500	1002	1090	1155	1225	1305	1380	1495	1650	1900	1950
1750	1002	1115	1195	1280	1365	1475	1610	1800	2050	2170
1900	1002	1130	1210	1310	1395	1515	1660	1860	2115	2250
2000	1002	1140	1220	1320	1415	1535	1685	1880	2155	2275
2247	1012	1160	1240	1340	1440	1565	1705	1915	2205	2325
2499	1021	1180	1260	1360	1460	1585	1725	1925	2210	**2350**
3500	1060	1225	1320	1425	1525	1645	1775	1965	2235	**2350**
3750	1080	1225	1330	1435	1530	1645	1780	1970	2235	**2350**
3990	1100	1225	1330	1445	1540	1650	1780	1970	2215	2320
4250	1120	1225	1330	1445	1540	1650	1780	1980	2170	2260
4494	1149	1225	1328	1445	1540	1645	1780	1965	2070	2140
4746	1200	1225	1325	1429	1530	1655	1772	1900	1950	1950

15.4) On our X axis we have engine RPM and on our Y axis we have Injected quantity (mg of fuel). Now our first issue is this map only goes up to 50mg in all our maps before we have been calling for more than 50mg of fuel as our maximum, we also have 2350mbar from the turbo and we have google'd "130pdi standard boost" to see that it is 1.32 bar and that using the maths above we have 2318mbar so we are in lots of trouble right? Wrong because we understand stoic we are not in trouble, our "bad tuner" is and he will make a catalogue of mistakes.

The calculations in this table are based on the stoic values used in the Smoke map the manufacture made, thinking back to our smoke map we made improvements in "efficiency" to use air that was already available so if the theory is correct we will not need to change the figures inside the table. As the Y axis only goes to 50mg and we want 67.6mg we will have to change these numbers.

15.5) To do the calculations it is easier to convert the Boost map to MAF (mass air flow as in our smoke map) and correct it to 1013mbar i.e. no boost then work out our new numbers using our stoic numbers and then convert it back to Boost pressure. We will now do a single number calculation. When we are mapping we will actually build a set of tables in Excel with the formula built into them as we did on our stoic calculations and again Excel will give us answers as soon as we copy and paste our original Boost map in.

15.6) The maths:

Converting Boost pressure into MAF.

To do this we need to know the size of the cylinder, if we think back to the BMW 530td this was 3000/6 = 500cc in our 1.9TDi it is 1900/4 = 475.

Now we can take our ambient air pressure and divide it our cylinder volume 1013/475= 2.13.
The MAF is boost pressure divided by our volumetric figure 2350/2.13 = 1103.
The stoic value is MAF divided by mg of fuel 1103/50 = 22.06
As we are using a stoic of 17.0 we can reverse this formula and use our new fuel quantity

67.6 x 17.0 = 1149. 1149 x 2.13 = 2447. So we need 2447 of boost pressure for our 67.6mg of fuel.

Now what we should actually do when we are mapping a car is look at this map first. We already have in our mind what we think, or what we have calculated, our target stoic to be. If we use this and do the maths we will find out that our stock turbo and our stock turbo map will provide a quantity of fuel that we can inject.

The Math using all the formula above is to take the boost divide it by the (MAF/cylinder size) to get our MAF at no boost (our smoke map has no boost calculations) then we take this figure and divide it by our target stoic and we get 2350/2.13 = 1103 then 1103/17 = 64.8.

We now know that our current Boost map will support 64.8mg of fuel. Yes we have calculated our desired maximum as 67.6mg of fuel but we can have 64.8mg without changing this map. If we now refer back to the smoke map that I created (this is the green coloured one on page XXXXXX) you will see my max figure is at 2001rpm and 1050mg of air and it is 63.6. So I can get 63.6mg of fuel into the engine without changing any map other than the smoke map.

All I have done is found "maximum pre-existing efficiency" that is I have used what is already there. This will give me 22% more power and this is what "freepower" is all about and this is our best map.

15.7) Now we have two things to cover before we can finish this section, we need to look at what we have to do if there is not enough available in our current maps for an acceptable amount of power increase, for example if we do all the math and we get under 7% more fuel. I choose 7% because my cut off is 8%. A stage 1 map needs to make 8% as a minimum in my opinion and 8% is a noticeable increase for our car driver, remember we increase both torque and BHP and we have increased the usable "power" band so now we have a car that will accelerate faster and go faster the increase in the power band will give our brain a feel of a lot more available power, if you tell the owner its just 8% change he will not believe you this is because the original drop off in torque as RPM increased has changed and the gear ratio effect. If we remember 50nm at the engine with a 3 to 1 gear ratio will gave us 150nm torques at the wheel, if we have 8% more that is 54nm at the engine which doesn't sound like much until we apply the gear ratio and we get 162nm now that's a noticeable amount.

15.8) First up the most important thing we need to know and it is the one thing all "bad tuners" overlook. As we know our turbo actually had enough air to give us all this extra power but we have overlooked the other thing we need, fuel. But we have covered that haven't we? We asked our "Drivers Wish" for more and we adjusted our "Smoke" map so we could use it, what have I missed?

We haven't looked at our injectors to see if we can supply more fuel, we have only looked at asking for more fuel. To inject an amount of fuel we need to look at the "Start of Injection" and the "Duration" maps these 2 maps control how much fuel is actually injected into the engine. Our ECU will use this information, and our requested quantity, to determine the actual opening of the injector and the fuel passing through it.

A fuel injector has a size to it, this size is in CC and is how much fuel it can flow when fully open over time measures in Minutes so a 550cc injector will flow 550cc of fuel in 1 minute at a given fuel pressure. I will cover how to size a fuel injector in a later paper so that you can fit a bigger fuel injector.

We can change our maximum quantity fuel into the engine in one of 3 ways. We can open our fuel injector for a longer period of time. We can use a bigger fuel injector, or we can increase the fuel pressure. Let's do a little math to demonstrate this.

The figures used below are to demonstrate the options they are not calculated figures, if you go back to our hosepipe with the nozzle fitted the correct maths are in those formula's.

A 550cc injector open for 1 second at 10psi gave us 55mgs of fuel

A 550cc injector open for 2 seconds at 10psi gave us 110mgs of fuel

A 660cc injector open for 1 second at 10psi would give us 66mgs of fuel

A 550cc injector open for 1 seconds at 20 psi would give us 110mgs of fuel
(this figure needs to be calculated and relies on the density of the fuel)

How do we use this then? We need to look at our maximum duration of injection possible and our injector size. We can google and calculate all this information or we can use what we have already. Remember earlier when we used the manufactures offsets in our smoke map calculations for the numbers outside of our forced stoic values, well here again we can look to the manufactures for help. If we look at the duration map (we will look at it later in the guide for now I will just tell you the figures) we can see that the maximum injected quantity on the X axis is 60mg, so we can't have our 63.6mg because the ECU doesn't know how to inject that much. So we either work with what we have or we have to make changes. If we work with 60mg of fuel our power increase is now 20%, that will still make enough power for me to not to need to change anything other than my "smoke" map.

If we don't have enough or we deicide that we want 63.6 then we will need to change our "duration" map if we change our "duration" map we have to change of "start of injection". We will discuss this in detail later when we look at these maps but in this section we just want to see what we can have not work out how we get it in the cylinder.

How do we calculate these numbers, we can google things or we can calculate things. We need more duration for more fuel we can have a reasonably accurate guess to these numbers by taking what is in the "duration" map and using it to make a new number. Our duration map has an X and Y axis our X is injected quantity and our Y is RPM the numbers in the map are degrees of crankshaft rotation.

If we take our maximum of 60mgs of fuel and our maximum 5000rpm we can see we have a maximum figure of 29.81 degrees of rotation we can calculate our injectors flow rate for 1mg of fuel.

Then we can use this figure to calculate our new degrees of crankshaft revolution.

The math 29.81/60 = 0.49683 then 0.49683 x 70 = 34.78 degrees of crankshaft revolution.

However this does not take into effect the variation in the pistons velocity and the fact it is constantly changing from Vmax to stationary as the crankshaft goes round, to calculate this we need to know the stroke, the crankshafts outer diameter and the crankshaft journals diameter, we will cover this subject when we look at our "start of injection" and "duration" maps here you just need to be aware that we will need to calculate this.

In our scenario above it equates to 1.00164, so we would take 34.78 and multiply it by 1.00164.

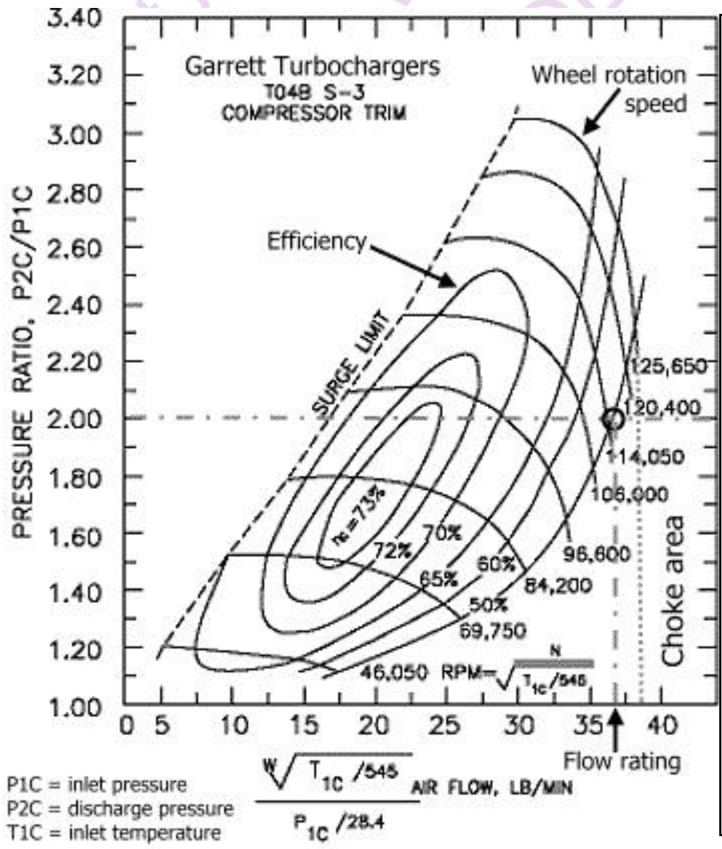
The math 34.78 x 1.00164 = 34.84 our actual duration is 34.84 degrees of crank rotation at 5000rpm.

15.9) That's our quick look at fuel covered now we need to move onto what to do if we do not have enough air in our "boost" map.

What if we need more air? For more air we need the turbo to provide it so we need to calculate the new figure first of all. If we go back to our "boost" map and the table we produced adjusted to MAF then we can use those figures to calculate 70mg of fuel.
The math we had above gave us this final equation.

67.6 x 17.0 = 1149. 1149 x 2.13 = 2447. So we need 2447 of boost pressure for our 67.6mg of fuel.
Using the same formula for our 70mg of fuel we will get
70.0 x 17.0 = 1190. 1190 x 2.13 = 2535. So now we need 2535 of boost pressure for our 70mg of fuel.

15.10) At this point we should look at turbo compressor maps, this is a map that shows what a turbo can produce at different turbine rpm and pressure ratio. The map below is not the map for the 130PDi it was the best one I could find on the internet that helps us look at what information it has for us.



This map is a good example to use.

On it we have numbers connected to lines for example 96,600, this is the turbine rpm. We have marked on it the "surge limit" this is the point where the turbo pressure is unstable, it goes up and down uncontrollably it is in "surge"
We have marked on it "choke" this is the area where the exhaust fan will be slowing the flow of exhaust gasses to such a degree we have a build of backpressure which is bad for performance. This backpressure is what lorries use when you select "engine breaking" to help them slow down as they come down a hill.
We have our new best friend marked on it too "efficiency"
At the very bottom we have some handy equations, we will use these later.

