Au-delà de l'Industrie 4.0: Industrie 5.0 et vers une Société « Smart Digital Green »

Source: Deborsi Basu, Sept. 2021

Hany Moustapha
Professor and Director, Innovation 5.0 Network
Siemens Chair on Industry 4.0 Technology Integration
and Pratt & Whitney Canada Chair on Propulsion System
Février 2022

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

ÉTS
Le génie pour l'industrie

AGENDA

Réseau Innovation 5.0 Network

Vers une société Smart, Digital & Green

- **Industry 4.0 Evolution (2000-2021)**
- **Industry 4.0 Workforce Challenges**
- **Industry 5.0: Human-Machine Reunion**
- **Réseau Innovation 5.0**

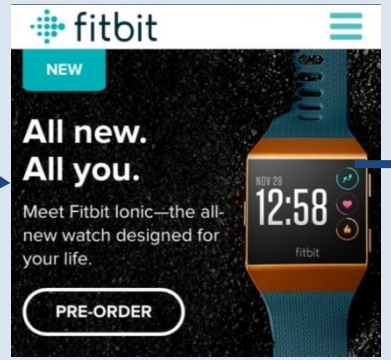
Some slides in this presentation include information from conferences presentations with proper acknowledgement and reference of the sources

Industry 4.0/5.0 is Already in Our Daily Life: Internet, GPS, Iphone, Facebook, etc.

Shared Economy – Electronics Platforms: Uber and Airbnb

"Connecting the Unconnected"

- Big Data
- Internet of Things
- Connectivity
- Cloud Computing
- Artificial Intelligence
- Predictive Maintenance



- Steps
- Kms
- Floors
- Minutes
- Calories
- Sleeping
- Weight
- Heart
- Water

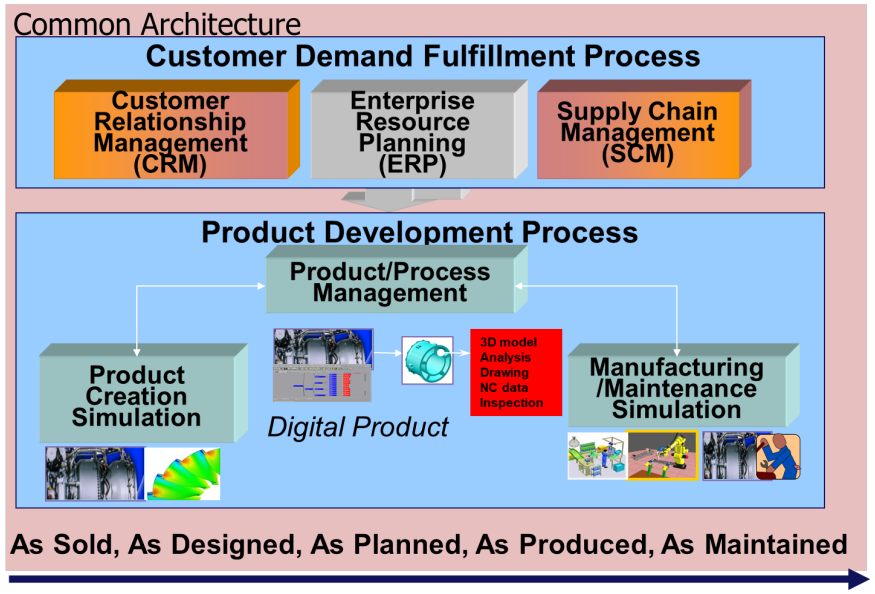
Industry 4.0 is not an End-Point
It is a "Journey": Industry 4.0, 4.1, 4.2, .., 5.0, X.0

H. Moustapha, March 2018

Evolution of 4.0 (2000-2021)

PÔLE INNOVATION 5.0 HUB

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.

Artificial Intelligence (AI) and (Big) Data Analytics (DA): What is the Difference?

Artificial Intelligence (AI) is a branch of computer science that refers generally to systems that can think and learn as intelligent humans would.

Machine Learning (ML) is a subset of AI that refers to **algorithms** that can learn from and make predictions on data.

Deep learning is a branch of machine learning, rebranding of artificial neural networks using layers of nonlinear processing units.

Data Analytics (DA) is related to the **processing** of data sets in order to build **insights** with a view to monetizing.

Big Data encompasses **software** technologies to collect and store massive, **heterogeneous** and **fast changing** sets of data in order to bring sense and value (money).

Big Data Analytics combines both big data and DA.

AI: Knowledge and Decision Making

Data Rich….BUT…..Information Poor

When Artificial Intelligence becomes the Mother of All Technologies

(Roland Berger, 2018)

In less than two decades, **three waves of technological disruption** have swept across our economies and societies:

1. **Hardware,** with IBM, Apple and Intel as the big winners
2. **Software** and operating systems, which Microsoft largely pioneered
3. **Smartphones** or Apple's iPhones that have since become the remote control of our lives

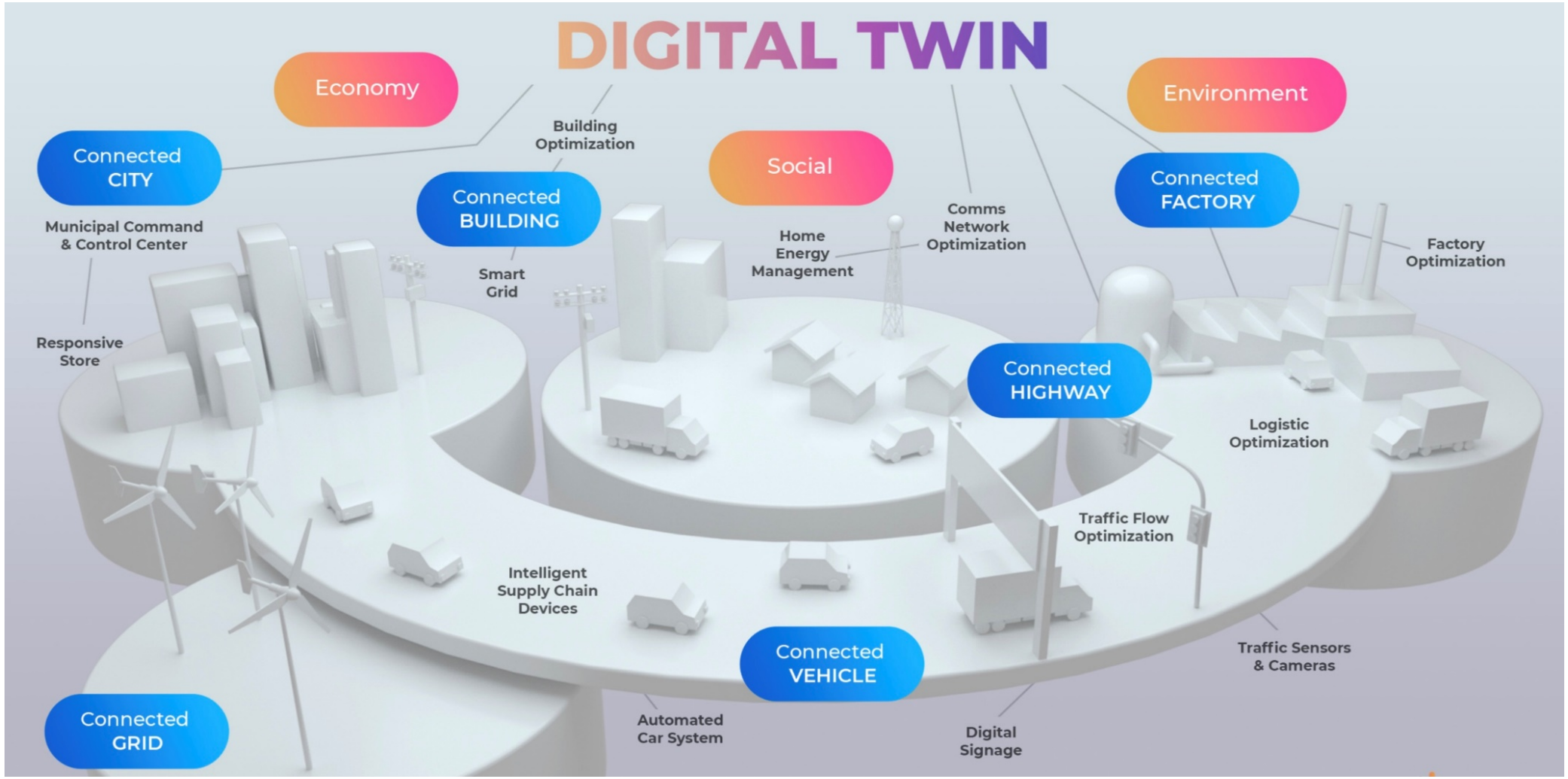
Today, we are about to enter a **fourth wave**, which will combine existing **hardware and software, fueled by powerful AI**

