The main purpose of this document is to inform the tuning strategy, implementation, and technical capability of the cp-e™ Standback™ 2. Some may be aware that I have been beta testing the Standback™ 2 for some time. I volunteered for this because I’m close to cp-e™, have a technical background (Chemist), love cars and also love making them go faster. The Standback™ has come a long way in the time that I’ve been working with them and now that the product is very near its release, I’d like to share some of the things we’ve learned and how we dealt with the issues in tuning the car.

The secondary purpose of this post is to inform the masses on the general methods for piggyback tuning and get rid of the “black box” mentality that is pervasive. Basically, it’s not smoke and mirrors and we’ll show you how it’s done.

The big requirements for piggyback tuning are control of boost, AFR, and timing all the while keeping the DME happy and most importantly the throttle plate open. You will never make power with a closed throttle.

Boost was a very big hurdle that cp-e™ worked on for over two years before settling on a scheme for controlling it. They have had the ability to control boost from the beginning but lacked the scheme to make the car happy when calling for boost higher than the factory setting. Innumerable attempts were made to adjust the wastegate duty cycle (WGDC) based on the DME signal to no avail. Boost was unstable and no amount of tuning or changing of the control algorithm achieved a good stable quality boost control. In the end the decision was made to simply take over the wastegate solenoid control and just control boost with the unit. The stock WGDC signal is run to ground and the Standback™ 2 drives the solenoids completely independently. The Standback™ 2 was actually designed to do this but because it was incapable of lying to the car in a satisfactory way, there was always trouble in the form of 30FF Turbocharger Low Pressure codes when the values weren’t high enough and throttle closure when the values were too high. For a long while we worked on developing a map for lying to the car. Here’s an example below in (Figure 1).
Figure 1. Screen shot of the fake boost map originally used in the n54 Standback™ 2. Boost pressure is on the top axis while RPM is on the left.

Here you see the values that the ECU saw when in the RPM and boost region specified by the table – actual boost pressure is on the top while RPMs are on the left. The problem with this approach is that the target boost is very temperature dependent and so while this map worked for one range, if it got colder the throttle would close as the boost was higher than target. Warmer weather resulted in low pressure codes. Clearly this wouldn’t work.

We next employed a scalar algorithm where one scalar adjusted the fake Manifold Absolute Pressure (MAP) value according to the DME commanded WGDC and the other adjusted the fake MAP value according to the throttle plate. For example, scalar 1 added to the fake MAP value if the DME commanded WGDC was lower than maximal while scalar 2 subtracted if the throttle plate began to close. This technique required loads of testing but eventually we came to a good spot with decent throttle opening and no codes. It wasn’t perfect though and occasionally low pressure codes happened or significant throttle closure occurred and temperature played a significant role.

About this time the chip manufacturer that produces the processor chip for the Standback™ 2 announced that the replacement part had, in fact, increased its memory and overall functionality. This was truly the pot of gold at the end of the rainbow for me and for cp-e™. This newfound capability allowed the Standback 2™ to monitor and input CAN messages with the DME. Voila. Now we could read the target boost in real time and send a percentage of that value back to the DME. No more throttle closure or 30FF codes. Within days we developed a new method for creating fake boost. We use a fake MAP table to lie to the ECU based on the MAP voltage and RPM. An example of that map is given in Figure 2.
Figure 2. Screen shot of the fake boost map employing CAN boost targets (negative numbers), 0s (actual MAP voltage passed through), and positive numbers (fake boost or MAP values) sent to the DME in the n54 Standback™ 2. MAP voltage is on the top axis while RPM is on the left.

Note: The software will look different here b/c this is the internal beta software. The map is MAP voltage vs. RPM. The negative numbers are a percentage of the CAN target boost, e.g. -9.5 is 95% of target boost, -8.5 is 85%, etc. I’ve found that you need to continually tell the DME less and less of the target boost at higher RPMs in order to keep the throttle plate open. In the positions with zeros in the table, the Standback™ 2 feeds the actual MAP value back to the DME. This is ideal for light cruise when the car is not under boost. The positive numbers (0.01) are direct fake boost numbers fed to the DME, i.e. 0.01 = 0.01 PSI. This is done at higher rpm and low MAP values to eliminate the shift bog for the MT cars. It works flawlessly as the car sees a low enough MAP to open its throttle immediately.

