Industria 4.0 – Perché la nuova rivoluzione industriale è un'opportunità per le nostre aziende

Andrea Marinoni - Partner
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A. **The industrial downfall**: What has happened and how we can impact it
New industrial countries capture ≈40% of global industrial added-value

Global Manufacturing added value\(^1\) [EUR bn]

<table>
<thead>
<tr>
<th>Year</th>
<th>New industrial</th>
<th>Old industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>3.493</td>
<td>6% 2% 3%</td>
</tr>
<tr>
<td></td>
<td>25% 17% 34%</td>
<td>3%</td>
</tr>
<tr>
<td>2000</td>
<td>4.407</td>
<td>6% 2% 11%</td>
</tr>
<tr>
<td></td>
<td>29% 14% 31%</td>
<td>4%</td>
</tr>
<tr>
<td>2012</td>
<td>6.725</td>
<td>5% 3%</td>
</tr>
<tr>
<td></td>
<td>23% 11% 22%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Share of new industrial

<table>
<thead>
<tr>
<th>Region</th>
<th>1990</th>
<th>2000</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>0%</td>
<td>-</td>
<td>5%</td>
</tr>
<tr>
<td>South America</td>
<td>3%</td>
<td>1%</td>
<td>-</td>
</tr>
<tr>
<td>Asia excl. Japan</td>
<td>22%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Russia and central Europe</td>
<td>6%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other countries</td>
<td>0%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>North America</td>
<td>23%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Japan</td>
<td>11%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Western Europe</td>
<td>2%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other developed countries</td>
<td>3%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Growth 2000-2012

- New industrial: +195%
- Old industrial: +14%

\(^1\) UNCTAD data in constant USD (2005 rate), converted in EUR (2005 exchange rate)

Source: UNCTAD, Oanda
Industry related employment is decreasing in developed countries, while increasing in developing ones

Evolution of manufacturing employment rate [2000-2013; Mln of employees, %]

<table>
<thead>
<tr>
<th>Country</th>
<th>2000</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>7.7</td>
<td>7.3</td>
</tr>
<tr>
<td>Italy</td>
<td>4.9</td>
<td>4.3</td>
</tr>
<tr>
<td>France</td>
<td>3.7</td>
<td>2.8</td>
</tr>
<tr>
<td>UK</td>
<td>3.8</td>
<td>2.5</td>
</tr>
<tr>
<td>China</td>
<td>162.2</td>
<td>235.7</td>
</tr>
<tr>
<td>Brazil</td>
<td>9.5</td>
<td>13.8</td>
</tr>
</tbody>
</table>

- **Share of manufacturing sectors employees on total employment**
- **1)** Including the construction sector

Three main reasons for deindustrialization: service outsourcing, productivity gains and loss of competitiveness

Loss of industrial jobs\(^1\): Example France [1975-2010; million jobs]

\[5.5 \to 25\% \to -2.3 \text{ m} (-41\%) \to 3.2\]

1) Salaried and non-salaried jobs

Source: French Treasury report on deindustrialization in France; INSEE; Roland Berger analysis
Nevertheless, European countries maintain a high level of industrial added value – France and UK strongly decrease

Industrial share in added value in selected countries [2001-2011]

Poland: +3% from 17% in 2000 to 18% in 2013
Germany: -2% from 22% in 2000 to 22% in 2013
Italy: -23% from 20% in 2000 to 15% in 2013
Sweden: -30% from 21% in 2000 to 15% in 2013
France: -33% from 15% in 2000 to 10% in 2013
United Kingdom: -37% from 16% in 2000 to 10% in 2013

Europe 2013 average: 15%

Source: Eurostat
Europe becomes split in strong and weak industrial countries

Industrial\(^1\) share in added value [2011; Industrial added value/ Total added value]

1) Excluding electricity, mining and quarrying

Source: Eurostat, UNCTAD
Industrial value-added growth is directly correlated to the machine park quality

Correlation analysis between the industry weight and industrial equipment modernity

**Industrial Value Added growth and investments [2002-2012]**

**Industrial Value Added growth [2002-2012]**

*Investment: number of years ahead or behind* ¹)

**Industrial Value Added growth and automation rate [2002-2012]**

*Automation rate adjusted for the sector mix effect [Number of robots per 10,000 employees]*

NB: Perimeter: Mining industry, Manufacturing industry and Utilities

¹) \( \sum (\text{CapEx} - \text{Depreciation})/\text{Years of average CapEx} \)

Source: IHS Global Insight, Eurostat, IFR, Roland Berger analysis
Initiatives have raised in main manufacturing countries across the world – however, project status and budget varies across countries

### Initiatives for Industry 4.0 in the world

1. **smart industry**
   - **Status:** Implemented
   - **Budget:** EUR 15 m to manufacturing
   - **Budget:** tbd
   - **Status:** Implementation kick-off
     - **Budget:** tbd

2. **EFFRA**
   - **Status:** Strategy determination
   - **Budget:** EUR 600 m
   - **Status:** Implementation

3. **Made Different**
   - **Status:** Awareness
   - **Budget:** EUR 15 m
   - **Status:** Creation
   - **Budget:** tbd (kick-off 2015)

