Mastering the Challenges in Embedded Software Development

October 6th, 2008
Dr. Juergen Moessinger
Vice President
Automotive System Integration
Robert Bosch GmbH
Agenda

➔ Bosch Group
➔ Challenges in Automotive Development
➔ Solutions
  - Architecture Based Development – SW Reuse
  - Processes
➔ Conclusion – Implementation at Bosch
➔ Summary
Bosch Group

Structure of the Bosch Group

Business sectors

Automotive Technology
Sales: 28.4 billion euros
Share of total sales: 61%

Industrial Technology
Sales: 6.0 billion euros
Share of total sales: 13%

Consumer Goods & Building Technology
Sales: 11.7 billion euros
Share of total sales: 26%

1) Including other business areas
## Key data

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales revenue*</td>
<td>43,684</td>
<td>46,320</td>
</tr>
<tr>
<td>Associates&lt;sup&gt;1)&lt;/sup&gt;</td>
<td>261,291</td>
<td>271,265</td>
</tr>
<tr>
<td>located in Germany</td>
<td>110,480</td>
<td>112,300</td>
</tr>
<tr>
<td>located outside Germany</td>
<td>150,811</td>
<td>158,965</td>
</tr>
<tr>
<td>Capital expenditure*</td>
<td>2,670</td>
<td>2,634</td>
</tr>
<tr>
<td>Research and development cost*</td>
<td>3,348</td>
<td>3,583</td>
</tr>
<tr>
<td>Profit before tax*</td>
<td>3,081</td>
<td>3,801</td>
</tr>
<tr>
<td>Profit after tax*</td>
<td>2,170</td>
<td>2,850</td>
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</table>

<sup>1)</sup> As per January 1, 2007/2008

*Currency figures in millions of euros
Bosch Group

Research and Development Expenditure

<table>
<thead>
<tr>
<th>Year</th>
<th>EUR m</th>
<th>% of sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>2,650</td>
<td>7.3</td>
</tr>
<tr>
<td>2004</td>
<td>2,715</td>
<td>7.0</td>
</tr>
<tr>
<td>2005</td>
<td>3,073</td>
<td>7.4</td>
</tr>
<tr>
<td>2006</td>
<td>3,348</td>
<td>7.7</td>
</tr>
<tr>
<td>2007</td>
<td>3,583</td>
<td>7.7</td>
</tr>
</tbody>
</table>
In 2007, Bosch applied for patents for a total of 3,281 new inventions (approx. 14 per day).

In April 2007, the Bosch researchers Andrea Urban and Franz Lärmer received the EU Commission’s and European Patent Office’s “European Inventor of the Year” award.

Bosch remains the global technology leader in the field of automotive technology, a fact which is also shown by its strong patent position in leading countries:

- **Germany:** 1st place (German Patent and Trademark Office)
- **EP:** 1st place (European Patent Office)
- **U.S.:** 3rd place (United States Patent and Trademark Office)
- **WIPO (PCT):** 1st place (World Intellectual Property Organization)

Germany, EP, WIPO: published applications for patents
U.S.: patents granted
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Challenges in Automotive Development

Increasing Requirements

Reduction of emission, fuel consumption

Safety

Comfort

CO₂ reduction

Automotive Technology

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Drivers of Growth – Electronics / Software

- Share of electronics in vehicle value (in value)*:
  
  2004: 20% → 2015: 40%

- Share of software in vehicle value (in value)**:
  
  2000: 4.5% → 2010: 13%

- Number of ECU in vehicles strongly increases
  - mid size: e.g. Golf 50 ECU
  - high end: e.g. Lexus > 80 ECU

- SW in high end vehicles reaches 1 GB

Source: * McKinsey, Automotive Electronics - Managing innovations on the road
** Mercer Consulting, Automobile Technology 2010
Challenges in Automotive Development

The Challenge - Increase of Complexity

- master complexity
- keep quality & reliability of E/E systems at high level
- enable off shoring
- gain freedom for innovation
- reduce costs

Solution: SW Reuse and Sharing
Strategy: Standardization of SW architecture
Challenges in Automotive Development

Industrialized Countries - Shortage of Engineers

Low Birthrate
major trend in industrialized countries

Aging society
- population in Japan will decrease to 90 Mio. in 2055
- 41% of population will be older than 65 in 2055
-- Kyoto news 2008 --