15.11) Our X and Y axis we have "Pressure Ratio" and "Air Flow". Oddly most turbo maps have air flow in lbs/min (pounds per minute) but we can change that to our MAF easily it's just changing it to the metric system. So what is the "Pressure Ratio" well pressure ratio is the difference between our air pressure coming into the turbo and the air pressure going out of our turbo i.e. the amount of boost

If we have 34psi of absolute pressure coming out of the turbo and we are at sea level so we have 14.7psi incoming then the math is 34/14.7 that gives us a pressure ratio of 2.31.

15.12) We can use the compressor map to see what we can have at a given turbine rpm band i.e. our upper and lower turbine speeds, think back a few chapters we said we want to see speeds between 95,000 and 115,000 as a general rule of thumb, and at a given Psi by calculating our "pressure ratio". From this we can see the upper and lower amounts of air our turbo will provide, in this map the turbo's pressure ratio window is 2.1 to 2.6 for our 95k/115k rpm turbine speeds, so this tells us we can run from 30.8psi to 38.2psi of absolute pressure which is 16.1 to 23.5 of gauge or "boost" pressure.
We can also tell at a pressure ratio of 2.31 we can have from 20lbs/min of airflow at 100,000rpm turbine compressor speed to 35lbs/min at 125,000 rpm.
That's all we will cover in this section about turbo compressor maps. Now let's get back to our car and see how we have to change our "boost" map. We are going to do this with the info we have.

Here is our stock “boost” map again,

	Injected Quantity									
rpm	**0.0**	**5.0**	**10.0**	**15.0**	**20.0**	**25.0**	**30.0**	**35.0**	**45.0**	**50.0**
0	198	198	198	198	198	198	198	198	198	198
21	1002	1502	1102	1158	1195	1265	1350	1350	1350	1350
1008	1002	1058	1106	1153	1199	1265	1350	1350	1350	1350
1260	1002	1060	1119	1171	1225	1281	1373	1500	1710	1710
1500	1002	1090	1155	1225	1305	1380	1495	1650	1900	1950
1750	1002	1115	1195	1280	1365	1475	1610	1800	2050	2170
1900	1002	1130	1210	1310	1395	1515	1660	1860	2115	2250
2000	1002	1140	1220	1320	1415	1535	1685	1880	2155	2275
2247	1012	1160	1240	1340	1440	1565	1705	1915	2205	2325
2499	1021	1180	1260	1360	1460	1585	1725	1925	2210	**2350**
3500	1060	1225	1320	1425	1525	1645	1775	1965	2235	**2350**
3750	1080	1225	1330	1435	1530	1645	1780	1970	2235	**2350**
3990	1100	1225	1330	1445	1540	1650	1780	1970	2215	2320
4250	1120	1225	1330	1445	1540	1650	1780	1980	2170	2260
4494	1149	1225	1328	1445	1540	1645	1780	1965	2070	2140
4746	1200	1225	1325	1429	1530	1655	1772	1900	1950	1950

15.14) We know that we can change the 50mg to 60mg because 2350 air is enough at out 17.0 stoic so to modify this map we could simply change the 1 number at the top the 50 to 60 and we would probably escape without changing any numbers in the map, that said we would never do this because we are good tuners we will use our formula that we did before to change all the numbers to new ones and we can build an Excel table to automate this process, it can be set up to use our target stoics table we made when we were doing the “smoke” map and calculate the formula we used to work out that we had enough air for 60mg of fuel.

For 70mg of fuel we need new numbers in our quantity of air.
70.0 x 17 = 1190. 1190 x 2.13 = 2535. So now we need 2535 of boost pressure for our 70mg of fuel.

We would now need to add 2 more columns a 60mg column and a 70mg column, but we can’t do that. If we refer back to chapter XXXXXXXXXX we cannot simply add more columns or rows the ECU will not see them, so as we did with our “drivers” wish map when we made full throttle at 57%TPS by copying and pasting the columns we need to move the information currently in the map to the left and delete 2 rows to allow our new information in. There is a lot of discussion as to which we should remove and which we should keep, or should we completely rewrite all of the information?

We should never delete the first column, often an ECU will look for the number in this first column as a “hand shake” before it uses the map, it will say “hello boost map 0x0.0” and the boost map will reply “hello ECU 198” this is the information in the map in the column and row X 0 and Y 0.0 if we delete it the ECU will not get its reply thinking it has a major fault and cut the engine for safety.

To be at the top of our profession we would change all the Y axis numbers. So they represent the same ratio as the original ones and then calculate all the numbers we need to have in the table.
0.0 – 5.0 – 10.0 – 15.0 – 20.0 – 25.0 – 30.0 – 35.0 – 40.0 – 50.0
now becomes
0.0 – 7.0 – 14.0 – 21.0 – 28.0 – 35.0 – 42.0 – 49.0 – 56.0 – 70.0

To make our “boost map” we use Excel to calculate everything for us.
First here is our table with our new Y axis, this table has been made by taking the original “boost” map table, dividing the numbers in the table by the original Y axis and then multiplying it by our new Y axis figure, the math at 1008rpm and 5.0mg of fuel we had 1058 in the table if we divide 1058 by 5 we get 211.6 then we times it by our new figure 7.0mg to get 1481, oh that doesn’t work so its not that simple then, what we have to do is work out the “relationship” between the numbers so……..

Injected Quantity										
rpm	0.0	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	70.0
0	198	222	203	200	200	198	201	198		
21	1002	1192	1173	1216	1323	1350	1368	1352		
1008	1002	1198	1171	1220	1323	1350	1368	1352		
1260	1002	1204	1188	1244	1343	1500	1657	1713		
1500	1002	1239	1238	1328	1455	1650	1835	1943		
1750	1002	1271	1290	1394	1562	1800	1987	2148		
1900	1002	1288	1317	1426	1608	1860	2051	2225		
2000	1002	1299	1327	1446	1631	1880	2085	2253		
2247	1012	1322	1348	1473	1656	1915	2130	2303		
2499	1021	1344	1368	1493	1676	1925	2137	2324		
3500	1060	1399	1434	1557	1731	1965	2168	2329		
3750	1080	1401	1444	1562	1734	1970	2169	2329		
3990	1100	1401	1451	1571	1736	1970	2156	2301		
4250	1120	1401	1451	1571	1736	1980	2131	2244		
4494	1149	1401	1451	1570	1734	1965	2060	2129		
4746	1200	1400	1438	1563	1734	1900	1958	1953		

So now we have this table, how did I make it? I used 1 formula but had to have 2 versions of it.
This is the base formula: It is taken from 35mg of fuel at 3500rpm
=((H13/H$2)-((((H13/H$2)-(I13/I$2)))/(I$2-H$2))*(S$2-H$2))*S$2

Now I you know you’re looking at that and thinking “I have no chance, you’ve lost me there is no way I will ever understand that formula let alone have to write a new version of it myself”
Would I let you down now? Course not lets go through it.

First of all a little knowledge on Microsoft Excel. Excel is a spreadsheet that is it spreads the information over a sheet of virtual paper. To keep track of this information Excel uses rows and columns. The Rows are numbered from 1 to well to as many lines as you write, the table above has 18 rows. Then we have Columns these are lettered from A to Z, for the first 25 then it goes AA to AZ for 26 to 50 and BA to BZ for 51 to 75 and so on. So if we want Excel to calculate something for us we can ask it to take a number from a cell. A cell will have 2 vales to it, the Column value and the row value, a cell will be H13. H13 on our table is 35mg of fuel and 3500rpm
We use the (xx/xx) to ask Excel to do this sum and then take the answer and apply the next part of the formula to it. Where there is ((xx/xx)-(xx/x)) we are asking Excel to carry out 2 sums and then use the 2 answers to do the overall sum. The $ signs we will cover later they are just “holders”
Let’s put some numbers in and demonstrate it.
((20/5)-(10/5)) so that would be (20/5=4)-(10/5=2) = 2. Now that wasn’t too hard was it.
So why do we use H13 and not use the number 1775? Well the formula will work on any numbers in any cells by specifying the cell we can allow Excel to make the next calculation by copy and pasting this one formula all across the page. Additionally if we loaded a map from another car into our table of formula Excel will do all the maths over the entire table in less than 1/1000th of a second.

To understand this formula I have taken a screen capture of Excel so you can see all the Row and Column details, this is small on the page but you can use the PDF reader to magnify it.

	A	B	C	D	E	F	G	H	I	J	K
1	Injected Quantity										
2	rpm	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	45.0	50.0
3	0	198	198	198	198	198	198	198	198	198	198
4	21	1002	1052	1102	1158	1195	1265	1350	1350	1350	1350
5	1008	1002	1058	1106	1153	1199	1265	1350	1350	1350	1350
6	1260	1002	1060	1119	1171	1225	1281	1373	1500	1710	1710
7	1500	1002	1090	1155	1225	1305	1380	1495	1650	1900	1950
8	1750	1002	1115	1195	1280	1365	1475	1610	1800	2050	2170
9	1900	1002	1130	1210	1310	1395	1515	1660	1860	2115	2250
10	2000	1002	1140	1220	1320	1415	1535	1685	1880	2155	2275
11	2247	1012	1160	1240	1340	1440	1565	1705	1915	2205	2325
12	2499	1021	1180	1260	1360	1460	1585	1725	1925	2210	2350
13	3500	1060	1225	1320	1425	1525	1645	1775	1965	2235	2350
14	3750	1080	1225	1330	1435	1530	1645	1780	1970	2235	2350
15	3990	1100	1225	1330	1445	1540	1650	1780	1970	2215	2320
16	4250	1120	1225	1330	1445	1540	1650	1780	1980	2170	2260
17	4494	1149	1225	1328	1445	1540	1645	1780	1965	2070	2140
18	4746	1200	1225	1325	1429	1530	1655	1772	1900	1950	1950

L	M	N	O	P	Q	R	S	T	U	V	W
	Injected Quantity										
	rpm	0.0	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	70.0
	0	198	222	203	200	200	198	201	198		
	21	1002	1192	1173	1216	1323	1350	1368	1352		
	1008	1002	1198	1171	1220	1323	1350	1368	1352		
	1260	1002	1204	1188	1244	1343	1500	1657	1713		
	1500	1002	1239	1238	1328	1455	1650	1835	1943		
	1750	1002	1271	1290	1394	1562	1800	1987	2148		
	1900	1002	1288	1317	1426	1608	1860	2051	2225		
	2000	1002	1299	1327	1446	1631	1880	2085	2253		
	2247	1012	1322	1348	1473	1656	1915	2130	2303		
	2499	1021	1344	1368	1493	1676	1925	2137	2324		
	3500	1060	1399	1434	1557	1731	1965	2168	2329		
	3750	1080	1401	1444	1562	1734	1970	2169	2329		
	3990	1100	1401	1451	1571	1736	1970	2156	2301		
	4250	1120	1401	1451	1571	1736	1980	2131	2244		
	4494	1149	1401	1451	1570	1734	1965	2060	2129		
	4746	1200	1400	1438	1563	1734	1900	1958	1953		

We have 2 tables, the one on the left is our original table the one on the right is our new table with room for the 70mg fuel column. Rather than just do a "bad tuner" quick fix we want to make this map as smooth as possible. To do this we have changed all the figures across the top except our 0mg we now have 7 instead of 5 and increasing all the way across to 49 instead of 35, we now have 2 new numbers 56mg and 70mg. These column are blank I will discuss why later after the math below.

If we look at the formula again we can start to break it down and fill in all the numbers.
=((H13/H$2)-((((H13/H$2)-(I13/I$2)))/(I$2-H$2))*(S$2-H$2))*S$2

The = sign, this is how we tell Excel we want to do a calculation.
H13 is 1775 from the table on the left
H$2 is 30mg from the table on the left
I13 is 1965 from the table on the left
I$2 is 35mg from the table on the left
S$2 is 35mg from the table on the right

So the formula above is asking Excel to use a figure that is in H13 and divide it by the figure in H2
Then we want Excel to do all the math from the ((((to)) before the last * and deduct this from the answer above. Then we want it to multiply the answer by S$2.
We are asking Excel in this formula to take a number that relates to 35mg column in the left side table and calculate the new figure for our right side table which is also 35mg, why? We can just copy the numbers across we know they are the same. We do this on this column first because it is the same axis value i.e. it is 35mg on both tables, after we have done our formula we should have the identical numbers in both tables, if we do our formula is correct, if we don't then we know our formula is wrong and can fix it. If we did the 50mg to 49mg column first we would not know if it was correct as the numbers will always be different, we would have to take a calculator and check it.