Gradually moving from deep learning technologies to machine reasoning and genetic algorithms, there will also be progress in the development of new forms of AI solutions and technology.

Personal Portable AI Devices which will be Heavily Disruptive

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

SIEMENS
Ingenuity for life

Data-driven feedback

feed back insights to continuously optimize product and production

Product & Production Data Collection

Digital Twin product

Digital Twin production

Digital Twin performance

The Digital Thread integrates Digital Twins across value chains throughout the product lifecycle

SIEMENS
Ingenuity for life

The Digital Thread
Teamcenter PLM Platform

Product Design | Production Planning | Production Engineering | Production Execution | Data Driven Services

Digital World

Digital Product
Requirements
Product Structures
Bill of Materials
Virtual Models
Performance Simulation

Planning
Bill of Process
Work Instructions
Advanced Quality Planning
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

Industry X.0 (2016)

Digital Reinvention of Products (Eric Schaeffer, 2019)

From Passive Traditional Products to Smart Connected Products

From Traditional to Connected to Intelligent to Autonomous Product

Product X.0: A Product becomes a Service with Experience (Sustainability)

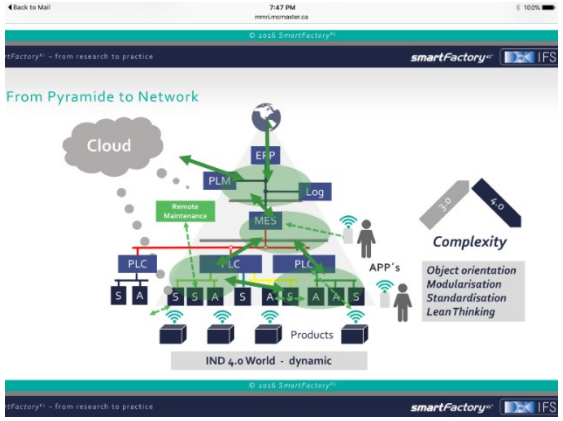
Product Reinvention Quotient (PRQ): Intelligence Q (IQ) and Experience Q (EQ)

Evolution of 4.0 (2000-2021)

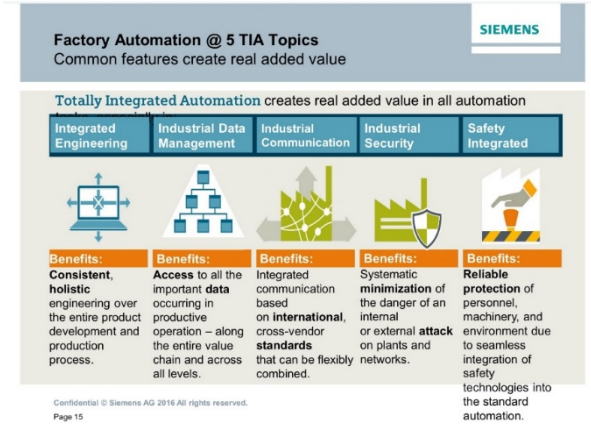
PÔLE INNOVATION 5.0 HUB

Industry 4.0 Factories

Germany Smart Factory (2005)

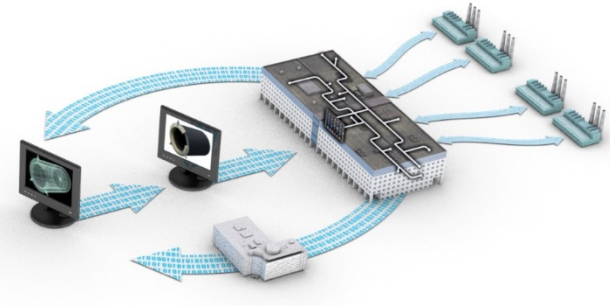


Siemens Digital Factory (2012)