The Standback™ 2 uses a PID control loop or Proportion, Interval, Derivative. This is a very complex and powerful control loop algorithm that, when done properly provides excellent control. When done improperly is an absolute nightmare. Here’s the configuration page with the PID variables highlighted.
Exhaustive, painstaking testing was conducted to achieve stable boost. These values are also user completely user adjustable but will work fine for all stock turbo n54 applications. If you’re stock, leave them alone and you’ll never have a problem. If you were to use upgrade stock turbos or switch to a completely new turbo setup these would likely require adjustment. When doing so it’s a good idea to get familiar with PID control loops and how they work. A good strategy for setting them up is to set all but P equal to zero. Gradually increase P until the target just becomes unstable. Reduce it back to 30% of that value and that’s your P. Once you’ve found that P, you can begin to increase the rate at which the target is achieved by increasing “I”. Increasing D slows the rate and prevents or mitigates overshoot – in this case boost spikes.
Figure 4. Log of boost and other variables from a 3-4 shift at wide open throttle. $vTPSin$, $ppV$, MAP-PSI, DesMAP, and Exp’d MAP are throttle position sensor voltage, MAP or boost pressure, target boost pressure, and the CAN DME target boost pressure, respectively.

Above in (Figure 4), is a log of that control. DesMAP is the target boost while MAP-PSI is the actual boost. $vTPSin$ is the throttle plate. There is absolutely zero shift bog with this tune. The boost is ~1 psi higher immediately following the shift but drops very quickly back to the commanded value. This log was taken of a 3-4 shift on an open road so holding WOT in 4th longer that what is shown was not something I could control b/c of traffic. Here’s the P, I, and D with WGDC of that same log. Ideally you want $P=0$ ASAP and that’s what we get.

Figure 5. Log of the same 3-4 shift at WOT as above with $WG_{opt}\%$, $WG-P$, $WG-I$, and $WG-D$ as wastegate duty cycle, and boost control parameters P, I, and D, respectively.
Figure 6. Screen shot of the boost control map used in the n54 Standback™ 2. Pedal position sensor (PPS) volts is on the top axis while RPM is on the left.

The Standback™ 2 boost is set using the boost table. Above in (Figure 6) is an example of mine at 14psi. The axes are RPMs and PPS or pedal position sensor volts. The 30x30 table coupled with the PID boost control results in a very linear power delivery. I can hold 2, 4, 5, 6, 7 etc psi with my foot just holding it steady. It’s really direct control over boost. As mentioned and shown before the fake MAP value table operates over the entire span of the running conditions and so for the most part the throttle is fully open. In this regard you actually control the car with boost. It’s very linear, predictable and can be made as quick as you want. I have a soft boost onset going from 1 psi to my peak. If you wanted a faster response to your pedal you would simply make the boost higher in the lower PPS voltage regions – highlighted in RED.

Another area to notice is the one highlighted in orange. This is a region of the pedal voltage that the car has when idling at start and after it warms up. Calling for a small boost here will result in the wastegates closing to try and make the requested boost. The car cannot actually develop boost because the exhaust flow is so low at idle but the wastegates are closed and this eliminates the rattle. When someone says they “close the wastegates to eliminate wastegate rattle” this is what they mean and how it is accomplished with the Standback™ 2. The higher RPMs are left alone b/c when in cruise control the PPSVs is between 0.5V and 0.8V and I didn’t want my wastegates closed when cruising. This is my preference but I felt the turbos didn’t need to be spinning all of the time. Adding boost here would close the wastegates but I doubt anyone could tell a difference in noise when cruising on the highway.

Another aspect of this table is highlighted with the yellow arrow. I’m drawing your attention to the fact that I don’t hit peak boost until 3100 rpm. Again, this is personal preference but I’ve been told not to “load up” a turbo car with a lot of boost at low rpm as it stresses the motor. This setup works for me perfectly but “to each his own.” All of these maps are available with the Standback™ 2 software so an end user can do as they wish.
Figure 7. Screen shot of the boost control map used in the n54 Standback™ 2. Pedal position sensor (PPS) volts is on the top axis while RPM is on the left. This map has been set up for drag racing to maintain boost when shifting.

