Collaborative Robots and the factory of the future

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Strong Growth for Collaborative Robots Forecasted

4.3 CONCLUSION AND FORECAST 2017-2020

Bright and challenging prospects for industrial robot installations:

- Industry 4.0, linking the real-life factory with virtual reality, will play an increasingly important role in global manufacturing.

- **Collaborative robots, IoT and Machine Learning/AI will lead robotics in the coming years.**

- The new generation of lightweight robots enables man and machine to work closely and safety together – without fences.

- Robots will acquire or adapt new skills through learning processes.

- Smarter robots with a "brain" in the cloud as a basis will benefit from big data and collective learning.

- Simplifications - Ready to use applications are getting more popular with the customers.

1.7 million new industrial robots by 2020

Double-digit average annual increase

Estimated annual worldwide supply of industrial robots 2008-2016 and 2017-2020

Source: IFR World Robotics 2017
Robots have a key role in the ‘Factory of the Future’

Low Mix, High Volume to High Mix, Low Volume Shift needs Flexible Automation

*Efficient at every level*
(Robotstudio)

*Reliable and available*
(Connected Services)

*Integrated ecosystem*
(Connected Devices)

*Flexible and agile*
(AI & ML)

The Factory of the Future is characterized by flexibility and enabled by collaboration & digitalization
Collaboration means different things to different people
It is about productivity and flexibility as much as safety

**Flexibly accommodate high mix low volume production**
Entirely new applications for entirely new robot users

**Easy to install, program and use**
Three YuMi® assemble electrical socket in a product line
# Why Collaborative Robots?

Main customer drivers for Collaborative Robots

<table>
<thead>
<tr>
<th>Increase output/reduce labor</th>
<th>Adapt to low volume/high mix</th>
<th>Enabling SMEs to automate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative robots are shifting the traditional limits of “what can be automated”</td>
<td>From mass production to mass customization</td>
<td>Small footprint, lightweight, easy to use and can work side-by-side with human co-workers</td>
</tr>
<tr>
<td>Robots and human workers collaborate, each doing what they do best to achieve higher productivity together</td>
<td>Add automation to existing lines with limited space without changing layout</td>
<td>Robots can be programmed in-house, without hiring specialists</td>
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<tr>
<td></td>
<td>Ability to carry out different tasks, quick changeover</td>
<td>Lower total investment leading to shorter ROIs for automation</td>
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Collaborative Robots are also Connected Robots

Technology will drive Simplicity and Cost Reductions

**Connected, Collaborative Robots**

Safe and flexible collaborative robots are only the starting point.

The full benefits of the Factory of the Future will come from **Collaboration** coupled with **Digitalization** - connecting robots to the broader manufacturing ecosystem

The “Internet of Things” is moving from the consumer world to industrial automation
# Key Characteristics of Collaborative Robots

What makes a good Collaborative Robot?

<table>
<thead>
<tr>
<th>Safety</th>
<th>Ease-of-use</th>
<th>Productivity</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Safety design: YuMi best-in-class</td>
<td>– Lead through programming</td>
<td>– High speed: YuMi best-in-class with 1.5m/s</td>
<td>– Light-weight, small footprint, mobile</td>
</tr>
<tr>
<td>• No pinch/trap points</td>
<td>– Easy programming</td>
<td>– High precision 0.02mm</td>
<td>– Easy to redeploy to adapt to flexible manufacturing</td>
</tr>
<tr>
<td>• Rounded padding</td>
<td>– Built-in sensing capabilities such as integrated vision and force control</td>
<td>– Path accuracy, superior motion control</td>
<td>– Lower integration cost / faster ROI</td>
</tr>
<tr>
<td>• Integrated cabling</td>
<td></td>
<td>– Application engineering support</td>
<td>– RobotStudio, offline programming, virtual commissioning</td>
</tr>
<tr>
<td>• Light weight</td>
<td></td>
<td>– Reliability, robustness &amp; customer service</td>
<td></td>
</tr>
<tr>
<td>– Inherently safe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Safety through robot controls</td>
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</tbody>
</table>
YuMi – Market Leading Safety Concept

YuMi – The Inherently Safe Robot

**Mechanical measures:**
- Lightweight magnesium arms
- Low Payload (0.5kg)
- Padding
- No pinch points
- Back-drivable brakes
- Collision detection (Software Comfort Function)
- Safely designed “hand”

**Controller Safety Functions**
- Protective stop with PL= b
- Supervised speed at hand and elbow with max. 1500 mm/s
- Possible to modify max speed

Safe by design
## Safety Regulations

Collaborative Robot is a type of Industrial Robot, follows the same ISO standards

### Norms/Specifications

<table>
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<tr>
<th>Norm</th>
<th>Title</th>
<th>Status</th>
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<tr>
<td>Machinery Directive 2006/42/EC</td>
<td>Safety of machinery - General principles for design - Risk assessment and risk reduction</td>
<td>Standard</td>
</tr>
<tr>
<td>ISO 12100:2010-11</td>
<td>Safety of machinery - General principles for design</td>
<td>Standard</td>
</tr>
<tr>
<td>ISO 13849-1:2015</td>
<td>Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design</td>
<td>Standard</td>
</tr>
<tr>
<td>ISO/TS 15066</td>
<td>Robots and robotic devices - Collaborative robots</td>
<td>Technical Specification</td>
</tr>
</tbody>
</table>