4. **Tekes**
   - **Status:** Implementation
   - **Budget:** EUR 600 m

5. **Platform Industrie 4.0**
   - **Status:** Implementation
   - **Budget:** Part of EUR 250 m Industry 4.0 development plan

6. **Industrial Internet Consortium**
   - **Status:** Implementation
   - **Budget:** Part of national network for manufacturing innovation (NNMI), EUR 700 m

7. **usines du futur**
   - **Status:** Strategy determination
   - **Budget:** tbd

8. **aew ProTrans Industrie 4.0**
   - **Status:** Implementation

9. **ffra**
   - **Status:** Strategy determination
   - **Budget:** tbd

---

1) To be matched by the private sector; 2) EUR 200 m to cyber security, EUR 200 m to Industry 4.0 and EUR 200 m to smart services; 3) Annual public subsidies, expected to increase to EUR 25

Source: Roland Berger
These pilot projects are largely funded by governmental support and financing programs.

Support and financing programs for advanced industry in Europe

<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Supporting institution</th>
<th>Support volume</th>
<th>Content/ Goal</th>
<th>Project partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zukunftsanprojekt Industry 4.0</td>
<td>BMBF¹</td>
<td>Up to EUR 200 m</td>
<td>Support Germany industry to be prepare and ready for future challenges</td>
<td>165 partners from the industry and economy</td>
</tr>
<tr>
<td>2</td>
<td>Autonomik für Industry 4.0</td>
<td>BMWi²</td>
<td>Up to EUR 40-50 m</td>
<td>With the technology program Autonomic modern technologies are to be connected with industrial production using innovation potentials</td>
<td>91 providers from the industry, research and universities</td>
</tr>
<tr>
<td>3</td>
<td>Industry 4.0 – Forschung auf den betriebl. Hallenböden</td>
<td>BMBF¹</td>
<td>n.a.</td>
<td>Intelligent interconnection in the production by making use of modern cyber – physical production systems (CPPS)</td>
<td>Currently in phase of application</td>
</tr>
<tr>
<td>4</td>
<td>SPARC Robotics</td>
<td>EU Commission</td>
<td>EUR 700 m</td>
<td>Support from EU to the robotics industry and value chain, from research through to production</td>
<td>&gt;180 members from industry &amp; research</td>
</tr>
<tr>
<td>5</td>
<td>ICT Innovation for Manufacturing SMEs</td>
<td>EU Commission</td>
<td>EUR 145 m</td>
<td>Support from EU in adoption of next generation ICT advances in the manufacturing domain</td>
<td>Phase of application</td>
</tr>
<tr>
<td>6</td>
<td>Future Internet Technologies</td>
<td>EU Commission</td>
<td>EUR 300 m</td>
<td>Support from EU for topics related to future internet usage and different experimental projects</td>
<td>125 members - new in each phase</td>
</tr>
<tr>
<td>7</td>
<td>Horizon 2020</td>
<td>EU Commission</td>
<td>EUR 13,500⁴</td>
<td>Support from EU for various projects, i.e. Intelligent Manufacturing, action plans steel industry or clean production</td>
<td>Currently in phase of application</td>
</tr>
</tbody>
</table>

¹ Bundesministerium für Bildung und Forschung  
² Bundesministeriums für Wirtschaft und Energie  
³ Information- and Communication-Technology  
⁴ Industry part only

Source: Roland Berger
Industry 4.0 will require ~60 B€ extra investment per year in Europe until 2030 and can generate 500 B€ of value-added and 6M jobs

**Industry weight in Europe**

<table>
<thead>
<tr>
<th>Employees [million]</th>
<th>25</th>
<th>6</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value added [EUR bn]</td>
<td>1,500</td>
<td>500</td>
<td>2,000</td>
</tr>
</tbody>
</table>

**Investment plan**

<table>
<thead>
<tr>
<th>[EUR bn]</th>
<th>~1,200</th>
<th>~1,700</th>
<th>~2,900</th>
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**Gap to be filled**

<table>
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<tr>
<th>European value added, 2011</th>
<th>Gap to be filled</th>
<th>European target value added (2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x%</td>
<td>15.1%</td>
<td>5.0%</td>
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</table>

**Target net capital employed**

<table>
<thead>
<tr>
<th>(2011)</th>
<th>(2030)</th>
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<tr>
<td>~1,700</td>
<td>~2,900</td>
</tr>
</tbody>
</table>

**Net capital employed**

<table>
<thead>
<tr>
<th>Return On Capital Employed, Long-term hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
</tr>
<tr>
<td>5.3%</td>
</tr>
</tbody>
</table>

**Employees**

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<td>x%</td>
<td>15.1%</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

**Source:** analyse Roland Berger

1) EU 15, Industry excluding Energy and Mining 2) Return On Capital Employed, Long-term hypothesis
B. **Industry 4.0**: The emergence has started and we are at the beginning
Mechanization, electrification and computerization influenced our working world radically – Industry 4.0 is the next step

