Beyond Industry 4.0/5.0: Towards a Smart, Digital and Green Society
A Canadian Perspective in Education and Research

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OUTLINE

➢ Industry 4.0/5.0 Evolution (2000-2022)

➢ Canadian Perspective

Some slides in this presentation include information from conferences presentations with proper acknowledgement and reference of the sources.
Evolution of 4.0 (2000-2022)

Pratt & Whitney Canada
Digital Enterprise
(H. Moustapha, P&WC, 2000: Industry 4.0 started before 2011)

Industry 4.0
“Cyber Physical Production System”
(Germany, 2011)

Digital Enterprise
(Siemens, 2019)

Industry 4.0 has been Already in Our Daily Life: Internet, GPS, Iphone, Facebook, etc.
Evolution of 4.0 (2000-2022)

Industry 4.0 Factories

Germany **Smart Factory** (2005)

Siemens **Digital Factory** (2012)

Europe **Factory of the Future** (2013)

GE **Brilliant Factory** (2014)

(Ref. Siemens and GE presentations)
It is not only about **Factory**
It is not only for **Industry**
It is **Technology** and for the total **Society**

(Red. Japan, Keidanren, 2017)
Industry 4.0 Major Challenge

Automa-nation: Will robots take your job?
A new report suggests 42% of the Canadian job market is at risk
Workforce Challenges

➢ Will automation, autonomous systems, AI, Cobots, etc. results in higher unemployment?

(USA aerospace industry lost 40% of its workforce between 1990 and 2000)

➢ Will we do more with less people

(USA aerospace industry sales:
2000: $118 Billions with 1.3 millions people
2020: $909 Billions with only 2.2 millions people)
Workforce Challenges

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➢ Will automation and improved productivity result in 4 day working week?

➢ Will AI replace most of HI (Human Intelligence)? Ethical issues with AI?

➢ Will Robots replace key personnel: teachers, preachers, lawyers, etc.?
Industry 4.0 Workforce of Tomorrow (BCG, Sept. 2015)

- Net increase of 350,000 jobs by 2025 for Germany
  - Greater use of robotics and computerization will reduce the number of jobs in assembly and production by 610,000
  - Creation of 960,000 new jobs in IT and industrial data science
- Digital jobs: 41M (2020) to 190M (2025)
- Retrain workforce
- Revamp organization models
- Strategic recruiting and workforce planning
- Education systems to respond to Industry 4.0 needs

"Some Jobs will Disappear: Protect Workforce and Not Jobs"
"The Future: Focus on Tasks and not Jobs"
The Workforce of the Future

Technological Unemployment Theory (Keynes, 1930)
Economizing the use of labor is outrunning the pace at which we can find new uses for labour

- Jobs transformed and workers adapted with new advances in automation and technology
- Disruptive technologies created opportunities for jobs that are more strategic
- Over two centuries of innovation, the global economy has provided more and better jobs
- Keeping the status quo to protect the current skillset is suicide for brands in technology and manufacturing

Surviving the Technology:
Bank Teller vs ATM - Air Travel vs Skype Meetings
Technology-Productivity-Growth

From 2 Engine Families in 1978 to 12 Engine Families in 2018
With same headcount and budget
Industry 5.0 (Europe, 2020): A Correction for Industry 4.0

Human-Machine Reunion – Humanizing Robots

Source: Dr. Marcel Vollmer, 2021
Industry 5.0: Human in Control and Bringing Back Humans into the Action

➢ Human-Machine cooperation
➢ Harmonizing human intelligence with cognitive computing
➢ Mass customization
➢ Personalization for customers
➢ Augmented Artificial Intelligence
Industry 5.0: Human-Centric

INDUSTRY 1.0 – INDUSTRY 5.0

Industry 1.0: Mechanization
Time: 18th C.
Keywords: Water, Steam

Industry 2.0: Electrification
Time: 19th C.
Keywords: Electricity, Assembly line

Industry 3.0: Automation
Time: 20th C.
Keywords: Computers, Automation

Industry 4.0: Digitalization
Time: 20th/21st C.
Keywords: Networking, Communication

Industry 5.0: Personalization
Time: 21st C.
Keywords: Collaboration, Sustainability

To resume: Industry 5.0 is a complement to Industry 4.0 and mainly focuses on a sustainable, human-centric, and resilient industry.

Why Industry 5.0?

- Reduced cost due to resource efficiency
- Improved safety and well-being
- EMPOWERED workers remaining in control
- Competitive edge in new markets
- Adapting training for evolving skills
- Competitive industry by attracting best talent

Industry 5.0 is a SOLUTION PROVIDER for people and for our planet.