**Same standard for all industrial robots including collaborative robots**

**New Technical Specification for Collaborative Robot Systems**
ISO/TS 15066

New standard for Collaborative Robot Systems

- To be used by integrators for collaborative robot system risk assessment as a supplement to ISO 10218-2
- Defines contact situations between robot and human as Quasi-static contact or Transient contact
- Introduces a body model with a list of biomechanical limits associated with contact with different parts of the body

**Contact Force Range of Pain**

<table>
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<th>Intended use</th>
<th>Foreseeable misuse</th>
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<tbody>
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<td>Collaborative operation</td>
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- Threshold for touch sensation
- Threshold for pain sensation
- “S0” for low-level injury
- “S1” for reversible injury
- “S2” for irreversible injury

- Only YuMi has so low contact force while working in high speed, other robots can only make safe contact in very slow speed, <250mm/s
Collaborative Application Risk Assessment Considerations

Collaborative Application need additional assessment – PFL ISO/TS15066

Free Contact (transient)

- Tool
- Workpiece
- Robot

Clamp Contact (quasi static)

- Tool
- Workpiece
- Robot

Foreseeable misuse

- Observe robot:
  - bend over
  - head in working area of Robot
  - Manual intervention in the workspace e.g. reflexively
  - Hand-/Upper-/Lower arm in workarea colliding with Robot
YuMi’s High Precision Collision Detection – Advanced Motion Control

No force or torque sensors are used!
Different Modes of Collaborative Operations

Degree of collaboration

Low

Coexistence
Fenceless robot, no workspace sharing

Synchronized
Intermittent sharing of workspace

High

Cooperation
Continuous sharing of workspace

Traditional caged cell (no collaboration)
YuMi fits perfectly in this work place, taking the same space as a human operator and working side by side with its co-workers.
Close Collaboration - Human workers and YuMi

YuMi increasing productivity in Small and Medium Sized companies
Intermittent Collaborative Operations with IRB1200

Demonstrating intermittent sharing of workspace between robot and human operators.
ABB’s Collaborative Robot Portfolio

From truly collaborative to higher performance, ABB offers different solutions to suit different collaborative operations, always with safety and productivity in mind.

### Inherently Safe & Truly Collaborative
- Unique robots designed based on inherently safe principles
- Robots able to share workspace with human continuously
- External sensors or fences not required*
- Robot can maintain high working speed and still make safe contact with human

### Higher Performance, Intermittent Collaboration
- Robots have higher payload and/or speed
- Suitable for intermittent collaboration
- SafeMove 2 + external sensors ensure human safety
- Robot will adjust speed depending on distance to human and stop before contact
Collaborative Factory of the Future

Technology Enablers

Teaching by Demonstration

In order to enable anyone to automate using robotics, easy robot programming is a must. Teaching a robot to do a task should be like teaching a human operator to do a task.

Advanced Sensors

Robots of the future will have more advanced capabilities for sensing, from 3D vision to force sensing to detecting human presence in a factory.

Mixed Reality Tools

Making use of Virtual Reality and Augmented Reality to facilitate programming, commissioning, maintenance, and even virtual meetings to review cell design.
YuMi Disassembling Watch Movement

Extremely high precision
A Conductor Teaches YuMi How To Conduct A Concert

Using Lead-through teaching, YuMi is able to repeat the conductor’s moves, just like teaching a person.
From Mass production to Mass Customization

YuMi customizing Urban Ears’ headphones in Sweden
ABB Ability and digital development in our portfolio

Increasing Uptime, Reliability and Efficiency throughout the Life Cycle

Yesterday
- Pioneers in Remote Services

Today
- Remote Access and Assistance
- Service Intelligence Unit

Tomorrow
- Production Optimization
- Customized Applications
- Condition Monitoring
- Fleets of robots with shared, distributed control
- Virtual Commissioning
- Digital Twin

Connected Services
- Robots controlled locally, offline
- API services

Robot Controller
- Robots controlled locally, offline
- Virtual Robot Technology
- Fleet management

Robot Studio
- Off-line programming
Connected Services with ABB Ability
Robot performance information at your fingertips, proactive and immediate support

Connected Services

- Condition Monitoring & Diagnostics
- Backup Management
- Fleet Assessment
- Asset Optimization
- Remote Access

Up to 25% fewer incidents, 60% faster response times and issue resolution
RobotStudio – Simulation, Offline Programming & Communication Tool

RobotStudio®
With touch-enabled user interface taking advantage of new PC models

Programming

Commissioning

RobotStudio® Online
Four apps for editing, calibration, jogging, and management, that will run on industrial tablets

Supervision

Remote Services
MyRobot for smartphones

Operation

ABB CP600
Operator Panels now compatible with IRC5
Robots & Applications

RobotStudio – Simulation, Offline Programming with physics
The Collaborative Factory of the Future

- Collaborative robots of different sizes will increase factory automation, become helpers to human co-workers
- Higher payload robots working fencelessly with the help of SafeMove and advanced sensors
- Inherently safe robots working side by side with human operators
- Collaboration with Digitalization, connected robots