Development stages of industrial manufacturing

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1784</td>
<td>Mechanical weaving loom, Introduction of mechanical production assets based on water and steam power</td>
</tr>
<tr>
<td>1923</td>
<td>Introduction of a &quot;moving&quot; assembly line at Ford Motors, Introduction of mass production based on division of labor and electrical energy</td>
</tr>
<tr>
<td>1969</td>
<td>First programmable logic controller (PLC), Introduction of electronics and IT for higher automation of production</td>
</tr>
<tr>
<td>2014</td>
<td>Real time, self optimizing connected systems, So far &lt; 10% advanced</td>
</tr>
</tbody>
</table>

Impact of each Revolution

- Introduction of new products and means of producing existing ones
- Disruption of the competitive status quo (both within and between countries and enterprises)
- New requirements to workforce and infrastructure

Source: Bitkom/Fraunhofer, DFKI, Roland Berger
Despite different definitions for "Industrie 4.0" there are various aspects which have developed into common understanding

Key aspects around Industry 4.0

**What?**
- **Real and virtual world** growing together (humans, machines, technologies, Internet)

**Who?**
- **Providers of infrastructure**: provide supporting structures and services, e.g. cloud computing or storage for Big Data (e.g. TelCos, Cisco, Amazon)
- **Industrial users**: Globally operating manufacturers such as VW or BASF.
- **Providers of technologies**: provide key technologies for production such as collaborating robots or remote maintenance systems

**How?**
- Via intelligent, horizontal and vertical linking-up

**Why?**
- Individualized or **mass customized products**
- Highly **flexible production**
- **Integration** of customers and value adding partner into value creation
- Coupling of **production** and high-value services
- **Cost** and **efficiency** benefits and **quality** improvements

Source: Bitkom, Fraunhofer
Industry 4.0 can be understood as the full integration and digitalization of the industrial value creation.

Definition of Industry 4.0 (not exhaustive)

> Digital transformation refers to the changes associated with the application of digital technologies in all aspects of human society.

> Industry 4.0 is the industrial application of the concepts applied in the digital transformation, key elements are:
  - Complete connectivity with real-time ability
  - Decentralized, intelligent and self optimizing / organizing
  - Modular and reconfigurable

> Assessment of Industry 4.0 impact needs to take analogies from digital transformation and specifics of the manufacturing industry into account.

> The digital transformation in the consumer goods sector is much more advanced than the industrial application.

Source: Plattform Industry 4.0, MIT Sloan Management Review, Roland Berger
Digital transformation: four Critical Insights…

1st Insight: The only constant is change & the rate of change is increasing

2nd Insight: You either disrupt your own company/products, or someone else will. Standing still = death

3rd Insight: Your competition is no-longer the multinational overseas. It is the explosion of exponentially empowered entrepreneurs

4th Insight: Technology is transforming "Scarcity – Abundance"

Source: Peter Diamandis – Singularity University
Technology is transforming "Scarcity – Abundance": $5 a carat - flawless diamonds made in a lab

"Technology can take that which was scarce, and makes it Abundant."

… So what else do we consider scarce?

… What is scarce in your business?

Source: Peter Diamandis – Singularity University
Industry 4.0 is a long journey and technologies will take 10~15 years to reach maturity in the market.

Industry 4.0 roadmap

- **Today**
  - Pilot solutions
  - Solutions barely existing as products in the market – Mainly showcases or laboratory solutions in development

- **~2020**
  - Mid-term Industry 4.0 use cases are driven mainly by technology; Pilot solutions in the scale of full plant will be developed

- **2025**
  - The penetration of the market with isolated solutions will lead to an interconnection of many solutions via existing connectivity channels – A gradual replacement of most machinery will begin

- **2030+**
  - Transition to "True Industry 4.0"
  - Along the lifecycle of most production machinery the transition to true Industry 4.0 will start to be more comprehensive once most machinery and employees are Industry 4.0 ready and the connectivity infrastructure has been adapted to the new needs and standards
The various technologies which make up Industry 4.0 are expected to reach the plateau of productivity at different points in time.

Gartner Hype Cycle for Emerging Technologies 2014

Plateau will be reached in:
- < 2 years
- 2-5 years
- 5-10 years
- > 10 years

Source: Gartner (July 2014)
Industry 4.0 combines a wide set of technologies with different maturity

Example of technology mapping – Extract

Source: Roland Berger
C. **Industry 4.0:** What is at stake and what will that change for all parties
Industry 4.0 will have fundamental impacts on traditional ways of doing

Impacts of Industry 4.0

<table>
<thead>
<tr>
<th></th>
<th>Flexibility / Mass customization</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt; Ability to reduce changeover time – seamless production change</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Dynamic product schedules allowing to adapt real-time to customer needs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct client relationship</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>&gt; Closer relationship between producer and customers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Disintermediation and change of business rules</td>
<td></td>
</tr>
<tr>
<td></td>
<td>De-laborization</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&gt; Reduced share of labor cost – Reduced dependency to LCC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asset rotation</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>&gt; Increase machine open time &amp; utilization, reduce breakdown time thanks to conditional maintenance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Reduce stocks along the value chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decentralization / Regionalization</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>&gt; Reduce impact of size / scale effect – Ability to decentralize processes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Possibility to relocate production process close to customer needs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fast-product launch</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>&gt; New product industrialization is performed seamlessly and without disruption</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; People are guided through virtual tools to adopt new products</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shift of skillset</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>&gt; Less working forces in daily operations thanks to automated robotics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Maintain of needs for medium-qualified workers due to simplified Human-Machine Interface</td>
<td></td>
</tr>
</tbody>
</table>