Reduced no. of students
- no. of students for applied engineering faculty decreased below 300,000 in 2007 (less than half of 1992)
-- NE 16.6.08 article --

Change in automotive market

Lack of educated engineers
Agenda

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Architecture Based Development – SW Reuse

AUTOSAR

- **Architecture - AUTOSAR Basis-SW**
  - Uniform behavior of the ECU in the vehicle
  - Easier integration of ECU in the vehicle
    (Mastering complexity)

- **Methodology**
  - Shift from ECU based to function based SW development

- **Application Interfaces**
  - Support of SW re-use and SW Sharing between vehicle platforms, OEM and Tier x

Increase of quality and reduced time to market, cost reduction by SW re-use
SW Reuse

- Pre-condition for integration of application software
  - Standardized BSW
  - Standardized ASW interfaces
  - Well structured and modular application architecture

Application Software

Proprietary BSW

Non standard interfaces

Hardware

Conventional

AUTOSAR

Application Software

AUTOSAR RTE

Hardware

standardized

HW-specific
## AUTOSAR Roadmap

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Release 2.1</td>
<td>Release 3.0</td>
<td>Release 3.1</td>
<td>Release 4.0</td>
</tr>
<tr>
<td>• Resolved release notes</td>
<td>• Start-up / Wake-up behavior</td>
<td>• OBDII</td>
<td>• Error handling</td>
</tr>
<tr>
<td>• Application interfaces</td>
<td></td>
<td></td>
<td>• Functional safety</td>
</tr>
</tbody>
</table>

### Status / Achievements

- AUTOSAR Rel. 3.0 / Rel. 3.1 released
- Product development based on AUTOSAR started at OEM and Tier X
Processes

Processed based development

- Organization processes improvement (Capability Maturity Model Integration)
- Process steps are defined
- Constant process improvement by
  - defined processes
  - increased visibility
  - traceability
- Reproducibility
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Migration to AUTOSAR @ Bosch

Bosch SOP 2012/13
All BOSCH divisions are committed to exploit AUTOSAR.
Processes

Processes at Bosch

- Bosch Engineering System (BES)
  - Innovation Management
  - Product Engineering
  - Project Management
  - Process Management
  - Knowledge Management
  - Competence Management

- Maturity Model of BES is based on CMMI

- Rollout of CMMI is part of BES: Software quality by design
  - Coding guidelines according to standards – e.g. MISRA
  - Code generation (e.g. via ASCET)
  - Quality Methods (e.g. FMEA, Fault-tree, DRBFM, 6-sigma, DOE)

Released man power by process based development used for new innovations
Human Resources

49 Automotive Development Sites in 18 Countries

Associates by region

- Germany: 112,300
- Rest of Europe: 38,782
- Americas: 72,724
- Asia Pacific: 47,459

Total: 271,265

Development Sites with ≥ 50 Associates, Status January 2008

- Including other countries
- As per January 1, 2008
Human Resources

Recruiting and Training of Software Engineers

- Engineers from German university
  - reputation of engineering is growing among students
  - many foreign students in Germany (~ 10 %), especially in engineering

- Immigration of engineers from Eastern Europe

- Offshoring – Low barrier due to internationalization of business

- Systematic training of software developers
  - Curriculum Engineering Software Intensive Systems (CMMS)

- Bosch invests in Germany
  some 100 Mio € in training of its associates
# Human Resources

## Offshoring of Development to Bosch India

- 100% subsidiary of Robert Bosch GmbH
- No. of associates: 4500+
- Largest Bosch development centre outside Germany

- CMMI L5 (July 2006), ISO 9001:2000 company
- M2006 start of operation in Coimbatore 300 km southwest of Bangalore

### Development locations at India

- Bomanahalli (Bmh)
- Naganathapura (NhP)
- Koramangala (905)
- Coimbatore (Cob)

