Well positioned in attractive markets
A true global player – team, culture, and presence

Revenue split 2016

- Mature markets (54%)
- Emerging markets (46%)

Europe
- 33%
- $11.3 bn

Americas
- 29%
- $9.7 bn

AMEA
- 38%
- $12.8 bn

Top 200 managers
- >3/4 from outside Switzerland and Sweden
- 27 nationalities from 6 continents
- 7 nationalities in the Executive Committee

ABB has a unique global team with local presence everywhere
## ABB: the pioneering technology leader

<table>
<thead>
<tr>
<th>What (Offering)</th>
<th>Pioneering technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products</td>
<td>58%</td>
</tr>
<tr>
<td>Systems</td>
<td>24%</td>
</tr>
<tr>
<td>Services &amp; software</td>
<td>18%</td>
</tr>
</tbody>
</table>

| For whom (Customers) | | |
|----------------------|-----------------|
| **Utilities**        | ~35% of revenue|
| **Industry**         | ~40% of revenue|
| **Transport & Infrastructure** | ~25% of revenue|

<table>
<thead>
<tr>
<th>Where (Geographies)</th>
<th>Globally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia, Middle East, Africa</td>
<td>38%</td>
</tr>
<tr>
<td>Americas</td>
<td>29%</td>
</tr>
<tr>
<td>Europe</td>
<td>33%</td>
</tr>
</tbody>
</table>

| ~$35 bn revenue | ~100 countries | ~132,000 employees |
Robotics and motion division in nutshell

Three global business units

<table>
<thead>
<tr>
<th>Drives</th>
<th>Motors and Generators</th>
<th>Robotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Drives image]</td>
<td>![Motors and Generators image]</td>
<td>![Robotics image]</td>
</tr>
<tr>
<td>~ 9.2 Billion in revenue</td>
<td>~30,000 Employees in &gt;80 countries</td>
<td>~ 70 Manufacturing sites across all regions</td>
</tr>
<tr>
<td>~ 100 Countries</td>
<td>~70</td>
<td>~ 100 Countries</td>
</tr>
</tbody>
</table>
Attractive markets: Energy and Fourth Industrial Revolutions

The Energy Revolution

Utilities

Energy

The Fourth Industrial Revolution

Industry

Transport & Infrastructure
**Business Unit Drives in nutshell**

We want to be the preferred partner to customers in drive

<table>
<thead>
<tr>
<th>What (Offering)</th>
<th>To whom (Customers)</th>
<th>Where (Geographies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV+MV Drives/Traction</td>
<td>OEM</td>
<td>AMC</td>
</tr>
<tr>
<td>Service</td>
<td>Distributors</td>
<td>EUC</td>
</tr>
<tr>
<td></td>
<td>EPC/ SI/EU</td>
<td>AMA</td>
</tr>
</tbody>
</table>

- > 2.5 Billion in revenue
- ~ 6,000 Employees in >80 countries
- 12 Manufacturing sites across all regions
- 14 Service centers
BU Drives

We serve all industries, all applications
Global presence

- Germany, Menden
- Poland, Lodz
- Italy, Genova
- China, Beijing
- Finland, Helsinki
- Estonia, Jüri
- USA, Richmond
- Switzerland, Turgi
- India, Bangalore
- Sorocaba, Brazil
- USA, Wisconsin
- Germany, Menden (Central stock Europe)
- Singapore, Central stock Asia
- Finland, Jyväskylä
- USA, Richmond
- India, Bangalore
- Sorocaba, Brazil
- USA, Wisconsin
- Germany, Menden (Central stock Europe)
- Singapore, Central stock Asia
- Finland, Jyväskylä
- USA, Richmond
- India, Bangalore
- Sorocaba, Brazil
- USA, Wisconsin
- Germany, Menden (Central stock Europe)
- Singapore, Central stock Asia
You choose, we respond. Globally.

ABB is a reliable service partner

- Over 600 ABB field service engineers
- Services in more than 60 countries
- 500 service partners
- Providing services for almost 40 years

- Global Service Center (3)
- Regional Service Center (11)
- Service workshops (30)
- ABB or partner service
- Covered by closest HUB
The forerunner of technology
Cornerstones of innovation

Over
45 years
of experience

1969 AC drive development started
1975 High power PWM drive
1985 Megastar 3-level pulse width modulation (PWM) MV drive with vector control, digital flux vector control
1995 Direct torque control (DTC)
1997 IGBT based high power LV drive with DTC
1999 IGBT based high power LV drive with DTC, air and liquid cooled
2004 Standard LV AC drive with intuitive user interface
2005 Scalable, compact AC500 PLC
2006 Servo performance LV AC drives
2009 Insulated gate bipolar transistor (IGBT), active neutral point clamping 5 level (ANPC-5L) MV drive
2011 All-compatible platform
2013 Safety PLC and I/O

©ABB
November 10, 2017 | Slide 10
## Recent innovations: e-buses

Electric buses redefine urban mobility

### Modern charging and traction systems for electric and hybrid buses

**TOSA: first electric articulated bus without overhead lines**
- Ultrafast charging times at chosen bus stops (15 seconds)
- After a successful pilot phase, the City of Geneva ordered 12 TOSA buses (replacing diesel busses from 2018 on).

