DENSO Software Research Projects

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Chief Engineer

Corporate Electronic Platform (e-PF) Department
DENSO Corporation
**DENSO Corporate Profile**

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**Established**  
December 16, 1949

**Capital**  
(as of March 31, 2007)  
187.4 billion yen (US$1.6 billion)

**Net sales**  
(April 1, 2006-March 31, 2007)  
- Consolidated basis: 3,609.7 billion yen (US$30.6 billion)
- Non-consolidated basis: 2,292.9 billion yen (US$19.4 billion)

**Net income**  
(April 1, 2006-March 31, 2007)  
- Consolidated basis: 205.2 billion yen (US$1.7 billion)
- Non-consolidated basis: 137.9 billion yen (US$1.2 billion)

**Employees**  
(as of March 31, 2007)  
- Consolidated basis: 112,262
- Non-consolidated basis: 34,090

**Consolidated subsidiaries**  
(as of March 31, 2007)  
- (Japan 68, The Americas 38, Europe 33, Asia/Oceania 49)  
188

**Affiliates under the equity method**  
(as of March 31, 2007)  
- (Japan 14, The Americas 6, Europe 2, Asia/Oceania 8, Others 2)  
32

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Notes:  
U.S. dollar amounts have been translated, for convenience only, at the rate of 118 yen = US$1, the approximate exchange rate prevailing on March 31, 2007. Billion is used in the American sense of one thousand million.
## DENSO Major Products

<table>
<thead>
<tr>
<th>Category</th>
<th>Products</th>
<th>Increased by percentage</th>
<th>Percentage of Net Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Automotive</strong></td>
<td><strong>Thermal Systems</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Diesel Engine-related Products</td>
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<td></td>
<td>Engine Cooling Components</td>
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<td></td>
<td>Increased by 4.3% per year on year to ¥164.3 billion.</td>
<td>33.4%</td>
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<td></td>
<td><strong>Powertrain Control Systems</strong></td>
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<td></td>
<td>Transmission Control Components</td>
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<td>Increased by 11.2% per year on year to ¥644 billion.</td>
<td>23.3%</td>
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<td></td>
<td><strong>Electronic Systems</strong></td>
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<td></td>
<td>Ready Electronic Products</td>
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<td>Increased by 10.2% per year on year to ¥324.9 billion.</td>
<td>15.2%</td>
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<td></td>
<td><strong>Electric Systems</strong></td>
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<td></td>
<td>Engine-related Components</td>
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<td></td>
<td>Driving Control and Safety Systems</td>
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<td>Increased by 13.5% per year on year to ¥454.4 billion.</td>
<td>11.3%</td>
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<td><strong>Small Motors</strong></td>
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<td>Increased by 5.6% per year on year to ¥284 billion.</td>
<td>6.4%</td>
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<td><strong>ITS (Intelligent Transport Systems)</strong></td>
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<td>Car navigation systems, electronic toll collection (ETC) systems,</td>
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<td>increased by 4.3% per year on year to ¥107.9 billion.</td>
<td>4.3%</td>
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<td><strong>Industrial Systems</strong></td>
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<td>Industrial Automation (FA) Systems</td>
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<td>Increased by 8.7% per year on year to ¥31.0 billion.</td>
<td>2.1%</td>
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<td><strong>Consumer Products</strong></td>
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<td>Intelligent household appliances</td>
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<td>Increased by 9.7% per year on year to ¥145.9 billion.</td>
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</tbody>
</table>

*PRODUCT EXAMPLES*
- FROM LENS TO LIGHT • Electric compressor with incorporated inverter • Air-conditioning unit • Liquid cooled modules
- PRODUCTS EXAMPLES
- FROM LENS TO LIGHT • Rear View System • Integrated Air-Conditioning Module • • Sky Sensor
- PRODUCTS EXAMPLES
- FROM LENS TO LIGHT • Instrument Cluster • Vehicle ECU • Cruise Control sensor
- PRODUCTS EXAMPLES
- FROM LENS TO LIGHT • Rearview Camera System (RCS) • AEC • Sensor for • • Sky Sensor
- PRODUCTS EXAMPLES
- FROM LENS TO LIGHT • Internal backup system • Power window motor • • Motor
- PRODUCTS EXAMPLES
- FROM LENS TO LIGHT • Car navigation system • ETC (Electronic Toll Collection) • Data Communication Module
Sales Breakdown (April 1, 2006-March 31, 2007) (Consolidated basis)

3,609.7 billion yen

- Thermal Systems: 31.5%
- Powertrain Control Systems: 16.2%
- Information and Safety Systems: 9.2%
- Electric Systems: 8.6%
- Electronic Systems: 6.9%
- Small Motors: 1.8%
- Other Automotive: 1.5%
- Industrial Systems/Consumer Products: 1.3%
- Others: 1.3%
Sales by Customer Location (Consolidated basis)

- Japan: 51.5%
- The Americas: 21.3%
- Europe: 14.1%
- Asia & Oceania: 12.8%
- Others: 0.3%

