INTRODUCTION

To understand how and why Honda built the NSX exotic sports car, it is first necessary to understand the high level of car enthusiasm that permeates every aspect of Honda's worldwide organization. Honda has always been a "racing" company. From its initial interest in motorcycle racing in the '60s to its current involvement in Formula One, Honda has always taken racing as a serious endeavor. And its involvement with motorsports is an integral part of the philosophy of Soichiro Honda, founder of Honda Motor Co., Ltd. He believed that cars, no matter what their market niche, should be amply endowed with a large dose of driving fun. The intention in creating the Acura NSX was to produce a hand-built, exotic, mid-engine sports car that would establish entirely new levels of performance, refinement, driveability and reliability. The NSX is designed to represent an entirely new definition of the exotic sports car.

CONCEPTS AND GOALS

In 1984, the engineers at Tochigi Research and Development Center created a list of attributes the future NSX had to possess:

- Top-rank performance equal to or greater than existing exotics.
- Excellent liveability. The NSX had to be as easy to live with as any other Acura.
- Light weight.
- Forgiving handling characteristics.
- Limited production.

OVERVIEW

The mid-engine, 2-seater NSX is powered by an all-aluminum, 3.0-liter V-6 which produces 270 hp and 210 lbs-ft of torque. The normally aspirated engine is equipped with dual overhead cams, four valves per cylinder, a Variable Valve Timing and Lift Electronic Control (VTEC) system, and a Variable Volume Induction System (VVIS) intake configuration. The engine also offers Programmed Fuel Injection (PGM-FI) and a direct ignition system which uses an individual coil mounted atop each spark plug instead of a single coil for the entire system. A 5-speed manual transaxle is standard with an electronically controlled 4-speed automatic available as optional equipment.

The chassis features all-aluminum construction for light weight. The 4-wheel independent double-wishbone suspension also features aluminum alloy control arms and hub carriers front and rear, and aluminum subframes for the front and rear suspension. The braking system features ventilated 4-wheel discs front and rear, and an advanced Honda R&D-designed 4-channel Anti-Lock Braking System (ABS). A sophisticated Traction Control System (TCS) has been designed to help limit wheelspin and enhance control on slippery surfaces.

OVERVIEW

The NSX engine is an all-aluminum, 90-degree, 3.0-liter (2977 cc), dual overhead cam, 4-valve per cylinder, V-6 which produces 270 hp at 7100 rpm when mated to the manual transmission, and 252 hp at 6600 rpm when mated to the automatic transmission. The torque rating is 210 lbs-ft at 5300 rpm for both manual and automatic transmissions. The redline for the manual is 8000 rpm, while that for the automatic is 7500 rpm. Fuel cutoff is 8300 rpm for the manual and 7800 rpm for the automatic.

An exclusive electronically controlled Variable Valve Timing and Lift Electronic Control (VTEC) system optimizes volumetric efficiency at both high and low engine speeds. A unique Variable Volume Induction System changes the configuration of the intake system with varying engine speeds, working with the VTEC system to broaden the torque curve and increase peak power output.

ENGINE BLOCK, CYLINDER HEADS, CRANKSHAFT

To achieve both light weight and durability, the block is made of aluminum alloy with cast-in-steel cylinder liners. The crankshaft is a fully counter-weighted forged-steel unit. The cylinder heads are low-pressure cast aluminum. The combustion chamber is a pent-roof design with generous squish area to promote swirl and enhance combustion efficiency. The spark plug is centrally located for optimum flame propagation, and features a platinum tip for improved durability and longer service life.

TITANIUM CONNECTING RODS

The connecting rods are made of a specially patented titanium alloy. While titanium rods are common in Formula One and other race engines, this is the first application of titanium in a production car. Compared to a steel connecting rod for the same engine, these titanium rods each weigh 190 grams less but are significantly stronger.

VARIABLE VALVE TIMING AND LIFT ELECTRONIC CONTROL (VTEC) SYSTEM

Without question, the Variable Valve Timing and Lift Electronic Control (VTEC) system is a breakthrough in engine technology. It convincingly solves the age-old trade-offs between low-end torque and high-end power.

The heart of the VTEC system is a unique camshaft and rocker arm system. For each cylinder's set of two intake (or exhaust) valves, there are three corresponding lobes on the camshaft. The two outboard lobes each have a profile suited for low- to mid-engine speed operation. The third, or center, cam lobe, has a dramatically different profile designed for longer duration and higher lift; this lobe profile is designed to optimize breathing and horsepower production at high engine speeds. At part throttle and low load operation, this third lobe is inactive and doesn't act on the valves. During high-speed operation, the VTEC computer sends a signal to a spool valve, which in turn delivers engine oil to small pistons in the rocker arms. Oil pressure causes the pistons to slide outward, locking all three rocker arms together. Once locked together, the rocker arms are forced to follow the center cam lobe. The cross-over from low lift to high lift occurs in 0.1 seconds and is virtually undetectable to the driver.