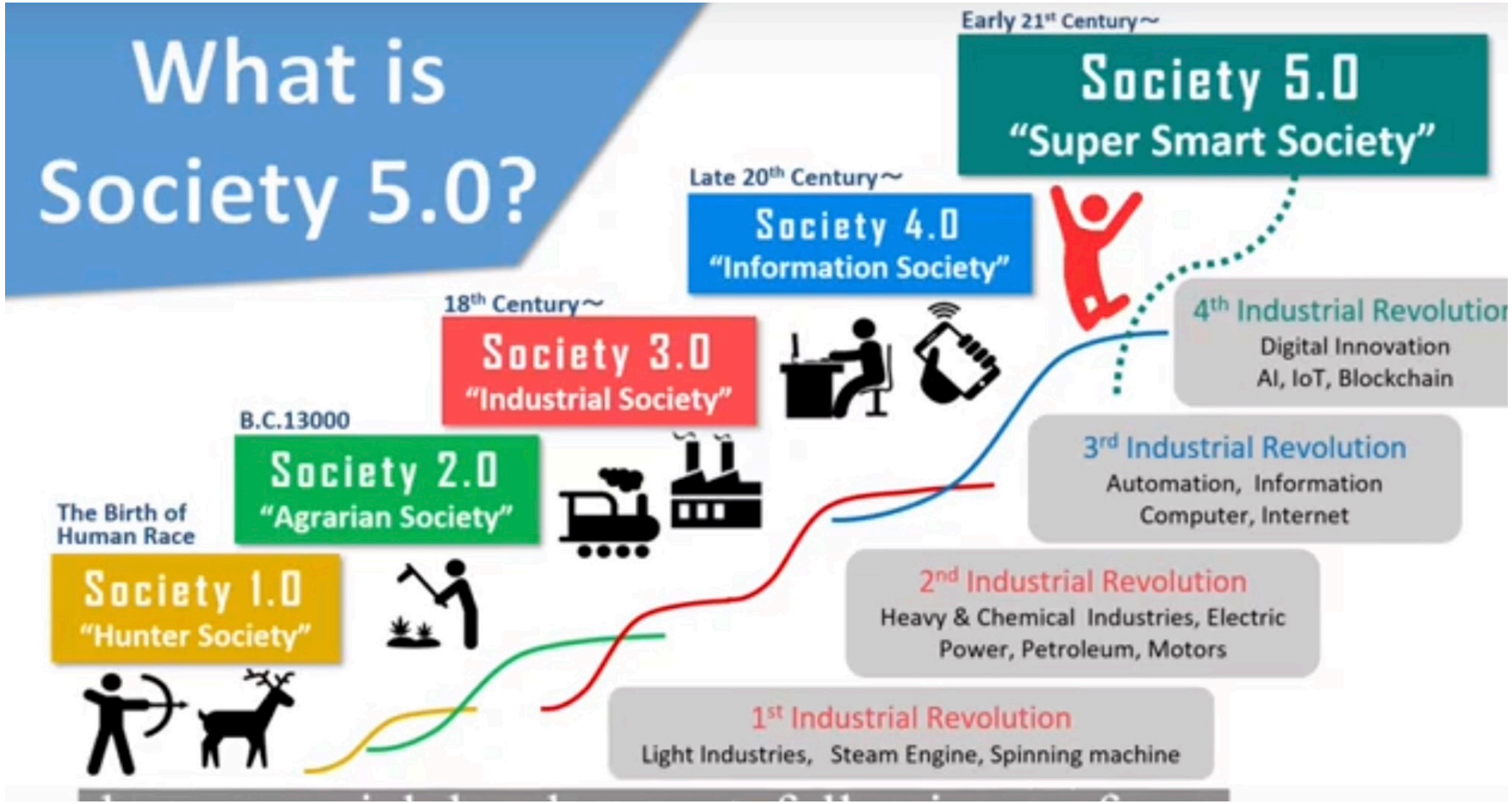
Europe Factory of the Future (2013)

GE Brilliant Factory (2014)



(Ref. Siemens and GE presentations)

It is not only for Factory:
It is for the total Society
Japan: Society 5.0

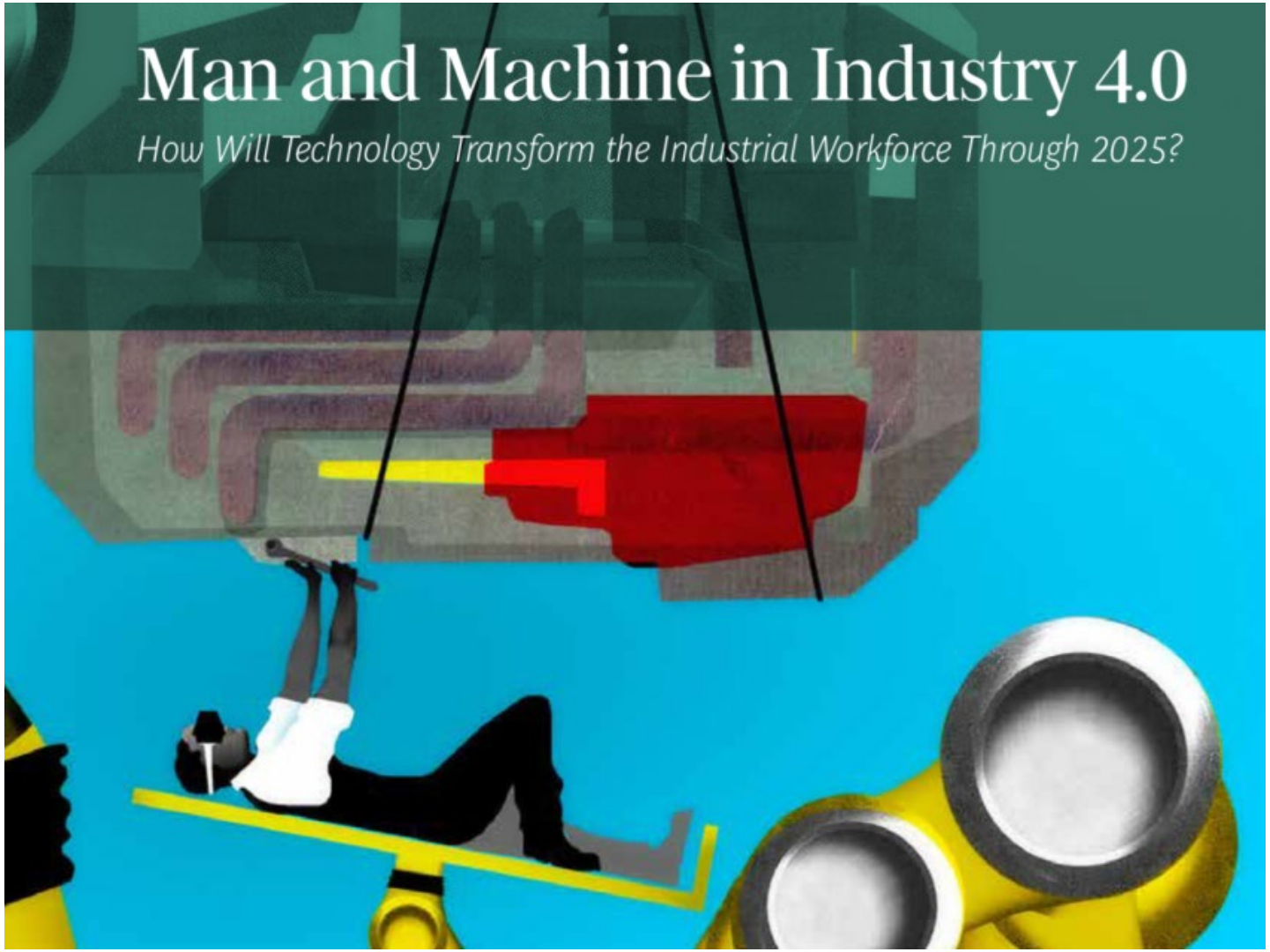


Japan (2017)