### Marketing offices worldwide

- Fh, USA
- Si, Germany
- Hig, Japan
- Kor, India
## Human Resources

### Embedded Offshore Development at Bosch India

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>➔ Embedded s/w</td>
<td>➔ PLC and CNC prog.</td>
<td>➔ ASIC Design</td>
<td>➔ Back office support</td>
</tr>
<tr>
<td>➔ Tools</td>
<td>➔ Engineering frameworks</td>
<td>➔ IC-Test development</td>
<td>➔ Comm. Center</td>
</tr>
<tr>
<td>➔ Diagnostics</td>
<td>➔ Functional Test Bench Solutions</td>
<td>➔ Board-Level Electronic Design</td>
<td></td>
</tr>
<tr>
<td>➔ Testing</td>
<td>➔ Plant/Manufacturing Automation Solutions</td>
<td>➔ PCB Layout Design</td>
<td></td>
</tr>
<tr>
<td>➔ h/w &amp; s/w Dev.</td>
<td>➔ Embedded s/w</td>
<td>➔ SW development for ASIC and FPGA applications</td>
<td></td>
</tr>
<tr>
<td>➔ System Dev.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>➔ ECU Projects</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Business Solutions

<table>
<thead>
<tr>
<th>SAP R/3, Consulting</th>
<th>Oracle, Microsoft</th>
<th>Java, IBM Solutions</th>
<th>User Access Mgmnt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>➔ E-Learning</td>
<td>➔ Product info/ 3D animation</td>
<td>➔ Design</td>
<td>➔ Accounts Receivable</td>
</tr>
<tr>
<td>➔ Mechanical Engineering</td>
<td>➔ Learning Mgmt.</td>
<td>➔ FEA, Simulations</td>
<td>➔ Accounts Payable</td>
</tr>
<tr>
<td>➔ Shared Services Accounting</td>
<td></td>
<td>➔ Drawings, Modeling</td>
<td>➔ General Ledger</td>
</tr>
<tr>
<td>➔ Accounting</td>
<td></td>
<td>➔ Administration</td>
<td>➔ Fixed Assets</td>
</tr>
<tr>
<td>➔ Back office support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>➔ Comm. Center</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

### Translation, Documentation, Web

- DE⇔EN, EN⇔JP
- Tech. & Commercial
- Digital Archiving
- Web Pages

### Shared Services Accounting

- Accounts Receivable
- Accounts Payable
- General Ledger
- Fixed Assets
## Human Resources

### Offshoring Embedded – Key to Sustainable Success

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategy</strong></td>
<td>Offshore Support from India/Bangalore</td>
</tr>
<tr>
<td><strong>Psychology</strong></td>
<td>Advantage for Engineers and Managers To Overcome Fear of Loss: Control/Responsibility/Job!</td>
</tr>
<tr>
<td><strong>Commercial</strong></td>
<td>Efficient Interfaces Prerequisites are processes and architecture</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>Regular Contacts at All Levels</td>
</tr>
<tr>
<td><strong>Vision</strong></td>
<td>Competitiveness by Cooperation</td>
</tr>
</tbody>
</table>
Bosch values the experience of its older associates, and employs measures specifically designed to support them, while at the same time challenging them.

Every year, more than 6000 young people around the world receive occupational training at Bosch.

Bosch has considerably expanded its activities to attract young talent, especially internationally.

Apart from attractive development programs for associates, Bosch attaches importance to internal career planning within the framework of its manager development schemes.

Flextime working models, childcare, initiatives for parents, and social work help keep Bosch competitive.

Bosch values the experience of its older associates, and employs measures specifically designed to support them, while at the same time challenging them.

In Germany alone, Bosch invests some 100 million euros every year in training for its associates. A structured and systematic approach ensures that the skills needed are available in the right place at the right time.

In 2007, more than 2,300 specialists and managers were working on long-term assignments outside their home countries.
Bosch Group

Bosch Values

1. Future and Result Focus
2. Responsibility
3. Initiative and Determination
4. Openness and Trust
5. Fairness
6. Reliability, Credibility and Legality
7. Cultural Diversity
Mastering the Challenges in Embedded Software Development

Summary

- Mastering the above mentioned challenges is the basis for innovation
- Architecture and process based software development is mandatory for efficient offshoring
- Offshoring reduces the lack in engineers (global development)
- Organization needs to support the climate for innovation

Innovation in SW Development

Processes
- organizational
- technical

Architecture
based development
e.g. AUTOSAR

People
with skills, training and motivation
Mastering the Challenges in Embedded Software Development

Thank You

Innovation in SW Development

Processes
- organizational
- technical

Architecture
- based development
  e.g. AUTOSAR

People
- with skills, training
  and motivation

Automotive Technology

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