VARIABLE VOLUME INDUCTION SYSTEM

In addition to variable valve timing, the NSX engine also uses a Variable Volume Induction System. This system uses a separate intake air plenum, located beneath the main intake manifold. This second plenum is separated from the primary manifold by six butterfly valves, which open between 4600 and 4900 rpm and are actuated by manifold vacuum.

When the valves open, the added volume of the secondary plenum creates a higher resonance frequency, which in turn creates a sonic pressure wave. This sonic pressure wave hits each pair of intake valves just as they open, promoting more rapid and complete cylinder filling. This system was designed to work in concert with VTEC to improve low-end torque.

FUEL INJECTION

Programmed Fuel Injection (PGM-FI) ensures that each cylinder receives the precise amount of fuel necessary for the present load and speed conditions. This system has been specially tailored to the unique capabilities of the induction and VTEC systems.

DIRECT IGNITION SYSTEM

To ensure a hot, stable spark at high rpm operation, the single-coil ignition system has been superseded by a coil mounted atop each spark plug, a design similar to that used in the Honda Formula One engine.

MANUAL TRANSMISSION

The standard manual transmission is designed to provide impressive durability, with short shift throws and quick, precise response. A dual-cone synchronizer is used for second gear, for quicker, smoother shifting, and reverse gear is also equipped with synchromesh.

TWIN-DISC CLUTCH

To handle the high torque and power output of the NSX engine, a twin-disc clutch was developed. The twin-disc design increases the torque capacity of the unit, while retaining a light clutch feel and reducing rotating inertia.

AUTOMATIC TRANSMISSION

The optional 4-speed automatic transmission allows the driver to select and hold each gear manually. To enhance smoothness during upshifts and downshifts, an ignition retard control system is used to momentarily reduce engine output. The automatic is also equipped with a programmed lockup torque converter to improve fuel economy and reduce slippage. Lockup is available in third and fourth gear and, unlike other automatic transmissions, it occurs in four increments, rather than one abrupt transition, to provide smooth operation. The transmission is unique in that it maintains lockup while the car is decelerating.

TORQUE CONTROL DIFFERENTIAL

The torque control differential employs a multi-plate clutch and planetary gearset to help maintain vehicle stability at speed in crosswinds and when driving over split friction surface conditions. The unit reacts to the rotational difference between the rear wheels and attempts to maintain the same rate of rotation at both wheels.

If the NSX should be forced off the intended direction in a crosswind, the differential will detect the rotational difference between the two rear wheels and transfer torque to the slower rotating wheel. This has the effect of directing the car back into the desired path.

TRACTION CONTROL SYSTEM (TCS)

The goal of the Traction Control System (TCS) was to minimize rear wheelspin on slippery or uneven road conditions. This unique Honda R&D development was created as a high-performance system rather than a pure low-speed traction enhancing device. TCS uses the wheel-speed sensors of the Anti-Lock Braking System (ABS) to detect the rotational differences between the two rear wheels. If the computer determines that the surface is slippery, CPU signals are sent to decrease the amount of air and/or fuel delivered to the engine. The driver can elect to disengage TCS by a switch located on the instrument panel.

SUSPENSION

The desired goals for the NSX suspension went well beyond the typical goals of high lateral adhesion, transient response and linear response to control input. The engineers wanted a suspension that allowed the driver to easily control the car right to the limit.

The basic configuration is similar to that of a Formula One car in that it employs an upper and lower control arm (or double-wishbone) design with a coil-over shock absorber and stabilizer bar front and rear. The rear suspension also has an additional transverse link for greater wheel control. All the suspension arms are made of extremely rigid and durable forged aluminum. The front steering knuckles and the rear hub carriers are also made from aluminum forgings. The springs are straight rate with an extended rubber bump stop mounted on the chassis which acts as a progressive springing element at the limit of wheel travel.

The shock absorbers are nitrogen filled and feature a newly designed Honda Progressive Valve (HPV). The progressive opening of this valve produces a more favorable damping profile, and more precise damping control than a conventional valve system in which the fluid control orifices are either fully opened or closed.

The front and rear suspension components are mounted on separate aluminum subframes. These subframes are castings mounted to the chassis by rubber bushings, designed to reduce vibration, yet limit flex and shift of the subframes relative to the chassis.