UN 17 SDGs


17 PARTNERSHIPS FOR THE GOALS
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
1 NO POVERTY
15 LIFE ON LAND
Using remote sensing and oceanographic data for monitoring and management of water quality, forests, land degradation, biodiversity, etc.
2 ZERO HUNGER
Boosting food production by smart agriculture utilizing IoT, AI and Big Data
Improving nutritional status with smart food produced by cutting-edge biotechnology
14 LIFE BELOW WATER
3 GOOD HEALTH AND WELL-BEING
Developing early warning alert system for the prevention of infectious diseases by combining different types of monitoring data
Society 5.0
for
SUSTAINABLE DEVELOPMENT GOALS
Citizen
Government
Large enterprise
SME
Startup
Organization
Investor
Academic institution
Educational institution
Medical institution
Community
GovTech
FinTech
InsurTech
InsTech
RETech
TourTech
AutoTech
TransTech
DPTech
UrbanTech
InfraTech
ConTech
EdTech
SportsTech
HomeTech
Fashion Tech
EneTech
RetailTech
AdTech
MediaTech
Entertainment Tech
HealthTech
CareTech
AgriTech
EnviTech
BioTech
FoodTech
Frontier Tech
LegalTech
JobTech
CivicTech
BigData
IoT
AI
Robot
Drone
Sensor
3DPrint
Block chain
PKI
Sharing
OnDemand
Mobile
Edge
Cloud
5G
VR
AR
MR
13 CLIMATE ACTION
Resolving climate change issues with the simulation based on the analysis of meteorological and other observation data by using High Performance Computing
4 QUALITY EDUCATION
Make high quality education affordable for everyone on the earth with e-learning systems utilizing state-of-the-art technologies
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
Creating smart cities where convenience, safety and economic efficiency are made compatible
5 GENDER EQUALITY
Empowering women with access to education and information through the Internet
Providing women with opportunities for startups by utilizing ICT
11 SUSTAINABLE CITIES AND COMMUNITIES
Building global innovation ecosystems by connecting industries, academic institutions and other related stakeholders
6 CLEAN WATER AND SANITATION
10 REDUCED INEQUALITIES
Building resilient infrastructure and promoting sustainable industrialization by using i-Construction
7 AFFORDABLE AND CLEAN ENERGY
Managing electric power supply and demand in a sustainable way by constructing smart grid systems
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
8 DECENT WORK AND ECONOMIC GROWTH
Keidanren supports the SDGs

Industry 4.0: Workforce Challenges



(Ref.: BCG, Sept. 2015)

Industry 4.0 Major Challenge

WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

Global Challenge Insight Report

The Future of Jobs

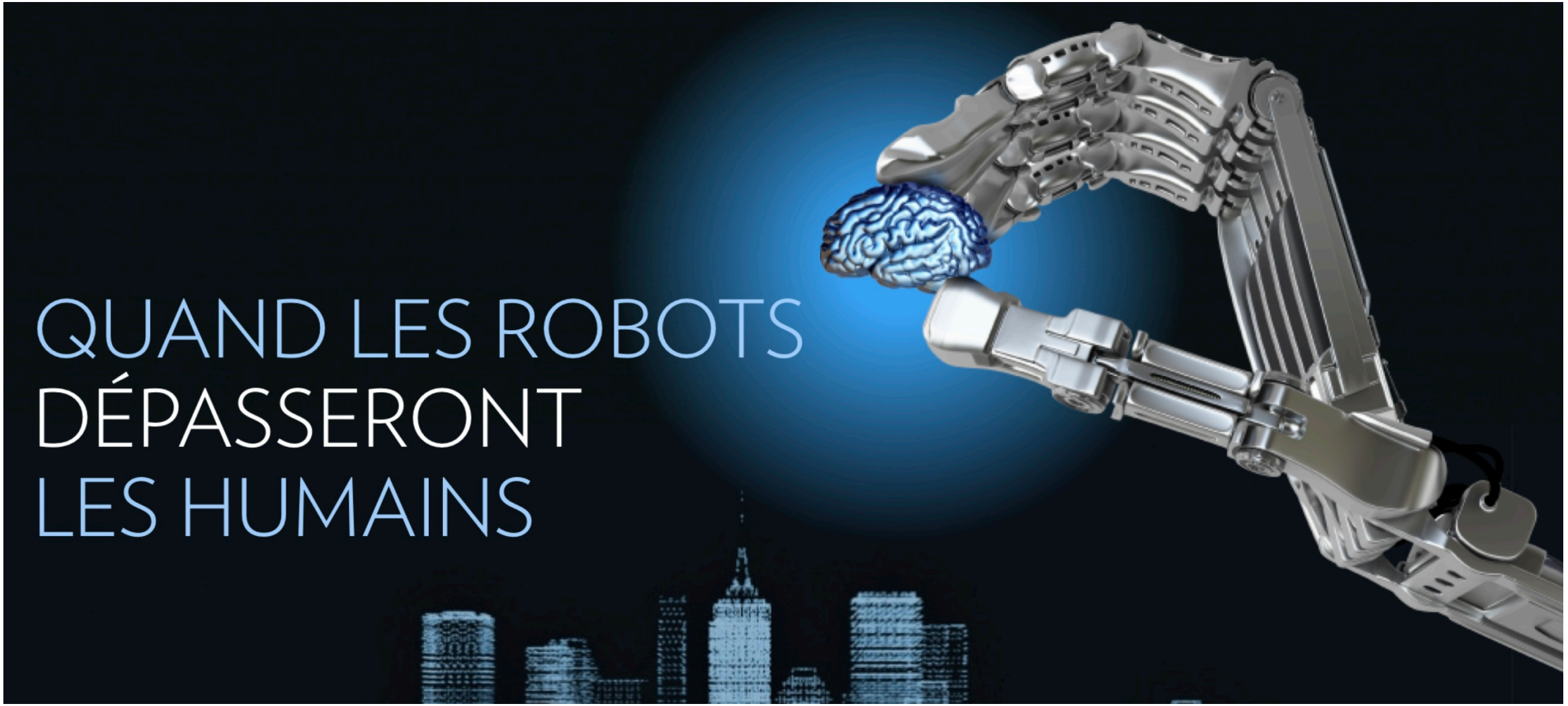
Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution

January 2016

Automa-nation: Will robots take your job?

A new report suggests 42% of the Canadian job market is at risk

Industry 4.0 Major Challenge



LaPresse, 23 janvier, 2022

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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(USA aerospace industry sales:
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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. ?

