Industry 4.0 in Automotive, Transportation & Aerospace and Defence

Intelligent | Connected | Automated | Autonomous
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Industry 4.0 is now an undisputed reality with the ability to cause significant disruption to the existing value chains.

Development stages of industrial manufacturing:

- **First industrial revolution**
  - 1784
  - Mechanical weaving loom
  - Introduction of mechanical production assets based on water and steam power
- **Second industrial revolution**
  - 1923
  - Introduction of a "moving" assembly line at Ford Motors
  - Introduction of mass production based on division of labor and electrical energy
- **Third industrial revolution**
  - 1969
  - First programmable logic controller (PLC)
  - Introduction of electronics and IT for higher automation of production
- **Fourth industrial revolution**
  - 2014
  - Real time, self optimizing connected systems

Source: Bitkom/Fraunhofer, DFKI, Roland Berger
Industry 4.0 (i4.0) refers to the digitalization of production, enabling further automation through usage of connectivity, data & AI analytics.

**Industry 3.0:**
Computers and Automation

- Fenced Industrial Robots
- Industrial software (rule based)
- Automation equipment (e.g. conveyors)
- PLC

> **Replacing manual labor** with automation on a large scale

**Years**
High

**Implementation time**

**Add. CAPEX spending vs. existing equipment**

**Focus**

**Industry 4.0:**
Cyber Physical Systems

- Advanced automation & co/self-learning robots
- Integrated/connected value chains
- Augmented operators
- Autonomous logistics and material handling
- Data and AI analytics

> Free existing staff from repetitive tasks and use experience for process improvement
> Use data to enhance process, products, quality and find new ways of differentiation

**Few months** (once the solution is ready)

**Low – Medium**

Source: Roland Berger
Industry 4.0 can be referred as digital transformation of industrial value creation; it has holistic impact across the whole value cycle

i4.0 impact across the value cycle

This consistency of value chain impact is seen across Automotive, Transportation and Aerospace & Defence

Source: Platform Industry 4.0, MIT Sloan Management Review, Roland Berger
For industry at large and Canadian industry in particular this has led to a new way of doing business and new profit pools.

Source: Roland Berger
At a technology level, Canadian Auto and A&D industry is now having to work with an intermesh of cyber and physical technologies

Potential Industry 4.0 solutions

Cyber world

Computing Hardware
- Data storage hardware
- Embedded systems
- High-performance computing
- In-Memory computing
- LCD / touch interfaces
- Micro computing

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

Software
- Real-time data processing
- Business process software
- Database management systems
- Cloud computing
- Real-time image processing (e.g., OCR)
- Machine learning

Connectivity
- 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)

Connectivity

Base Technologies

Potential solutions

Source: Roland Berger
... impacting future capability and development of platforms at various levels of maturity

Example of technology mapping – Extract


Available maturity/industrial diffusion
Emerging maturity/limited diffusion
Future maturity/precursors

Source: Roland Berger
The time impact for different technologies differs for each industry type, however the scale of impact is significant in each case.

Industry 4.0 readiness assessment in the automotive industry

Value add for an Automotive Tier-1/2

- Very high
  - Intelligent rush/new order management
  - Predictive Quality/Enhanced Throughput
  - Self-optimizing systems
  - Unitary, RFID-based parts tracking
  - Demand driven provision of material and tools
  - Additive manufacturing/Rapid prototyping
  - Demand response energy management systems
  - Smart products
  - Autonomous vehicles

- Very low
  - Cobotics
  - Self-learning robots
  - Augmented Reality
  - Virtual work preparation
  - Customer triggered lot-size 1 production
  - Self-reconfiguring machines
  - Predictive Maintenance
  - Smart storage
  - User-friendly operations dashboards
  - Self-diagnosing machines
  - Digital Prototyping
  - Logistics/warehouse automation 4.0

Implementation horizon

- Very long: Needs at least 10-15 years
  - Virtual process optimization
  - Modularized production
  - Centralized machinery planning
  - Interactive robotics
  - Modularized production
  - Smart environment recognition

- Very short: Already in widespread use today
  - Unitary, RFID-based parts tracking
  - Demand driven provision of material and tools

Source: Roland Berger

Use cases with expected high impact and short-/mid-term widespread use

- Production-Internal logistics
- Production - Planning/Steering
- Cross-functional
- Service/Maintenance
- Engineering
- Cross-functional
... and this technology impact is not only limited to manufacturing process but also to platform and product attributes

Example – Defence platform (APC/IFV/MBT) linkage to Industry 4.0

- New technologies/disruption and platform capabilities are needed in context of key platform attributes (Mobility, Firepower, Survivability and Battlefield Transparancy/Networked platform)
- Each of these technologies/delivery capabilities is driven by a different mix of Industry 4.0 disruptions - AI/Robotics, IoT, Cloud Computing, Additive Manufacturing and HMI

