



The Official 2AZFE Engine Management Write-Up. Brought to you by Dezod Motorsports...We ARE performance.

As a source of continuing support & knowledge for the Toyota High Performance Aftermarket, we here at Dezod Motorsports felt that there was a void of knowledge in engine management systems and tuning the 2AZFE engines. This article is here to set the record straight, and lay all of the facts on the table from the get go!

Before we dive head first into the topics at hand, I feel some background information is necessary to define and classify each of the engine management systems and their inherent properties. This article will not only define the properties of each of the engine management systems, but also with their pros and cons, their cost, their features and some inside information about each.

Let's get started shall we? I will start first with the most popular of the engine management systems due to cost and availability: **Piggybacks**.

Piggyback Engine Management

A piggyback engine management system is the most popular form of engine management used in the high performance aftermarket tuning of Toyota engines. This is largely due to the fact that piggybacks are cheap, readily available and typically do not require a lot of work to get running. These attributes make signal modifiers like this a popular choice.

The piggyback simply takes and alters a signal or channel on the stock engine management to get what you need out of it with some minor laptop plugging. This is why we call it a signal modifier. It modifies the MAP or MAF, maybe injector pulse width or ignition timing. The bottom line is that it fools with the signals that the stock engine management system outputs. Some units are more sophisticated than others, and not all piggybacks are created equal, and I will delve into that a bit later in the article.

These piggyback units use a large amount of the stock engine managements' programming untouched to allow for ease of setup and tuning. Cold starts, air conditioning, throttle enrichment, decal fuel cut, variable valve timing and several others are typically not touched by most piggybacks. The units do however, typically modify or read: throttle position, cam signal, crank signal, coil packs, injector output etc. Again, not all are created equal.

Often piggybacks fall prey to not having the control or necessary channels of getting you the results you need. This is very common on the 2AZFE engine, where the current based primary O2 sensor is stunningly accurate and the factory engine management is VERY good at getting what it needs regardless of what you have entered

into your piggyback and such. The classic case on this engine is when the vehicle is in closed loop operation, which is typically below 70kpa and below 4000 RPMs. This means that the factory engine management system is using a severe amount of feedback from various sensors to get the most accurate combustion for emissions, torque and fuel economy. This agenda as a whole usually is the polar opposite of what you need with the exception of maximum torque. ☺

The average street cost of a piggyback from one of the major players in the the game will set you back about \$400-650 before you have to add on any accessories like additional sensors, wiring etc. The cost point, readily available, ease of setup and the lack of extensive programming make these units the most popular. The units I will break down are the AEM FIC and the GReddy E-Manage Ultimate. Starting with the top of this order, let's roll with the AEM FIC first.

AEM FIC Piggyback

I did write a previous review on this engine management when it first arrived to the market; back a few years ago. The unit is fairly sophisticated and allows for some very good control in all facets of the combustion cycle, but still is limited as a whole. This is a universal item that is not designed to work on one vehicle, but many. With this being said, it makes for more work or programming to get some things to work properly.

In a nut shell, this signal modifier can control fuel, MAF sensor manipulation, O2 sensor feedback and ignition control (retard only) and converts to speed density (MAP sensor based tuning). Let's see that in chart format shall we?

Engine Management	Speed Density	Fuel Control	Ignition Control	O2 Sensor Skewing	Cost
AEM FIC	◆	◆	◆	◆	\$400

The AEM FIC offers an on-board MAP sensor to tune off of, which converts the tuning to speed density (reading off of a MAP than a MAF). This does have its' inherent drawbacks such as lack of accuracy, no small VE adjustments being made on it's own (responsiveness to mild bolt-on changes), temperature changes and a few other things are not able to be done with the use of other tables and such under speed density.

The FIC has the ability to add or remove fuel from the setup. Other units do not offer full subtraction, but just addition of fuel. This exact scenario was popular with the GReddy E-manage Blue.

The FIC also offers ignition control, but only in the form of retard and not advance. So if you are looking for an engine management to control cams with, keep looking. Those Brian Crower Stage 2 cams that love some good ignition advance up top won't be getting it from this engine management. The FIC can only retard timing. That's all!