Workforce Challenges

Remote Working vs Physical Presence

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

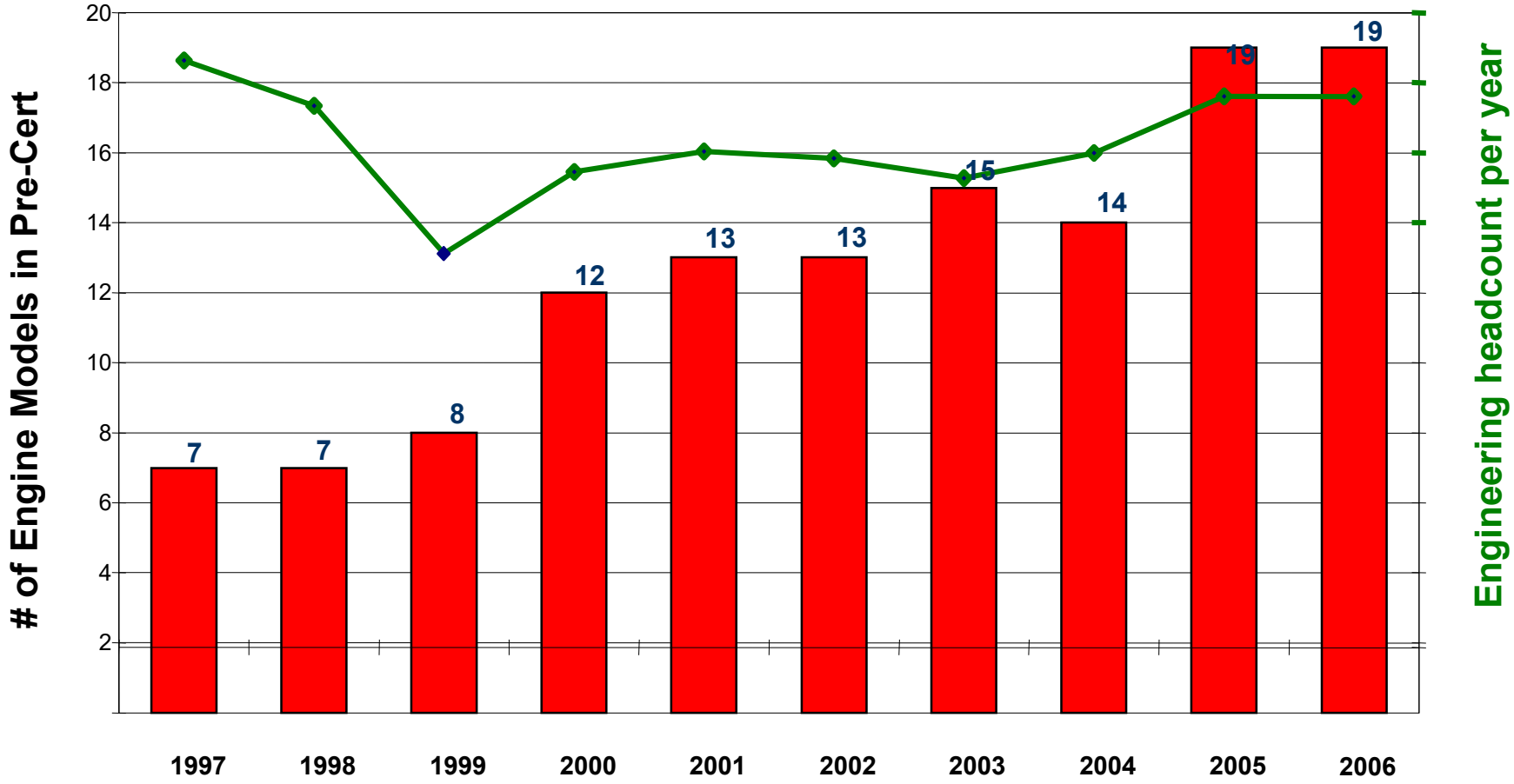
Technological Unemployment Theory (Keynes, 1930)
Economizing the use of labor is outrunning the pace at which we can find new uses for labour

- 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 4.0 Future Work Force

- There will be closed, modified and new jobs (T. Walsh, Data61)
- There is future for people who are re-inventing the future
- Social emotional intelligence jobs
- Artistic creative (handmade) jobs

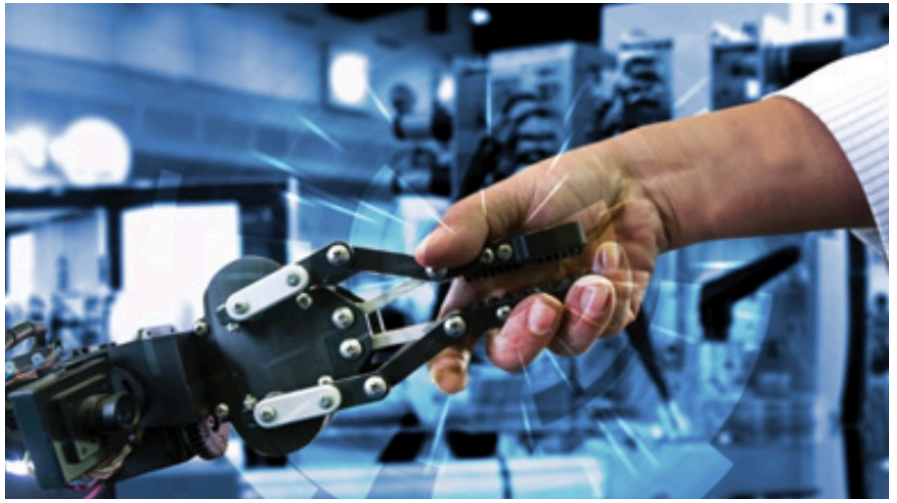
Berlin, Sept. 24 2018

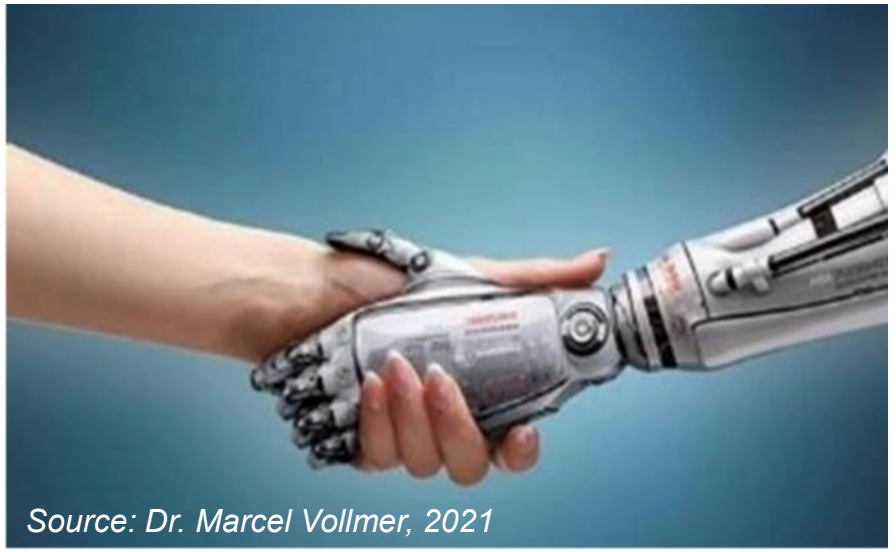
- Re-skilling – Less work week hours
- 2062: The World that AI Made (T. Walsh, Data61)
- Internet of Thinking
- Human Centricity

Artificial Intelligence, created by human, is not a job killer and will drive growth

(HPE and IoT World 2018 Survey)

Industry 5.0 (Europe, 2020)
Human-Machine Reunion – Humanizing Robots





Source: Dr. Marcel Vollmer, 2021

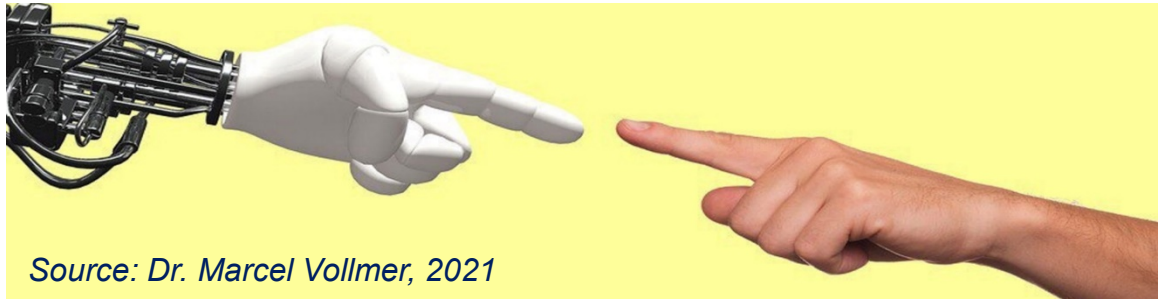
Industry 5.0: Human in Control and Bringing Back Humans into the Action