If we fill in all the numbers and do it one (xx xx) part at a time.
H13/H$2 = 1775/30 == 59.1667
I13/I$2 = 1965/35 == 56.1429
I$2-H$2 = 35-30 == 5
S$2-H$2 = 35-30 == 5
If we now do our "first" level () maths it now reads (59.1667)-((59.1667)-(56.1429)/(5))*(5)*35
So our next level () will give us 59.1667 – ((3-0238)/5*5) x35
And the next level () will give us 59.167 – 3.0238 *35 = 56.1429

If we now do our 49mg at 3500rpm conversion we have the formula
=((J13/J$2)-((((J13/J$2)-(K13/K$2)))/(K$2-J$2))*(U$2-J$2))*U$2

We now have:
J13 = 2235 from the table on the left
J$2 = 45 from the table on the left
K$13 = 2350 from the table on the left
K$2 = 50 from the table on the left
U$2 = 49 from the table on the right

Our last 2 numbers in this list are different, in our first list the last 2 were both 35 and so our equation cancelled its self out to give us the result in the 35mg column, now we have a difference of 50 and 49 where 50 was our old axis value and 49 is our new axis value. So the formula will calculate our 49mg column for us. Now you may think but that’s a different formula from before, well it’s the same, what you are seeing is different letters in it but the same numbers, the numbers are the same because we are on the same row, we are on the 3500rpm row the letters are different because we are on the 50mg column.

So how is this the same? It’s the same because the relationship between the letters is the same. If we put both formula together we can see this more easily.

=((H13/H$2)-((((H13/H$2)-(I13/I$2)))/(I$2-H$2))*(S$2-H$2))*S$2
=((J13/J$2)-((((J13/J$2)-(K13/K$2)))/(K$2-J$2))*(U$2-J$2))*U$2

Now you can see the relationship, H to H becomes J to J the letters are different but the relationship is the same I to H is 1 letter of the alphabet along and K to J is also 1 letter along. Finally S to H is 11 letters different and U to J is err yep its 11 letters again. Excel helps us here because when we copy the formula in cell S13 by pressing CTRL and C and then paste it into cell U13 by pressing CTRL and V Excel will change all the Letters and keep the relationship intact for us.
Where we have used the $ sign this forces Excel to always use whatever follows the $ sign and not change it when it changes the relationship, in our formula we are using the $ sign to force Excel to use the figures in the Y axis, the mg of fuel. If we had H2 and not H$2 what would happen in the new formula we would get H2 and not J$2 the $ sign has kept the H and the 2.

The reason for our formula is to take the old number at the top i.e. the 45mg of fuel and taking the new number at the top in our new table the new 49mg of fuel calculate what should be in the cells i.e. the new boost pressure, this is based on the relationship between the 2 old numbers for both mg of fuel and old boost numbers. What I mean by this is we take the relationship between 45 and 2235 then take the relationship between 50 and 2350 and use this to work out the relationship for 49.

That’s enough of a lesson about Excel, well it’s not but we will move on now because we have 2 empty rows that we need to fill in, and then we have to correct all the numbers, correct them? Yes we have made this table based on our original file we will need to correct it for our “efficient” stoics.

15.16) First we must fill in the 2 empty rows, then we will correct it as we already know what we can achieve and as we managed earlier on to make a new smoke map because we had spare air available and we did this by using the “stoic” values from our original files and correcting them for more “efficiency”. This new map we are making now is to replace the original map that had 0 to 50 on it with one that has 0 to 70 on it, it is not stoic corrected so after we have all our new column numbers we will then take our stoic map and use that to correct the numbers in this map, it will become our “interim” map, to generate our “final” map.
So right now you’re thinking this is going to be a load more math and time, were talking days not hours, no Excel will help us with all these stages, in fact once you have built a series of Excel tables with formulas to make new tables and then taken the new table and another new table (like the old smoke map and the new one and the old drivers wish and the new one) we can use new table A divided by new table B to give us our final answer in table C and because we can build the “relationship” formulas and copy and paste them we actually can build a series of tables so when we input all the original files into the first set of tables, then we put in our new axis numbers (in our last table this is for 70mg of fuel and all the new offsets) Excel will fill in our new finished tables quicker than we can see. We can reuse these tables on other cars and then we can map a car in an hour, we just need to calculate a few numbers to change the axis and the stoic and hey presto leave Excel to work it all out.

15.17) Our empty rows, we have 3 ways to solve this.

1)We nip over to VW and we take 9 engines, 3 new ones 3 50,000 mile engine’s and 3 100,000 mile engines. We then use 9 dyno’s and run each of our 3 matching engines at 3 above sea level height’s i.e. the 1000, 800 and 600mbar we had in our torque map. We then get 10 engineers to monitor each engine and run it though 1000 test cycles, we then collect all the data and give it to 1000 university degree holders from the fields of chemistry and maths and allow them to use 1000 super computers to calculate the new numbers or us, because that’s what’s happening today at VW with the new 2017 Golf TDi engine.

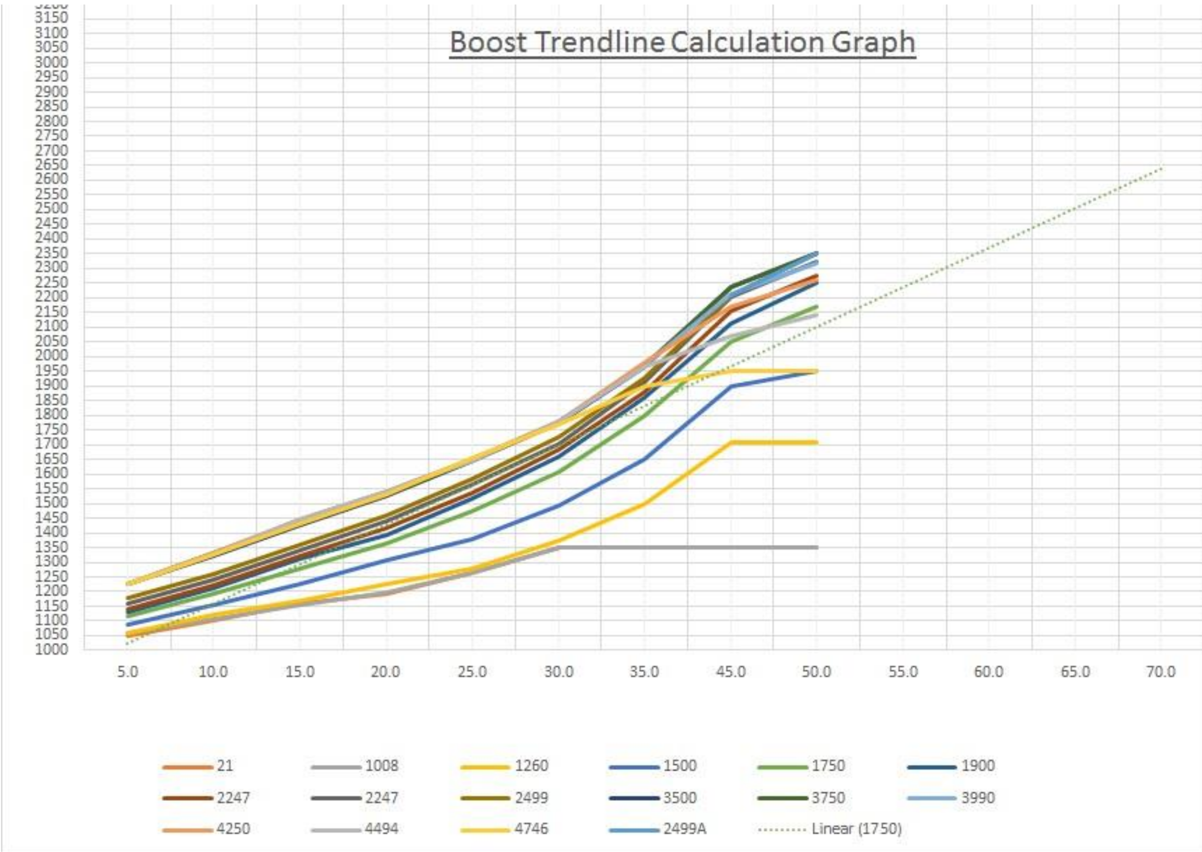
2)We take all of these people and all of this equipment and squash it up with an amazing amount of force and condense it all into a piece of chewing gum, we then put a pencil behind our ear and place the chewing gum in out mouth and start to chew… After a reasonable amount of time with our customer sat in front of us we can predict the new numbers and inform the customer of our great expertise in the field………… Err yeah that’s our “bad tuner” and my sarcasm!!!

3)We can take all of that expertise in 1) and we can interrogate the information they provided and use Excel to predict with an astonishingly high degree of accuracy the new figures.

Another load of math? No we have a new feature to look at in Excel the “Graph”

In Excel we can select a range of information from our tables and make a graph from it, takes 3 clicks of the mouse, we can then ask Excel to predict where the next point on the graph will be. We have several ways we can ask Excel to create the new point, we can ask it to look at the numbers and predict an “average” of the ones we have and apply this average to the next row, or we can ask it to look at the “pattern” and predict the next row. Below are examples of both methods, we will look at them and compare the information they provide, then we can use them to predict our missing 56mg and 70mg columns.

At the end of this guide there is a short section on how to use Excel and how we make these graphs.



The graph above has on its axis our "boost" amounts and our fuel in mg amounts. The different coloured lines represent the different rpm, across the bottom is a colour guide to indicate which rpm is which and then there is one that says "linear 1750" this is Excels calculated line in linear mode at 1750rpm. If we interrogate this graph we can see we have a larger portion of the lines following the same relative shape in a stack, the lines we have that are majorly different represent 0rpm, 21rpm, 4494rpm and 4746rpm. If we ignore these and look at the ones left then we can see a clear similarity between them, this is called a "trend" in a graph. The green dotted line you see is what's called a "trendline linear forecast", that is Excel has looked at the trend of the green line only and calculated what the averages are between each step and used this average trend to give us a predicted line for 56 and 70mg

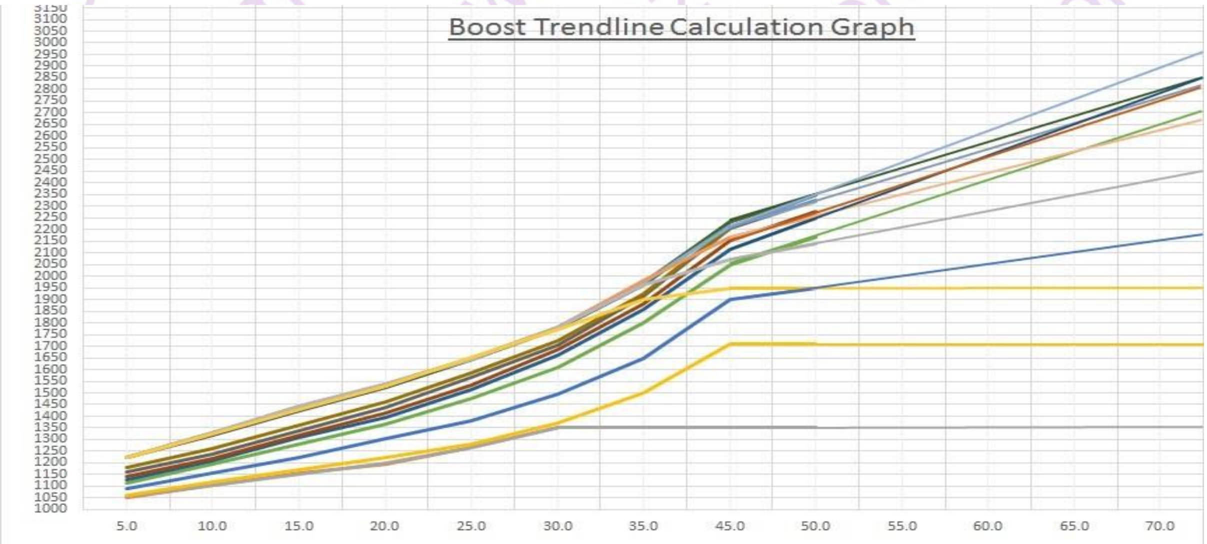
We can do this for all the lines we have and get our figures for the 56 and 70mg columns. The only problem with this method is the linear prediction doesn't have a curve to it, our lines that already exist have a curve and then a noticeable change in shape at the end, so how do we deal with this?