Source: Roland Berger
Industry 4.0 is potentially changing the paradigm

Characteristics of new Industry 4.0

<table>
<thead>
<tr>
<th>Traditional industry approach</th>
<th>New Industry 4.0 paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Economies of scale through volume</td>
<td>&gt; Economies of scale through knowledge</td>
</tr>
<tr>
<td>&gt; High hidden complexity cost through product variants proliferation</td>
<td>&gt; Affordable product diversity – &quot;cost of one = cost of thousand&quot;</td>
</tr>
<tr>
<td>&gt; Make to stock based on product forecasts and economical order quantity</td>
<td>&gt; Make to order based on adaptive production planning and pricing (yield management)</td>
</tr>
<tr>
<td>&gt; New product launch is a source of launch cost</td>
<td>&gt; Seamless product launch is a source of value</td>
</tr>
<tr>
<td>&gt; LCC footprint localization with large size plants</td>
<td>&gt; Proximity footprint localization</td>
</tr>
<tr>
<td>&gt; Large size plant with one roof concept</td>
<td>&gt; Network of decentralized and small production units by technology</td>
</tr>
<tr>
<td>&gt; Medium / low capital intensity – Low margin</td>
<td>&gt; High capital intensity – High margin</td>
</tr>
<tr>
<td>&gt; Blue collar driven workforce</td>
<td>&gt; White collar driven workforce</td>
</tr>
</tbody>
</table>

Source: Roland Berger
The future "Factory 4.0"

Factory 4.0 – Overview

- CYBERSECURITY
  - Stronger protection for internet based manufacturing
  - Technology products with longer life cycle

- CLOUD COMPUTING
  - 3D PRINTING / ADDITIVE MANUFACTURING
    - Scrap elimination
    - Mass customization
    - Rapid prototyping

- BIG DATA
  - ADVANCED MANUFACTURING SYSTEMS
    - Cyber Physical Systems (CPS)
    - Numerical command
      - Full automation
      - Totally interconnected systems
      - Machine to machine communication

- TECHNOLOGY WITHIN THE FUTURE
  - SENSORS
    - Zero default / deviation
    - Reactivity
    - Traceability
    - Predictability
  - AUTONOMOUS VEHICLE
    - Flow optimization
    - Increased security
    - Lower costs
  - ROBOT
    - Real-time - Autonomy - Productivity
    - Full transparency (contextualization, comprehensiveness, collaborative robot) on data reporting
  - LOGISTICS 4.0
    - Fully integrated supply chain
    - Interconnected systems
    - Perfect coordination
  - MASS CUSTOMIZATION
    - Customer & marketing intimacy
    - Flexibility
    - Perfect match with customer's needs with production mass efficiency
    - On demand manufacturing
  - INTERNET OF THINGS
    - Object tagging
    - Internet-object communication via low power radio
    - Real-time data capture
    - Optimized stocks
    - Reduced wastes
  - RESOURCES OF THE FUTURE
    - Clean and renewable energies everywhere
    - Energy Storage
    - Alternative raw materials

Source: Roland Berger
Data and communication will be the backbone of Industrie 4.0 – Some players with already wide offering and new players entering

Positioning of different players for Industry 4.0 – Factory view

Source: Roland Berger

1) Not exhaustive; examples only

Players

Players

ERP System

> All transaction data
> Asset data
> Price/cost data

MES System

> Shopfloor transaction data
> Machine data
> Maintenance data
> Logistic data

Sensors/Automation

> Sensor status like pressure, position etc., communication with other sensors
> Machine control data

Building Automation

> Status of all building data, e.g. temp., light, access control, ventilation

3D Data

> Product 3D data
> Factory 3D data
> PLM data

New players

Big Data Services

> Storage capacity
> Algorithms and analytics
> Connectivity

Data/ Funct.1)
Virtual design verification, test/simulation, factory planning and "virtual" prod. networks will create new business models and SC

Virtual reality(ies) as support for design and production

![Diagram showing the flow of design, simulation, and manufacturing processes involving various companies and services.]

1) Finite Element Analysis

Source: Dassault, Siemens, EOS, Roland Berger, NASA/Oculus Rift
Industry 4.0 can create significant added-value for the European industry

Estimated potential [Germany, selected industries, EUR bn, Δ value add 2025 vs. 2013]

