

IAA 2011

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## **Technology built for progress Sept. 14 2011.**

Good morning, everyone.

When the first automobiles were hitting the roads more than 100 years ago, a driver's main concern was keeping the car running so they could simply get from point A to point B.

Those drivers could never have imagined what today's driving experience would be like. 100 years later, drivers still want their cars to get from point A to point B, but they also want cars that are:

Clean and Green.

Safe and Secure.

Connected and Comfortable.

At DENSO, we've been focusing on developing products and technologies that customers and consumers will want in their vehicles.

Let me tell you about just a few of the technologies we're working on right now.

### **Clean and Green**

The European Union has set a goal to limit average carbon dioxide emissions from new vehicles to 130 g/km by 2015, with plans to further tighten it in stages.

To satisfy the 130g/km regulation, we believe that efficiency improvements for combustion engines—both gasoline and diesel—and stop/start technology are essential for small to mid-size vehicles, and hybrid technologies for mid to large-size vehicles. And we believe the need for hybrid and electric vehicles will increase to meet future regulations.

DENSO is developing technologies for all of these powertrains.

Let's start with gasoline engines.

For gasoline engines, direct injection systems will increase.

DENSO first mass-produced Gasoline Direct Injection components back in 1996, and since then, we have manufactured more than 20 million fuel injectors.

In 2011, we developed a new Direct Injection System, including a high-pressure fuel injector and a high-pressure pump, which can achieve better fuel efficiency and lower emissions.

Our new injector can achieve the world's smallest level of fuel particle spray – approximately 10 to 15 micron meters. This is smaller than the thinnest strand of human hair. Also it has a unique valve structure that allows more accurate control of injection quantity and low operating noise.

The plunger of our new high-pressure pump is covered with a distinctive coating that enables it to achieve the world's highest injection pressure of up to 20 MPa while maintaining durability.

Our new injector and pump are now installed on Japanese and U.S. vehicles. They also will be installed on the Mazda CX5 with SKYACTIV-G, Mazda's new-generation direct injection engine, which you can see at the Mazda booth.

SKYACTIV-G also uses DENSO's unique electric variable cam timing or electric VCT that can realize precise valve control at a wider operation range than a conventional hydraulic VCT. Combined with the direct injection technology, our products contribute to the improvement in fuel efficiency and output found in Mazda's new engine.

Diesel engines will continue to capture half of the market in Europe, and DENSO has developed the world's first technology for common rail systems called i-ART or intelligent accuracy refinement technology.

i-ART uses DENSO's unique injection pressure-measuring sensors mounted inside each injector to automatically control injection quantity and timing on a real-time basis. Compared to the conventional open-looped technology, i-ART can improve fuel efficiency by 2 percent while reducing emissions and automakers' calibration costs. More importantly, this technology will enable diesel systems to meet EURO 6 regulations, while reducing dependency on after-treatment systems.

In an effort to make diesel engines even cleaner, we are working to raise fuel injection pressure to a range of 250 MPa to 300 MPa depending on vehicle type, including passenger and commercial vehicles.

Now, let's talk about stop/start systems. Stop/start systems stop the engine when the vehicle idles at a stop light or in other traffic situations. You'll see more and more of these systems on both gasoline and diesel engines in Europe.

DENSO has recently developed a tandem solenoid or TS starter for stop/start systems.

Our TS starter is the first in the world to use a structure that separately controls starting the motor and shifting the pinion gear, and which can fit in the same space as a traditional starter. That means there is no need to modify the engine.

The TS starter is unique, because it restarts the car's engine before zero rpm. So if a light changes to green fast or another traffic situation demands a quick move, the car will restart smoothly.

When this starter is used in stop/start systems that cut the fuel supply during deceleration, which is earlier than a conventional system, fuel efficiency can potentially increase by about 4 to 5 percent.

Right now we're working on a stop/start system that combines the TS starter with a deceleration regeneration system composed of a highly efficient alternator and high-volume power source to more effectively use deceleration energy. This system could improve fuel efficiency by up to 8 percent.

We can't talk about environment and efficiency without talking about hybrid and electric vehicle technologies. These technologies will be indispensable in reducing CO2 emissions, and car makers are accelerating the development of a variety of hybrid, plug-in hybrid, range extender and electric vehicle systems.

DENSO has been developing electric vehicle-related technologies since the 1970s. That extensive experience allowed us to develop the products introduced on the first Toyota Prius launched in 1997.

Since then, we've developed and manufactured a variety of products.

For example, in 2007, we commercialized the world's first inverter that cools both sides of

semiconductor elements. That change allowed the inverter to achieve 60 percent higher output density than a conventional structure. This type of inverter is now installed on 4 vehicle models, the Lexus LS, and RX, Hino's light duty truck, Dutro, and the recently released, Toyota Camry hybrid. Our focus is to standardize the inverter's components to reduce cost and expand market share.

- Right now we're working on several new products including:
- Motor generator using the winding techniques of our alternators
- Smaller, highly efficient EV battery charger
- Battery pack including a battery, battery monitoring unit, and cooling fan
- Heat pump for heating

These products will allow us to expand our hybrid and electric vehicle product line-up while we continue to pursue higher performance and lower weight, size and cost in our current products to meet the needs for our customers around the world.

