“Electronic & Mechatronics Issues that Affect Heavy Duty Remanufacturers”

Joe Kripli & Jeff Stukenborg
ABOUT WABCO

GLOBAL TECHNOLOGY LEADER in commercial and automotive vehicle industry

Sales of $1.5 BILLION in 2009

Over 8,100 EMPLOYEES in 31 countries; 1,250 ENGINEERS

18 PLANT LOCATIONS in 10 countries

Listed on NYSE with the stock symbol WBC
Targeted Business

- **CUSTOMER PRODUCTS** – Provide direct REMAN solution to the OE/OES

  - Initial targeted market focus is on OE(s) within the Passenger Car, Commercial vehicles, Agriculture and non competing TIER 1’s.
  - Collaboration to use customers technical information to provide OE certified products.
  - Core management solutions to meet Customer needs.
  - Initial focus on Electronics and Mechatronics products:
MARKET FOCUS

Products, systems, services and support for vehicle manufacturers and aftermarket customers.

TRUCK
- CNHTC
- DAIMLER
- FREIGHTLINER
- HINO
- MAN
- PACCAR
- SCANIA
- VOLVO
- among others

TRAILER
- CIMC
- GREAT DANE TRAILERS
- KÖGEL
- KRONE
- SCHMITZ CARGOBULL
- WABASH
- among others

CAR

BUS
- EVOBUS
- MAN
- NISSAN
- YUTONG
- among others

REMAN SOLUTIONS

Audi
- BMW
- DAIMLER
- GENERAL MOTORS
- PSA
- PEUGEOT CITROEN
- SSANGYOUNG
- among others

Commercial vehicles
Industrial/Agricultural vehicles
Passenger cars

SERVICES
- Supporting fleet and truck owners over vehicle lifetime
- Distributors
- Workshops
- Fleets
ABOUT WABCO – Historical Milestones

2009 WABCO acquires majority control of award-winning WABCO-TVS in India
2008 WABCO completes joint venture agreement with FUWA to produce air disc brakes in China
   - WABCO opens test track extension in Jeversen, Germany
   - WABCO-TVS inaugurates two manufacturing facilities in India
2007 WABCO becomes independent public company on August 1, 2007. Listed on New York Stock Exchange (NYSE) with stock symbol WBC
2005 Manufacturing facility inaugurated in Chennai, India with joint venture partner
2003 Aftermarket training center opens in Hanover, Germany
2002 Joint venture manufacturing facility established in Jinan, China
2001 Manufacturing facility opens in Wroclaw, Poland
   - Manufacturing facility opens in Pyongtaek, Korea
1996 Manufacturing facility in Charleston, South Carolina, USA joins WABCO as part of joint venture with Cummins
1994 WABCO opens test track in Jeversen, Germany near the company’s major research, development and production facility in Hanover.
   - Acquisition of Deutsche Perrot Bremsen in Mannheim, Germany
1990 Arvin Meritor and WABCO form Meritor WABCO joint venture for North America
1988 WABCO opens its first wholly owned test track in Rovaniemi, Finland
1985 Manufacturing facility opens in Meppel, the Netherlands
1981 Manufacturing facility opens in Campinas, Brazil near Sao Paulo
1977 WABCO enters into Sundaram Clayton Limited (SCL) joint venture in Chennai, India
   - Manufacturing facility acquired in Leeds, United Kingdom
1969 American Standard acquires WABCO.
1922 Manufacturing facility opens in Gronau, Germany
1884 WABCO headquarters for its German operations established in Hanover, Germany
1869 Westinghouse Air Brake Company (WABCO) founded in USA by George Westinghouse
WABCO Reman Stanowice (WRS) FACILITY

Stanowice, PL Fact Sheet

Size – 53,820 sq. ft. (5,000 Sq. M)
Location - 16 miles (25km) from Wroclaw
SOP – Effective October 18, 2010
Quality Cert. - TS16949 and ISO14001 (to be completed in 2011)
WABCO Reman Rochester Hills (WRR) FACILITY