The FIC has a primary O2 skewing function to help in partial throttle control on those boosted apps where you may tip into boost in running through the gears. This O2 sensor skewing allows for a limited amount of correction in the right direction on a boosted app. Tip into one and two pounds of boost in a gear and 14.7:1 air/fuel ratio is not a good thing. The O2 skewing helps in this scenario when in closed loop, and can

help achieve much lower air/fuel ratios of, for example, 12.5 to 1 or lower. This is achieved on the 2AZFE by using several functions of the AEM FIC together to work harmoniously.

The MAF sensor can also be clipped with the AEM FIC as well. This permits the MAF from seeing too much boost and making corrections against partial throttle desired AFRs. A properly clamped MAF map, a properly established O2 map and your main fuel map coinciding will allow for partial throttle air/fuel ratio control.

With the average street price of \$400 and all of the wiring & software included, an on-board pressure sensor and the options it offers, makes the AEM FIC an excellent choice on the budget.

GReddy E-manage Ultimate Piggyback

A lot of users think this is the end all of piggybacks, but I think it lacks in a few areas and how it operates to really make that statement. It does offer some nice bells and whistles, but most of these do not help tune the car. They are extra luxuries and nothing more.

Again, we are faced with a universal item that was made to work on the 2AZFE. This is a universal item that is not designed to work on one vehicle, but many. With this being said, it makes for more work or programming to get some things to work properly.

The EMU (E-Manage Ultimate) does offer a LOT more control (in some areas) than the FIC, but again lacks in others. The unit offers the option of MAF removal (the FIC does too), multiple map support through use of a dip switches, factory speed limiter cutting, auto trans shift manipulation, coolant temp correction, air inlet temp correction, acceleration correction, individual cylinder adjustment for fuel & ignition and a few others. These are all great, but it lacks a few crucial areas, which involve the O2 sensor.

Engine Management	Speed Density	Fuel Control	Ignition Control	O2 Sensor Skewing	Cost
AEM FIC	◆	◆	◆	◆	\$400
E-manage Ultimate	◆	◆	◆		\$650

The EMU offers fuel trimming and addition like the FIC. This unit can be tuned on a throttle position based map or MAP sensor based (speed density-with the purchase of the GR pressure sensor & harness). On the boosted apps with a decent sized turbo, I'd recommend doing the tune MAP sensor based, while TPS based on a small turbo that spools nearly instantly.

The ignition control of the EMU is rather fuzzy and does not really work too well on the 2AZFE platform. I have played with it on numerous cars, but have yet to see it really work as well as the AEM FIC in that category.

The individual trim of cylinders is really cool and kudos to GReddy for offering that on a cost effective unit. That is so nice especially if you have a poor intake manifold design that may cheat 1-2 cylinders of air flow, in this case, you can compensate accordingly.

The EMU also offers aux table inputs to help for temp correction and coolant temp correction, but again this would not be needed if it worked with the stock MAF, which is far more accurate than any MAP sensor will ever be.

Being able to modify the stock “pump shot” during acceleration is a nice feature especially if you have a high volume fuel pump and some large injectors. The factory ECU pump shot may bring your acceleration enrichment to a 10.0:1 or lower, which may not be necessary or more in line with your AFR trajectory once peak boost is achieved. Another leg up for GReddy!

The major downfalls in my eyes the EMU lacks is O2 sensor manipulation on this app, which is damn near essential on this application along with better ignition control. With a car remaining in closed loop for a lot of normal driving (sub 70kpa and sub 4000 rpms) that means it does not have control over partial throttle to provide accurate air/fuel ratio control when tipping in to boost between gears. This ultimately leads to issues of lean scenarios, which lead to your block with holes in it.

The Ultimate has even more features than I mentioned, but by the time you buy the unit at \$650, the wiring for another \$120 (because it's not included), the MAP sensor (another \$150), then you are into GReddy for \$900+. That's half the price (if not more) of a standalone ECU with a lot less control.

Overall for the money, the FIC wins hands down for control on this application, but GReddy offers a lot of control in other areas, but you must pay for it all. \$400 AEM FIC vs a \$900 GReddy EMU. The choice is yours. On/off cars are not fun and not practical especially for a daily driver. This does not make for a fun car to drive. So pick your poison accordingly.

In-Line Engine Management

The in-line ECU option is a new phenomenon to even us here at Dezod Motorsports. We have seen and done quite a bit, but this version of ECU has truly captured our love and excitement for engine management again. The reason why we have this newly found adoration is due to the flexibility, control and simplicity of it as a whole.