<table>
<thead>
<tr>
<th>Industry</th>
<th>Levers [examples]</th>
<th>Value-added potential [Eur Bn]</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive</td>
<td>&gt; Versatile products due to flexible automation&lt;br&gt;</td>
<td>14.8</td>
<td>&gt; Automotive industry is face to next challenges:&lt;br&gt;- High CAPEX investment&lt;br&gt;- More and more mass customization &amp; more complex supply chain&lt;br&gt;- More global network&lt;br&gt;- By leveraging on advanced technologies, Industry 4.0 can:&lt;br&gt;- Improve machine utilization and ROCE&lt;br&gt;- Digitalize supply chain and make it more flexible&lt;br&gt;- Introduce dynamic production planning and improve manufacturing efficiency</td>
</tr>
<tr>
<td>ICT 1)</td>
<td>&gt; Enhanced product offering to offer solutions for easy-to-use &amp; flexible real-time production-planning and -monitoring</td>
<td>14.1</td>
<td>+15% of segment value add&lt;br&gt;- By leveraging on advanced technologies, Industry 4.0 can:&lt;br&gt;- Improve machine utilization and ROCE&lt;br&gt;- Digitalize supply chain and make it more flexible&lt;br&gt;- Introduce dynamic production planning and improve manufacturing efficiency</td>
</tr>
<tr>
<td>Electrical</td>
<td>&gt; Increased configurability of world wide production processes through real-time data transfers</td>
<td>12.1</td>
<td>+30% of segment value add&lt;br&gt;- By leveraging on advanced technologies, Industry 4.0 can:&lt;br&gt;- Improve machine utilization and ROCE&lt;br&gt;- Digitalize supply chain and make it more flexible&lt;br&gt;- Introduce dynamic production planning and improve manufacturing efficiency</td>
</tr>
<tr>
<td>Mechanical</td>
<td>&gt; More innovation through network-like usage of operating-, status- &amp; environment-data of installed base</td>
<td>23.0</td>
<td>+30% of segment value add&lt;br&gt;- Automotive industry is face to next challenges:&lt;br&gt;- High CAPEX investment&lt;br&gt;- More and more mass customization &amp; more complex supply chain&lt;br&gt;- More global network&lt;br&gt;- By leveraging on advanced technologies, Industry 4.0 can:&lt;br&gt;- Improve machine utilization and ROCE&lt;br&gt;- Digitalize supply chain and make it more flexible&lt;br&gt;- Introduce dynamic production planning and improve manufacturing efficiency</td>
</tr>
<tr>
<td>Engineering</td>
<td>&gt; Improved productivity through real-team usage of operating-, status- &amp; environment-data in process monitoring</td>
<td>12.0</td>
<td>+30% of segment value add&lt;br&gt;- Automotive industry is face to next challenges:&lt;br&gt;- High CAPEX investment&lt;br&gt;- More and more mass customization &amp; more complex supply chain&lt;br&gt;- More global network&lt;br&gt;- By leveraging on advanced technologies, Industry 4.0 can:&lt;br&gt;- Improve machine utilization and ROCE&lt;br&gt;- Digitalize supply chain and make it more flexible&lt;br&gt;- Introduce dynamic production planning and improve manufacturing efficiency</td>
</tr>
<tr>
<td>Agriculture</td>
<td>&gt; More flexible and real-time production planning due to ad-hoc connectivity of agricultural machinery</td>
<td>2.8</td>
<td>+15% of segment value add&lt;br&gt;- Automotive industry is face to next challenges:&lt;br&gt;- High CAPEX investment&lt;br&gt;- More and more mass customization &amp; more complex supply chain&lt;br&gt;- More global network&lt;br&gt;- By leveraging on advanced technologies, Industry 4.0 can:&lt;br&gt;- Improve machine utilization and ROCE&lt;br&gt;- Digitalize supply chain and make it more flexible&lt;br&gt;- Introduce dynamic production planning and improve manufacturing efficiency</td>
</tr>
</tbody>
</table>

1) Information and Communication Technology
2) Return of capital employed

Source: BITKOM, Roland Berger
Disruptive trends are converging significantly reshaping the Automotive landscape

Key drivers

Major disruptions

> Re-prioritizing of customer expectations & buying criteria
> New and open eco-system
> Innovation in business models
> Change in value centers
> Fast development cycles
OEMs and suppliers with different need for action for future value generation

Share of own value-add at OEMs (as % of total manufacturing costs) – Selection

Key trends

- Decreasing value creation for OEMs driven by:
  - increasing system competences of Tier-1
  - cost pressure from material cost increase
  - higher possible return for OEM shareholders by focusing on design/assembly

Value generation from...

- Increase of customer value
- Business model enhancement
- Productivity increase

Need for action for

<table>
<thead>
<tr>
<th>OEMs</th>
<th>Suppliers</th>
</tr>
</thead>
</table>
| Product
Innovators¹) | Procees
specialists²)      |

Source: Company information; Roland Berger

¹) Business model based on innovative products with differentiation potential
²) Business model based on process expertise (while product differentiation potential is limited)
Automotive companies put huge hopes to Industry 4.0

Why do automotive companies plan use Industry 4.0?

| Shorten development cycles | > Connectivity leading to improved interfaces with suppliers  
|                          | > The resulting time gain is a true competitive advantage |
| Attractive products and efficient processes | > Via networked systems located inside and outside company premises, enabled by horizontal and vertical integration |
| Mass customization | > Respond flexibly to meet individual customization needs and shortening production time through interconnection between devices, corporate IT systems, and people. |
| Unique selling position through classic & digitization | > Trying to combine classic themes such as design with new aspects such as digitization |
| Optimized value chains | > Dual approach: Sell Industry 4.0 solutions and use them in practical by itself to reduce complexity in the overall value chain |
| Productivity gains | > Goal: 10% improved efficiency for 2018 by using a digital factory concept, up-to-date ‘tools’, motivation and teamwork |