**Rochester Hills, MI Fact Sheet**

- **Size**: 61,200 sq. ft. (5,865 Sq. M)
- **Location**: 15 miles (24km) from Detroit
- **SOP**: Effective October 13, 2010
- **Quality Cert.**: TS16949 and ISO14001 (to be completed in 2011)
REMAN MARKET DRIVERS

- **Pressure from customers** for reduced pricing options and meeting long term supply requirements.
- **Increasing complexity** resulting in the inability of competent service/repair.
- **Escalating number of ECU’s** in vehicles drives the need for solutions to produce service components effectively.
- **Extending useful life** of Commercial and Passenger vehicles is driving the replacement requirements of older vehicles with obsolete components.
- **Rising costs** in energy and raw materials globally.
- “**Green”/sustainable** environmental movement.
Today’s Presentation

- Markets
- Global Impact
- Technology Impact
- Product
- Opportunities
Module Invasion

- 2007-Average 6 Modules per Vehicle
- 1,066,000 Trucks X 6 = 6,396,000 ECU
- Last 6 Years = 6,062,000 Diesel Trucks means 36,372,000 Modules in Market
- Class 8 = 1,378,000 Trucks=8,268,000 Modules Valued at $10B
The decline in U.S. vehicle sales has been dramatic and the forecasted recovery is slow.

Source: Longbow Research
Similar to the U.S. auto market, the Class 8 truck market has suffered a dramatic decline and a slow recovery is forecast.
GLOBAL TRUCK & BUS PRODUCTION

WESTERN & EASTERN EUROPE

NORTH AMERICA

JAPAN & KOREA

CHINA & INDIA

(1,000 units; over 6 tonnes Gross Vehicle Weight)
<table>
<thead>
<tr>
<th>Region</th>
<th>Price</th>
<th>Price in Market</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORTH AMERICA</td>
<td>&lt;$1,000</td>
<td>$80K</td>
<td>- Less advanced technology vs. Western Europe</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Large OEMs: Daimler, Volvo, PACCAR, ITE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Large fleets, able to influence OEM design</td>
</tr>
<tr>
<td>SOUTH AMERICA</td>
<td>&lt;$1,500</td>
<td>$65K</td>
<td>- Less advanced technology – mostly from Brazil</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Main OEMs: Daimler, VW, Volvo, Scania</td>
</tr>
<tr>
<td>WESTERN EUROPE</td>
<td>&gt;$3,000</td>
<td>$130K</td>
<td>- Advanced technology, high electronics penetration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 6 OEMs: Daimler, Volvo, MAN, Iveco, PACCAR, Scania</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Few large, pan European fleets</td>
</tr>
<tr>
<td>JAPAN &amp; KOREA</td>
<td>&lt;$1,000</td>
<td>$80K</td>
<td>- Technology moving towards Western Europe</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Main OEMs: Hyundai, Hino, Isuzu, Nissan Diesel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Targeting global market</td>
</tr>
<tr>
<td>EASTERN EUROPE</td>
<td>&lt;$500</td>
<td>$70K</td>
<td>- Fast growing production</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Improving quality and safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Global and local OEMs: KamAZ, MAZ, RusBus, Tatra, Roman</td>
</tr>
<tr>
<td>CHINA</td>
<td>&lt;$300</td>
<td>$30K</td>
<td>- Basic technology; advanced technology penetration under 10% of total market</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 3 large OEMs: FAW, DFM, CNHTC; many small</td>
</tr>
</tbody>
</table>
Today’s Presentation

- Markets
- Global Impact
- Technology Impact
- Product
- Opportunities
Where did the light duty truck and passenger car market go?