## **Safe and Secure**

Did you know that traffic accidents around the world account for 1.3 million deaths?

Our commitment to safety dates back to the 1970s when we started working on airbag development, before these systems were government mandated.

Our first focus was passive safety to minimize damage in a collision. In 1989, we began supplying our airbag sensing system with semiconductor sensors to automakers around the world.

Then we expanded our focus to active safety to prevent collisions.

Collisions are mainly categorized as head-on, rear-end, road departure, and intersection. DENSO has been developing sensing and control technologies to help avoid all these types of collisions.

In 1997, we began supplying laser radar and ECU for adaptive cruise control systems (\*), and in 2003, we launched the millimeter wave radar and ECU for the world's first pre-crash safety

system. The adaptive cruise control system helps avoid rear-end collisions, and the pre-crash safety system can additionally help avoid head-on collisions.

(\*) including an alarm function for when vehicles' distance close in

To prevent lane departure, we introduced cameras for lane departure warning systems in 2003 and for lane keeping assist systems in 2004.

Now we're working on high-performance and low-cost millimeter wave radars and cameras to meet Europe's advanced emergency braking system and lane departure warning mandates for trucks.

Preventing collisions at intersections is more challenging, because current on-vehicle sensors cannot detect obstacles around blind corners. DENSO has been working with automakers and government agencies around the world, including Europe, on wireless communication technology that has a much wider range than current sensors. We have supplied more than 200 on-board communication devices for their verification tests. These devices allow data to be transmitted from the roadside to vehicles or from vehicle to vehicle, providing warnings if it's not safe to enter an intersection or if a vehicle is approaching from a blind corner.

But this is not enough.

Accident data analysis shows us that 75 percent of accidents are caused by driver error or driver behavior.

If we really want accident-free driving, we need technology that addresses the human element. And DENSO has been developing driver monitoring technologies to achieve this goal.

We recently developed a technology that monitors where a driver is looking as well as eyelid movement to detect inattentive driving and driver drowsiness. When our system determines the risk of an accident, it alerts the driver.

Also, there are times when all of us momentarily lose our concentration while we're driving. When that happens, we're likely to miss possible dangers that we would usually notice. In response to this, DENSO is working on technology that can measure drivers' attention level by looking at a variety of factors including: facial movement and driver operation patterns of steering, accelerating and braking.

We're even looking at driver health. We are developing technologies that monitor a driver's heart rate, pulse and autonomic nerve activity to detect a sudden change in physical conditions. These

technologies will become more important as the number of elderly drivers increases.

Combining our expertise and technologies in sensing, communication, control, and HMI or human machine interface to develop more advanced safety systems will help us eliminate the problems that cause accidents and maximize the safety of everyone—drivers, passengers and even pedestrians.

### **Connected and Comfortable**

Wi-fi, smart phones and other portable terminals allow people to stay online and connected nearly everywhere, all the time. And they want that experience to continue inside their cars.

DENSO is collaborating with automakers and telecommunication companies on ways to balance the demand for connectivity with safety. Right now, we're working with these partners on standardizing an interface that will allow you to see your smart phone or portable terminal display inside your car in the safest way possible. We plan to introduce our new in-vehicle device with this interface in Europe sometime next year.

In addition, DENSO and Toyota have co-developed Toyota Entune. Entune allows Internet- and Bluetooth-equipped smart phones to bring a variety of applications into a car's infotainment system. Entune's touch panel and voice recognition system allow drivers to safely and easily use the applications while driving. Entune is now installed on Toyota's Prius V in the U. S.

But drivers also want to access to safety-related information like that provided by the adaptive cruise control system, lane departure warning system, or night vision.

DENSO provides a wide variety of HMI or human machine interface systems, including instrument clusters, in-vehicle infotainment systems, remote touch controllers and head-up displays or HUD.

DENSO's current HUD uses a compact projection unit that provides high luminance yet requires little electrical power. This technology is realized by using DENSO's expertise in simulating light projection, and our design and production technology of optical components. Currently, we are working on making the HUD full-color and increasing the size of images projected on the windshield.

In addition, because of our wide range of technology and products, DENSO is developing an HMI manager that coordinates our human-machine interface systems and determines the best method

to safely and comfortably share information with a driver, depending on the current conditions in and around the vehicle.

Here's an example of how our HMI manager will work.

Imagine you're driving around Frankfurt and talking to a friend on your hands-free phone when you come to a roundabout. Our HMI manager will be able to detect that you're approaching a roundabout—which requires a bit more driver focus—so it will automatically put your call on hold until you navigate through. This is just one way the HMI manager can help realize safe driving without causing driver distraction.

DENSO's vision is a world without traffic accidents, less burden on the environment and a driving experience that is enjoyable and safe.

Clean and Green.

Safe and Secure.

Connected and Comfortable.

We will continue to develop and manufacture products that can make our vision a reality.

Thank you.

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