Technologies and Products

Quality has been central to the development and production of automobile components at DENSO since the company's inception. Thanks in large part to this relentless quest for excellence, DENSO today supplies components and systems to automakers around the world. As the first step in the creation of any product, R&D is vital to preserving and enhancing quality. DENSO is constantly expanding its base of core technologies to hone its competitive edge by supplying products in step with and ahead of the latest market trends.

Today, DENSO's R&D programs need to address the challenges posed by the restructuring and realignment of the global automobile industry. The greatest challenge is raising quality while lowering prices. There are many ways to accomplish this. We try to create products that suffuse existing functions and can be made in an innovative way that strikes just the right balance between cost and quality. We also use different materials and production processes to bring down costs. But any solution to this dilemma must originate at the R&D level.

At the same time, R&D programs need to target three key aspects of automobile performance that will be most in demand by drivers and society at large: safety, environment, and comfort. Here, we will draw on core technologies to devise new ways to meet these needs, and in the process, elevate the DENSO brand to a higher plateau.

> THE ROLE OF THE R&D SYSTEM

We conduct far-reaching R&D activities in a number of facilities located in Japan and overseas. R&D is principally undertaken by DENSO Research Laboratories, the Corporate R&D Department at corporate headquarters, Nippon Soken, Inc., and DENSO IT Laboratory, Inc. In fiscal 2001, the year ended March 31, 2001, we formed a software development team to focus on this area of growing importance to our business. With the goal of making our software development more efficient, this team's primary responsibility will be reexamining software architecture and devising software development tools.

R&D covers all aspects of operations from powertrains, thermal equipment, and electric and electronic systems and components to telecommunications and industrial equipment. Synergies between technologies and business operations assist the development of innovative components and systems. All this contributes to our goal of manufacturing the world's best products.

Expenditures in R&D for fiscal 2001 totaled ¥177.0 billion, 10.6% more than in the previous year. This figure amounted to 8.8% of net sales.

In the current fiscal year, we are boosting investments in software, a field that is certain to become one of our core technologies of the future. DENSO IT Laboratory was established in Tokyo in August 2000 to

from left:
A motor generator for electric and hybrid vehicles
An audio-visual communication navigation system, which plays an important role in transport telematics
A laser radar and a distance control ECU for an adaptive cruise control (ACC) system

develop core software for telematics equipment, such as advanced car navigation systems. DENSO now operates four software development companies.

> MEETING INDUSTRY DEMANDS WITH DENSO TECHNOLOGY

Safety, environment, and comfort will shape the automobile industry in the 21st century. And our technologies are in place to support automakers in all three of these areas.