- Human-Machine **cooperation**
- Harmonizing **human intelligence** with **cognitive computing**
- Mass **customization**
- **Personalization** for customers
- **Augmented** Artificial Intelligence

The 3 pillars of Industry 5.0 according to the EC – human-centric, resilient and sustainable – full PDF here

Europe (2020)

Industry 5.0: Human-Centric

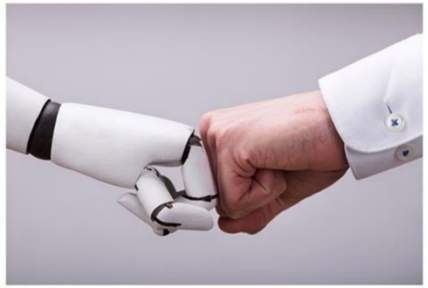


Source: Dr. Marcel Vollmer, 2021

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 – source and courtesy infographic EC

July 30, 2020 By James Jardine, Staff Writer, MasterControl



Smart Digital Green "SDG" Society for Sustainable Development Goals (SDG)

- Connecting the Unconnected
- Real Time Connectivity: Digital Thread
- Smart Connected Products
- Products: Services with Experience (Sustainability)
- Clothes Connected to Internet
- AI-Personalized Smart Phones
- Information+Operational Technologies

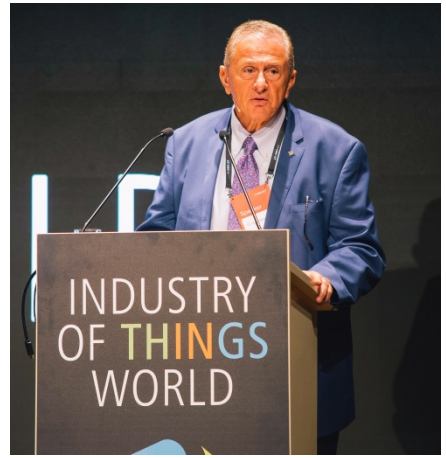
(Ref. Japan, Keidanren, 2017)

Smart-Digital-Green Home, Transport, City, Hospital, Universities, Etc.

Demystifying Industry 4.0/5.0

"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)

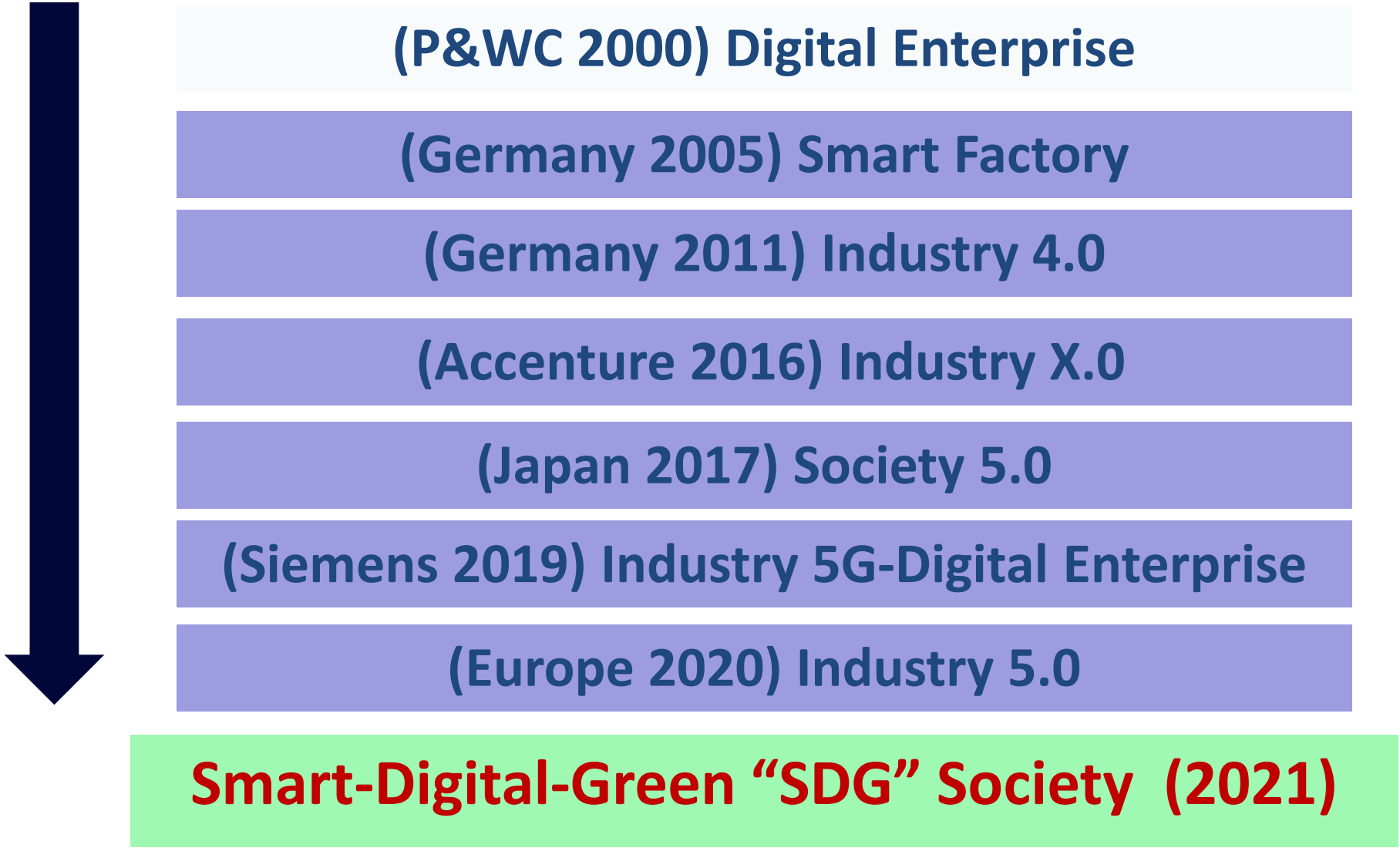


Smart Digital Green “SDG” Society

- Skilling - Reskilling – Upskilling
- Critical and Creative Thinking
- Integration Skills
- Internet of Behavior
- Emotional Intelligence vs Intellectual Intelligence (EQ vs IQ)
- Augmented Artificial Intelligence “AAI”: Human-Machine Reunion
- Multi-Disciplinary: Fluid and Structural Mechanics
- Inter-Disciplinary: Mechatronics – Bio-Engineering
- Trans-Disciplinary: Academia with stakeholders
- Metaverse: Extended Reality integrating Virtual, Augmented and Mixed Realities