Why Industry 5.0 – source and courtesy infographic EC
“Democratization of Technology: Humans, computers, machines and products collaborate digitally and communicate seamlessly through integrated and optimized processes across the total product value stream within an enterprise, and upstream (suppliers) and downstream (customers) of the enterprise”

(Ref. Aérospatiale 4.0, H. Moustapha, Juillet 2016)
Smart Digital Green “SDG” Society (Canada, 2021) for UN Sustainable Development Goals (SDG)

- Connecting the Unconnected
- Real Time Connectivity: Digital Thread
- Smart Connected Products
- Products: Services with Experience (Sustainability)
- Augmented Artificial Intelligence
- AI-Personalized Smart Phones
- Harmonizing human intelligence with cognitive computing

(Ref. Japan, Keidanren, 2017)
Smart Digital Green “SDG” Society

➢ Skilling - Reskilling – Upskilling - Multiskilling
➢ Critical and Creative Thinking
➢ Integration Skills
➢ Internet of Behavior
➢ Emotional Intelligence vs Intellectual Intelligence (EQ vs IQ)
➢ Augmented Intelligence: Human-Machine Reunion
➢ Multi-Disciplinary: Fluid and Structural Mechanics
➢ Inter-Disciplinary: Mechatronics – Bio-Engineering
➢ Trans-Disciplinary: Academia with stakeholders

Education – Exposure - Experience
A Digital Twin is a Connected, Reliable and Accurate Digital Replication of a Physical Entity

(Sources: CAE)
Digital Twins are the building blocks of Industrie 4.0 capabilities

Digital Replication of a Physical Entity

- Data-driven feedback
- Feed back insights to continuously optimize product and production

- Digital Twin product
- Digital Twin production
- Digital Twin performance
The Digital Thread integrates Digital Twins across value chains throughout the product lifecycle

**Digital World**

**Digital Product**
- Requirements
- Product Structures
- Bill of Materials
- Advanced Quality Planning
- Performance Simulation

**Planning**
- Bill of Process
- Work Instructions
- Production Simulation

**Digital Equipment**
- Configuration
- Validation
- Virtual Commissioning
- Data Connectivity

**Digital Plant**
- Advanced Scheduling
- Real Time Execution
- Worker Assistance
- Optimization – CI
- Closed Loop Quality

**Digital Services**
- Condition monitoring
- Preventative maintenance
- Mobile Reporting
- Data analytics
- Product/Plant intelligence

**Real World**
Evolution of 4.0 (2000-2022): Summary

(P&WC 2000) Digital Enterprise

(Germany 2005) Smart Factory

(Germany 2011) Industry 4.0

(Accenture 2016) Industry X.0

(Japan 2017) Society 5.0

(Siemens 2019) Industry 5G-Digital Enterprise

(Europe 2020) Industry 5.0

Smart-Digital-Green “SDG” Society (Canada 2021)
HUIT UNIVERSITÉS QUÉBECOISES SE SONT ASSOCIÉES POUR CRÉER LE

Réseau
Innovation 5.0
Network
Towards a Smart, Digital & Green Society

https://www.reseauinnovation4network.com/

Merci à nos commanditaires

$3B Clusters

$50M Infrastructures

Digital Twin

Physical Entity

NGen
Next Generation Manufacturing Canada

ENCQOR 5G

Collision center
Incubator 4.0

Yoshua Bengio named 'Scientist of the Year' by Radio-Canada
For his outstanding contribution to the advancement of artificial intelligence in Canada.
Évolution de l’écosystème 5.0 universitaire

Les initiatives académiques 4.0 au Québec

qui ont amenées à la création du Réseau Innovation 5.0 et à l’octroi de la FCI4.0
Le Réseau Innovation 5.0
(créé en janvier 2019)
Nos universités: des catalyseurs pour l’Industrie 5.0

Secteurs et domaines de recherche

Collaboration

Industrie, CCTT, Consortia, National, International
Réseau Innovation 5.0 (crée en Janvier 2019)
8 universités: des catalyseurs pour l'Industrie 5.0
Nos réalisations depuis Janvier 2019

✓ Identification de 8 Leaders 5.0 du Réseau Innovation 5.0

✓ Mission, objectives et plan (réunions mensuelles)

✓ École d’été 5.0:
  ✓ 1ère édition (26-28 août, 2019)
  ✓ 2e édition (6 mai 2021)
  ✓ 3e édition (7 juin 2022)

✓ Forum Innovation 5.0:
  ✓ 1ère édition (6 novembre 2019)
  ✓ 2e édition (9 novembre 2022)

✓ Demande et octroi infrastructures FCI 5.0

✓ Demande MEI-OTN pour PMEs

✓ Maitrise en entreprise numérique (janvier 2023)
Smart-Digital-Green R&D Projects

Energy OEMs
Industry 4.0 Technology Integration ($5M)

Advanced Manufacturing Automation, Digitization and Optimization
“AMADO”

A Digital Technology Platform for Supply Chain
“DTPSC”

Aerospace SMEs
MACHFab4.0 ($19.5M)

3 universities – 3 projects – 15 professors – 20 students / year
Siemens 350 k$/year + Government 650 k$/year

60 projects
50 SMEs
Digital Manufacturing Technology and Training Platform ($12M) for « SDG »