Source: Roland Berger COO Insights, Company Websites, Deutsche Bank, Germany Trade & Invest, ABC Advisory group
Automotive sector will be at the forefront of Industry 4.0 – all players are launching initiatives or even pilot projects

Overview of selected current automotive Industry 4.0 projects

Focus on production [initiatives]

<table>
<thead>
<tr>
<th>Company</th>
<th>Partners</th>
<th>Industry 4.0 Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>Universal Robots</td>
<td>&quot;Collaborative Robotics&quot;: A new generation of safer, more user-friendly robots works more closely alongside humans as a team in assembly line as a team</td>
</tr>
<tr>
<td></td>
<td>TUM</td>
<td>&quot;3D Printed Thumb&quot;: 3D printing customized thumb that can bring reinforcement for factory workers and to help them to work safely and efficiently with minimum strain on their hands.</td>
</tr>
<tr>
<td></td>
<td>Fraunhofer IML</td>
<td>&quot;Gesture-based quality assurance&quot;: Gesture-based quality assurance; to improve quality assurance process for painted bumpers by gesture interaction</td>
</tr>
<tr>
<td></td>
<td>Opel</td>
<td>&quot;WEPRO&quot;: Modular/job-shop production with de-central intelligence</td>
</tr>
<tr>
<td></td>
<td>Continental</td>
<td>&quot;mecPro2&quot;: Model-based new development process for cyber physical systems</td>
</tr>
<tr>
<td></td>
<td>Bosch</td>
<td>&quot;smARPro&quot;: Smart assistance for humans in production systems</td>
</tr>
<tr>
<td></td>
<td>BorgWarner</td>
<td>&quot;KapaflexCy&quot;: Self-organizing capacity flexibility in human-cyber-physical system</td>
</tr>
<tr>
<td></td>
<td>OPEL</td>
<td>&quot;LUPO&quot;: Performance assessment of autonomous production objects</td>
</tr>
</tbody>
</table>

Focus on production planning / logistics / engineering [pilot stage]

<table>
<thead>
<tr>
<th>Company</th>
<th>Partners</th>
<th>Industry 4.0 Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volkswagen</td>
<td>TUM, ART, KIT</td>
<td>&quot;Applied reference architecture for virtual services and programs&quot;</td>
</tr>
<tr>
<td>Daimler</td>
<td>DAIMLER, FESTO</td>
<td>&quot;Synchronous production through partly autonomous planning and human-centric decision support&quot;</td>
</tr>
<tr>
<td></td>
<td>DAVID, GROB, VONWERK</td>
<td>&quot;Collaborative Robotics&quot;: A new generation of safer, more user-friendly robots works more closely alongside humans as a team in assembly line as a team</td>
</tr>
<tr>
<td>Continental</td>
<td>SIEMENS</td>
<td>&quot;Condition monitoring&quot;: Optimized up-time of Schuler presses in the key plant in Wolfsburg</td>
</tr>
<tr>
<td></td>
<td>FESTO, KIT</td>
<td>&quot;RFID-based parts tracking&quot;: Optimizing logistics processes based on RFID technologies for the automotive industry</td>
</tr>
<tr>
<td></td>
<td>SIEMENS, IBM</td>
<td>&quot;Optimization of cylinder head manufacturing&quot;: With the help of data mining technologies and real-time analytics capabilities</td>
</tr>
<tr>
<td></td>
<td>Fraunhofer IML</td>
<td>&quot;Intelligent headlamp technology&quot;: Actuator-based systems for self-aligning intelligent headlamp to improve road safety, incl. new production concepts</td>
</tr>
<tr>
<td></td>
<td>TECAN, MPDV</td>
<td>&quot;Intelligent heat transfer for efficient electric vehicles&quot;: to develop a self-regulating thermal management system for electric vehicles</td>
</tr>
</tbody>
</table>

Source: Company websites, Roland Berger
D. **Implications**: How to approach Industry 4.0 challenge?
Five key questions need to be addressed to unleash the full potential of Industry 4.0 opportunities

### Key questions to address to capture 4.0 benefits

| What value for the customer? | > What key performance can bring value to the customer?  
> In which aspect Industry 4.0 can help to create a rupture?  
> What value proposition could be a differentiator for the customers? |
|-----------------------------|---------------------------------------------------------|
| What are the opportunities? | > What are the key improvement levers to increase performance?  
> What Industry 4.0 opportunity brings to enable those levers?  
> What would be the expected economical benefits? |
| Which technical short & mid-term solutions? | > What technical solution can match the needs? What short term actions could be undertaken? What is the maturity? With which partners?  
> Which time horizon for implementing each of them? |
| What is the impact on organization, processes and competencies? | > What practice / processes have to change / be modified?  
> What is the impact on current skills base? What impact on the workforce?  
> How quick this transformation can happen? |
| Which roadmap and governance | > Which projects to launch to complete the gaps? How to reposition some current initiatives? (e.g. IT-oriented projects, Capex projects, etc..)  
> Which governance to steer this initiative? At which level of organization? |

Source: Roland Berger
We have structured a 4-step approach to frame Industry 4.0 vision and priorities and deliver a tailor-made roadmap:

1. **Priority Objectives**
   - What objective(s) for your company?
   - Which opportunities for your company?
   - Which potential for your company?
   - Which way to excellence?