The in-line ECU allows for full control of closed loop and open loop fuel control. This is a MUCH more elaborate form of engine management and is sort-of still a signal modifier, but is not at the same time. The intricacies are a bit cumbersome, but I will try to simplify it as much as possible.

This style unit uses the stock ECU to your advantage. It allows for one to use Toyota's millions of dollars invested into fuel and ignition delivery to your advantage. Quite simply, it's almost like reprogramming the stock ECU to get what you want out of it. I can't think of any other way to explain it, but it's merely that simple.

So drive-ability is very important to most people, and other than the cumbersome stand-alone tuning, this is probably the next best way of getting reliability and drive-ability all in one ball of wax.

Much like a piggyback, this unit leaves cold starts, variable valve, air conditioning and a few other odd-ball things to the stock ECU, but makes the combustion cycle completely controllable otherwise.

Allan Phillips Racing In-Line Engine Management

The APR X1 ECU is a wonderful unit and allows for full control over fuel and ignition control. We, here at Dezod, feel that this is the best option for those looking to build a radical street machine that will also do well at the track. This unit could also be used on a full blown race application as well as it supports a lot of additional sensors and such as thermocouples, boost inputs, widebands etc.

This unit, which is the opposite of all of the units mentioned, was designed and built to perform on this application ONLY. We here at Dezod Motorsports spent nearly one year working on this unit to be specifically for this platform and to provide damn near OEM quality to your tuning.

The unit uses the stock MAF for tuning and reads in absolute pressure (Vacuum & Boost) in kilopascals (kPA). It has high resolution tables for fuel and load along with spark and load to read off of and makes for VERY easy control.

The stock MAF sensor offers far superior advantages to any and all speed density tuning. Not only is the MAF more accurate, it's like 3D or 4D modeling of your air flow into the engine. Quite simply, the MAF takes into account ambient temperature, barometric pressure & air flow all in one swoop. MAP sensor based apps, only read air pressure. You then must use a supplemental intake air temperature sensor and barometric pressure sensor to get all of the data you get from your one lonely MAF sensor. Not to mention, if you had all three of the sensors in the MAP based system, you'd also have to program individual trims for each of the conditions. For example, in Denver, Colorado at 90 degrees would be a different trim than Miami, Florida at 90 degrees. Why? The answer is barometric base pressure due to altitude. This is the foundational pressure in which all pressure is measured. If that base pressure is lower due to altitude, then your overall output of relative boost pressure will be down as well.

With all of this being said, why would you not want to use that MAF? If you answered something funny there, and still have your heart set on using a MAP sensor, the APR X1 can use a MAP sensor as well for up to 5 BAR of pressure.

Since the X1 uses the stock MAF, I am sure a few people are talking about maxing it out or thing something along those lines. In a nut shell, no worries should be had there as well. With the X1 there are two MUCH higher flowing MAFs that can be dropped right onto this system and used like a stock MAF. The MAFs can be run to total up to 900 g/s² of air flow! THAT is a lot of boost! Just a couple of key strokes and you are done. Now let's talk spark!

The APR X1 let's the stock ECU select the final timing value before you modify it. So for example, it may determine that at wide open throttle it needs 22 degrees of advance. With the X1, you can advance or retard from that value to get what you need as far as spark is concerned. This is truly different and offers more standalone control in comparison to the piggyback ECUs, which is exactly why I said it's more of a hybrid unit.

With the X1, there is no need to worry about O2 maps at all. Because this system uses the stock ECU to your advantage, all you need to do is program the main fuel map and make sure your injector transfer function is mint, and you are golden. The stock ECU does the rest to ensure your new fuel base calibration is ascertained in part throttle closed loop and/or open loop wide-open throttle.

In all, I feel with still having the all of the OBD2 readings in tact like the piggybacks, but offering more standalone control, the X1 is an excellent alternative. Not to mention, I am not going to get into the drivability of the damn thing, but it's about as parallel as a well tuned stand-alone engine management or an OEM turbocharged vehicle as it gets. With a price tag of \$1850, I feel it's a good value and available exclusively through Dezod Motorsports.

Stand-Alone Engine Management

A stand-alone engine management system is the most controllable form of engine management used in the high performance aftermarket tuning of Toyota engines. This is largely due to the fact that it stands alone without the stock engine management's assistance.. One does not need the stock ECU at all (with the exception of powering the drive-by-wire), and the chosen unit controls all of the combustion cycle, cold starts etc. There are different degrees of standalones in the 2AZ market, but all share similar price tags and have different amounts of control. One common thread is the fact of no OBD2 plug-in emissions tests will allow any of these units to pass inspection because several signals are stripped from the factory engine management, which makes for lots of angry codes to be output into the OBD2 port.