The Americas
Europe
Asia-Oceania
China
DENSO Operations in the Americas

1. DIAM - DENSO INTERNATIONAL AMERICA, INC.
2. DSCA - DENSO SALES CALIFORNIA, INC.
3. DMMI - DENSO MANUFACTURING MICHIGAN, INC.
4. AIMS - AMERICAN INDUSTRIAL MANUFACTURING SERVICES, INC.
5. DMTN - DENSO MANUFACTURING TENNESSEE, INC.
6. DMAT - DENSO MANUFACTURING ATHENS TENNESSEE, INC.
7. MACI - MICHIGAN AUTOMOTIVE COMPRESSOR, INC.
8. TBDN - TBDN TENNESSEE COMPANY
9. AFCO - ASSOCIATED FUEL PUMP SYSTEMS CORPORATION
10. DWAM - DENSO WIRELESS SYSTEMS AMERICA, INC.
11. ACTIS - ACTIS MANUFACTURING, LTD. LLC.
12. DMAR - DENSO MANUFACTURING ARKANSAS, INC.
13. TACG - TD AUTOMOTIVE COMPRESSOR GEORGIA, LLC
14. DRAM - DENSO REINSURANCE AMERICA, INC.
15. DMCN - DENSO MANUFACTURING CANADA, INC.
16. DSCN - DENSO SALES CANADA, INC.
17. DNMX - DENSO MEXICO S.A. DE C.V.
18. DNBR - DENSO DO BRASIL LTDA.
19. DNAZ - DENSO INDUSTRIAL DA AMAZONIA LTDA.
20. DMBR - DENSO MAQUINAS ROTANTES do BRASIL LTDA.
21. DTBR - DENSO SISTEMAS TERMICOS do BRASIL LTDA.
22. DNAR - DENSO MANUFACTURING ARGENTINA S.A.

(as of March 31, 2007)
Organization in 2008

Board of Directors

Chairman, Vice Chairman, President C.E.O., Executive Vice President

Thermal Systems Business Group

Powertrain Control Systems Business Group

Electric Systems Business Group

Information & Safety Systems Business Group

Electronic Systems Business Group

Corporate ePF (electronic PlatForm) Department

Engineering Research & Development Center

Production Promotion Center

Sales Group

Administration Center

Corporate Center
Challenge of Automotive E/E systems

• Increasing system scale and complexity
  – Increasing number of ECU (Electronic Control Unit)
    • Over 70 ECUs in luxury car
  – Distributing functionality on heterogeneous bus systems
    • CAN, LIN, FlexRay, MOST
  – Service integration with outside infrastructure
    • ETC, VICS, Car to Car or Car to Road Communication

• Dominating Standardization
  – AUTOSAR, ISO26262, Automotive-SPICE

Improving FLEXIBILITY, PRODUCTIVITY, and QUALITY
Characteristics of Automotive software

• A lot of features
  – more than 4000 features within one vehicle
• Hard Realtime
  – Micro second order for driving sensor/actuator
• Limited resources usage
• Distributed functionalities
• Heterogeneous networking
  – CAN, LIN, FlexRay, MOST
• High quality criteria
• Often requirement changing
• Many variants
Increased System Scale

Node (ECU) Number
Of typical luxury car

1995 13 00 03 06
5 70

Another luxury car
50('05) ⇒ 60('08)
Network System in Vehicle

Central to distributed • Heterogeneous Networking
e.g. Research Projects relating Software platform

- **Component-based Architecture (1996~)**
  - Introducing Object-oriented technologies to our automotive software development
    - Software Component (SW-C)
    - layered structure based on hardware abstraction

- **AUTOSAR software platform (2005~)**
  - Open standard architecture using IT technologies
    - Virtual Functional Bus (VFB)
    - XML-based system description
Automotive System Trend

Control Systems

Stand Alone Systems

Networked Sub-systems

Integrated Vehicle Systems

Service Integrated Systems (Vehicle and Infrastructure)

Methodology

Code-based Development

Component-based Development

Model-based Development

Platform-based Development

Next Research Area

- Environment
- Safety
- Comfort
- Convenience
Service Integrated Systems

Service Integration

- Satellite communication
- Digital broadcast
- TV / radio station
- Street / garage
- Vehicle-to-vehicle communication
- Vehicle-to-roadside communication

Integration with Customer Services

Integration with Broadcast Services

Integration with Information Services

Integration with ITS Services

Integration with On-board Services (ECU Integration)

Information Service Center

Terminal at convenience store

Service contents

Internet

Car dealer

On-board information station

Sensor / actuator

Data terminal

Body

Control

Multi-media

DENSO
Challenge for Establishing Service Integrated Systems

• Service model definition and implementation
  – Abstract Model of Vehicle Service
  – Interface between each services
• Implementing protection mechanism against invalid access from outside
  – Secure Platform
  – Firewall
• Adapting to dynamical change of system configuration
  – Installing ad-hock communication system
  – Dynamic Configuration
SOA (Service Oriented Architecture)

Mapping to Automotive domain

- Automotive Use case
- Automotive Service
  e.g. ETC, VICS, etc.
- AUTOSAR Profile
- E/E system resource
  e.g. ECU, E/E server, etc.

Figure 1. A Service Oriented Architecture. [1]
Some of the OMG MDA Standards that Support SOA are listed on the right in blue.
Thank you for your attention!