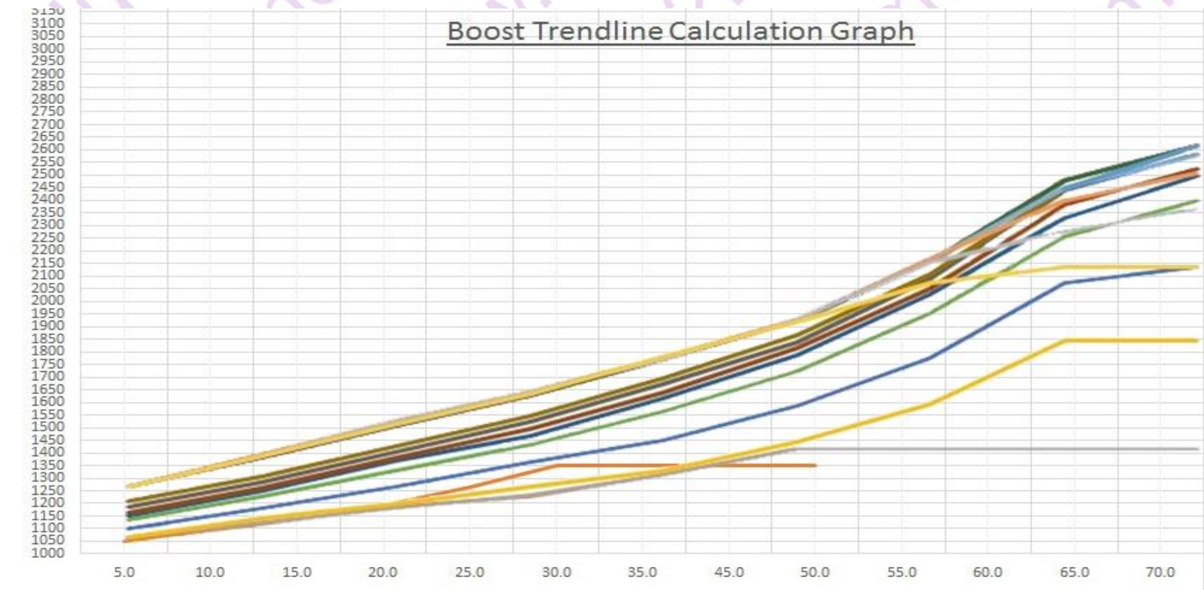
We have 2 options.

The first is we take the "relationship" in the graph for the last 2 plotted points 45mg and 50mg and extend the line. We get a straight line again as we are only using the 2 points to calculate the line.

The second is we take our current graphs shape and use it to re-plot our graph. The best way to imagine this is if we took the lines from the graph and took a photograph of them, then took our photograph and made it bigger so it was the same width of our graph including the empty section and then stuck it back on top of the graph. We now have to place this on the graph in the correct place, to do this we can calculate where the top number should be using stoic. Originally our graph's top point was 50mg of fuel, 2750rpm and 2350 of turbo pressure, this would give us a stoic of 22.06.

If we work out 70mg at 22.06 we get 3289 for our new turbo figure. If we now set our “photo” of the lines over the graph with 3289 as our mark to align the graph we would get all our figures and they would be pretty accurate for the manufactures original stoic values. We would then need to correct all our figures for stoic “efficiency”, but there’s a better way lets work out that top figure for our new stoic values. If we take a stoic of 17.0 we will have a target number of 2535, if we set that as our new mark to align the graph with we would get a graph giving us new values stoic corrected.
This is our graph with our “liner” extension from our 45 and 50mg numbers. You can read of the numbers from the lines for 56 and 70mg at any rpm, write then down and do a stoic calculation on them. For example lest read 65mg at 2499rpm. The formula for the math is (“boost”/2.13)/mg of fuel (2525/2.13)=1185 Then 1185/65=18.24 If you’re wondering where did 2.13 come from and why did we use it? Earlier we had to use the math 1013/475, this was ambient air pressure divided by our engines cc per cylinder. We us it here because to calculate our stoic values we need MAF not boost.





On the second graph we use the “photo” process. IF we now read off the same line 65mg of fuel at 2249prm we get 2465, this gives us a stoic of 17.80, how good is that?
We have just successfully nipped over to VW and borrowed all their expertise, ok so we have still had to average it out but I know we are close, very close to what they would have come up with.

When we were looking at graphs you may have noticed that I calculated the new number at 70mg to allow me to align the graph up. We can actually calculate all the numbers in this table, I have done this section on graphs so you understand graphs and how to use them and how to manipulate them. It is important we can do this especially if you have a customer that wants to know what he can get before he will let you modify his car. The maths, which is what we need, means nothing to a customer and trying to explain it to them would take about the time it has taken you to read this guide. Give them a graph and they will be happy, you can also use them in a different way, if you do all your new tables and print of graphs of before and after they will also probably think you have a rolling road be far more impressed and later show their mates, and that brings you more customers.

To do the maths its simple, we will use Excel again, this time we will make a set of tables, basically the same process as the smoke map, We will convert the “boost” map into a “MAF” table so the smoke map but with our boost map X and Y values, then convert this to actual stoic, then set our new target stoics using the same principles we applied to our smoke map, then convert the stoics back to MAF and then back to “boost”.

15.22) If we do this we end up with the table below, this table is our actual finished table with all the correct for stoic numbers in it. I have used 2 methods to calculate the numbers, as per our “smoke” map some numbers I have manually set to what I want them to be, then I have used Excel to calculate the numbers in the area around them based on the original manufactures “relationship” values to smooth the changes, I have then corrected the extreme figures the 0,21,4494 & 4746rpm’s

Injected Quantity Graph with New Mass Air Flow Figers Converted back to Boost										
rpm	**0.0**	**7.0**	**14.0**	**21.0**	**28.0**	**35.0**	**42.0**	**49.0**	**56.0**	**70.0**
0	198	198	198	198	198	198	198	198	239	298
21	1002	1192	1173	1216	1323	1350	1368	1352	1551	1938
1008	1002	1198	1171	1220	1323	1350	1368	1352	1551	1938
1260	1002	1204	1188	1244	1343	1500	1657	1713	1789	2237
1500	1002	1239	1238	1328	1455	1650	1835	1943	2028	2237
1750	1002	1271	1290	1394	1562	1800	1987	2148	2266	2535
1900	1002	1159	1185	1118	1193	1342	1610	1879	2040	2535
2000	1002	1169	1194	1118	1193	1342	1610	1879	2147	2535
2247	1012	1189	1213	1118	1193	1342	1610	1879	2147	2535
2499	1021	1210	1231	1118	1193	1342	1610	1879	2147	2535
3500	1060	1259	1290	1118	1193	1342	1610	1879	2147	2535
3750	1080	1261	1299	1118	1193	1342	1610	1879	2147	2535
3990	1100	1261	1306	1342	1491	1640	1879	2071	2147	2535
4250	1120	1401	1451	1571	1736	1980	2131	2244	2386	2535
4494	1149	1401	1451	1570	1734	1965	2060	2129	2028	2087
4746	1200	1400	1438	1563	1734	1900	1958	1953	2028	2087

15.23) If we examine this table we now have in 35mg of fuel at 1900rpm a need for 1193 of boost, in our old table we had 1860. We still have enough air for our fuel, instead of having a stoic of 28 we now have a stoic of 20, still well above our 14.7 and a good percentage above our self set 17 ratio. The advantage we now have is that in our old maps the ECU would need to see 1860 befroe it would allow the 35mg of fuel, now it only needs to see 1193 so we do not have to wait for the turbo pressure to build up to 1860 before we get our fuel so we have a more responsive car it has less “turbo lag”.

15.24) Below are all the tables I made in Excel to create this finished table.
The process and math are as follows:

Table 1: Our table we made earlier when we changed all the numbers in it to allow for our new axis where we increased the mg of fuel by 7mg not 5mg per step to make room for 56mg and 70mg.
Table 2: This table takes the figures in our first table and converts them to MAF. To do this we simply use the equation =B3/2.13 where B is our Column and 3 is our Row from the original table.
Table 3: This table now converts our MAF conversion numbers in table 2 and turns them into stoic. We use the equation =N3/B$21 We have the $ sign as want to force Excel to always use the numbers in the top of the axis, the MG's of fuel. If we look at this table we can see a pattern to the stoics as we go across the table at a given rpm. We can now carry this pattern over to our missing 56 and 70mg columns and see the figures we get, this is the same process we used in the graphs before.
Table 4: This table we have manually selected the figures we want to use in the performance areas we want to increase the most, then we have used Excel to calculate the other numbers, now also in RED, to apply "smoothing" to the table i.e. to prevent sudden jumps.
Table 5: we now convert these numbers back to our MAF using the equation =N22 x N$21
Table 6: Finally converting back to "boost" using the equation =B41 x 2.13

Injected Quantity Graph with Boost Figers in Table

rpm	0.0	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	70.0
0	198	198	198	198	198	198	198	198		
21	1002	1192	1173	1216	1323	1350	1368	1352		
1008	1002	1198	1171	1220	1323	1350	1368	1352		
1260	1002	1204	1188	1244	1343	1500	1657	1713		
1500	1002	1239	1238	1328	1455	1650	1835	1943		
1750	1002	1271	1290	1394	1562	1800	1987	2148		
1900	1002	1288	1317	1426	1608	1860	2051	2225		
2000	1002	1299	1327	1446	1631	1880	2085	2253		
2247	1012	1322	1348	1473	1656	1915	2130	2303		
2499	1021	1344	1368	1493	1676	1925	2137	2324		
3500	1060	1399	1434	1557	1731	1965	2168	2329		
3750	1080	1401	1444	1562	1734	1970	2169	2329		
3990	1100	1401	1451	1571	1736	1970	2156	2301		
4250	1120	1401	1451	1571	1736	1980	2131	2244		
4494	1149	1401	1451	1570	1734	1965	2060	2129		
4746	1200	1400	1438	1563	1734	1900	1958	1953		

Injected Quantity Graph converted to Mass Air Flow Figers in Table

rpm	0.0	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	70.0
0	93	93	93	93	93	93	93	93		
21	470	560	551	571	621	634	642	635		
1008	470	563	550	573	621	634	642	635		
1260	470	565	558	584	630	704	778	804		
1500	470	582	581	623	683	775	862	912		
1750	470	597	606	655	734	845	933	1008		
1900	470	605	618	670	755	873	963	1044		
2000	470	610	623	679	766	883	979	1058		
2247	475	620	633	691	777	899	1000	1081		
2499	479	631	642	701	787	904	1003	1091		
3500	498	657	673	731	813	923	1018	1093		
3750	507	658	678	733	814	925	1018	1093		
3990	516	658	681	737	815	925	1012	1080		
4250	526	658	681	737	815	930	1000	1054		
4494	539	658	681	737	814	923	967	999		
4746	563	657	675	734	814	892	919	917		

Injected Quantity Graph MAF Converted to Current Stoic Figers in Table and New Numbers by Pattern

rpm	0.0	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	70.0
0	93	13	7	4	3	3	2	2	2	2
21	470	80	39	27	22	18	15	13	13	13
1008	470	80	39	27	22	18	15	13	13	13
1260	470	81	40	28	23	20	19	16	15	15
1500	470	83	42	30	24	22	21	19	17	15
1750	470	85	43	31	26	24	22	21	19	17
1900	470	86	44	32	27	25	23	21	19	17
2000	470	87	45	32	27	25	23	22	20	18
2247	475	89	45	33	28	26	24	22	20	18
2499	479	90	46	33	28	26	24	22	20	18
3500	498	94	48	35	29	26	24	22	20	18
3750	507	94	48	35	29	26	24	22	20	18
3990	516	94	49	35	29	26	24	22	20	18
4250	526	94	49	35	29	27	24	22	20	18
4494	539	94	49	35	29	26	23	20	17	15
4746	563	94	48	35	29	25	22	19	17	15