**«Swisstrolley plus»: High performance trolley bus**
- Innovative traction system from ABB combined with modern battery technology
- Bus produces electricity when breaking or when driving downhill. This electricity is used to charge the battery or fed into the grid.
- Test operation in Zürich

ABB is also leading with other charging technologies and traction systems for electric or hybrid buses. Ongoing projects in Belgium, Sweden, Luxemburg and Canada.
The world’s demand for energy will not go away

ABB drives/propulsion help use energy more efficiently

Great saving potential

Less than 10% of world's motors are equipped with variable speed drives

Improving energy efficiency worldwide is the fastest, the most sustainable and the cheapest way to reduce energy consumption and lower CO₂ emissions

Electricity demand

+90% by 2035

Motors consume about 28% of the world’s electricity
Energy efficiency with ABB drives
Helping customers do more using less

Our installed base saved 490 TWh of electricity* and prevent 410 million tons of CO2 emissions

Equivalent to the annual energy consumption of more than 120 million households if that electricity was generated by fossil fuels the saved emissions equal to roughly the yearly emissions of over 90 million cars

* In 2015
Digitalization opens new opportunities

From traditional maintenance to predictive future

Smart, connected drives…

..send data to secure cloud…

… where analysis turns data into knowledge.

Knowledge turns into predictive actions.

- Key performance indicators show where to focus the actions.
- Detailed report gives more information on the issue.
- Expert can recommend and support the actions needed.
- Condition based predictive alerts ease follow up.

Digitalization provides real time knowledge to reduce customers’ costs and increase their revenues
Shipbuilder Brødrene Aa, Norway
MS Vision of the Fjords sightseeing vessel

Application
Hybrid-electric carbon fiber catamaran with reduced environmental footprint
- Designed to carry 400 passengers
- Operating in Nærøyfjord on the west coast of Norway.

ABB scope
HES880 drives (10 pcs) installed in
- Ship propulsion
- Thrusters
- Battery charging
- Off-grid

Customer benefits
- Small size
- Rugged design
- Silent running
- Environmental solution for fjords
Shakti Pumps

ABB’s solar pump drive made new pump technology totally independent from the electricity grid and diesel fuel.

“Once the system is installed, there are no fuel costs, no emissions, and no CO2 generation. Instead, we have a quiet, non-polluting, dependable water pumping system with low maintenance and a lifetime of up to 25 years.”

Ankit Patidar
Vice President of Sales & Marketing

<table>
<thead>
<tr>
<th>ABB scope</th>
<th>Set up</th>
<th>Customer benefits</th>
</tr>
</thead>
</table>
| Shakti Pumps chose the ACS355 solar pump drive with built-in maximum power point tracking (MPPT) technology | ![Solar pump diagram] | - The new series fills a market niche for solar pumping systems
- Pumping is totally independent from electricity grid so it can be used in remote-access locations
- Can be run on both solar energy and the grid. |
Broad portfolio of traction solutions
For all railway applications

- 120+ years of experience in electric propulsion
- Leading independent supplier of electric traction equipment
- Flexible, very compact and lightweight design
- Proven retrofit solutions

Long-term and reliable partner to the railway industry
ABB solutions for all rolling stock applications
New vehicles and retrofit

Very high-speed and high-speed
- Metro

Multiple unit trains
- Light Rail Vehicles, People mover

Locomotive, dual, electric, diesel-electric
- E-Bus
ABB traction system provider

Individual components to complete traction systems

1. Train Control Monitoring System
2. Surge Arresters
3. Low Voltage Components
4. Traction Motors
5. Traction Transformers
6. Traction Converters
7. Battery Chargers
8. Auxiliary Converters
BORDLINE® CC – Compact Converter

Versatility and customization based on standard power modules
Low Floor Converter for High Speed Train, Europe
Multi system converter to operate in all European networks