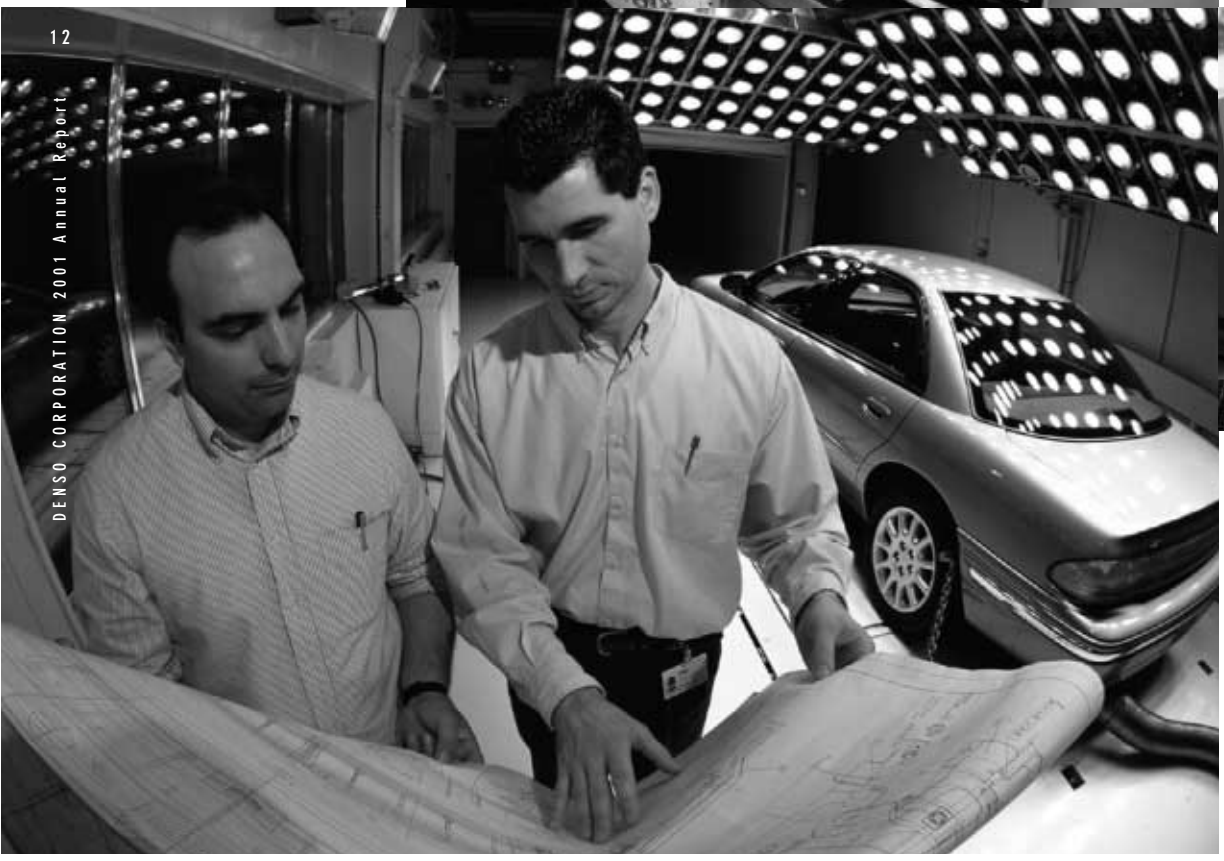
For example, in the area of comfort, we are developing adaptive cruise control (ACC) systems, telematic navigation systems, electronic toll collection (ETC) systems, fleet management systems with global positioning systems and satellite communications, and human-machine interfaces, which bring IT to the automobile. R&D efforts are targeting smart airbags, antilock braking systems (ABS), and vehicle stability control (VSC) systems to improve automobile safety. We are also at work on environmentally friendly products such as common rail fuel injection systems, gasoline direct injection systems, and motor generators, convertors, inverters, and battery ECUs for electric and hybrid vehicles. In all these endeavors, we are constantly looking to fuse our knowledge of core technologies and automobiles into an organic, coherent whole.