Injected Quantity Graph with Current Stoic Figers in Table and New Numbers Calcualted

rpm	0.0	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	70.0
0	93	13	7	4	3	3	2	2	2	2
21	470	80	39	27	22	18	15	13	13	13
1008	470	80	39	27	22	18	15	13	13	13
1260	470	81	40	28	23	20	19	16	15	15
1500	470	83	42	30	24	22	21	19	17	15
1750	470	85	43	31	26	24	22	21	19	17
1900	470	78	40	25	20	18	18	18	17	17
2000	470	78	40	25	20	18	18	18	18	17
2247	475	80	41	25	20	18	18	18	18	17
2499	479	81	41	25	20	18	18	18	18	17
3500	498	84	43	25	20	18	18	18	18	17
3750	507	85	44	25	20	18	18	18	18	17
3990	516	85	44	30	25	22	21	20	18	17
4250	526	94	49	35	29	27	24	22	20	17
4494	539	94	49	35	29	26	23	20	17	14
4746	563	94	48	35	29	25	22	19	17	14

Injected Quantity Graph with New Stoic Values Converted back to Mass Air Flow Figers in Table

rpm	0.0	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	70.0
0	93	93	93	93	93	93	93	93	112	140
21	470	560	551	571	621	634	642	635	728	910
1008	470	563	550	573	621	634	642	635	728	910
1260	470	565	558	584	630	704	778	804	840	1050
1500	470	582	581	623	683	775	862	912	952	1050
1750	470	597	606	655	734	845	933	1008	1064	1190
1900	470	544	556	525	560	630	756	882	958	1190
2000	470	549	561	525	560	630	756	882	1008	1190
2247	475	558	569	525	560	630	756	882	1008	1190
2499	479	568	578	525	560	630	756	882	1008	1190
3500	498	591	606	525	560	630	756	882	1008	1190
3750	507	592	610	525	560	630	756	882	1008	1190
3990	516	592	613	630	700	770	882	972	1008	1190
4250	526	658	681	737	815	930	1000	1054	1120	1190
4494	539	658	681	737	814	923	967	999	952	980
4746	563	657	675	734	814	892	919	917	952	980

Injected Quantity Graph with New Mass Air Flow Figers Converted back to Boost

rpm	0.0	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	70.0
0	198	198	198	198	198	198	198	198	239	298
21	1002	1192	1173	1216	1323	1350	1368	1352	1551	1938
1008	1002	1198	1171	1220	1323	1350	1368	1352	1551	1938
1260	1002	1204	1188	1244	1343	1500	1657	1713	1789	2237
1500	1002	1239	1238	1328	1455	1650	1835	1943	2028	2237
1750	1002	1271	1290	1394	1562	1800	1987	2148	2266	2535
1900	1002	1159	1185	1118	1193	1342	1610	1879	2040	2535
2000	1002	1169	1194	1118	1193	1342	1610	1879	2147	2535
2247	1012	1189	1213	1118	1193	1342	1610	1879	2147	2535
2499	1021	1210	1231	1118	1193	1342	1610	1879	2147	2535
3500	1060	1259	1290	1118	1193	1342	1610	1879	2147	2535
3750	1080	1261	1299	1118	1193	1342	1610	1879	2147	2535
3990	1100	1261	1306	1342	1491	1640	1879	2071	2147	2535
4250	1120	1401	1451	1571	1736	1980	2131	2244	2386	2535
4494	1149	1401	1451	1570	1734	1965	2060	2129	2028	2087
4746	1200	1400	1438	1563	1734	1900	1958	1953	2028	2087

16) Map Change 5 the Boost Limit and the single figure SVBL

That concludes our "boost" map now we need to look at our "SVBL" and our "boost limit" maps.

16.1) Our "boost limit" map, this map has to limit our boost according to our "ambient" air pressure, this is the pressure outside of the car and is related to how high above sea level we are.
Now we see here our bottom line, is actually 1100mbar, this is to allow for unusual air pressure conditions, such as driving under the Channel Tunnel and for weather conditions such as tornado's which could cause a drop in ambient air pressure, if we did not have the margin then our car would go into limp mode or shut the engine off completely to prevent damage.

The other numbers in the map where originally made by VW by changing the atmospheric pressure in the "DYNO" facility. We will use the "relationship ratio" in our new map to calculate these. To make our new "boost limit" map we are going to insert new numbers into the 1100mbar row and get Excel to calculate the other numbers by the relationship between the original map numbers.

	Engine rpm									
Air Pre:	**1500**	**1750**	**1900**	**2250**	**2500**	**3000**	**3500**	**4000**	**4300**	**4700**
600	1600	1825	1950	1965	1955	1915	1715	1505	1365	1305
650	1650	1875	2000	2015	2015	1985	1790	1595	1460	1390
700	1700	1925	2040	2055	2055	2035	1855	1670	1555	1495
750	1750	1975	2100	2125	2125	2105	2020	1835	1720	1590
800	1800	2025	2150	2175	2175	2175	2110	1930	1815	1675
850	1850	2075	2200	2225	2225	2225	2195	2080	1970	1810
900	1900	2125	2250	2300	2300	2300	2280	2205	2110	1940
950	1950	2175	2325	2375	2375	2375	2355	2300	2215	2075
980	2000	2225	2350	2400	2400	2400	2400	**2350**	2275	2160
1100	2000	2225	2350	2400	2400	2400	2400	**2350**	2275	2160

The numbers on our axis for rpm do not exactly match the numbers for rpm in our "boost" map but they are close enough that we can use our numbers from the closest match, 2499rpm in our "boost" map is close enough to use in our 2500rpm boost limiting map. It is important to remember that this map will limit our boost we need to add in a small amount of safety, where we had 2350 as our maximum in the "boost" map we now have 2400 in our "boost limit" map.

16.3) The math for our safety zone 2400/2350= 1.021 if we take our new maximum of 2535 and multiply it by this factor we get 2535 x 1.021 and we get 2588, we will round this up to 2590 for our new Vmax.

The math for the rest of the table if we use 2500rpm at 980mbar we have 2400 and if we look at 950mbar we now have 2375, so we can do a simple equation of 2400/2375= 1.011. We can do the same going sideways i.e. at 1100mbar for 2500rpm and 3000rpm and so on, we only actually need to do this calculation where we have the changes i.e. between 3500 and 4000

On the next page is the series of Excel maps I have used

The original map table

The relationship table

Then finally our calculated table.

	Engine rpm									
Air Press	**1500**	**1750**	**1900**	**2250**	**2500**	**3000**	**3500**	**4000**	**4300**	**4700**
600	1600	1825	1950	1965	1955	1915	1715	1505	1365	1305
650	1650	1875	2000	2015	2015	1985	1790	1595	1460	1390
700	1700	1925	2040	2055	2055	2035	1855	1670	1555	1495
750	1750	1975	2100	2125	2125	2105	2020	1835	1720	1590
800	1800	2025	2150	2175	2175	2175	2110	1930	1815	1675
850	1850	2075	2200	2225	2225	2225	2195	2080	1970	1810
900	1900	2125	2250	2300	2300	2300	2280	2205	2110	1940
950	1950	2175	2325	2375	2375	2375	2355	2300	2215	2075
980	2000	2225	2350	2400	2400	2400	2400	**2350**	2275	2160
1100	2000	2225	2350	2400	2400	2400	2400	**2350**	2275	2160

	Engine rpm									
Air Press	**1500**	**1750**	**1900**	**2250**	**2500**	**3000**	**3500**	**4000**	**4300**	**4700**
600	1.031	1.027	1.026	1.025	1.031	1.037	1.044	1.060	1.070	1.065
650	1.030	1.027	1.020	1.020	1.020	1.025	1.036	1.047	1.065	1.076
700	1.029	1.026	1.029	1.034	1.034	1.034	1.089	1.099	1.106	1.064
750	1.029	1.025	1.024	1.024	1.024	1.033	1.045	1.052	1.055	1.053
800	1.028	1.025	1.023	1.023	1.023	1.023	1.040	1.078	1.085	1.081
850	1.027	1.024	1.023	1.034	1.034	1.034	1.039	1.060	1.071	1.072
900	1.026	1.024	1.033	1.033	1.033	1.033	1.033	1.043	1.050	1.070
950	1.026	1.023	1.011	1.011	1.011	1.011	1.019	1.022	1.027	1.041
980	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1100	1.113	1.056	1.021	1.000	1.000	1.000	1.000	1.021	1.033	1.053

	Engine rpm									
Air Press	**1500**	**1750**	**1900**	**2250**	**2500**	**3000**	**3500**	**4000**	**4300**	**4700**
600	1720	1962	2096	2112	2102	2059	1844	1618	1467	1403
650	1774	2016	2150	2166	2166	2134	1924	1715	1570	1494
700	1828	2069	2193	2209	2209	2188	1994	1795	1672	1607
750	1881	2123	2258	2284	2284	2263	2172	1973	1849	1709
800	1935	2177	2311	2338	2338	2338	2268	2075	1951	1801
850	1989	2231	2365	2392	2392	2392	2360	2236	2118	1946
900	2043	2284	2419	2473	2473	2473	2451	2370	2268	2086
950	2096	2338	2499	2553	2553	2553	2532	2473	2381	2231
980	2150	2392	2526	2580	2580	2580	2580	2526	2446	2322
1100	2150	2392	2526	2580	2580	2580	2580	2526	2446	2322

16.5) Now we need to look at the final part in the "BOOST SERIES" the SVBL which is or single boost limit value. This is a single number, go over it and we will get either an engine cut until the boost drops naturally or we will get a car going into limit.

The original SVBL was 2620 and our old max boost was 2350, now we have a new max of 2580 which is still under our SVBL but it is close to it. Here we have a lucky break, as our new "boost" is below the SVBL we do not need to work out if the engine is going to take our "new boost" levels but we do need to change the SVBL otherwise we will have "cut" or "limp" situations. The old relationship value was 2350 to 2620 (2620/2350 = 1.115) applying this relationship we get 2877. AS the relationship ratio is 11% I would happily set this figure, we can reasonably assume that the manufactures safe calculations will allow for a 15%, it is probably actually in the 20% to 25% region

What to do if we are over this 15% limit?

We are stage 1 mapping so we need to reign the boost levels down and recalculate our maps.

If we are stage 2 mapping we would look at the engines build, its compression ratio etc.. This is covered in another paper as it is longer than this guide.

17) Map Change 6 and 7 the "Start of Injection" and "Duration" of Injection maps

We need to look at both of these maps together to be able to make any changes. Our "bad tuner" will usually only make changes to the "duration" to inject more fuel and if he makes changes the start of injection they will be guesses, there is a well know technique taught to do the guess which we will look at first. Then when we look at how to actually do it you can see how bad this way is.

17.1) Before we look at the maps there is 2 important things we need to understand.
The first is that the actual important factor is END and not START of injection as this is the "timing" of the engine, on a petrol engine we adjust the time of the spark, we must get this correct to get all the power out of our engine we can, this is our "efficiency" that we always chase.
The second and this is why so many "bad tuners" exist is that any alteration we make here the ECU cannot fix, with al our other maps and alterations if we got something wrong then other maps and the ECU feedback from its sensors will tune out the issues, it won't save us from real bad mistakes but it will sort out a lot, however that is at the expense of the quality of our overall tune. The SOI and Duration maps directly control the output to the injector signal, get these maps wrong and when the ECU gets feedback from a sensor and makes a new calculation and sends a new signal to the SIO and Duration maps it doesn't get the output it expected so its ability to correct has gone.