<table>
<thead>
<tr>
<th>Application</th>
<th>Customer benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly compact and efficient traction solution for diverse market requirements (multisystem); compact battery charger built with SiC power semiconductors</td>
<td>- Multi-system traction concept for various traction supply systems: 25 kVAC, 15 kVAC, 3 kVDC, 1.5 kVDC</td>
</tr>
<tr>
<td></td>
<td>- Compact traction solution for low-floor train with maximum space and comfort for passengers (underfloor mounting for traction transformer and traction)</td>
</tr>
<tr>
<td></td>
<td>- High energy efficiency and availability</td>
</tr>
</tbody>
</table>
Converter replacement for high-speed trains, Germany DB

Significant increase in energy efficiency and availability

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Application

Replacement of old thyristor converters with IGBT converters in high-speed trains ICE 1 (DB) without any modification to control, transformer, traction motor and train control system

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Customer benefits

- Energy consumption cut by at least 15 percent
- Massive reduction in operating cost
- Massive gain in reliability and availability
**Converter replacement for locomotive Re 460, Switzerland SBB**

Improved reliability and availability for next 25 years

<table>
<thead>
<tr>
<th>Application</th>
<th>Customer benefits</th>
</tr>
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</table>
| Replacement of GTO converters with state-of-the-art IGBT based ABB traction converters. Existing traction transformer and motors are retained. 101 locomotives to be retrofitted until 2021. | - Significantly lower energy consumption  
- Increase of train availability  
- Easy maintenance  
- Lower total cost of ownership |
**Traction package for maintenance vehicles**

Powerful dual-mode traction system (Diesel / 15 kV)

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**Customer Need**
- Powerful dual-mode traction technology (Diesel/15 kV AC) for Gotthard base tunnel
- Compact and light-weight design

**ABB Solution**
- Solution based on well proven and standardized multisystem traction converter and transformer
- Low-voltage IGBT platform
- Two redundant traction converters

**Customer Benefits**
- More payload possible due to light-weight design
- Highly efficient electrical traction chain

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**Countries:** CH

**Operators:** Swiss Federal Railways SBB

**Category:** Railway Maintenance Vehicle

**Scope of supply for 24 vehicles:**
- BORDLINE CC750 Traction Converter
- Traction transformer

**Key data:**
- 700 kW /vehicle in AC mode

**Deliveries:** 2015 - 2017
Traction system replacement for diesel-electric metro rail cars
Upgrade GTO to IGBT technology

Country: AUS
Operator: Metro Adelaide
Category: Metro
Scope of supply: Traction Converter TCMS GenSet incl. Diesel Engine and Generator
Key data
2x130KW / 2x350kW (Motoring / Braking)
Deliveries: 2017 / 18

Customer Need
- Form, Fit and Function; replacement of existing GTO converter by state of the art IGBT converter
- Complete upgrade of the TCMS (Train Control and Management System)
- Replacement of GenSet (Diesel Engine – Generator)
- No modifications to existing traction motors

ABB Solution
- Retrofit of traction system highly customized to operators’ requirements
- State of the art traction converters with integrated aux. converters
- Low emission / High Efficiency GenSet

Customer Benefits
- Higher energy efficiency
- Higher reliability and availability
- Noise reduction during standstill at stations / lower emission
- Lower total cost of ownership
Compact Converter for metros

Traction converters – Metro Shenzhen (L 4) and Nanjing (L1, 2)

Country: China
Operators: MTR Hongkong
Vehicle type: Metro
Scope of supply for 75 metro trains:
BORDLINE CC750
BORDLINE M230
Traction motor
Key data:
1.5 kVDC
Up to 1.9 MW /converter
Deliveries: 2009 - 2017

Customer Need
- 1.5 kV DC supply
- Light-weight and compact solution

ABB Solution
- Based on well proven BORDLINE® CC400 converter family
- Liquid-cooled solution
- Highly integrated solution with auxiliary converter and battery charger
- Field-proven state-of-the-art power electronic building blocks

Customer Benefits
- Service-friendly, high availability of spare parts
- Modern and predictive diagnostics for easy maintenance
Traction package for double-deck EMUs (Stadler)

> 840 traction packages

**Countries:** CH, DE, AT, RU; US

**Operators:** SBB, BLS, BeNEX/ODEG, Westbahn, CFL, WestfalenBahn

**Category:** Double-deck EMU (regional / intercity)

**Scope of supply:** 4 traction packages / train: BORDLINE CC1500
Traction transformer
Battery chargers

**Key data:** 6 MW per train

**Deliveries:** Since 2009

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**Customer Need**
- Highest reliability, based on proven technologies
- Minimum weight

**ABB Solution**
- Combination of two FLIRT converters, reduced and optimized components
- Robust all-aluminum cabinet
- Optimized transformer

**Customer Benefits**
- 20% higher power density, 35% less weight
- Higher reliability through less components
- Higher energy efficiency through low voltage solution and high frequency switching
- More space for passengers and comfort
- "Double floor train with the highest power, acceleration and braking effort"
- "Converter with the highest power density on the market"
ABB in the United States

Investment and growth

- Region headquarters
  Cary, North Carolina

- Entered U.S. in 1925 when BBC formed
  ABBEC (American Brown Boveri Electric Corp.)