The suspension development program was far-ranging and took place at the Tochigi Proving Grounds, the Suzuka circuit and the 179-turn Nurburgring course in Germany. In addition to the standard evaluations conducted in-house by the suspension engineers, the car was subjected to evaluation by top-rank drivers such as **three-time** Formula One World Champion Ayrton Senna, Indianapolis 500 winner Bobby Rahal, and Formula One driver Satoru Nakajima.

BRAKES

The NSX is equipped with 4-wheel ventilated disc brakes and dual piston steel calipers. The diameter of the front and rear discs are 282 mm (11.1 in). The braking targets were to set new standards of braking performance, fade resistance, provide good pedal feel, linear braking response and low pedal effort.

FOUR-CHANNEL ANTI-LOCK BRAKING SYSTEM

Developed by Honda R&D, this new 4-channel Anti-Lock Braking System controls each wheel independently with a new 16-bit microprocessor. This 4-wheel independent capability allows fine control of the anti-lock function especially when the car is braking on a surface with a split coefficient of friction — for instance, if the left side wheels are on snow, ice or standing water and the right side wheels are on dry pavement.

The basic configuration is independent parallel hydraulic circuits. In addition to the primary, non-anti-lock braking circuit, the anti-lock system has its own hydraulic reservoir, pump, modulator unit, solenoids and control pistons. If a failure in the anti-lock hydraulic circuit should occur, normal braking force will be fully retained by the primary braking circuit.

RACK-AND-PINION STEERING SYSTEM

NSX models with the manual transmission are equipped with a manual, non-assisted rack-and-pinion steering system. To ensure maximum reliability, it features a sealed gearbox design.

VARIABLE ELECTRIC POWER-ASSISTED STEERING SYSTEM

Available only on the automatic transmission-equipped NSX, this power-assisted steering system is the first of its kind on the American market. The system consists of a rack-and-pinion steering gear with an electric motor installed concentrically around the steering rack. The steering system is a direct design which functions with no assist at higher vehicle speeds. A speed sensor in the electronic control unit determines road speed and, coupled with a steering sensor for torque and rotation, feeds a signal to the motor. To ensure reliability, the electrical system for this unit features gold-plated connectors.

FORGED ALLOY WHEELS

To further reduce unsprung weight and provide the highest strength possible, the engineers specified forged-aluminum alloy wheels. To produce the wheels, a new facility was built exclusively for this purpose by Sumitomo Light Metals. The result is a very light wheel with the strength and impact resistance of a much heavier steel wheel. The rear wheels are 8x16 inch, and the front wheels are $6^{1}/_{2}$x 15 inch. Compared to cast aluminum, the total weight savings of all four wheels amounts to 12 kilograms (26.4 pounds).

TIRES

The suspension engineers, working in conjunction with Yokohama Tire Company and Bridgestone Tire Company, sought to produce a tire that would not only provide excellent traction and handling, but also allow the driver to "feel" the limits of the tires' performance.

The result was a remarkable tire of unique design that met all the high performance targets the engineers established early in the program. But since any tire is a delicate compromise, the engineers compromised heavily in favor of performance. As a result, while performance is increased dramatically, tread life is less than one would usually expect in a conventional passenger car tire. The tire sizes for both are 205/50 ZR15 front and 225/50 ZR16 rear. These tires provide excellent wet and dry weather traction, high-speed stability and predictable reaction to steering input.

OVERVIEW

A rigid structure is of paramount importance in a performance car. High rigidity provides a stable platform for proper suspension geometry and alignment, and it makes possible a tight, rattle-free interior. Additionally, central to the goal of performance is a favorable power-to-weight ratio; a very light car can achieve high performance levels with less horsepower. After an intensive research effort, it was determined that the most efficient way to meet the rigidity and weight targets for the NSX was to build the car exclusively of aluminum.

Using a Cray II supercomputer, the engineers performed millions of Finite Element Modeling and stress analysis calculations. The result of this research and development effort is a chassis that weighs 210 kg (462 lbs) with doors, hood and deck lids installed — about 40% less than a steel chassis — but with the same rigidity and impact protection. The NSX structure is significantly stiffer than every other competitor currently on the market.

EXTRUDED ALUMINUM SIDE SILLS

To attain a structure of high rigidity, complex aluminum extrusions were used for the crucial side sills of the unit body. These extrusions, with their carefully braced internal structure, contribute to the extremely high torsional stiffness of the NSX.

RADIUSED FRONT FRAME RAILS

To maximize occupant protection, the front frame rails of the unit body are designed with large-radius curves where they meet the passenger cabin. This design helps to dissipate energy in a collision, spreading out impact loads and diverting them under the passenger cell.

PERIMETER ROOF RAIL

An innovative perimeter roof rail design helps to maximize the structural rigidity of the roof. The closed-section rail securely ties the four body pillars together, helping to resist torsional forces imposed on the body in hard cornering or on bumpy roads. This improves handling precision and reduces the possibility of squeaks and rattles.