**Key deliverables**:
- Validated list of priority objectives to cover through the program
- Internal diagnosis of company current 4.0 performance
- Review of current initiatives
- Defined target for the company
- Gap analyses to target
- List of operational prioritized improvement levers
- Financial target impact on CAPEX, WCR, Gross margin
- Detail of impacts on job and skills (resource shift, new skills to capture)
- Operational roadmap including main milestones
- Adjusted budget including program financial impacts
- Program governance set up

**Opportunity identification**
- Customer needs / differentiation
- Internal performance diagnosis
- Disruptive new technological solutions
- Prioritization of levers
  - Quantification of full potential (financial, skills) & impacts
- Mapping of building blocks (regulations, technology, cyber security, standards, ...)

---

**Graphical Representation**

- Visual representation of the 4-step approach with corresponding key deliverables and opportunity identification.

---

**Image Source**
15_11 Convegno FSI_AIDAF.pptx
In order to prioritize Industry 4.0 levers, we used a proven RB framework which consist basically in a selection of levers based on several logical filters.

Conceptual framework for Industry 4.0 lever selection and prioritization

**Enablers**

- Connectivity
- Cloud Computing / Digital data
- Digital devices

**Potential opportunities from Industry 4.0**

- Overall industry 4.0 solutions listing and clustering

**Selection of initiatives applicable**

- Selection of Industry 4.0 initiatives based on applicability on the business model

**Initiatives prioritization**

- Prioritization of initiatives based on:
  - Impact on business/capex/time
  - Relevance on costs/revenues

**Illustrate best practices and positioning**

- Evaluation of current position vs the market
  - Initial positioning from the management perception
  - Validation of the positioning on the market

**Detailed business case of the selected initiatives**

Source: Roland Berger
Industry 4.0 solutions are conventional production methods backed up with state-of-the-art IT systems and pioneer software algorithms.

Potential Industry 4.0 solutions

Cyber world

- Demand driven provision of material and tools
- Intelligent rush/new order management
- Self-reconfiguring machines
- Cobotics
- Computing Hardware
  - Data storage hardware
  - Embedded systems
  - High-performance computing
  - In-Memory computing
  - LCD / touch interfaces
  - Micro computing
- Connectivity
  - Real-time data processing
  - Business process software
  - Database management systems
  - Cloud computing
  - Real-time image processing (e.g. OCR)
  - Advanced algorithms
  - Machine learning

Physical world

- Autonomous vehicles
- Modularized production
- Additive manufacturing
- Logistics automation 4.0
- Self-diagnosing machines
- Smart storage bin
- Smart products
- Unitary, RFID-based parts tracking
- Smart environment recognition
- Interactive robotics
- Predictive Maintenance

Software

- High speed mobile broadband (e.g. 3G / 4G)
- Industrial Ethernet
- Internet protocols (IPv6)
- Local broadband (e.g. WIFI)
- Short range/low power transmissions (e.g. Bluetooth, NFC)

Production Hardware

- Robotics
- New joining technologies
- Traditional Machinery
- Automation equipment

Interfaces

- Visual sensors
- RFID
- Biometrics
- Magnetic stripes
- Camera & imaging systems
- Semiconductor based sensors
- Traditional sensors

Source: Roland Berger
Harley Davidson achieved fast, low cost mass customization based on a networked manufacturing system and ERP infrastructure

Automotive OEM Use Cases – **Automated & networked manufacturing system**

**Starting point**

- Harley offers over 1,200 of customizing options
- Key issues:
  - The process of customization in the old factory was complex and it took over 20 days
  - Since each bike is unique, workers needed to continuously adjust without knowing what’s coming next in the assembly line – This creates huge inefficiencies

**Industry 4.0 solution by Harley Davidson**

- **Full integrated ERP infrastructure**
- **Fully vertically integrated factory**

**Networked manufacturing system**

- Highly networked and data-driven manufacturing process (by SAP ERP & HANA) with automated guided vehicles allows the factory respond flexibly to higher priority orders and order machines to re-tool immediately
- The new smart factory can produce an individual customized bike only 6 hours compared to 21 days before
- In an Automotive context, OEMs can go for both offering a variety of customizing options to meet customer’s individual needs and shortening production time
- The new factory allowed Harley Davidson for the first time to fully customize bikes already in the factory – The existing molding/tuning shops were heavily hit by that move a lost a significant part of their business

**Impact**

- **Lead time:** -99%
  - An individual customized bike is produced in the new factory within only 6 hours compared to 21 days before
- **Output:** +13%
  - Take time of one new motorcycle reduced from 89 seconds to 79 seconds
  - Output raised from 40 motor-cycles/hr to 46 motorcycles
- **Asset productivity:** +57%
  - Streamlined plant assets from 1.5 million sqft in 41 buildings to 650,000 sqft in 2 buildings (one for manufacturing with expansion, one for storage)
- **Headcount savings:** 100 m$ per year
  - 1,968 hourly employees reduced to 700-800 hourly employees
  - 285 salaried employees reduced to 150 salaried employees

Source: SAP, Harley Davidson, Roland Berger
BMW obtains greater efficiency and flexibility by interactive robots working with human workers in factories