17.2) Below is our "bad tuners" revised Duration map to add in 65 and 70mg of fuel

	100	200	600	800	1000	1250	1500	1750	2000	2500	3000	3500	3800	4000	4500	5000
0.50	8.09	7.97	7.12	6.23	5.37	4.83	3.94	3.23	2.25	0.26	-1.66	-2.86	-3.47	-3.87	-4.05	-4.41
2.00	9.12	9.00	8.20	7.15	6.28	5.88	5.44	4.76	3.77	2.04	0.28	-1.50	-2.41	-2.65	-3.35	-3.77
5.00	10.52	10.36	9.09	8.09	7.05	6.59	6.30	5.70	5.02	3.47	1.65	0.12	-0.89	-1.41	-2.39	-2.84
7.00	11.18	11.06	9.80	8.91	7.71	7.24	6.82	6.40	5.67	4.31	2.93	1.48	0.40	-0.28	-1.45	-1.92
10.00	11.67	11.55	10.45	9.68	8.51	7.76	7.45	7.27	6.59	5.32	4.20	2.98	1.83	1.05	-0.37	-0.84
15.00	12.19	11.98	11.02	10.27	9.47	9.52	9.21	8.58	8.41	7.69	6.82	6.70	5.32	4.41	2.93	1.76
20.00	12.66	12.42	11.53	10.92	10.27	10.38	10.34	9.84	10.38	9.91	9.21	9.75	9.28	8.79	7.12	5.02
25.00	13.20	12.96	12.23	11.72	11.25	11.60	11.72	11.53	11.81	12.45	12.35	12.42	12.14	12.21	11.53	10.29
30.00	13.92	13.69	12.96	12.59	12.26	12.94	13.31	13.22	13.80	14.32	14.69	15.35	14.93	14.95	14.60	14.09
35.00	14.60	14.37	13.66	13.34	13.55	14.32	15.02	15.42	15.66	16.34	16.94	17.84	18.07	18.00	17.48	17.16
40.00	15.35	15.12	14.27	14.41	15.07	15.56	16.62	17.11	17.37	18.16	19.15	19.97	20.37	20.48	20.79	20.79
45.00	15.87	15.52	14.81	15.02	16.12	16.80	17.98	18.54	19.34	20.60	21.80	22.38	23.02	23.39	24.02	24.00
50.00	16.45	16.17	15.37	15.70	16.90	17.88	19.05	19.87	20.84	22.96	23.86	24.54	25.41	25.59	26.18	26.32
55.00	17.37	17.02	16.10	16.50	17.62	19.17	20.32	21.49	22.62	24.16	25.83	26.58	27.28	27.42	28.01	28.17
60.00	17.93	17.58	16.92	17.46	18.70	20.39	21.56	22.78	24.00	25.55	27.28	28.24	28.97	29.18	29.58	29.81
65.00	17.58	16.92	17.46	18.70	20.39	21.56	22.78	24.00	25.55	27.28	28.24	26.97	29.18	29.58	29.81	
70.00	18.92	17.46	18.70	20.39	21.56	22.78	24.00	25.55	27.28	28.24	26.97	29.18	29.58	29.81		

17.3) What he has done is the "trick" to guessing. He has taken the number from 2000rpm and 60mg of fuel and put it in the box for 65mg of fuel at 1750rpm, he has done this all across the 65mg row. Then he has taken the numbers from the 65mg row and used them in his 70mg row by moving them again 1 column to the left. This has left the 65mg 5000rpm and the 70mg 4500 and 5000rpm columns empty. He now does one of 2 things, he either has a guess what they should be or he uses the same numbers in the last cell (29.81) and puts it in the missing 3 cells, after all we are never going to have a situation where we need this much fuel at this rpm as the torque map cuts it 0mg .

17.4) So what is the correct way, well we have to actually consider a lot of factors here, because we have to time the "end of injection" with a piston travelling at different rpm and also differing velocities with the rpm i.e. a piston travelling at 3000rpm goes up and down 50 times a second but it also has to be stationary and change direction of travel at the top and the bottom of the cylinder so it has a varying velocity as well. What does this mean to our SOI? If we start our injection sooner it is happening when the piston is actually at a greater velocity it as Vmax when it is half way up the cylinder and V0 when at the top so we have to factor in the extra velocity. Truthfully in our stage 1 mapping we do not need to calculate this we can use a figure of 1.00164 and be acceptably close.

How we do our Start of Injection and duration of injection maps. Excel again with its powers! We take our SOI and Duration maps and overlay them to give us our "END of Injection" we can then use this to calculate the correct "start of injection" for our new fuel requests.

17.5) Here are our map tables and our new "end of injection" table that we have made.

Start of Injection														
	0.0	5.0	7.5	10.0	15.0	20.0	22.5	25.0	30.0	35.0	40.0	45.0	50.0	55.0
100	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99
400	0.00	0.00	0.00	0.00	1.99	5.49	9.00	12.00	13.99	15.00	15.00	15.00	15.00	15.00
800	0.00	0.00	0.00	0.00	1.99	5.49	9.00	12.00	13.99	15.00	15.00	15.00	15.00	15.00
1000	0.00	0.00	0.00	0.00	1.99	5.49	9.00	12.00	13.99	15.00	15.00	15.00	15.00	15.00
1250	0.70	0.70	0.70	0.70	1.99	5.49	9.00	12.00	13.48	15.00	15.00	15.00	15.00	15.00
1500	1.71	1.71	1.71	1.71	2.39	4.64	6.14	7.60	10.01	12.31	13.01	13.01	13.01	13.01
1750	2.42	2.42	2.42	2.42	3.21	4.85	6.17	7.29	8.51	10.67	11.51	11.51	11.51	11.51
2000	2.95	2.95	2.95	2.95	3.68	5.04	6.24	7.29	8.51	10.50	12.00	12.00	12.00	12.00
2250	3.75	3.75	3.75	3.75	4.43	5.88	7.03	7.99	9.10	11.04	13.24	13.24	13.24	13.24
2500	5.51	5.51	5.51	5.51	6.21	7.15	8.16	9.31	10.60	12.00	14.60	14.60	14.60	14.60
2750	7.57	7.57	7.57	8.32	9.24	10.24	11.37	12.21	13.20	14.13	16.01	16.48	16.48	16.48
3000	9.33	9.33	9.33	10.95	12.28	13.24	14.20	15.02	15.77	16.57	17.72	18.42	18.42	18.42
3500	12.26	12.26	12.26	14.44	16.55	17.39	18.07	19.01	19.88	20.42	21.19	22.24	22.24	22.24
4000	15.00	15.00	15.00	17.25	19.99	21.00	21.59	22.01	22.50	23.06	23.51	24.00	24.00	24.00
4250	15.94	15.94	15.94	17.95	20.81	21.47	21.99	22.43	23.02	23.51	23.98	24.45	24.45	24.45
5000	17.35	17.35	17.35	19.17	21.75	22.52	22.99	23.42	24.09	24.56	25.03	25.50	25.50	25.50

Duration of Injection														
	0.50	2.00	5.00	7.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	55.00
100	8.09	9.12	10.52	11.18	11.67	12.19	12.66	13.20	13.92	14.60	15.35	15.87	16.45	17.37
200	7.97	9.00	10.36	11.06	11.55	11.98	12.42	12.96	13.69	14.37	15.12	15.52	16.17	17.02
600	7.12	8.20	9.09	9.80	10.45	11.02	11.53	12.23	12.96	13.66	14.27	14.81	15.37	16.10
800	6.23	7.15	8.09	8.91	9.68	10.27	10.92	11.72	12.59	13.34	14.41	15.02	15.70	16.50
1000	5.37	6.28	7.05	7.71	8.51	9.47	10.27	11.25	12.26	13.55	15.07	16.12	16.90	17.62
1250	4.83	5.88	6.59	7.24	7.76	9.52	10.38	11.60	12.94	14.32	15.56	16.80	17.88	19.17
1500	3.94	5.44	6.30	6.82	7.45	9.21	10.34	11.72	13.31	15.02	16.62	17.98	19.05	20.32
1750	3.23	4.76	5.70	6.40	7.27	8.58	9.84	11.53	13.22	15.42	17.11	18.54	19.87	21.49
2000	2.25	3.77	5.02	5.67	6.59	8.41	10.38	11.81	13.80	15.66	17.37	19.34	20.84	22.62
2500	0.26	2.04	3.47	4.31	5.32	7.69	9.91	12.45	14.32	16.34	18.16	20.60	22.96	24.16
3000	-1.66	0.28	1.65	2.93	4.20	6.82	9.21	12.35	14.69	16.94	19.15	21.80	23.86	25.83
3500	-2.86	-1.50	0.12	1.48	2.98	6.70	9.75	12.42	15.35	17.84	19.97	22.38	24.54	26.58
3800	-3.47	-2.41	-0.89	0.40	1.83	5.32	9.28	12.14	14.93	18.07	20.37	23.02	25.41	27.28
4000	-3.87	-2.65	-1.41	-0.28	1.05	4.41	8.79	12.21	14.95	18.00	20.48	23.39	25.59	27.42
4500	-4.05	-3.35	-2.39	-1.45	-0.37	2.93	7.12	11.53	14.60	17.48	20.79	24.02	26.18	28.01
5000	-4.41	-3.77	-2.84	-1.92	-0.84	1.76	5.02	10.29	14.09	17.16	20.79	24.00	26.32	28.17

END of Injection														
	0.50	2.00	5.00	7.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	55.00
100	2.90	1.87	0.47	-0.19	-0.68	-1.20	-1.67	-2.21	-2.93	-3.61	-4.36	-4.88	-5.46	-6.38
200	-7.97	-9.00	-10.36	-11.06	-9.56	-6.49	-3.42	-0.96	0.30	0.63	-0.12	-0.52	-1.17	-2.02
600	-7.12	-8.20	-9.09	-9.80	-8.46	-5.53	-2.53	-0.23	1.03	1.34	0.73	0.19	-0.37	-1.10
800	-6.23	-7.15	-8.09	-8.91	-7.69	-4.78	-1.92	0.28	1.40	1.66	0.59	-0.02	-0.70	-1.50
1000	-4.67	-5.58	-6.35	-7.01	-6.52	-3.98	-1.27	0.75	1.22	1.45	-0.07	-1.12	-1.90	-2.62
1250	-3.12	-4.17	-4.88	-5.53	-5.37	-4.88	-4.24	-4.00	-2.93	-2.01	-2.55	-3.79	-4.87	-6.16
1500	-1.52	-3.02	-3.88	-4.40	-4.24	-4.36	-4.17	-4.43	-4.80	-4.35	-5.11	-6.47	-7.54	-8.81
1750	-0.28	-1.81	-2.75	-3.45	-3.59	-3.54	-3.60	-4.24	-4.71	-4.92	-5.11	-6.54	-7.87	-9.49
2000	1.50	-0.02	-1.27	-1.92	-2.16	-2.53	-3.35	-3.82	-4.70	-4.62	-4.13	-6.10	-7.60	-9.38
2500	5.25	3.47	2.04	1.20	0.89	-0.54	-1.75	-3.14	-3.72	-4.34	-3.56	-6.00	-8.36	-9.56
3000	9.23	7.29	5.92	5.39	5.04	3.42	2.16	-0.14	-1.49	-2.81	-3.14	-5.32	-7.38	-9.35
3500	12.19	10.83	9.21	9.47	9.30	6.54	4.45	2.60	0.42	-1.27	-2.25	-3.96	-6.12	-8.16
3800	15.73	14.67	13.15	14.04	14.72	12.07	8.79	6.87	4.95	2.35	0.82	-0.78	-3.17	-5.04
4000	18.87	17.65	16.41	17.53	18.94	16.59	12.80	9.80	7.55	5.06	3.03	0.61	-1.59	-3.42
4500	19.99	19.29	18.33	19.40	21.18	18.54	14.87	10.90	8.42	6.03	3.19	0.43	-1.73	-3.56
5000	21.76	21.12	20.19	21.09	22.59	20.76	17.97	13.13	10.00	7.40	4.24	1.50	-0.82	-2.67

If we look at the end of injection we can see at the peak power ranges the end of injection has a – in front of the number, this is that the injection has occurred after TDC and in the economy range it is a positive number. To calculate our new numbers we can change our end of injection mg axis to our new numbers as we are going to be adding more fuel and more boost it is a safe rule of thumb to change the 55mg heading to 70mg if we work out our increase in boost (and correct it for our stoic change) and our increase in fuel we get 27% increase in fuel and 29% increase in MAF

17.6) If we change our table to add in 60mg and 70mg we can in this scenario remove our 5mg column and copy over our 7mg axis heading and our 7mg column data, and I will also remove the 45mg axis and column data copying over the 55mg axis and column data. My reasons for this are that the change in end of injection figures are relatively linear between 45mg and 55mg and our 5mg is such a small amount that removing it when we have data for 0,2,5,7 and 10 that our ECU will be able to calculate all these figures anyway. When we copy the data across we end up with the 45mg column being out of sync, the numbers go up as we see in the modified table below.