> MAKING THE WORLD'S BEST PRODUCTS

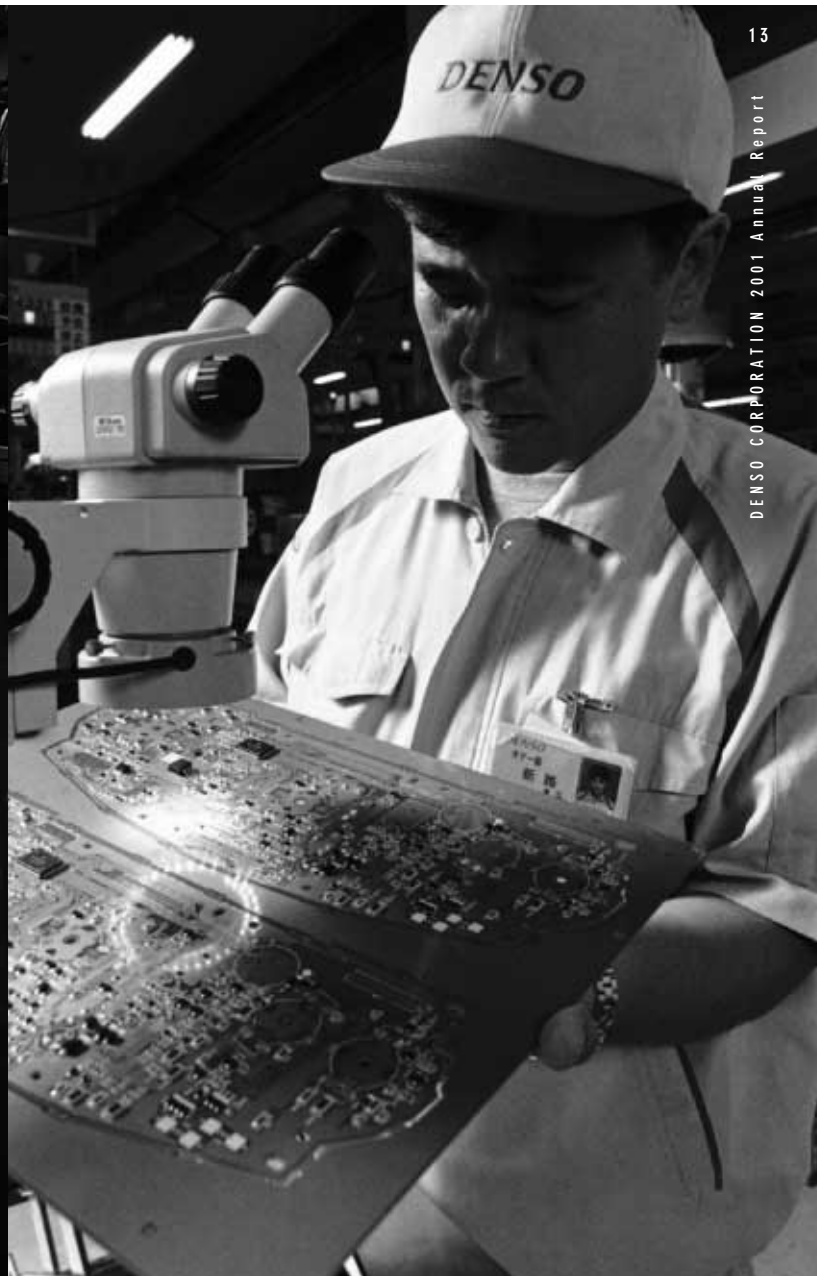
Through the years, DENSO has always channeled its energies into creating the world's best products—products that can meet the expectations of our customers. The figures tell the story. At present, we hold the world's highest market share in a range of different products. We hope that a number of new products will also grow to command leading market shares. For example, we believe we have struck gold with our equipment for hybrid vehicles and common rail fuel injection systems. In fiscal 2001, new developments included our segment conductor (SC) alternators and cooling modules.

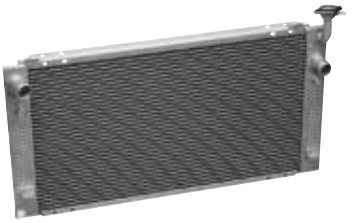
In April 2001, we began selling a water-heating system that uses carbon dioxide as a coolant. This system has attracted attention for its environmentally sound technology, which achieves total equivalent warming impact 1,700 times lower than hydrofluorocarbons (HFCs). Applying this coolant to car air-conditioning systems is also a distinct possibility.

In fiscal 2001, we became the world's first company to launch mass production of cooling modules. Integrating a radiator and an air-conditioning condenser in a single unit, the cooling module reduces by around 40% the space required by conventional models. Moreover, it improves the cooling performance of both the engine coolant and the air conditioner refrigerant. Our ability to address the issue of heat transfer testifies to DENSO's dedicated efforts to unlock new heat transfer technologies.