Automotive OEM Use Cases – BMW's Interactive Robotics

Starting point

> **Robots** have been a part of automotive manufacturing for decades
> **Key issues:**
  - Manufacturing robots are powerful and precise, but it’s never been safe for humans to work alongside them
  - A significant number of final assembly tasks, in auto plants and elsewhere, were performed almost entirely by hand

Industry 4.0 solution by BMW

> A new generation of safer, more user-friendly robots works more closely alongside humans as a team
> Robots can help people in production at hand and remove them hard physical labor, thus increase production efficiency
> In an Automotive context, collaborative robotics can utilize its power and mechanical accuracy and to support human workforce healthy for a long time

Impact

> With assembly cost further reducing, Tier-1 suppliers will even more increasingly need to focus on full solutions rather than components
> Suppliers could potentially differentiate by designing products in an assembly friendly way

Source: BMW, MIT, Roland Berger
Predictive maintenance is a key to reduce unplanned interruptions to production for Automotive suppliers.

Use Case – Predictive Maintenance by **connectivity and big data analytics**

### Starting point

- **Down-time** is very costly due to disruptions to other business process and Automotive OEMs' production schedule
- Traditional maintenance methods:
  - **Incident based**: Fix when machine is broken
  - **Condition monitoring**: Fix when parameters move out of defined range
  - **Preventive maintenance**: Fix in certain fixed time-intervals

### Industry 4.0 solution by **BOSCH**

#### Traditional maintenance

- ![Diagram](attachment://traditional_maintenance.png)

#### Predictive maintenance

- ![Diagram](attachment://predictive_maintenance.png)

- **Overall goal** is to **forecast machine failures long before they happen**, so that the issue can be solved with planned maintenance
- **Predictive maintenance system** could be bought from a **machinery company** (e.g. Bosch) or an **independent company** (e.g. IBM)
- System systematically analyzes the data collected from machinery by condition monitoring sensors (e.g. vibration, temperature etc.) and **general data** (e.g. machine type, number of days in operation, failure history etc.) to **detect patterns of errors & malfunctions** by relying on algorithms and big-data
- Subsequently, the current status of every asset can be evaluated and a maintenance schedule can be created where inspections and/or maintenance are performed **dynamically to prevent failures**
- Thereby **unplanned down-time** is reduced, **service & maintenance cost** could be lowered

### Impact

- **Maintenance cost**: up to -30%
  - Decrease in inventory costs for repair parts and labor
  - 10% cost savings over preventive maintenance program
  - Potentially energy savings driven by fewer and less sudden restart processes
- **Unplanned breakdowns**: up to -75%
  - Increase machine operational life/availability
  - Allow for preemptive corrective actions
  - Limited sudden interruptions to the supply chain
- **Downtime**: up to -45%
  - Schedule maintenance activities to minimize overtime
  - Decrease in equipment or process downtime
- **Throughput**: up to +25%
  - Improve worker and environmental safety
  - Improve worker morale.
  - Better product quality

Source: Bosch, IBM, U.S. Department of energy, Roland Berger
The research plant Smart Factory integrated augmented reality into maintenance tasks

Smart Factory\textsuperscript{KL} - Augmented reality

Starting point

> Manufacturing systems become more and more complex for OEM / OES with more and more customization, diversity...

> Operators need to have constantly assistance to be informed "which part to produced" and "which production process to be used"

> Innovative devices for maintenance and service tasks already emerging in the manufacturer-independent research and demonstration plant Smart Factory in Kaiserslautern

Industry 4.0 solution by smartFactory\textsuperscript{KL}

Impact

> Augmented reality enabling:
  - extended view on production process and assistance for human operators to fulfill their tasks
  - significant simplification and acceleration of maintenance, reparation or installation work on complex systems
  - increase of manufacturing plant efficiency and potentially reduced risk of accidents

> Future development will further intensify the socio-technical interactions

Source: Smart Factory\textsuperscript{KL}; Roland Berger
Bosch equipped Diesel injector parts with memories to make their production process smarter

Use case - Internet of Thing

Starting point

> Tracking of automotive parts is currently realized by an unique part number and complex product management system
> It allows a tracking of several basic information in condition that it's correctly entered into information system
> Moreover, it doesn't allow a part location real-time tracking during delivery
> Finally, with the sophistication of supply chain, there could be potential risks of misdelivery

Impact

> Simplification & smarter of production process & interfaces:
  - Basic information directly tracked by the part itself
  - More accurate input without risk of errors
  - Centralized information in a cloud-based IT system

> Optimized supply chain & customer interface:
  - Real-time location tracking enabling OEM customer to adjust production planning
  - Easier verification process for requirements fulfillment

Industry 4.0 solution by BOSCH

> Production of diesel injectors only starts after an OEM anywhere in the world initiated an order
> A digital readable order card that travels with the part contains all information about technical requirements and the manufacturing sequence
> Intelligent sensor systems permanently record the location of the part along the way – the part finds its destination autonomously
> The client is always informed where his part is located and when the production will presumably be finished
> At the end of the production process an employee checks whether the product matches with the technological and quality requirements

Source: Robert Bosch GmbH; Roland Berger
Going forward, the focus need to be on the use cases with the highest impact that will be realized in the mid-term.

Derivation of use cases for an Automotive Tier-1/2

Source: Roland Berger