New END of Injection														
	0.50	2.00	7.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	60.00	70.00
100	2.90	1.87	-0.19	-0.68	-1.20	-1.67	-2.21	-2.93	-3.61	-4.36	-5.46	-4.88	-5.46	-6.38
200	-7.97	-9.00	-11.06	-9.56	-6.49	-3.42	-0.96	0.30	0.63	-0.12	-1.17	-0.52	-1.17	-2.02
600	-7.12	-8.20	-9.80	-8.46	-5.53	-2.53	-0.23	1.03	1.34	0.73	-0.37	0.19	-0.37	-1.10
800	-6.23	-7.15	-8.91	-7.69	-4.78	-1.92	0.28	1.40	1.66	0.59	-0.70	-0.02	-0.70	-1.50
1000	-4.67	-5.58	-7.01	-6.52	-3.98	-1.27	0.75	1.22	1.45	-0.07	-1.90	-1.12	-1.90	-2.62
1250	-3.12	-4.17	-5.53	-5.37	-4.88	-4.24	-4.00	-2.93	-2.01	-2.55	-4.87	-3.79	-4.87	-6.16
1500	-1.52	-3.02	-4.40	-4.24	-4.36	-4.17	-4.43	-4.80	-4.35	-5.11	-7.54	-6.47	-7.54	-8.81
1750	-0.28	-1.81	-3.45	-3.59	-3.54	-3.60	-4.24	-4.71	-4.92	-5.11	-7.87	-6.54	-7.87	-9.49
2000	1.50	-0.02	-1.92	-2.16	-2.53	-3.35	-3.82	-4.70	-4.62	-4.13	-7.60	-6.10	-7.60	-9.38
2500	5.25	3.47	1.20	0.89	-0.54	-1.75	-3.14	-3.72	-4.34	-3.56	-8.36	-6.00	-8.36	-9.56
3000	9.23	7.29	5.39	5.04	3.42	2.16	-0.14	-1.49	-2.81	-3.14	-7.38	-5.32	-7.38	-9.35
3500	12.19	10.83	9.47	9.30	6.54	4.45	2.60	0.42	-1.27	-2.25	-6.12	-3.96	-6.12	-8.16
3800	15.73	14.67	14.04	14.72	12.07	8.79	6.87	4.95	2.35	0.82	-3.17	-0.78	-3.17	-5.04
4000	18.87	17.65	17.53	18.94	16.59	12.80	9.80	7.55	5.06	3.03	-1.59	0.61	-1.59	-3.42
4500	19.99	19.29	19.40	21.18	18.54	14.87	10.90	8.42	6.03	3.19	-1.73	0.43	-1.73	-3.56
5000	21.76	21.12	21.09	22.59	20.76	17.97	13.13	10.00	7.40	4.24	-0.82	1.50	-0.82	-2.67

To correct this we just need to average the figures between the new 40 and 50mg columns, we can use Excel to do this by inserting the formula (only in the 45mg column) =(K61/2)+(M61/2), here we divide the number in our 40mg column in half and do the same for our 50mg column then add the 2 together and we have our average figure for the 45mg column.

17.7) My new end of injection table looks like this now.

New END of Injection														
	0.50	2.00	7.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	60.00	70.00
100	2.90	1.87	-0.19	-0.68	-1.20	-1.67	-2.21	-2.93	-3.61	-4.36	-4.62	-4.88	-5.46	-6.38
200	-7.97	-9.00	-11.06	-9.56	-6.49	-3.42	-0.96	0.30	0.63	-0.12	-0.32	-0.52	-1.17	-2.02
600	-7.12	-8.20	-9.80	-8.46	-5.53	-2.53	-0.23	1.03	1.34	0.73	0.46	0.19	-0.37	-1.10
800	-6.23	-7.15	-8.91	-7.69	-4.78	-1.92	0.28	1.40	1.66	0.59	0.29	-0.02	-0.70	-1.50
1000	-4.67	-5.58	-7.01	-6.52	-3.98	-1.27	0.75	1.22	1.45	-0.07	-0.60	-1.12	-1.90	-2.62
1250	-3.12	-4.17	-5.53	-5.37	-4.88	-4.24	-4.00	-2.93	-2.01	-2.55	-3.17	-3.79	-4.87	-6.16
1500	-1.52	-3.02	-4.40	-4.24	-4.36	-4.17	-4.43	-4.80	-4.35	-5.11	-5.79	-6.47	-7.54	-8.81
1750	-0.28	-1.81	-3.45	-3.59	-3.54	-3.60	-4.24	-4.71	-4.92	-5.11	-5.83	-6.54	-7.87	-9.49
2000	1.50	-0.02	-1.92	-2.16	-2.53	-3.35	-3.82	-4.70	-4.62	-4.13	-5.12	-6.10	-7.60	-9.38
2500	5.25	3.47	1.20	0.89	-0.54	-1.75	-3.14	-3.72	-4.34	-3.56	-4.78	-6.00	-8.36	-9.56
3000	9.23	7.29	5.39	5.04	3.42	2.16	-0.14	-1.49	-2.81	-3.14	-4.23	-5.32	-7.38	-9.35
3500	12.19	10.83	9.47	9.30	6.54	4.45	2.60	0.42	-1.27	-2.25	-3.11	-3.96	-6.12	-8.16
3800	15.73	14.67	14.04	14.72	12.07	8.79	6.87	4.95	2.35	0.82	0.02	-0.78	-3.17	-5.04
4000	18.87	17.65	17.53	18.94	16.59	12.80	9.80	7.55	5.06	3.03	1.82	0.61	-1.59	-3.42
4500	19.99	19.29	19.40	21.18	18.54	14.87	10.90	8.42	6.03	3.19	1.81	0.43	-1.73	-3.56
5000	21.76	21.12	21.09	22.59	20.76	17.97	13.13	10.00	7.40	4.24	2.87	1.50	-0.82	-2.67

17.8) We can now use this table to do the reverse of how we made it and we end up with the set of tables below which will give us our new start and duration if injection.

New END of Injection														
	0.50	2.00	7.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	60.00	70.00
100	2.90	1.87	-0.19	-0.68	-1.20	-1.67	-2.21	-2.93	-3.61	-4.36	-4.62	-4.88	-5.46	-6.38
200	-7.97	-9.00	-11.06	-9.56	-6.49	-3.42	-0.96	0.30	0.63	-0.12	-0.32	-0.52	-1.17	-2.02
600	-7.12	-8.20	-9.80	-8.46	-5.53	-2.53	-0.23	1.03	1.34	0.73	0.46	0.19	-0.37	-1.10
800	-6.23	-7.15	-8.91	-7.69	-4.78	-1.92	0.28	1.40	1.66	0.59	0.29	-0.02	-0.70	-1.50
1000	-4.67	-5.58	-7.01	-6.52	-3.98	-1.27	0.75	1.22	1.45	-0.07	-0.60	-1.12	-1.90	-2.62
1250	-3.12	-4.17	-5.53	-5.37	-4.88	-4.24	-4.00	-2.93	-2.01	-2.55	-3.17	-3.79	-4.87	-6.16
1500	-1.52	-3.02	-4.40	-4.24	-4.36	-4.17	-4.43	-4.80	-4.35	-5.11	-5.79	-6.47	-7.54	-8.81
1750	-0.28	-1.81	-3.45	-3.59	-3.54	-3.60	-4.24	-4.71	-4.92	-5.11	-5.83	-6.54	-7.87	-9.49
2000	1.50	-0.02	-1.92	-2.16	-2.53	-3.35	-3.82	-4.70	-4.62	-4.13	-5.12	-6.10	-7.60	-9.38
2500	5.25	3.47	1.20	0.89	-0.54	-1.75	-3.14	-3.72	-4.34	-3.56	-4.78	-6.00	-8.36	-9.56
3000	9.23	7.29	5.39	5.04	3.42	2.16	-0.14	-1.49	-2.81	-3.14	-4.23	-5.32	-7.38	-9.35
3500	12.19	10.83	9.47	9.30	6.54	4.45	2.60	0.42	-1.27	-2.25	-3.11	-3.96	-6.12	-8.16
3800	15.73	14.67	14.04	14.72	12.07	8.79	6.87	4.95	2.35	0.82	0.02	-0.78	-3.17	-5.04
4000	18.87	17.65	17.53	18.94	16.59	12.80	9.80	7.55	5.06	3.03	1.82	0.61	-1.59	-3.42
4500	19.99	19.29	19.40	21.18	18.54	14.87	10.90	8.42	6.03	3.19	1.81	0.43	-1.73	-3.56
5000	21.76	21.12	21.09	22.59	20.76	17.97	13.13	10.00	7.40	4.24	2.87	1.50	-0.82	-2.67

New Duration of Injection														
	0.50	2.00	7.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	60.00	70.00
100	8.09	9.12	11.18	11.67	12.19	12.66	13.20	13.92	14.60	15.35	15.87	16.45	17.93	20.92
200	7.97	9.00	11.06	11.55	11.98	12.42	12.96	13.69	14.37	15.12	15.52	16.17	17.58	20.51
600	7.12	8.20	9.80	10.45	11.02	11.53	12.23	12.96	13.66	14.27	14.81	15.37	16.92	19.74
800	6.23	7.15	8.91	9.68	10.27	10.92	11.72	12.59	13.34	14.41	15.02	15.70	17.46	20.37
1000	5.37	6.28	7.71	8.51	9.47	10.27	11.25	12.26	13.55	15.07	16.12	16.90	18.70	21.82
1250	4.83	5.88	7.24	7.76	9.52	10.38	11.60	12.94	14.32	15.56	16.80	17.88	20.39	23.79
1500	3.94	5.44	6.82	7.45	9.21	10.34	11.72	13.31	15.02	16.62	17.98	19.05	21.56	25.15
1750	3.23	4.76	6.40	7.27	8.58	9.84	11.53	13.22	15.42	17.11	18.54	19.87	22.78	26.58
2000	2.25	3.77	5.67	6.59	8.41	10.38	11.81	13.80	15.66	17.37	19.34	20.84	24.00	28.00
2500	0.26	2.04	4.31	5.32	7.69	9.91	12.45	14.32	16.34	18.16	20.60	22.96	25.55	29.81
3000	-1.66	0.28	2.93	4.20	6.82	9.21	12.35	14.69	16.94	19.15	21.80	23.86	27.28	31.83
3500	-2.86	-1.50	1.48	2.98	6.70	9.75	12.42	15.35	17.84	19.97	22.38	24.54	28.24	32.95
3800	-3.47	-2.41	0.40	1.83	5.32	9.28	12.14	14.93	18.07	20.37	23.02	25.41	28.97	33.80
4000	-3.87	-2.65	-0.28	1.05	4.41	8.79	12.21	14.95	18.00	20.48	23.39	25.59	29.18	34.04
4500	-4.05	-3.35	-1.45	-0.37	2.93	7.12	11.53	14.60	17.48	20.79	24.02	26.18	29.58	34.51
5000	-4.41	-3.77	-1.92	-0.84	1.76	5.02	10.29	14.09	17.16	20.79	24.00	26.32	29.81	34.78