PAINTING

The NSX is painted in a 27-step paint process, including an aircraft-type chromate coating designed for use with aluminum. A new water-borne paint for the base coat was developed to achieve a clearer, more vivid color and a smoother surface finish.

CONCEPT AND GOALS

The object was to create an interior that was the sports car equivalent of a jet fighter pilot's helmet. The key elements of this concept were unlimited visibility, a feeling of snugness or intimacy with the interior of the vehicle, and the sense that the cockpit and driver were out in the airstream rather than enclosed and isolated from the environment. To achieve this feeling, the seating space for the driver and passenger was designed to fit snugly at the hips and flow outward and upward to provide ample space for the head and shoulders.

SEATING POSITION AND VISIBILITY

A low seating position contributes to a low center of gravity and helps to reduce the frontal area for improved aerodynamics. Ordinarily, a low hip-point would impart to the driver the feeling of being buried in the interior and create a claustrophobic feeling. To avoid this, the body engineers created a very low cowl section which allowed them to lower the height of the dash and instrument panel. The low cowl also enhanced forward visibility.

INSTRUMENTATION AND CONTROLS

In designing the instrument panel, the approach was one of simplicity. Since the primary function of the instruments is to relay information as clearly and quickly as possible, the designers opted for a traditional analog execution.

The instrument faces are round with white numerals on a black background. The instrument panel is dominated by the tachometer on the left and the speedometer on the right. To the left of the tach are the smaller water temperature and oil pressure gauges. To the right of the speedometer are the fuel gauge and voltmeter.

All the major controls are clustered around the steering wheel column to make them easy to reach.

DUAL AIR BAG SUPPLEMENTAL RESTRAINT SYSTEM (SRS) WITH AUTOMATIC SEAT BELT TENSIONERS

The NSX is equipped with a driver's and passenger's side air bag Supplemental Restraint System (SRS). In conjunction with this, the NSX features automatic seat belt tensioners which use the same impact sensors as the air bags. The belt tensioners are activated simultaneously with the air bags, causing the belt to retract 50 mm to help restrain the occupants in a frontal collision.

LEATHER-TRIMMED UPHOLSTERY

Leather was a natural choice for the seat trim material; it is hand stitched and hand fitted to ensure quality craftsmanship and durability. The seat facings, door inserts, steering wheel and shift knob are covered with leather.

AUTOMATIC CLIMATE CONTROL SYSTEM

A compact Climate Control System has been developed specifically for the NSX. This is a fully automatic system, but the automatic function can be overridden and the system can be used in a fully manual mode.

ACURA/BOSE® MUSIC SYSTEM

Bose® engineers became involved with the NSX sound system at an early stage of interior design. This 4-speaker system was designed and calibrated specifically for the unique acoustics and resonances of the NSX interior and provides the highest quality imaging and spatial dynamics for both the driver and the passenger.

The Acura/Bose® Music System's speakers are precisely aimed so that the pressure wave of the speaker closest to each occupant doesn't overpower the pressure wave from the speaker which is farthest away. This produces a balanced sound from each speaker and the net result is true stereo performance.

The AM/FM stereo cassette features Dolby,® Dynamic Noise Reduction® and an FM diversity antenna system. The auto preset function will automatically lock on eight strong AM and eight strong FM stations and store them into the preset selector buttons. An optional CD changer is available.

THEFT-DETERRENT SYSTEM

A sophisticated alarm system is standard equipment on the NSX. If an unauthorized attempt is made to enter or start the NSX, the horn sounds, the flashers are activated and the ~~ignition~~ STARTER system is disabled. The system automatically arms 15 seconds after the doors are locked and is disarmed when a door is unlocked with the key.

MANUFACTURING

The new NSX assembly plant is the smallest of any Honda assembly facility and prides itself on having the slowest production rate: 25 cars per day is the capacity of the Tochigi plant's 200 associates. The associates were hand-selected; they each have a minimum of 10 years' experience and must have previously distinguished themselves in a significant manner. The central goal of this plant is to produce the highest-quality automotive product in the world.

This plant has no automated conveyor line. Rather, each car is mounted on a dolly and pushed by hand from one workstation to the next. Each team of workers is responsible for the quality of work performed at their station. The car is not passed on to the next area until the team is satisfied that their procedures have achieved the tolerances and goals required in the specifications. Each assembly station, in effect, becomes an inspection station.

Engine assembly is also done in a unique way to ensure the highest level of assembly quality. Contrary to typical mass production procedures, each NSX engine is assembled by an individual, highly skilled technician from start to finish. This process keeps tolerances to levels that would not be possible in a mass assembly procedure and helps assure reliability and durability.