- ~14,000 U.S. customers

- ~19,200 U.S. employees
  (~14% of ABB)

- $10.3 billion invested
  10 acquisitions since 2010

- One of ABB’s largest markets
  ~ $90 billion

- Nearly 60 Manufacturing & assembly locations

- 6 major country R&D centers

- Digital Center in San Jose, California

- Safety Observation Tours in 2016

- 30,600

- 6,000+ distributor locations

- More than $2 million given to U.S. communities in 2016
Traction converters for light rail vehicles (Inekon)

Catenary-free operation

City: US
Operator: SDOT
Vehicle type: Light rail vehicle
Scope of supply: BORDLINE 400 for 7 LRVs
Key data: At least 800 kW per LRV
Deliveries: 2013 - 2015

Customer Need
- State-of-the-art propulsion enabling catenary-free operation

ABB Solution
- Tailored propulsion converter with integrated traction battery charger, auxiliary converters, cooling unit and braking resistors
- Train Control Monitoring System (TCMS)

Customer Benefits
- Customized solution based on well-proven standard building blocks
- Minimized space consumption on the vehicle roof
Traction converters for light rail vehicles (Brookville)

Catenary-free operation

Customer Need
- State-of-the-art propulsion enabling catenary-free operation

ABB Solution
- Tailored propulsion converter with integrated traction battery charger, auxiliary converter and battery charger for on board battery
- Heat exchanger with integrated braking resistors

Customer Benefits
- Customized solution based on well-proven standard building blocks
- Minimized space consumption on the vehicle roof

Country: US
21 LRVs in
Dallas (DART)
Detroit (DOT)
Milwaukee (City of Milwaukee)
Oklahoma (OKC)

Category: LRV
Scope of supply: BORDLINE® CC400
Key data: At least 800 kW / LRV
Deliveries: 2014 - 2017
Traction chain retrofit for driverless metro
DC group drive to AC single motor control

Country: US
Operator: Newark Airport
Category: Driverless metro
Scope of supply:
72 x BORDLINE CC400
126 x Traction Motors AMX180
Key data:
Max Power at wheel: 360kW
Input Voltage: 600 VAC 60Hz
Deliveries: 2013 - 2018

Customer Need
- Upgrading the existing propulsion based on DC motors with a state-of-the-art three-phase AC traction system
- Compact mechanical integration in the available space
- Compatibility with three-phase 600 VAC input supply

ABB Solution
- Standard modules and components (retro-)fitted into old system cabinet
- Very compact rack including low voltage distribution and power module

Customer Benefits
- Optimized adhesion control results in less tire wear and smooth propulsion for second half of life-time
- Optimized life-cycle cost
Country: US
Operator: MTA Maryland
Category: LRV
Scope of supply: Traction Converter and TCMS for 27 LRVs
Key data
800 kW per LRV
Deliveries: 2017 - 2019

Customer Need
- Form, Fit and Function; upgrade of the traction converter from GTO to IGBT power semiconductors
- Complete upgrade of the TCMS (Train Control and Management System)
- No replacement of the traction motors

ABB Solution
- Forced air-cooled traction converter tailored according to operators’ requirements

Customer Benefits
- Higher reliability
- Lower total cost of ownership
Global factory network
Wisconsin, USA

Glendale factory and Discovery office

Number of employees 650

Focus
- LV Drives 200/400V 1-1000Hp
  MV Drives 4kV 500-4000Hp
- LV Products assembly

Functions
- Marketing, sales, project management
- Product development, application
- Drives regional service hub and repair center
- Customer service and tech support
- Training
Global factory network

United States

Richmond factory

Focus
  – Traction converters “Buy America”

Functions
  – Product management, engineering, SCM
  – Production and testing
Projects with Stadler in US

**GTW**
- eBart, GTW, USA
- Capital Metro, GTW, USA
- Texas, GTW, USA

**KISS160**
- Caltrain, KISS160, USA,

**FLIRT160**
- The T, FLIRT160, USA,