Transferring the Experience and Technology of Electric Mobility into Aircraft

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Toulouse

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Schaeffler Group – BU Aerospace
Transferring the Experience and Technology of Electric Mobility into Aircraft

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“Together we move the world”
Schaeffler Group

**Employees worldwide: More than 80,000**

**Sales (FY 2013) worldwide: € 11.2 billion**

**168 locations in 49 countries**

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales in million euros</th>
<th>Proportion in %</th>
</tr>
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<tbody>
<tr>
<td>2009</td>
<td>7,336</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>9,495</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>10,694</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>11,125</td>
<td>23</td>
</tr>
<tr>
<td>2013</td>
<td>11,205</td>
<td>56</td>
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</table>

**Structure in effect until December 31, 2013**

- **Europe**: 56%
- **Asia/Pacific**: 23%
- **South America**: 5%
- **North America**: 16%
<table>
<thead>
<tr>
<th>Category</th>
<th>Image</th>
<th>Bearing Type</th>
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<tr>
<td>Power Transmission</td>
<td><img src="image" alt="Gear" /></td>
<td>Tapered roller bearings</td>
</tr>
<tr>
<td>Heavy Industries</td>
<td><img src="image" alt="Roller" /></td>
<td>Ball bearings</td>
</tr>
<tr>
<td>Consumer Products / Medical Systems</td>
<td><img src="image" alt="Medical Equipment" /></td>
<td>Needle roller bearings</td>
</tr>
<tr>
<td>Railway</td>
<td><img src="image" alt="Train" /></td>
<td>Spherical roller bearings</td>
</tr>
<tr>
<td>Motorcycles</td>
<td><img src="image" alt="Motorcycle" /></td>
<td>Cylindrical roller bearings</td>
</tr>
<tr>
<td>Off-Highway</td>
<td><img src="image" alt="Off-Highway Vehicle" /></td>
<td>Linear technology</td>
</tr>
</tbody>
</table>
Main shaft and gearbox bearing supports, e.g. for the Boeing 787 Dreamliner and Airbus A 380

Gearbox, swash plate, and transmission shaft bearings for helicopters

Special bearings for rocket engines, e.g. turbo pump bearings (Space Shuttle) and cross pin bearings (Ariane 5)

High-precision bearings in the joints of the robotic arm of the Phoenix Mars lander
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Motivation: Reduction in Fuel Burn, Emissions & Noise

Fuel Burn - Level
2000

Today's Modern Aero Engines

Advanced Aircraft Configurations

Geared Fan

20-35% New Engines

Recuperating Aero Engines (with heat exchanger)

2030 Technologies

Open Rotor

20% New Aircraft Config's

Air Traffic Management (ATM)

10% ATM

Minimum 50% Reduction in Fuel Burn and Emissions

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High Efficient State of the Art Rolling Element Bearing Systems

- 40% Weight & Power Loss Reduction
- Advanced Bearing Designs
- Integrated Outer Ring Cooling System
- Integrated Shaft / Bearing Modules
- New Materials, Coatings & Surface Technologies
- Optimized Surfaces
- Advanced Bearing Cooling Systems
- Multi-Body-Calculation
- Calculation of Shaft / Gear / Bearing Systems
- Advanced Bearing Analysis
- Ceramic Rolling Elements
- Diamond Like Coatings on Rolling Elements

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Schaeffler Automotive: Covering the full range of powertrain and chassis electrification:

- Electric Axle Drive
- Hybrid Module
- eWheel
- Hybrid Module
- Active Roll Control System (ARC)
Transfer of the Passenger Car eWheel Technology into Aircraft: eTaxi

Technical data

- Torque: 525 Nm cont. / 850 Nm peak
- Power: 38,5 kW cont. / 60 kW peak
- Weight: approx. 66 kg
- Dimensions: approx. Ø 419 mm x 184 mm
Transfer of the Passenger Car eWheel Technology into Aircraft: eTaxi

- Average estimated fuel saving per taxiing & a/c: 13 kg/min
- Average taxi-time per day & a/c: 95 min
- Average estimated fuel saving per day & a/c\(^1\): 1.2 t
- Average estimated fuel saving per year & a/c\(^2\): US$ 200,000

\(^1\) electric power consumption and increased airplane weight not considered \(^2\) $US/bbl = 70

Example:

Airbus A320

6,799 total deliveries (10,504 family)
3,697 firm order backlog (6,132 family)

Source: EUROCONTROL, US Department of Transportation, Aircraft Commerce, IATA, Airbus
Note: *As of 30 June 2014
Transfer of the Passenger Car Active Roll Control (ARC) Technology into MEA

Technical description

• Nominal voltage 12V
• ø90 x 392 mm (without bars)
• Total weight 11.8 kg (w/o bars & cables)
• Nominal 900 Nm, peak 1,200 Nm
• Ramp-up speed 900 Nm at 200 ms
• Torque accuracy at life time 40 Nm (4%)
• ASIL A
Transfer of the Passenger ARC Technology into MEA

General benefits of the ARC

- Significantly improved comfort by
  - reduction of vehicle body roll at cornering
  - reduction of copy movements at poor roads
- Safety improvements due to reduction of over steering
- Improved vehicle dynamics and agility at any speed
- Enables differentiation of platforms from main stream

Benefits of the Schaeffler ARC

- CO₂ reduction by 8g /100km(*) due to power-on-demand
- High actuator dynamics (900Nm / 0.2s)
- High torque accuracy over lifetime
- Plug-and-play – easy handling and assembly
- Maintenance-free

*) 0.3l/100km

(*) 0.3l/100km
Transfer of the ARC Technology into Aircraft
Concept Case: Actuation of Slats and Flaps

State of the Art Hydraulic Flap Actuation System:

- Rotary or ball screw actuators
- Symmetrical deployment of flap panels
- "Easy to Lock" in case of asymmetry or power loss
- Many mechanical components in the drive system (joints, gearboxes, bearings etc.)
- No individual actuation of each single high lift surface possible
Transfer of the Passenger ARC Technology into Aircraft
Concept Case: Distributed Actuation of Slats and Flaps

Distributed Electromechanical Actuation System:
- Elimination of central hydraulic motor and mechanical drive systems
- Individual actuation of each single high lift surface possible, which allows for greater functionality
  - Varying wing profile options lead to improved lift distribution and reduced drag during cruise
  - Vortex decay due to individual deflection
  - Can compensate left / right wing fuel imbalance or OEI conditions
  - Adjustment of the Center of Lift in order to reduce wing bending moment in overload cases

Electromechanical Roll Control Unit as Flap Actuator
- Potential use as actuator in distributed flap actuation systems
  - high torque, torque acceleration, and torque accuracy
  - high reliability
  - low weight
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Summary

- Advanced mechanical aerospace bearing systems can be leveraged and incorporated in new electromechanical aerospace systems
- Automotive modules such as the eWheel and the ARC present potential for transfer into MEA
- The eWheel technology is a potential solution for direct electric landing gear drive (eTaxi)
- The ARC system presents a possible option for a distributed flap actuation system

Advanced aerospace bearing systems and new electromechanical systems derived from automotive applications can contribute to more efficient and reliable MEA
Thank you for your attention!