Education – Exposure - Experience

Evolution of 4.0 (2000-2021): Summary



AGENDA

Réseau Innovation 5.0 Network

Vers une société Smart, Digital & Green

- **Industry 4.0 Evolution (2000-2021)**
- **Industry 4.0 Workforce Challenges**
- **Industry 5.0: Human-Machine Reunion**
- **Réseau Innovation 5.0**

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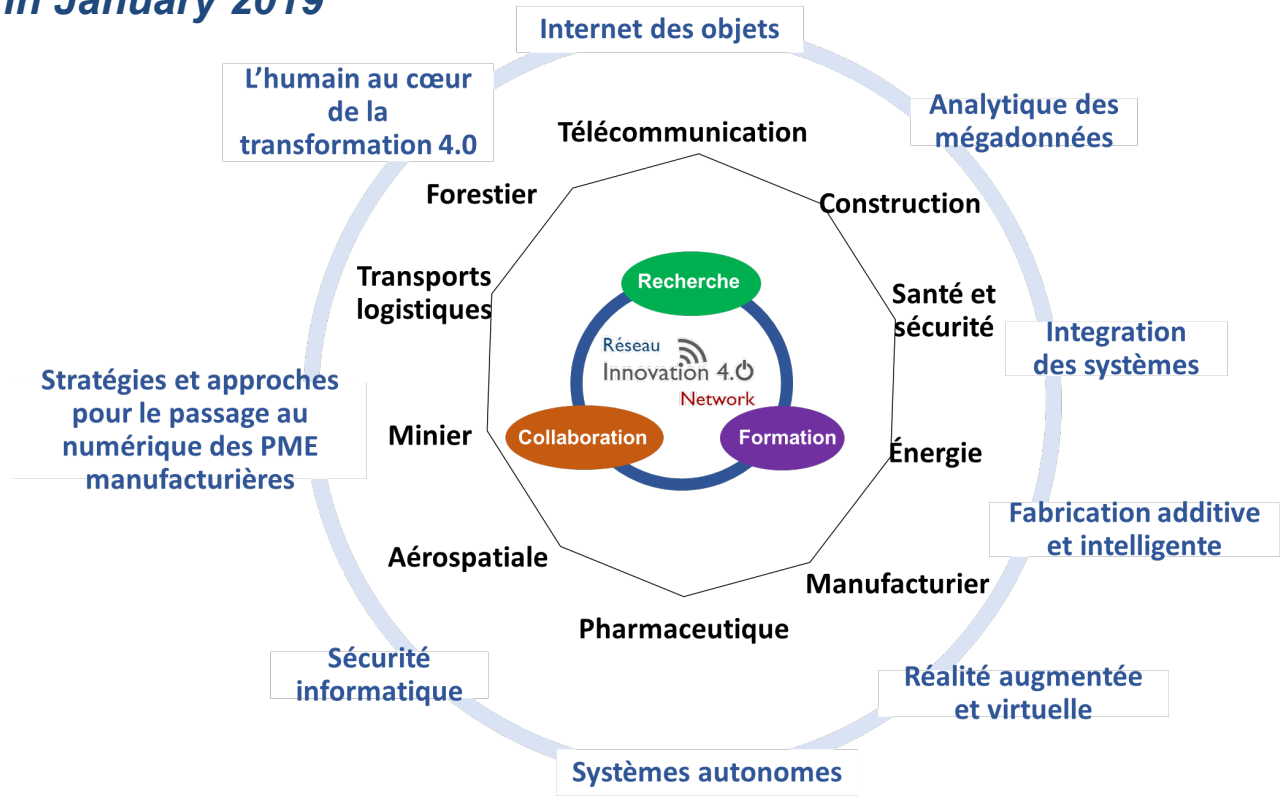
1- Réseau Innovation 5.0

Réseau Innovation 5.0 Network

Concordia University · ÉTS · Université Laval · McGill · Polytechnique Montréal · Université de Sherbrooke · UQÀM · UQTR

Created in January 2019

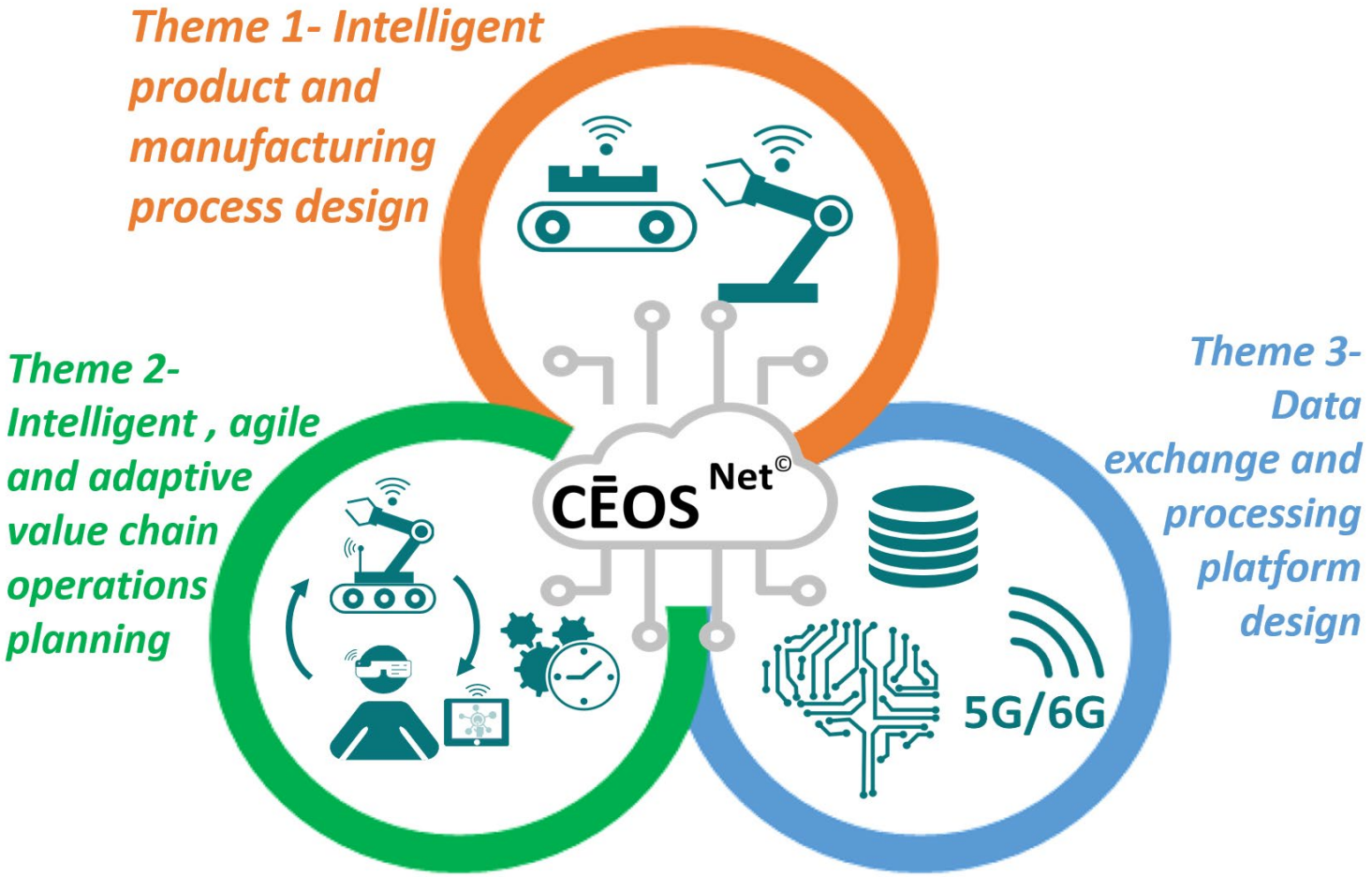
- First in North America
- 8 Universities
- Over 200 Profs 4.0
- All 4.0 technologies & sectors
- Joint academic programs
- Collaboration with industry
- Students activities
- Summer School 4.0
- Government funding



