Current Uses of Robotics and Teleoperation in Industry
Outline

ABB Group Overview
ABB Robotics Overview
ABB Experience in Robotic Teleoperation
ABB Group
A global leader in power and automation technologies

What (Offering)

Power & Automation
- Power ~40% of revenue
- Automation ~60% of revenue

For whom (Customers)

Utilities
- ~35% of revenue

Industry
- ~45% of revenue

Transport & Infrastructure
- ~20% of revenue

Where (Geographies)

Globally
- AMEA¹ 37%
- Americas 30%
- Europe 33%

~ $36 bn revenue
~100 countries
~135,000 employees
Single “A” credit rating
HQ Zurich

¹ Asia, Middle East, Africa
Innovation is ingrained in the DNA of ABB
ABB Group
A unique automation portfolio
<table>
<thead>
<tr>
<th>Segment</th>
<th>Image</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive</td>
<td><img src="image1.png" alt="Automotive Image" /></td>
<td>&gt;250,000 robots</td>
</tr>
<tr>
<td>Foundry &amp; Forging</td>
<td><img src="image2.png" alt="Foundry &amp; Forging Image" /></td>
<td>~53 countries</td>
</tr>
<tr>
<td>Metal Fabrication</td>
<td><img src="image3.png" alt="Metal Fabrication Image" /></td>
<td>~100 locations</td>
</tr>
<tr>
<td>Machine Tools</td>
<td><img src="image4.png" alt="Machine Tools Image" /></td>
<td>~5,500 employees</td>
</tr>
<tr>
<td>Plastics &amp; Rubber</td>
<td><img src="image5.png" alt="Plastics &amp; Rubber Image" /></td>
<td>Factories in US, Sweden, China</td>
</tr>
<tr>
<td>Food &amp; Beverage</td>
<td><img src="image6.png" alt="Food &amp; Beverage Image" /></td>
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<tr>
<td>Pharmaceuticals</td>
<td><img src="image7.png" alt="Pharmaceuticals Image" /></td>
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<tr>
<td>Transportation</td>
<td><img src="image8.png" alt="Transportation Image" /></td>
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<tr>
<td>Electrical &amp; Electronics</td>
<td><img src="image9.png" alt="Electrical &amp; Electronics Image" /></td>
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<tr>
<td>Renewable Energy</td>
<td><img src="image10.png" alt="Renewable Energy Image" /></td>
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ABB Robotics
Experienced from Over 250,000 Robots Delivered

- Arc Welding: 15%
- Spot Welding: 20%
- Other Appl: 12%
- Other Process: 10%
- Machine Tending & Materials Handling: 35%
- Painting: 8%
ABB Robotics
Products & Systems Overview

- **Robots**: Comprehensive range with capacity from 500 g to 800 kg
- **Application Equipment & Accessories**: Fully integrated for Welding, Handling, Gluing, Sealing, Painting
- **Software**: To support robots and systems throughout their entire life-cycle
- **Manufacturing Cells & Function Packages**: Modular cells based on globally proven solutions
- **Automotive Systems**: Fully engineered for B-i-W, Paint, Powertrain and Press Automation
ABB Robotics
The ABB Robot Family

Range suitable for a wide range of applications

Reach up to 3.5 m

Payload up to 800 kg
ABB Robotics
Robot-based Manufacturing Cells

FlexArc – Arc Welding Cells

- Graphical interactive HMI on FlexPendant
- Integrated weld error recovery
- Integrated production monitoring
- Intuitive production manager
- Navigator software
  - Cell calibration
  - Tooling calibration
  - Part measurement
  - Cell check
- Free digital replicas of cells in RobotStudio® format
ABB Robotics
Body-in-White Assembly

FlexLean – Modular Assembly Line Concepts

FlexControl
Cell automation in IRC5 enclosure

RPSC
Operator loading directly in robot hand with Robot Position Safety Controller

Flexicell Base
With integrated cabling & piping

IRB 6620
Dedicated lean spotwelding robot

MH Track
Material handling track motion

FlexGrip
Programmable end-effectors

FlexPLP
Programmable positioners for part locators

15 to 40 vehicles per hour with standard modules
ABB Robotics
Typical Manufacturing Cell

ABB TPW Cell Ford Sterling Axle

ABB Robotics
Typical Manufacturing Cell
ABB Robotics
Typical Robot Characteristics –big robots

| Specification          |  |
|------------------------|-----------------
| Reach                  | 2.2 m           |
| Handling capacity      | 150 kg          |
| Extra loads can be     | 50 kg on to the upper and 100 kg mounted on to the robot: on to the robot base. |
| Number of axes:        | 6               |
| Protection: IP 54      | IP 67 with Foundry Plus 2 option |
| Mounting:              | Floor, tilted or inverted |
| IRC5 Controller variants | Single cabinet  |

<table>
<thead>
<tr>
<th>Performance</th>
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<tbody>
<tr>
<td>Position repeatability:</td>
<td>0.03 mm</td>
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</tbody>
</table>

MBTF 50,000hrs
8 yr design life
900 kg weight
ABB Robotics
Typical Robot Characteristics – small robots

<table>
<thead>
<tr>
<th>Specification</th>
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<tbody>
<tr>
<td>Robot Version</td>
</tr>
<tr>
<td>IRB 14000-0.5/0.5</td>
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<table>
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<tr>
<th>Features</th>
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<tr>
<td>Integrated signal and power supply</td>
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<tr>
<td>Integrated air supply</td>
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<tr>
<td>Integrated ethernet</td>
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<tr>
<td>Position repeatability</td>
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<tr>
<td>Robot mounting</td>
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<tr>
<td>Degree of protection</td>
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<tr>
<td>Controllers</td>
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<table>
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<tr>
<th>Safety specification</th>
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<tbody>
<tr>
<td>Functional safety</td>
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ABB Robotics
Typical Robot Motion Capability

Superior Motion Control
by ABB Robotics
Remote Services Portfolio

- Remote Support 24/7
  - Immediate support and reduced MTTR
- Remote Monitoring and Failure Prediction
  - Avoid unplanned stops and increase MTBF
- Remote Services Robot Back-up
  - Increase uptime and disaster recovery
- Remote Services Reporting @MyRobot
  - Information and reporting at your fingertips

Portfolio developed mainly for end-customers
Motivation

- Uses the strength and accuracy of the robot for applications that cannot be programmed
- Removes user from hazardous environments and enables remote operation
- Increase the utilization of experts
- Example applications:
  - Local Operations: easily grind large, low volume castings in foundry production using a robot with a large grinding tool
  - Remote Operations: inspect, sample, push buttons, turn valves, pick up items, etc. at remote sites with a robot on a mobile platform
    - Oil & Gas
    - Mining
ABB Robotic Teleoperation
Lessons & Experience

Situational Awareness
- Is hard. Camera setup becomes complicated in order to cover the entire robot space
- Stereo (3D) vision helps a lot
- Immersive experience is too far away

QoS based Control
- Dedicated communication link is best for stability and performance
- Internet & wireless cause a lot of packet loss, jitter & delays. 5G is very promising
- QoS needs to vary gracefully with communication and operator

Ease of Use
- Hand eye calibration is required to reduce cognitive load
- Input devices are still lacking
- Semi-autonomous mode is best: human sets up the task, robot performs the task
- Learning from Demonstration can be applied here
Power and productivity for a better world™
Everybody likes robots…