Above in (Figure 7) you will see a boost map that I set up for the track. 14psi is held all the way back to 0.5 PPS V from 4500 to 6200. This will cause the car to maintain as much boost as possible between shifts. It’s worth a good 0.2 s when drag racing. I don’t have a log of this but the boost is maintained to approximately 12 psi between shifts. It really makes a difference.

Timing and fueling maps are the same layout. Below in (Figure 8 and 9) you can see examples of my tune.
Figure 8. Screen shot of the AFR adjustment map used in the n54 Standback™ 2. MAP sensor volts is on the top axis while RPM is on the left.

Figure 9. Screen shot of the timing adjustment map used in the n54 Standback™ 2. MAP sensor volts is on the top axis while RPM is on the left.
Both AFR and Timing are tuned with MAP voltage. In this way I’m modifying the timing and fueling as boost increases. This makes the maps very drivable and safe. I’ve spent time on cp-e’s dyno tuning up to 14 psi. Should I have some unforeseen problem and the boost spikes or rises somehow my maps have significant timing pulled and fuel added for anything over 15 or so psi. It’s my preference to tune this way with MAP voltage as it makes the most sense to me. The Standback™ 2 will allow however tuning using throttle plate sensor voltage or pedal position sensor voltage – I use PPSv for the boost control.

Figure 10. Screen shot of the configuration page used in the n54 Standback™ 2.

The areas highlighted in pink are the drop down menus for the axes of the maps. Again you can use MAPv, PPSv, or TPSv as your top axis for any of the maps listed on the left tree. Those are fuel, fuel pressure, fuel adder (meth or secondary injectors), timing, and boost. The MAP adjustment tables are where the fake boost percentages of the CAN target boost are specified. The drop downs highlighted in light blue are for use of the stock or alternative MAP sensor (AEM 3 bar), the boost control solenoid frequency, and the fuel adder pump frequency. Secondary injectors are 20-60 Hz while a meth pump is 610 Hz. The fuel adder tables are like the ones shown previously. In my case it will be methanol. The area in green is where the Standback™ 2 takes over control of the wastegate solenoids. We’re basically controlling them all of the time. The yellow circle indicates where my boost gauge becomes active. In my case any boost over 4 psi will activate my dash boost gauge – speedometer or fuel gauge. You can specify speedometer or fuel gauge in the orange circle area.

None of these tools would be useful without powerful logging capabilities to monitor the various sensors, timing, and RPMs of the car. The understanding gained from all of this testing was afforded by the Standback™ 2’s logging capability. The unit can capture over 35 variables that are monitored either directly or by CAN – only DME target boost is monitored by CAN currently.
These variables can easily be exported to Excel or any graphing software supporting comma separated values, .csv. One can also review the logs using Speedranker’s PMP software or review the data using the Standback™ 2 software itself. I chose Excel for the purposes of writing this document. The Speedranker software is available for free at www.speedranker.com. Figure 11 is a screenshot of a log that I recently took on the Standback™ 2 software. The areas highlighted in red are where you export the data to the various formats. The area in green allows you to configure the export so that you don’t have to sift through mountains of data and just export the variables you need – this is very convenient for tuning.

![Screenshot of logging page in Standback™ 2](image)

**Figure 11.** Screen shot of the logging page in the N54 Standback™ 2.

Basically, this should give a good sense about the Standback™ 2 and some stuff about tuning these cars. The Standback™ 2 can clear codes and change maps (2) from inside the car (hazard lights). When it’s released the software will be slightly different, more “user friendly”, but still retain all of the options I’ve laid out. It’s a very powerful tool. cp-e™ envisions this to be the open source option for tuning. They provide the tools and it’s up to the users to identify how to achieve the desired results, e.g. keeping the wastegates closed at idle or maintaining boost at the track, etc. cp-e™ set out to create an engine management unit that would allow the end user “full control of their N54 powertrain. Now you can add those upgraded turbos you have always wanted…..

Statement from Custom Performance Engineering, Inc.: Everyone will have different goals and different limitations when modifying their vehicles. We’ve created what we believe to be the best Plug and Play engine management system for the BMW N54 vehicles; giving you the freedom to now upgrade your N54 in any mechanical way you would like and have the ability to control it yourself. Not comfortable making the changes yourself? Have your local, trusted, tuner shop make the changes on the spot. For any questions regarding the cp-e™ Standback™ 2, please call us at our office, 301-576-6142, or visit our website, www.cp-e.com. Thanks for reading!