> The key questions to address for an OEM are:-
  > How does an OEM plan for these new platform capabilities?
  > Should one plan at capability level or should one plan at an attribute level?
  > What is core to an OEM? Is mobility a core (traditional but increasingly low contribution to platform by value) or is Battlefield Transparancy a core (historically tier 1 competence but increasingly high value contribution to platform)?
  > What should the OEM do on its own and what should be rolled out to Tier 1's?
..necessitating Canada to master a new set of Advanced materials that form the basis for an Industry 4.0 based manufacturing

Examples of Advanced Material – Light Metals, Composites, Steels

### Advanced Materials

**Light Metals**
- Titanium
- Magnesium
- Aluminium

**Composites**
- Carbon Fiber
- Kevlar
- Nano Composites
- Metal Laminates

**Steel**
- Dual Phase Steels
- Trip Steels
- Bale hardening steels

### Advantages of few Advanced materials

> **Magnesium**
- 22% of weight of iron and 65% of aluminium
- Magnesium alloys have 50% the strength of steel and are stiffer than most plastics.
- They are prone to corrosion

> **Carbon Fiber**
- Carbon Fiber is lightweight (75% lighter than steel)
- It has high stiffness (12 times that of steel)
- It is more durable (infinite fatigue life with suitable design parameters)

> **Titanium**
- As strong as steel
- Corrosion resistant
- High melting point
- Requires specialized machining and annealing processes

> **Applications**
- Aerospace applications: used in Jet engines and airframes

> **Carbon Fiber**
- Applications
  - Transport application, textile and printing machinery

> **Nano Composites**
- Applications
  - Engine covers, blades for vacuum cleaners, power tool housings

1) PP - Polypropylene

Source: VCAMM, AZO Materials, Scientific American, Roland Berger
... and new manufacturing techniques, all of which are transformative in the way their impact on the business value chain

Additive Manufacturing (3D Printing)

Starting point

> **Shorter Product Life Cycles** increases the need for fast availability of realistic, cost efficient and fully functional prototypes
> **Customization** of design elements is a growing trend, generally required in smaller volumes
> Further requirements for **light weight construction** or e.g. improved combustion processes require new design solutions and materials
> Demand for a flexible and agile **decentralized production**

Solutions provided by Additive Manufacturing

> Additive Manufacturing is the direct transfer of digital data (3D CAD data) into products
> Objects of virtually any geometry can be produced by this technology even in high performance materials like Inconel or Hast-X
> Due to the direct printing tooling is not required
> Production cost are independent from the batch size
> New manufacturing capabilities allow new opportunities for light weight designs or performance improvement (e.g. combustion)

Impact

> **Improved prototyping and small series production capabilities**
  - Wide range of materials (plastic/metal) and colours
  - Flexible production of small series
  - Extremely short Supply Chains
  - New design and engineering processes
> **New design capabilities**
  - Functional integration
  - New component capabilities like weight optimization or optimized heat transfer
> **New Business Models**
  - B2B business from an emerging supplier base for Additive Manufacturing
  - B2C via internet platforms
> **Series production readiness**
  - As young technology is maturing and achieving series production readiness, significant cost decrease is expected

Source: Roland Berger, EOS, SLM Solutions
As a result Canadian companies are required to transform their business models, also creating higher value for the customer.

Evolving business models that Canadian companies face in Industry 4.0 scenario

| **Engineering** | Drastic reduction in **time to market** via **ultra-short design cycles**, driving focus on **accelerated new product launches** as one of the key differentiators | **Customer value increase** |
| **Production** | Moving towards **mass customization** in manufacturing to provide even more individualized products – fuelled by full horizontal and vertical integration | **Business model change** |
| **Supply chain** | Huge increase in **supply chain agility/speed** – Easier to reconfigure and more responsive supply chain, **lowering boundaries** across companies and propelling **decentralization** of activities | **Customer value increase** |
| **Cross-functional** | **Intelligent algorithms** and **data** becoming the new differentiator | **Business model change** |

Significant **impact** on **process landscape** – Huge challenge to adjust processes with the same speed as new solutions emerge – **Organizational speed** might become a **competitive advantage**

Source: Roland Berger
This requires new types of Industry-academia interfaces, For example globally new types of alliances are emerging in the auto sector

