More Power: Tim Allen's 574-HP Stang

Turbo & Hi-Tech Performance

Twin-Turbo NSX

Middle-Class F40

Typhoon Transplant '38 Chevy AWD

MAY 1994

- Trick: Supercharged 535i BMW
- HOT! 575-Horse RWD 3000GT VR-4
- Intense: Volvo Turbo Sportswagon
- Wild! 440+HP 1245-Pound Spyder
A Pair Of Aerodyne Turbos Sound The Wakeup Call For Acura's Flagship
There was a time when 270 horsepower got some respect. Just a few years back, in 1991, when Acura introduced the NSX, Corvettes only made 245 horsepower. The 270-horsepower NSX, with its incredibly broad torque curve, two-seater layout and sexy lines was touted as a Japanese Ferrari 308. The Acura’s selling points are not achieved the old fashioned way. Here’s as complex a car as you’re likely to find on the street, complete with three-in-one switchable cam lobes for variable valve timing in the high revving V6, plus an engine management computer so sophisticated many tuners have been forced to use electronic countermeasures in order to hot rod it. But these days, ZR-1 Corvettes make 405 horsepower, and a regular LT1-powered ‘Vette makes 300. Even the Camaro makes 275. All this leaves the current or potential NSX owner—with the $65K or so it takes to bring one home—facing a potential identity crisis. In terms of power, the NSX is not in serious 1994 supercar territory. Wouldn’t you just hate it if a $17,000 Camaro driven by a guy who knows how to shift got the jump on you? Perhaps, a little hot rodding is in order, something maybe on the level of the Manhattan Project?

Once upon a time, hot rodding was easy. A high school student could handle swapping carbs, cams and headers onto American V8s. But emissions and safety laws in the last decade of the 20th century have made a lot of modifications illegal, complex or expensive. That’s why if you go into a Supershops speed shop these days, what you mostly see are a lot of tires and wheels. Many carb, header, cam and engine swaps are illegal. And even if they aren’t, attacking a modern fuel-injected engine, even a familiar small-block Chevy V8, with the goal of dealing with all that complexity under the hood to make it faster, can be an intimidating task. We see ’80s-vintage TPI Chevys all the time where experienced hot rodders have ripped out the injection and replaced it with the familiar old Holley carb. These days, hot rodding involves a full-tilt effort to pass the Federal Test Procedure for emissions compliance, in which a tuner must prove on a chassis dyno that the hot rodded engine is virtually as clean as stock. Achieving high horsepower is one thing, but the quest for clean high horsepower can be a high stakes risk when you’re taking on many hours of dyno time, with no guarantee of ultimate success. For all these reasons, modifying a car like the NSX can be a potential hassle.

As car computers go, the NSX engine management computer is something of a genius, controlling variable valve timing events, engine fuel management, emissions control, traction control, braking force and many other events. It can recognize 52 internal fault codes, with a bag of tricks and countermeasures to use against “unusual” conditions that include retarding timing, shutting down cylinders, ignoring various sensors it suspects are wrong, literally pushing back on the gas pedal, dropping rpm abruptly to 3000 or killing the engine entirely, as well as other strategies. As you can imagine, the Acura computer can be a worthy adversary in a tuner’s effort to turn the NSX into a truly formidable supercar. Tuner’s have been driven to extensive reverse-engineering research to map out the stuck NSX computer’s strategies, and have then attempted to counter the computer’s efforts to thwart them by using check valves, air bleeds, vacuum hose re-routing, vari-
able potentiometers that are intermittently substituted for stock thermistor engine sensors and other strategies. The idea is to fool the computer into viewing the world in a way that is compatible with goals for increased power.

Fortunately, the NSX featured here from Bell Engineering Group, Inc. (BEGI) of San Antonio, Texas, is a case study in both ’90s hot rodding elegance, and the reasons why such an undertaking need not resemble the Manhattan Project when you make the correct design choices.

**BEGI NSX Design Criteria**

In the good old days, hot rodding was largely a matter of horsepower and sex appeal. The design criteria for the 1991-’94 BEGI NSX package was a little more challenging.