**Government regulation**
- Tighter emission standards
- Increased safety requirements
- Increased CAFE fuel economy standards
- Recycling Requirements

**Technology Impact**
- **Increased number of electronic modules** (ECM, BCM, TCM, Safety, Security, etc.)
- **Increased engine performance** (direct Injection, turbocharging, diesel)
- **Driver convenience products increases** (bluetooth, navigation, web-enabled, video)
- **Complicated system integration** (CAN network)

**TECHNOLOGY EXPLOSION - Traditional mechanical systems are being replace by electronic and mechatronic systems**
Computer chips in the Chevrolet Tahoe

- Keyless Entry
- Compass
- DVD
- Sunroof Module
- Rear Seat Heating
- Rear Door Switches
- Power Liftgate
- Rear Park Assist
- Door Module
- Memory Seat
- Garage Door Opener
- Seat Position & Seat Heating
- Engine
  - Engine Control Module
  - Transmission Module
  - Stability Control
  - Active Suspension
  - Yaw Control
  - Valve Control
- Cruise Control
- Brakes
- Airbag Modules

Source: General Motors

WABCO Reman Solutions
Electric Steering Mechatronic

Example of a traditional mechanical system that is changing to a Mechatronic system
**Escape Hybrid**

**Four Cylinder Gasoline Engine**
- Highly efficient four cylinder engine uses an advanced combustion cycle
- V-6-like acceleration
- Maximizes fuel economy and reduces emissions

**Electric Transaxle**
- Combination of transmission and electric drive components
- Acts as traditional transmission, but is more efficient and provides an electrical boost when needed
- Electric motor can drive on battery alone, improving fuel economy

**Nickel-Metal Hydride Battery**
- Sealed battery modules
- Charges and discharges automatically
- Recharged by engine and regenerative braking system
- No plug-in required

**Vehicle System Controller (VSC)**
- "Brain" continuously monitors and controls the engine, electric transaxle and battery
- Automatically switches between operating modes
- Optimizes system performance and fuel efficiency

**Regenerative Braking**
- Captures energy otherwise lost as heat
- When vehicle slows or stops, energy from the wheels is converted into electricity and stored in the battery
HD industry is following the same path

Government regulation
- Emission Reduction
  - Selective Catalyst Reduction (SCR)
  - Exhaust Gas Recirculation (EGR)
- Safety Improvements
  - ABS/Stability Control
- Recycling Requirements

Technology Impact
- Move to common rail diesel injection
- Increased engine performance
- Driver convenience products increases (navigation, radios, refrigeration)
- Complicated system integration (CAN network)
- Hybrid powertrains (buses, delivery trucks)
- Fuel cell (auxiliary power units)

YOU HAVE 20/20 VISION OF WHAT IS COMING
EXAMPLE OF TECHNOLOGY IMPACT:

- Mandatory in EU in 2011; North America and Japan in 2012/13
- Includes yaw control to keep vehicle on steered course and avoid jack-knifing
- Roll Stability Support mitigates roll-over situations for coaches, trucks and trailers
- ESCsmart™: Industry’s first technology that uses computational simulation to certify ESC. Breakthrough homologation system approved in 27-country EU and in 20 other countries

SALES PROJECTIONS IN ELECTRONIC STABILITY CONTROL

<table>
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<tr>
<th>Year</th>
<th>Sales</th>
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<tbody>
<tr>
<td>2008</td>
<td>100,000</td>
</tr>
<tr>
<td>2011</td>
<td>321,000</td>
</tr>
<tr>
<td>2013</td>
<td>840,000</td>
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</table>

CAGR 53%
TRUCK AND TRAILER PRODUCTS

TRUCK
1. Electronic Control Units
2. Adaptive Cruise Control
3. EBS Proportional Relay Valve
4. Pedal Unit with EBS Brake Signal Transmitter
5. ABS Modulator Valve
6. Automatic Temperature Control
7. Electronically Controlled Air Suspension
8. Shock Absorber
9. Front Air Disc Brake
10. Steering Angle Sensor
11. Transmission Automation
12. Clutch Control
13. Retarder Control
14. Air Compressor
15. Rear Air Disc Brake
16. (Electronic-) Air Processing Unit
17. Reservoir
18. EBS Trailer Control Valve
19. Electronic Stability Control Module
20. EBS Axle Modulator

