Beyond Industry 4.0/5.0:

Towards a Smart, Digital and Green Society

A Canadian Perspective in Education and Research

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

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Siemens Chair on Industry 4.0 Technology Integration
and Pratt & Whitney Canada Chair on Propulsion System

July 2022

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Réseau Innovation 5.0 Network

Towards a Smart, Digital & Green Society

reseauinnovation4network.com

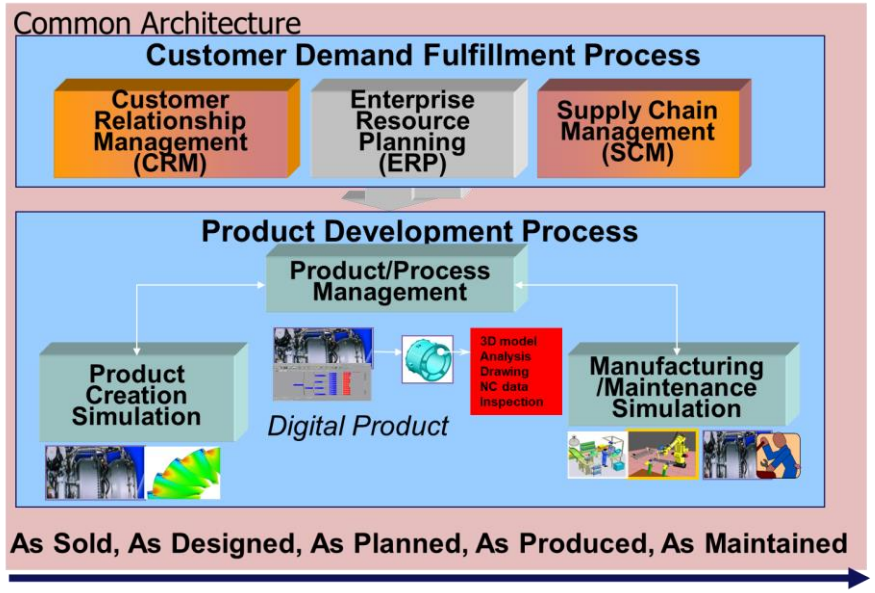
OUTLINE

- **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)

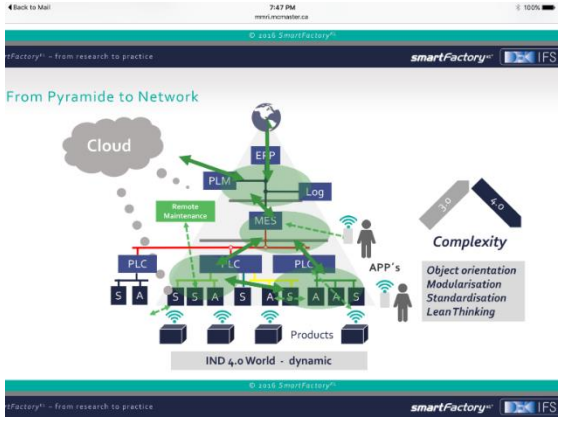
Digital Enterprise
(Siemens, 2019)

Industry 4.0 has been Already in Our Daily Life: Internet, GPS, Iphone, Facebook, etc.

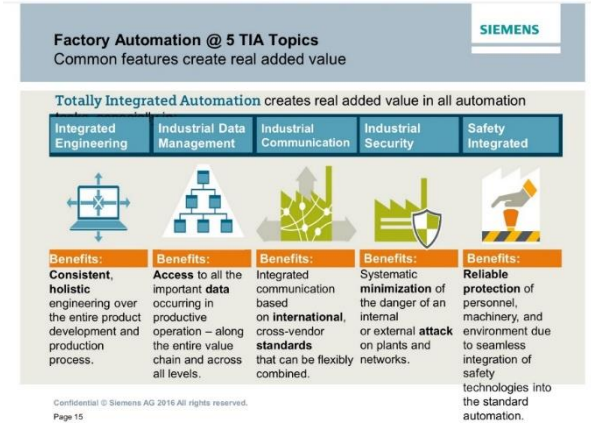
Evolution of 4.0 (2000-2022)

Industry 4.0 Factories

Germany Smart Factory (2005)

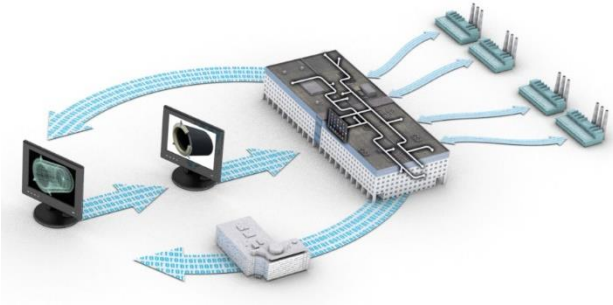


Siemens Digital Factory (2012)



Europe Factory of the Future (2013)

GE Brilliant Factory (2014)