1. **Easy Emissions Compliance for CARB Exemption Order**, implying:
   a) Engine remains absolutely stock.
   b) Keep the cats in stock position with no upstream changes to the exhaust system.
   c) No change to fueling system except under full throttle acceleration.
   d) Honda engine management electronics unaltered.
   e) Emissions remain within CARB guidelines for a stock NSX.
2. Power-to-weight ratio at the high end of the supercar category, which implies at least 100 additional horsepower, a 30-percent increase.
3. Little or no degradation of reliability and longevity.
4. Maintain the NSX’s quiet and elegant driveability.
5. Preserve the NSX’s excellent and broad torque curve under all conditions.

**Additional Power Strategy**

Clearly, the “no internal-engine-changes” implies some kind of supercharging, turbocharging, or nitrous injection. Nitrous wouldn’t necessarily require internal engine changes, but the driveability and utility could be sacrificed. The BEGI system is definitely designed for the enthusiast NSX owner who wants to...
At least one supercar tuner is offering a supercharged NSX, but BEGI takes the position that turbocharging can make much more low-end torque and power, and the idea that centrifugal compressor superchargers make more boost than turbos for a given engine rpm is false. Superchargers rob crankshaft power continuously, while turbos use engine heat as well as exhaust backpressure to make boost. Freewheeling under light load. Turbos, according BEGI, according to President Corky Bell, can spool from light load. Turbocharging, while maybe three times weight, cannot increase in speed at all until the engine changes speed. All winning forced-induction road racers now and the full throttle program. With our chips you can feel the increase in power immediately. We alter full throttle calculations of air flow at 1.36 pressure. There are many ways of increasing fuel delivery into a modern injected engine, including aftermarket programmable EFI computers, larger injectors, “black box” pulselwidth modifier computers, additional injectors, fuel pressure increases and various tricks to mislead the stock system regarding engine conditions. If additional air can be moved into an engine (increased volumetric efficiency) additional fuel must also be provided. Forced-induction not only requires more fuel for the additional air, but a richer mixture in order to fight thermal loading and detonation in motors with radically higher effective compression ratios.

For the quest for fuel enrichment, BEGI first investigated the unused capacity of the stock NSX injectors, using a pulselwidth meter to examine how much injector capacity was currently being used at maximum torque. Additional Fuelling Strategy

TWIN SEQUENTIAL TURBOS, ROUTING ALL EXHAUST THROUGH ONE AT LOW SPEED, USING BOTH AT HIGHER SPEEDS, OR 3) VARIABLE AREA TURBO NOZZLE (VATN) CONFIGURATION TURBO(S) WITH A DYNAMICALLY CHANGEABLE NOZZLE SIZE THAT ENABLES THEM TO ACT LIKE SMALL TURBOS AT LOW SPEED, LARGER ONES AT HIGH SPEED.

Fortunately, the relatively low horsepower increases necessary to achieve the design goals meant that much boost would be required. This made everything much easier as the Bell Group likes the Aerodyne "Aerocharger" VATN turbo. Calculations of air flow at 1.36 pressure ratio revealed two Aerochargers would do the job on the NSX.

American Cars
BUICK REGAL 3.8 +16 HP $200
BUICK REGATA 3.8 +16 HP $200
BUICK GRANDSPORT +14 HP $200
CADILLAC ALLANTE +30 HP $200
EDCADO 4.9L +16 HP $200
CHEVY 1500 4.3L +22 HP $200
BERETTA 2.6 +16 HP $200
BERETTA 3.1 +19 HP $200
CAVALLERI 224 +20 HP $200
CAMARO +40 HP $200
CORVETTE +40 HP $200
TIMHOON / SYCLONE 300 HP $350
PONTIAC GRANDAM +16 HP $200
BONNEVILLE 3.8 +16 HP $200
PONTIAC FIREBIRD +18 HP $200
Ford Cars
MUSTANG 5.0 +22 HP $200
MUSTANG COBRA +27 HP $200
MUSTANG V6 +40 HP $400
FORD TURBO +40 HP $200
FORD 3.0 & 3.2 +16 HP $200
FORD 3.8 +16 HP $200
FORD SUPER COUPE +40 HP $200
CROWN VICTORIA +16 HP $200
RANGER 2.3 +12 HP $200
RANGER 2.9 & 3.0 +16 HP $200
RANGER 4.0 +18 HP $200
LIGHTNING +24 HP $200
BRONCO 5.8 +22 HP $200
PROBE TURBO +175 HP $350
PROBE V6 +20 HP $200
NSX
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Expand the performance envelope of the mid-engine two-seater. Unfortunately, the stock engine's high compression ratio of 10.4:1, coupled with the need to use street fuel and the need for long-term durability, implied relatively low boost pressures.