TRUCK AND TRAILER
21. Brake Chamber
22. Tristop® Cylinder
23. Air Bellow
24. Integrated Vehicle Tire Monitoring ECU
25. IVTM Wheel Module
26. Double Diaphragm Spring Brake

TRAILER
27. Trailer Central Electronic
28. SmartBoard
29. Trailer Electronic Braking System
30. Electronically Controlled Air Suspension
31. Trailer Air Disc Brake

EBS: Electronic Braking System
ABS: Anti-Lock Braking System
ECU: Electronic Control Unit
BUS PRODUCTS

EBS Brake Signal Transmitter
EBS Proportional Relay Valve
ABS Solenoid Modular Valve
Electronic Stability Control Unit
EBS Backup Valve
EBS Axle Modulator
Adaptive Cruise Control Module
Hand Brake Valve
IVTM Display
IVTM Wheel Module
IVTM Electronic Control Unit
Automatic Traction Control Water Valve
ATC Operating Console
ATC Substation
Electronic Control Units EBS, CVC
ECAS Electronic Control Unit
ECAS Solenoid valve
ECAS Level Sensor
Air Disc Brake
Brake Chamber
Tristop Cylinder
(Electronic) Air Processing Unit
Compressor
MTS Sensor
MTS Door Cylinder
MTS Electronic Control Unit
MTS Door Valve

EBS: Electronic Braking System
ABS: Anti-Lock Braking System
CVC: Central Vehicle Controller
IVTM: Integrated Vehicle Tire Monitoring
ECAS: Electronically Controlled Air Suspension
MTS: Door Control for Bus
Hybrid Technology

Eaton Hybrid System for Commercial Trucks

Engine: 4.3 L 4-cylinders Diesel

Motor: PM DC 340 V

Battery 340 V Li-Ion 7.2 Ah (Shin-Kobe)

Inverter

- Engine
- Auto Clutch
- EMI
- 6-Speed AMT
- Reduction Gear

Rear Wheels

<table>
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<tr>
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<th>BL</th>
<th>HEV</th>
<th>Change</th>
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<tbody>
<tr>
<td>MPG*</td>
<td>9.3</td>
<td>13.42</td>
<td>45%</td>
</tr>
<tr>
<td>PM</td>
<td>0.158</td>
<td>0.0112</td>
<td>93%</td>
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<tr>
<td>NOx</td>
<td>12.9</td>
<td>5.8984</td>
<td>54%</td>
</tr>
<tr>
<td>HC</td>
<td>0.02</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>CO₂</td>
<td>1103</td>
<td>758</td>
<td>31%</td>
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<tr>
<td>CO</td>
<td>1.89</td>
<td>0.7352</td>
<td>60%</td>
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<tr>
<td>0-60</td>
<td>32.2</td>
<td>30</td>
<td>7%</td>
</tr>
<tr>
<td>Grade</td>
<td>4%</td>
<td>5.1%</td>
<td>28%</td>
</tr>
</tbody>
</table>

* Over the FedEx cycle, a modified FTP cycle
Technology Impact on the Industry?

• New diagnostic & training requirements at the repair level
  – System integration of multiple electronic products
  – CAAN communication

• Flashing/Software update requirements

• Life cycle production concerns
  – Past model electronic component shortages
  – Life time buy requirements *(how do you know how many you need?)*

• Core handling changes
  – Cannot damage connector or case
  – Cannot damage electronic components
  – Electro-Static Discharge (ESD) concerns
Opportunities
Turbocharger Mechatronic Actuator
Fuel Injection Mechatronic
Engine Controller
Truck ECM
ABS Mechatronic
ABS Controller
ABS EHCU
An opportunity for the HD Reman Industry

- There are lots of new reman opportunities
- Substainable Life Cycle Model
  - Provide service parts for 15-25 years
  - More affordable replacement parts
- Need to develop electronic testing and repair capabilities
- Core collection is critical (handling is a big concern)
THANK YOU!