Theme 1 - Intelligent product and manufacturing process design

Theme 2 - Intelligent, agile and adaptive value chain operations planning

Theme 3 - Data exchange and processing platform design

Intelligent Cyber Value Chain Network (CEOS\textsuperscript{Net})
FCI5.0 ($12M): Support au Projets PMEs

(CEOS$^{Net}$) \textit{Interactions among the research nodes}
FCI5.0 ($12M)

Intelligent Cyber Value Chain Network  \((\text{CĒOS}^\text{Net})\)

Research Program Overview

**T1- Intelligent product and manufacturing process design (FY1-Y5, EET1)**

- a) Mass customization manufacturing products (TRL3, RET1.1, RET1.2, RET2.8, RET2.9, Festo, Nanogrande)
- b) Self-learning advanced manufacturing (TRL2, RET1.1, RET1.2, RET2.2, RET2.8, RET2.9, PWC, Bombardier)
- c) Disassembly & product (material) tracking for circular manufacturing (TRL3, RET1.1, RET1.2, Recyc PHP, Finkl Steel)

**T2- Intelligent, agile and adaptive value chain operations planning (FY1-Y5, EET2)**

- a) Real-time and dynamic maintenance and operations planning (TRL5-6, (RET2.1 to RET2.6), PWC, APN)
- b) Collaborative human-robot ecosystem configuration (TRL4-6, RET2.2, (RET2.5 to RET2.12), RET3.1, RET3.3, Bombardier, Innovometric)
- c) Human shared reality and user experience optimization (TRL3-6, RET2.2, RET2.7, RET2.10, RET2.12, RET3.3, PWC, Siemens)
- d) Complex value chain network design and planning (TRL3-6, RET2.3, PWC, Siemens)

Legend:
- Tx: Research Theme x; x\(\in\{1, 2, 3\}\)
- FY: Forecast Year
- TRL: Technical Readiness Level
- EETx: Existing Equipment & Retrofit for Theme Tx
- RETx: Requested Equipment for Theme Tx
Research Centers for Circular Economy and Sustainable Development ($5M)

And Four Québec Centers of Excellence for Industrie 4.0
Digital Twin Platforms

Collaborative Innovation Lab (Decision Theater)

(Ref. CAE-ECHO)
Smart-Digital-Green Technologies Enablers
Siemens Industry 4.0 Software at Universities

Siemens PLM Software Business Segments

<table>
<thead>
<tr>
<th>Siemens PLM Software Business Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Engineering</td>
</tr>
<tr>
<td>Lifecycle Collaboration</td>
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<tr>
<td>Simulation and Test</td>
</tr>
<tr>
<td>Manufacturing Engineering</td>
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- **Product Engineering**: NX, Teamcenter, LMS, Tecnomatix
- **Specialized Engineering**: Fibersim, SDE, Syncrofit, QPE, SomEdge, Femap, CAM Express, Advantedge, SIMATIC IT, IBS, Preactor, WinCC

MindSphere
Cloud Based Open IoT Operating System

(Ref. Siemens, 2019 and 2021)
Training - Networking

- Summer School 4.0: 2019, 2021, 2022
  *Digital Transformation of Manufacturing*

- Forum Innovation 4.0 (2019): 440 participants
  *A National and Global Perspective on Industry 4.0 Technologies and Skills*

  Next Forum: Smart Digital Green Society, Fall 2022
# Work Integrated Learning (WIL)

“Digitization of the Manufacturing Industry”

## Competencies for the future:

**Digital Multidisciplinary Agile Graduate**
1. Digital technology
2. Mathematics and programming
3. Data valorization
4. System integration and automation
5. Process optimization
6. Business management
7. Organizational transformation

## Training Courses: (credit and non-credit)

1. Data analytics
2. Statistical analysis
3. Artificial Intelligence
4. Additive manufacturing
5. Collaborative robots
6. Predictive maintenance
7. Digital and entrepreneurship leadership
8. Value stream process mapping

## Experiential Learning

**Training Programs**
1. Industrial Internships
2. New Academic Programs
3. Professional Development
4. Summer School
5. Industrial Visits and International Missions

## Software:

1. Manufacturing Execution System (MES)
2. Product Lifecycle Management (PLM)
3. Enterprise Resource Planning (ERP)
4. Customer Relation Management (CRM)
5. Supply Chain Management (SCM)
6. Enterprise Asset Management (EAM)
7. Business Intelligence (BI)
8. Etc.

**ICT Skills Need to be Integrated in all Curricula**
Training Short Courses in Preparation for 4-6 months
Digital Work Integrated Learning « D-WIL »

Digital Enterprise Program

Introduction to digital technologies for the manufacturing sector
Support process for digital transformation and maturity
Introduction to software infrastructure and information technology for the digital enterprise
Introduction to the application of the Digital-Twin
Introduction to connected objects

Canadian Information and Communications Technology Council (ICTC)