Aerocharger VAT turbo.

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each additional psi of manifold pressure. BEGI investigated the additional capacity of the stock fuel pump, which turned out to be sufficient to deliver fuel for at least 390 horsepower at 92 psi.

**Intercooling**

High compression ratios produce hot combustion temperatures. Anything designers can do to reduce inlet manifold temperatures has the dual benefit of producing more power via a denser air mixture, as well as reducing ultimate combustion temperatures. This is done by reducing the starting temperature, reducing the tendency for abnormal combustion via spark knock (and can also reduce the formation of NOx pollutants). BEGI calculated that turbocharger compression would increase inlet air temperature roughly 80 degrees. Intercooling, at 80 percent or better efficiency, could reduce this to 16 degrees, which would mean an 11.5-percent denser mixture.

**Layout**

Since CARB certification was a ruling design criteria, BEGI elected to leave the stock catalytic converters in place, upstream of the turbos. This allows the cats to “light off” quickly without upstream turbos stealing heat from the exhaust, an urgent consideration in passing the warmup cycle of the emissions test. The use of the Aerocharger VATN turbos simplified turbo oiling, since the turbos are lubricated by a self-contained bath of synthetic oil, and require no hoses. Other considerations in layout included good cool air for the intercoolers, clean air for the filters without puddle or splash water, heat shielding of critical components, exhaust system/muffler ergonomics, quiet operation of all components and dealing with potential flexing of turbo plumbing components due to engine torque forces. BEGI located the 3.5-inch thick by nine-inch intercoolers in a space aft of the rear wheels, allowing

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The turbos are mounted on either side of the NSX in the back, underneath the car. The Aerodyne units have a variable area turbine nozzle (VATN) which gives the best of both worlds—a dynamically adjustable nozzle size that enables them to act like small turbos at low speed and larger ones at higher speeds.

(worst case). Since the injectors were open 67 percent at max torque, fueling could potentially be increased about 50 percent at any rpm, more than sufficient for the 30-percent power increase planned. However, changing the injector open time would require electronic control modifications which might make CARB approval more complex and expensive. BEGI decided to use the Cartech variable rate of gain (VRG) fuel pressure regulator to provide additional fuel and enrichment by increasing fuel pressure under turbo boost by the correct amount needed for additional fueling. The stock electronics would not know that each injector squirt was supplying more fuel in an equal length pulse under boost conditions. Simply increasing fuel pressure is not enough. With no other changes, one psi of boost pressure will increase fuel pressure by one psi via the manifold pressure-referenced fuel pressure regulator. However, the Cartech VRG regulator is designed to multiply boost pressure changes into much greater fuel pressure changes, and is adjustable. Roughly a seven psi fuel pressure increase is needed for

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**Results**

BEGI is currently constructing its sixth twin-turbo NSX. Driving the original prototype car on a mild fall day in San Antonio, it was not at all evident that the car was turbocharged, except that it made 100 more horsepower than stock. The owner had driven the car extensively, and it was now back at BEGI for a check up. The BEGI staff used a fuel pressure gauge taped to the windshield, as well as the interior turbo boost gauge, which is part of the BEGI kit, to assist in the check up. An agreement with the owner limited our more crazy and suicidal impulses. However, the car is so deceptively fast and smooth, that it’s possible to be going more than 40 mph faster than you’d think if you aren’t keeping an eagle eye on the speedometer. Step on the gas, there’s no turbo lag, no noise, just a rush of acceleration. The handling is incredible, the road feel excellent, and yet there is a curious kind of distance between driver and external world. Step on the gas, the fuel pressure rockets toward 92 psi, the boost gauge swings instantly toward five psi and the outside world begins to blur. The NSX now has the horsepower figures to play hard ball in the big leagues. Supercars be warned.