Linking all associates together are DENSO's superior technical capabilities and a powerful commitment to quality.





from left:
A cockpit module that mainly includes an air conditioning unit, an instrument cluster/panel, and a navigation system
A supply pump and injectors for the ECD-U2P common rail system
A radiator-condenser cooling module

> RAISING R&D EFFICIENCY

Automobile manufacturers are dramatically reducing the time needed to introduce new models. And we must move quickly to do the same. We are harnessing IT to expedite product development and are attempting to bring greater satisfaction to customers by halving production lead times in pursuit of higher levels of productivity.

One initiative is a digital engineering system that integrates all processes from product planning to production. Incorporating computer simulations from the outset removes the need to create a number of prototypes at different operational stages. Instead, the entire product development sequence can be realized digitally and concurrently. As such, we need only build a single prototype for final verification. The system integrates automakers' computer-aided design (CAD) software with our own to share three-dimensional data in all stages of the product development sequence. Digital engineering is being introduced throughout our operations in Japan and overseas.

Software has become an essential component in nearly every category of automotive systems. DENSO has raised productivity in R&D by adopting an innovative emulator for prototyping software. Our emulator enables engineers to virtually check the performance of engines without reprogramming the engine ECU.

> DEVELOPING A TEAM OF SKILLED RESEARCHERS

The development of skilled researchers is a critical task for any company that relies on R&D to bring forth the products that will shape its future. DENSO Research Laboratories is working to educate outstanding researchers in a number of ways. For example, we invite leading overseas researchers to Japan to share their knowledge. We stress that learning from our past projects is vital for the benefit of the company. And our senior researchers are committed to passing on their know-how, skills, and experience to young people coming through the ranks.

> BALANCING PERFORMANCE AND COST ISSUES

Ensuring high performance at a low cost might seem contradictory. But we are resolving this issue by reexamining our products from the design stage onward. The main emphasis is on devising techniques that lower costs without sacrificing performance. For example, air-conditioning systems have been completely redesigned for Toyota Motor Corporation's Vitz and other compact vehicles to save costs while maintaining performance.

We continue to identify ways to bring down costs while ensuring that the products we have spent years refining to achieve superior quality do not suffer as a consequence. This necessitates going back to the drawing board. Only from the design and R&D stage can new product concepts emerge.

> FUTURE TECHNOLOGIES

At present, we are working on a range of exciting new technologies that will offer greater safety and comfort for drivers, as well as exert less impact on the environment. Safety is a particularly current theme. Here, we introduce some examples of how we are helping provide drivers and passengers alike with vehicles that offer the very latest in safety technology.

Our approach to safety in R&D has evolved over the years. Initially, we based our R&D efforts on the concept of "active safety." Technologies were designed to avoid accidents. This involved creating superior handling and braking capabilities. Later, we also developed safety technology under the concept of "passive safety." This meant designing technologies on the premise that a collision is imminent at all times. A prime example is the airbag. The main thrust of our efforts now is back on active safety. We are focusing on three forms of technology.

The first is stand-alone technology that enhances safety within the vehicle. Laser radar and millimeter wave technology are generating new ways to make cars safer. The laser radar has already been utilized in our ACC systems, which reduce driving loads by adjusting the distance to the preceding vehicle. We are also working on millimeter wave technology. Vehicles of the future will be able to automatically avoid collisions by detecting and moving out of the way of obstacles in front of them. Image recognition technology, meanwhile, uses a laser to recognize objects in front of a sensor. The sensor can measure the time taken for the laser to reflect off objects and come back to the sensor, and compute the shape of the objects in line with distance. It can thereby achieve three-dimensional sensing. This image recognition technology is another possibility for future automobiles.

Second is technology that links the vehicle with its infrastructure. We are currently developing VSC systems that are linked to car navigation systems. The car navigation system recognizes data on the road conditions up ahead, for example if there is a sharp curve, and feeds this information to the VSC, thus avoiding potential danger.

Infrastructure is our third theme. We are working to develop technologies that prevent collisions as part of the traffic infrastructure, such as sensors laid down on existing roads. Road sensors are helping to prevent accidents by detecting whether roads pose a threat due to rainfall or snow.