reseauinnovation4network.com

2- Digital Manufacturing Technology and Training Platform ($12M) for « SDG »

Réseau Innovation 5.0 Network



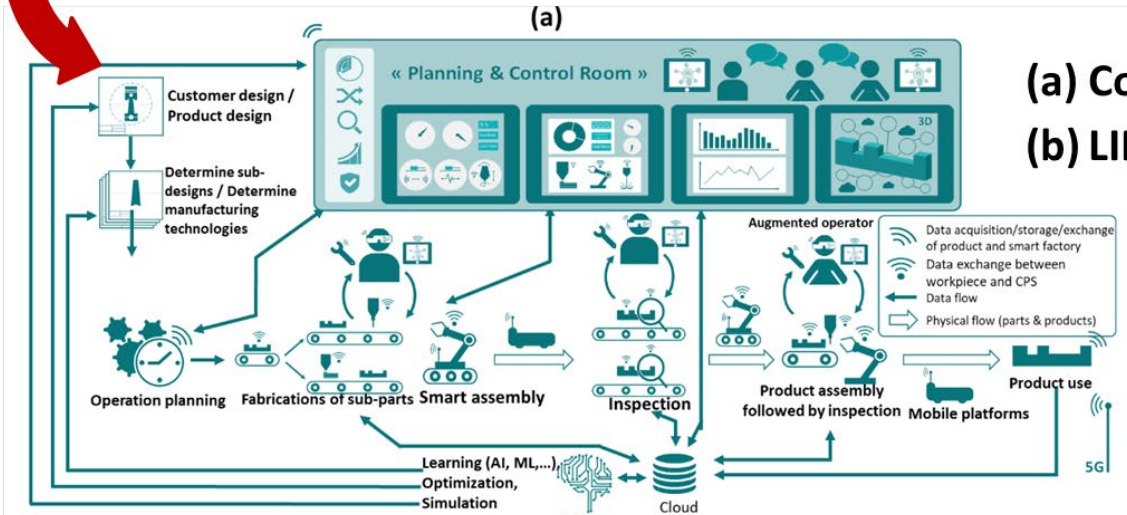
Intelligent Cyber Value Chain Network (CĒOS^{Net})

3- Digital Twin Platforms

ETS Collaborative Innovation Lab (Decision Theater)

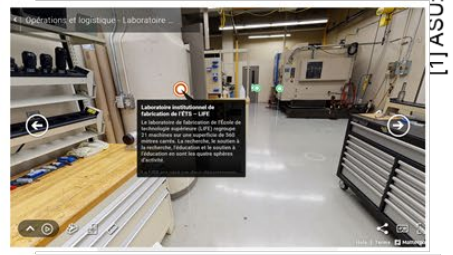
Directrice: Prof. Tasseda Boukherroub

(a)



(a) ColLabInnov

(b) LIFE / Usine du futur



Fabrication manufacturière

[1] ASU: Arizona State University. https://dt.asu.edu/. Last accessed n July 2016.

4- Training - Networking

Réseau Innovation 5.0 Network

- **Summer School 4.0: 2019 and 2021**

  Forum des étudiants 5.0 (8 Juin 2022, Université Laval)

- **Forum Innovation 4.0 (2019): 440 participants**

  Vers une Société « Smart-Digital-Green » (Octobre 2022)

5- Work Integrated Learning (WIL)

"Digitization of the Manufacturing Industry"

Réseau Innovation 5.0 Network

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

Experiential Learning
Training Programs

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

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
9. Etc.

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

6- Training Short Courses in Preparation for Internships
Digital Work Integrated Learning « D-WIL »

Digital Enterprise Program

Directeur: Prof. Amin Chaabane

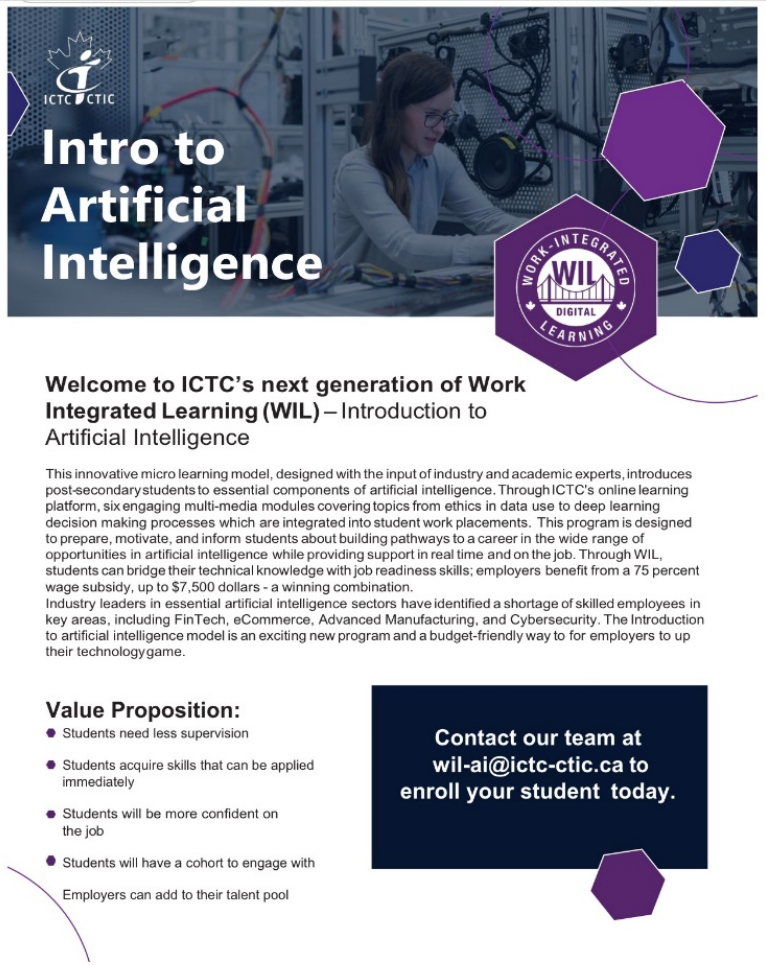
Introduction to digital technologies for the manufacturing sector

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)