Stand-alone engine management is truly a blank slate. All of the programming from firing order, injector phasing, ignition phasing, crank patterns, cold starts, accel enrichment etc all need to be programmed from scratch as well.. These units are not for the faint at heart and definitely for the advanced tuner whom needs maximum control.

Anyway, if control and a track based car is your game, this is your engine management. I will briefly touch upon AEM and Hydra.

AEM Stand-Alone Engine Management

The AEM EMS offers a wide variety of adjustment including, but not limited to: cold starts, full fuel control, full ignition control, variable valve timing, rev limiters, warm starts, throttle enrichment and just about everything under the sun. It's nearly 100% programmable in that aspect. It allows for the end user to dictate exactly how you want the car to run in all facets. If you want to idle at 10.0:1 air/fuel ratio and 22 degrees of advance, you can do it! Your engine, on the other hand, may not.....

The AEM EMS comes as just a unit and all of the sensors are sold ala-carte. So you will have to buy whatever sensors you need if you do not want to use the stock ones. Most people, with that being said, opt for the AEM sensors for ease.

The oxygen sensor of choice for the stand-alone units typically are a wideband, which can be implemented into the system for closed loop operation. Again, that wideband is sold ala-carte. The AEM can use PLX, AEM, Innovate, FJO, Motec and a few other widebands through the wizards. But, like any other sensor, if you have a schematic of voltage versus the output you can make a custom calibration for your sensor in the AEM software.

The V2 AEM EMS is being worked on here at Dezod Motorsports, and we expect to be bigger and better than the V1 stuff. Stay tuned as we finish up the R&D again, and release more data soon!

Hydra Stand-Alone Engine Management

The Hydra Nemesis offers a lot of control just like the AEM, but on a much more cryptic software that seems very dated. The software has lots of PF fey entry points, which makes it very difficult to take on if you are not familiar with the system.

The Hydra does come a touch more complete than the AEM with a built in MAP sensor and a built in wideband oxygen sensor. This makes it easier for a novice to get it rolling in one swoop rather than playing around with additional sensors or trying to make stock sensors work with the engine management, which can always be a treat.

Again, Hydra controls full fuel, ignition, variable valve and such just like the AEM, but offers a quite limited tuner base in comparison to the AEM stuff. The choice is yours, and be aware of what tuner base is in your area. Remember, with a standalone it's garbage in = garbage out. I'd recommend doing some research first and finding what reputable tuners in your area specialize in the chosen engine management. Some prefer Hydra, while some prefer AEM and yet others prefer Motec.....

Conclusions

There are plenty of ways to spend your hard earned dollars and even more ways to get the job done, but very few ways to get the job done right. I'd suggest you do your homework and really analyze your budget if you are concerned with making good power and making it reliable. One should look at their setup and seriously ask themselves, am I ever going to make it a true dedicated track car? Am I looking for the most reliability? Is this something I can tinker with on my own? Is this something I can afford? This is my daily driver and I can't afford to blow it up....Which is the single most thing heard every day here at Dezod, and the funning thing about it is that in my opinion, these guys need a ton of control. You are hitting tons of different types of areas in your maps everyday. It doesn't matter if it's creeping in 2nd or 1st in a parking lot, hammering it to make a quick pass in 3rd or screaming up an on-ramp in 4th....Cruising at 50mph....There is a lot of control that is needed there and the proper engine management should be selected for your budget and needs.

The engine management price tags are reflecting how much control you need and or want. The more expensive the unit, the more control it has. There is typically more reliability (assuming a good tune) and the more seamless it will feel when running through the gears. You do get what you pay for, and I see and hear it time and time again. The guys that want to make 400+whp, and want to run a \$400-600 piggyback to do it are just plain out of their minds. They want to trust their \$10,000 investment (between turbo kit and engine build) with a \$400 piggyback. That's the equivalent of having the janitor running your Fortune 500 Company. It makes no sense! Big builds require big budgets, which require more control to do the job right. There is no room for error at those power levels and I am sure you do not want to do a build like that 2 or 3 times to figure that out. So, with that being said, pick your poison wisely.