Overview of selected current automotive Industry 4.0 projects and partnerships

<table>
<thead>
<tr>
<th>Focus on production [initiatives]</th>
<th>Industry 4.0 Projects</th>
<th>Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td></td>
<td></td>
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<tr>
<td>BMW</td>
<td>&quot;LUPO&quot;; Performance assessment of autonomous production objects</td>
<td></td>
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<tr>
<td>TUM</td>
<td>&quot;Collaborative Robotics&quot;; A new generation of safer, more user-friendly robots works closely alongside humans as a team in assembly line as a team</td>
<td></td>
</tr>
<tr>
<td>Fraunhofer IML</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>
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<tr>
<td>&quot;Gesture-based quality assurance&quot;; Gesture-based quality assurance&quot;; to improve quality assurance process for painted bumpers by gesture interaction</td>
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<td></td>
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<tr>
<td>&quot;WEPRO&quot;; Modular job-shop production with de-central intelligence</td>
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<td></td>
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<tr>
<td>&quot;mecPro2&quot;; Model-based new development process for cyber physical systems</td>
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<tr>
<td>&quot;smARPro&quot;; Smart assistance for humans in production systems</td>
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<tr>
<td>&quot;KapaflexCy&quot;; Self-organizing capacity flexibility in human-cyber-physical system</td>
<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Focus on production planning / logistics / engineering [pilot stage]</th>
<th>Industry 4.0 Projects</th>
<th>Partners</th>
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</thead>
<tbody>
<tr>
<td>Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Applied reference architecture for virtual services and programs&quot;</td>
<td></td>
<td></td>
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<tr>
<td>&quot;Synchronous production through partly autonomous planning and human-centric decision support&quot;</td>
<td></td>
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<tr>
<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>
<td></td>
<td></td>
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<tr>
<td>&quot;Condition monitoring&quot;; Optimized up-time of Schuler presses in the key plant in Wolfsburg</td>
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<tr>
<td>&quot;RFID-based parts tracking&quot;; Optimizing logistics processes based on RFID technologies for the automotive industry</td>
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<td></td>
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<tr>
<td>&quot;Optimization of cylinder head manufacturing&quot;; With the help of data mining technologies and real-time analytics capabilities</td>
<td></td>
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<tr>
<td>&quot;Intelligent headlamp technology&quot;; Actuator-based systems for self-aligning intelligent headlamp to improve road safety.</td>
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<tr>
<td>&quot;Intelligent heat transfer for efficient electric vehicles&quot;; to develop a self-regulating thermal management system for electric vehicles</td>
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Source: Company websites, Roland Berger
All of this is resulting in opening up new avenues for Canadian companies to improve profitability and generate better ROCE.

**Iso ROCE curve**

**Profitability index** \([\text{EBIT/ Added Value}]\)

1. **Industrial Automation**
   - Products with high added value and high margin
   - CAPEX intensive production
   - High level of automation/ Modern machine park

2. **Industrial Obsolescence route**
   - Medium/ low added value, low margins
   - Labor intensive production
   - Amortized/ Obsolete production means

3. **Industrie 4.0 route**
   - High added value products, high margins
   - Flexible production
   - High ROCE

Capital employed : economical assets (fixed assets & working capital need)

Source: Brokers, Roland Berger analysis
At an country level, Industry 4.0 is redefining competitiveness; Question is where does Canada play and how?

Eg. Evolution of EBIT between 2000 and 2014 [Industry 1), EUR Bn]

<table>
<thead>
<tr>
<th>Country</th>
<th>Delta '00-'13</th>
<th>EBIT / VA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>-81%</td>
<td>5%</td>
</tr>
<tr>
<td>France</td>
<td>-68%</td>
<td>6%</td>
</tr>
<tr>
<td>Italy</td>
<td>-51%</td>
<td>11%</td>
</tr>
<tr>
<td>UK</td>
<td>-27%</td>
<td>22%</td>
</tr>
<tr>
<td>Spain</td>
<td>6%</td>
<td>25%</td>
</tr>
<tr>
<td>Korea, Rep.</td>
<td>51%</td>
<td>34%</td>
</tr>
<tr>
<td>US</td>
<td>54%</td>
<td>32%</td>
</tr>
<tr>
<td>Brazil</td>
<td>149%</td>
<td>31%</td>
</tr>
<tr>
<td>Germany</td>
<td>158%</td>
<td>23%</td>
</tr>
<tr>
<td>China</td>
<td>490%</td>
<td>33%</td>
</tr>
</tbody>
</table>

Source: IHS Global Insight, Roland Berger analysis

1) Incl. manufacturing, mining and quarrying and utilities
The future will see Canadian consumers in a new tech driven world. Will Canadian companies step up to the challenge of building it?
ATMS Toronto brings together the best of the Canadian Industry, academia and policy makers on this topic. Hope to see you there.

4-6 February 2020
Toronto Congress Center – Ontario | CANADA
Roland Berger is a global leader in strategy consulting; it works with almost 75% of fortune 1000 companies addressing critical challenges.

Subtitle

Founded in 1967 in Germany.

~220 RB Partners currently serving approximately

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Source: Roland Berger
Roland Berger helps firms plan and leverage Industry 4.0 across the value chain to effect performance improvement at all levels.

**Roland Berger – Industry 4.0 impact across the operations value chain**

### A Product line profitability
- Optimized product costs
- Systematic product cost review process
- Value-based product design

### B End-to-End process optimization
- Digital readiness / RPA opportunities
- E2E process efficiency levers
- Optimized interfaces

### C Sales excellence
- Decreased cost-to-serve
- Minimized non-value-adding activities
- Key account focused sales organization

### D Procurement excellence
- Increased ROI of procurement
- Optimized supplier portfolio
- Improved supplier management

### E Manufacturing & supply chain
- Best-cost-country optimized production footprint
- Cost efficient distribution and warehousing

### F Engineering efficiency
- Focused R&D project portfolio
- Right-sized engineering operations
- Mature "enablers"

### G SG&A
- Improved overhead structure
- Optimized SG&A indirect cost
- Functioning governance

### H Smart PMO & quick win implementation support
- Transparency "with one click"
- Risk management/back-up measures
- Holistic program management

Source: Roland Berger