New START of Injection														
	0.50	2.00	7.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	60.00	70.00
100	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	11.25	11.57	12.47	14.54
200	0.00	0.00	0.00	1.99	5.49	9.00	12.00	13.99	15.00	15.00	15.20	15.65	16.41	18.49
600	0.00	0.00	0.00	1.99	5.49	9.00	12.00	13.99	15.00	15.00	15.27	15.56	16.55	18.64
800	0.00	0.00	0.00	1.99	5.49	9.00	12.00	13.99	15.00	15.00	15.31	15.68	16.76	18.87
1000	0.70	0.70	0.70	1.99	5.49	9.00	12.00	13.48	15.00	15.00	15.53	15.78	16.80	19.20
1250	1.71	1.71	1.71	2.39	4.64	6.14	7.60	10.01	12.31	13.01	13.63	14.09	15.52	17.63
1500	2.42	2.42	2.42	3.21	4.85	6.17	7.29	8.51	10.67	11.51	12.19	12.58	14.02	16.34
1750	2.95	2.95	2.95	3.68	5.04	6.24	7.29	8.51	10.50	12.00	12.72	13.33	14.91	17.09
2000	3.75	3.75	3.75	4.43	5.88	7.03	7.99	9.10	11.04	13.24	14.23	14.74	16.40	18.62
2500	5.51	5.51	5.51	6.21	7.15	8.16	9.31	10.60	12.00	14.60	15.82	16.96	17.19	20.25
3000	7.57	7.57	8.32	9.24	10.24	11.37	12.21	13.20	14.13	16.01	17.57	18.54	19.90	22.48
3500	9.33	9.33	10.95	12.28	13.24	14.20	15.02	15.77	16.57	17.72	19.28	20.58	22.12	24.79
3800	12.26	12.26	14.44	16.55	17.39	18.07	19.01	19.88	20.42	21.19	23.04	24.63	25.80	28.76
4000	15.00	15.00	17.25	19.99	21.00	21.59	22.01	22.50	23.06	23.51	25.21	26.20	27.59	30.62
4500	15.94	15.94	17.95	20.81	21.47	21.99	22.43	23.02	23.51	23.98	25.83	26.61	27.85	30.95
5000	17.35	17.35	19.17	21.75	22.52	22.99	23.42	24.09	24.56	25.03	26.87	27.82	28.99	32.11

17.9) If we refer back to our “bad tuners” guesses we can see that at 4000rpm and 70mg of fuel he was calling for 29.81 degrees, our actual figure is 34.18 so he would actually be getting 61mg of fuel and the ECU cannot correct for this so we will be running lean and not making the power we wanted

And that is the power of Excel, oh and a special thanks to VW for lending us all their expertise.

James from www.OBD2Equipment.com

18) The correct process to map a car.

18.1) Understand what you have.
Before we map a car we should look at all the maps and see wht we have in them. From reading this document you will have seen several examples where we changed a map nly to see in the next map that we couldn't have what we wanted. Our first job is to gather all the information in a "crib sheet" I have included all my "crib sheets" at the end of this guide so I will not go through every detail now we will just deal with the basic numbers and maps and then we can see the correct order to map.

Drivers wish max 70mg

Smoke map max 58mg at 1050mbar of air

Torque map 52mg 1900-2750rpm

Boost map 2350mabr at 50mg 2500-2750rpm
Stoic value 22 stoic of 17 = 64mg of fuel possible at 2350

Boost limit 2400mbar at 2250 – 3500rpm

SVBL 2620 increased by 15% = 3000mbar

Start of Injection max 55mg

Duration of injection max 60mg

My crib sheet has a lot more factors in it that you should be aware of before you start.

18.2) How to use the information the process.
A) We can see that our boost map only allows for 50mg of fuel so we will need to modify this, however we can see that the boost map will allow 64mg when it is stoic corrected of fuel before we need to increase boost, as we have worked out 50mg to 64mg represents a 28% increase so we do not need to change the figures in the table on the numbers on the axis.
B) Look at the Duration of injection, we have 60mg on this table, 60mg of fuel gives us 20% increase, in our stage 1 map 20% is enough that I will use 60mg as my max and not alter the Duration map
C) Start of injection, only has 55mg so we need to add in a 60mg axis
D) SVBL as our boost map is ok then our SVBL is also ok there is no need to alter it
E) Boost Limit map, here we have to look at the peak boost rpm range and then decide if we need to modify it
F) Torque map needs to be increased to make use of the extra fuel we have
G) Smoke map needs to have all new values for our stoic in it, as we have 1103mbar available from our boost I will only change the last column axis value to 1100 instead of the original 1050 to make use of what we have and use it correctly.

1) Modify our Start of Injection to add in 60mg as the new max
2) Change our boost map using 60mg as our new max, lower the boost called for in the table to match our desired stoic values to improve turbo lag and responsiveness
3) Alter the boost limit map to match our desired performance rpm range, check against our stoics
4) Use our stoic values to change the smoke map, change the 1050 axis to 1100.
5) Use our new 60mg figure and our boost map to set new figures in the torque map 1000mbar
6) Refine all the other figures in the maps according to what you have learned in this guide
7) Set up your drivers wish as you decide you want to

James from www.OBD2Equipment.com

22) Tuning Software

There is a lot of tuning software out there and it is a personal choice for you to make as to what you use. I will compare ECM Titanium and WinOls in this quick guide and give reasons for and against.

ECM Titanium

This software is good for people starting out in tuning, but it is limited in what you can actually do. The software has a nice user interface and loading a file in gives you a column on the right with all the maps listed in it.
ECM does this by using a “protocol”, these protocols have to be written by the software maker and currently there is in the region of 22,500 available.
A protocol may cover many different cars a Golf TDI from 2004 will be the same as an Audi, Seat, or Skoda from the same year or maybe from a similar year. I have also seen a 2004 Nissan and 2006 Vauxhall with the same protocol but the 2004 and 2005 Vauxhall’s were different.

The advantage of this system is that it finds all these maps for you and arranges them nicely in a selection box for you to work on them as you please.
The downside is a) if there is no protocol you can’t do anything and b) like a modern car with its easy to use “auto wipers” and “auto lights” they are great 95% of the time but auto wipers only work if rain is on the sensor so a splash from a puddle after the rain can cover the windscreen where we need to see the road and not the sensor, or with auto lights they are great at night but what happens in heavy rain, fog or snow when you need them on so other cars can see you much easier. For ECM sometimes it gets the maps in the wrong place in the list, other times is just doesn’t see them at all. ECM will decide what you can see, it will not let you find something if it is not in the list.

WinOls

Our other example is WinOls.
WinOls allows you to find everything, it is the map writes must have software.
The problem with WinOls is you have to find the maps and work out what they are, you need to look at the entire ECU data and find each map in it.
Not easy at first but then nor was learning to ride a bike, you will struggle at first but there is plenty of help on the internet and the more you do it just like with the bike, the easier and better you become.

What should you do then?

It is worth spending the time however to learn WinOls but I would always advise you use ECM for the first 25 – 50 map writing exercises you do and that these should be on older Turbo Diesel cars such as the 1996 to 2004 range of VW TDi’s Then switch to WinOls and remap these same cars that way you are familiar with what you are looking at and how you modified the maps you started with.

James from www.OBD2Equipment.com

23) The Great MPG manufacturers scam

So you think your car does 35mpg, you even have one of those inbuilt computers that tells you your mpg instantly. Well is doesn't so let me explain.

Your car has a Speedometer which tells you how fast you're going, and it then has a milometer to tell you how far you have travelled the milometer calculates the distance travelled using the same sensor as the speedometer does.

So here is why you're MPG is so wrong, Speedometers have an amount of in-accuracy built into them. That is when you're doing 50mph on the speedo you're actual speed is less, if you have a sat-nav that is on your phone or is a unit you can stick to the dashboard (i.e. not an in-car built in) then you will be able to see your mph on it, this will be different from what you see on your speedo.

Why? Well the Speedo is set with a safe zone there are a few reasons for this.
Your height, the higher you sit changes the viewing angle between the speedo needle and the speedo dial.
The tyres you have fitted, identical cars can come with different wheel and tyre combinations, you may order your car with standard steel wheels, wheel covers and tyres that are 205/65/15 or you could order it with the 16 inch alloys option then you have 205/55/16. Now the issue is that a 205/65/15 tyre has a rolling radius of 648mm and the 205/55/16 has a rolling radius of 632mm, if we chose a 205/60/15 we will have 652mm when new.
Our 205/65/15 wheel when new has 9mm of tread that gives it the 648mm when it has only 2mm of tread its rolling diameter becomes 634mm, so now let's work out how far each wheel travels per revolution. 648mm x3.14 = 2034.74mm and our worn tyre travels 1990.76mm. The difference is 0.9783% at 60mph that is 58.6mph real mph.

If we apply that to our MPG figures we find that 35mpg is actually 34.2mpg. Not to bad you think we can live with that, well no there is another factor to consider, to prevent us from driving at an indicated 50mph and a speed camera flashing us because of our tyre size and our viewing angle manufactures work in a % safety factory normally between 5% and 8%, this is to avoid us trying to sue them if we get a speeding ticket. So if we now add in the extra factory safety we see our mpg is now not 35mpg, nor 34.2mpg but it is actually 31.4mpg.

This factoring of wheel sizes means the smaller the wheel size the bigger the difference is going to be, if we applied this to a small hatchback on 165/80/13 we end up with 45mpg being 40mpg.

We also need to look at this a different way, your 60,000 mile car has actually done 58,560 miles, so the manufacture is making you replace your car sooner if you use the mileage as a governing factor such as company or lease-plan cars.

And that is the great MPG scam.

James from www.OBD2Equipment.com

24) The water powered petrol engine.

This is how to make any petrol engine run on water, yes water from the tap.

Disclaimers.
This is an experiment that should only be performed in a laboratory with safety equipment. Below I described in detail how I did this at home in my garage. This is not something you should do and if you do try it you must be aware that serious injury or death from electrocution or explosion.

First of why a petrol engine can run from water, water is H(2)O, that is it has 2 parts of hydrogen to one part of oxygen. Hydrogen is very powerful gas, think of a hydrogen bomb and oxygen id the one thing you need for fire.

So we take a rubber bucket and remove the handle, this leaves us with the 2 U shaped hooks the handle was attached to.
We get 2 tent pegs, preferable the corkscrew type that are also used to tether goats or large dogs.
Next we need a 25mm block of wood and 3 cable ties.
Place the 2 pegs in the bucket so the top of each peg is opposite each other and cable tie the top to the U shaped hook left after removing the buckets handle, then place the 25mm block of wood between the 2 pegs approximately half way down and cable tie the pegs around the block to keep them at a set distance apart.
Now take the cable that runs to your electric cooker and (after turning the fuse box of) split the end so that the red and black wire can reach the top of the 2 pegs in the bucket and attach them to the pegs using gaffa tape or some other strong waterproof tape.
Now fill the bucket with water from the tap
Next you need a large glass "bell jar" this is a jar which has no bottom and the top has a hole in it, if you can't find now then get a large drum plastic is better, and cut the bottom out of it, then place tis over the bucket of water.
Get a petrol lawn mower and put it up on top of a table, remove all traces of petrol from it and then take the air filter apart exposing the carburettor air inlet.
Find a length of pipe, preferable a hosepipe, and drill a hole in your plastic water bucket cover, or slide it into the glass jars opening, and gaffa tape it to make an air tight seal.
Attach the other end to the lawn mowers air intake.
Take the end of the 30amp cooker cable to the house fuse box and locate a 60amp fuse or breaker.
Turn of the fuse box and connect this cable to the fuse or breaker.
Turn the fuse box back on
Wait approx. 1 minute and the bucket of water will be bubbling away, the bubbles are the water being broken down into Hydrogen and Oxygen, both of these gasses will rise up in our jar, or plastic container, and naturally travel along the pipe trying to escape.
Now start pulling on the lawnmower starter and hey presto it will run.
The issues with this are
1)If you get it wrong a stray spark will cause the gases in the jar or plastic container to explode, it'll be a large explosion and I'ne seen someone turn their garage into dust trying this.
2)This is why we will never see a water powered engine
It takes an amount of power to break down the water into Hydrogen and Oxygen, this power is mower than the engine can generate, it if you attach an alternator to the engine to make the electricity there is not enough power made by the engine to spin an alternator the size required to break down the water. There is not enough "efficiency"
James from www.OBD2Equipment.com