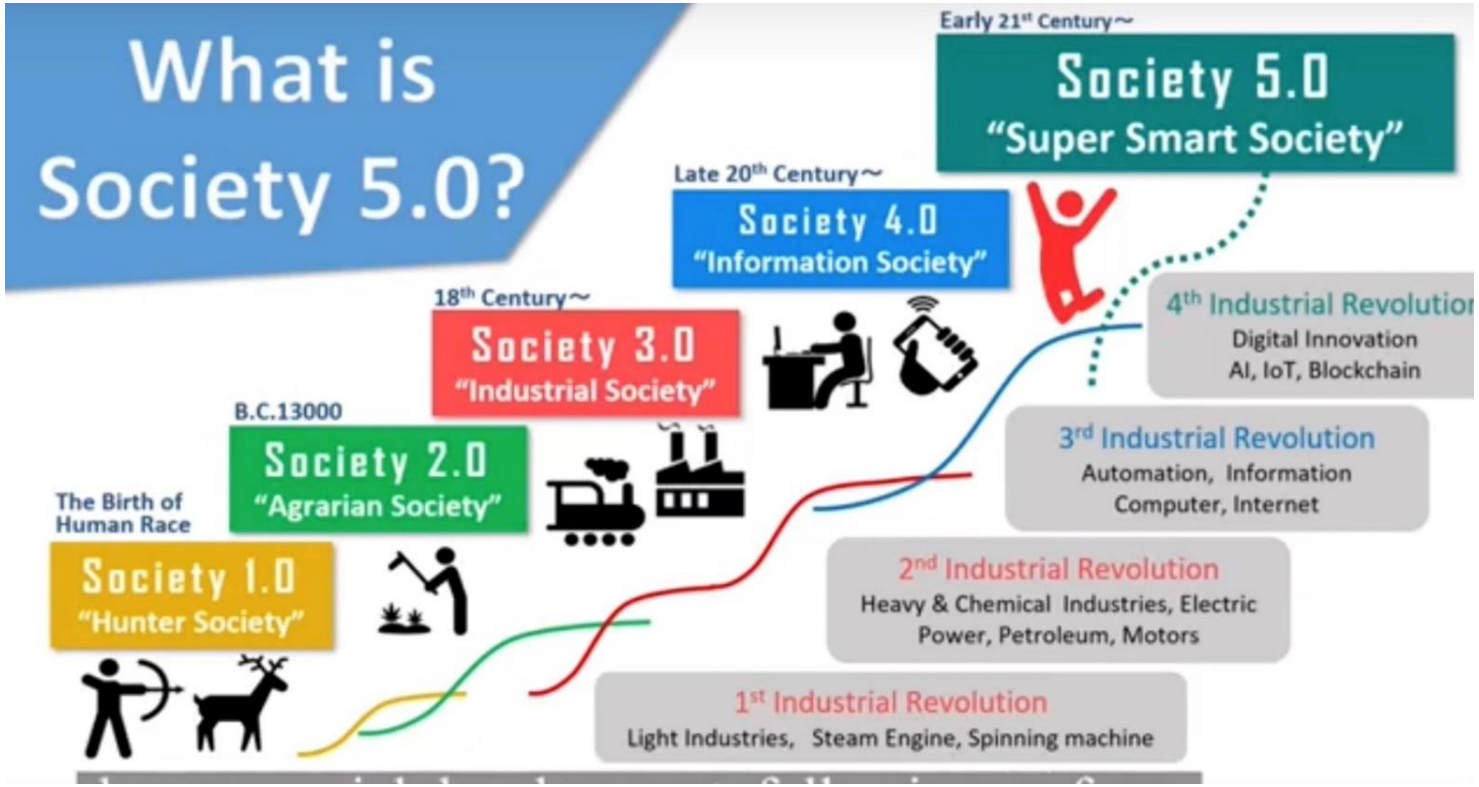


(Ref. Siemens and GE presentations)

Society 5.0 OR Industry 5.0

Society 5.0
(Japan, 2017)

It is not only about Factory
It is not only for Industry
It is
Technology
and for the total Society

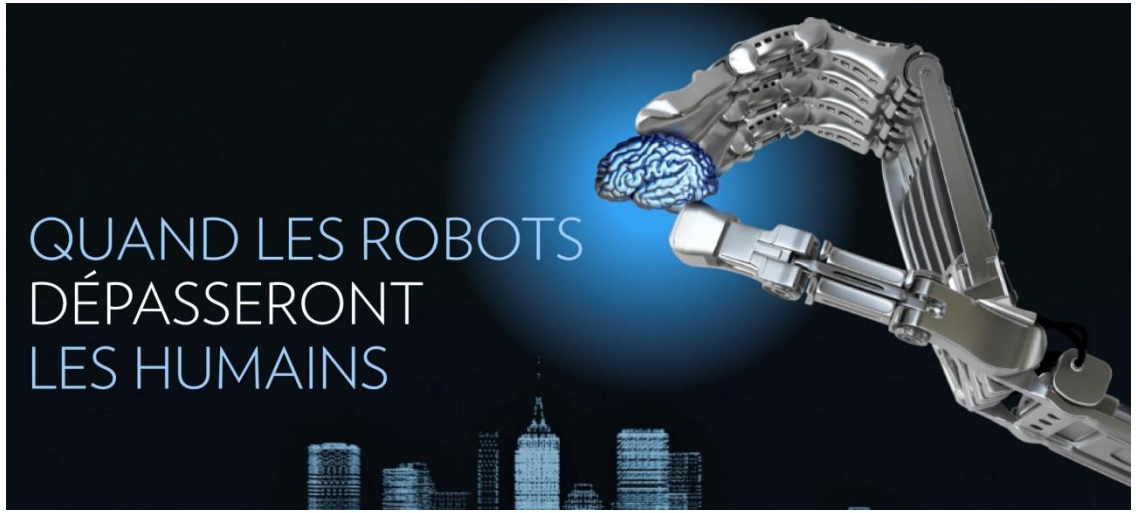


(Ref. Japan, Keidanren, 2017)

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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(USA aerospace industry sales:
2000: $118 Billions with 1.3 millions people
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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

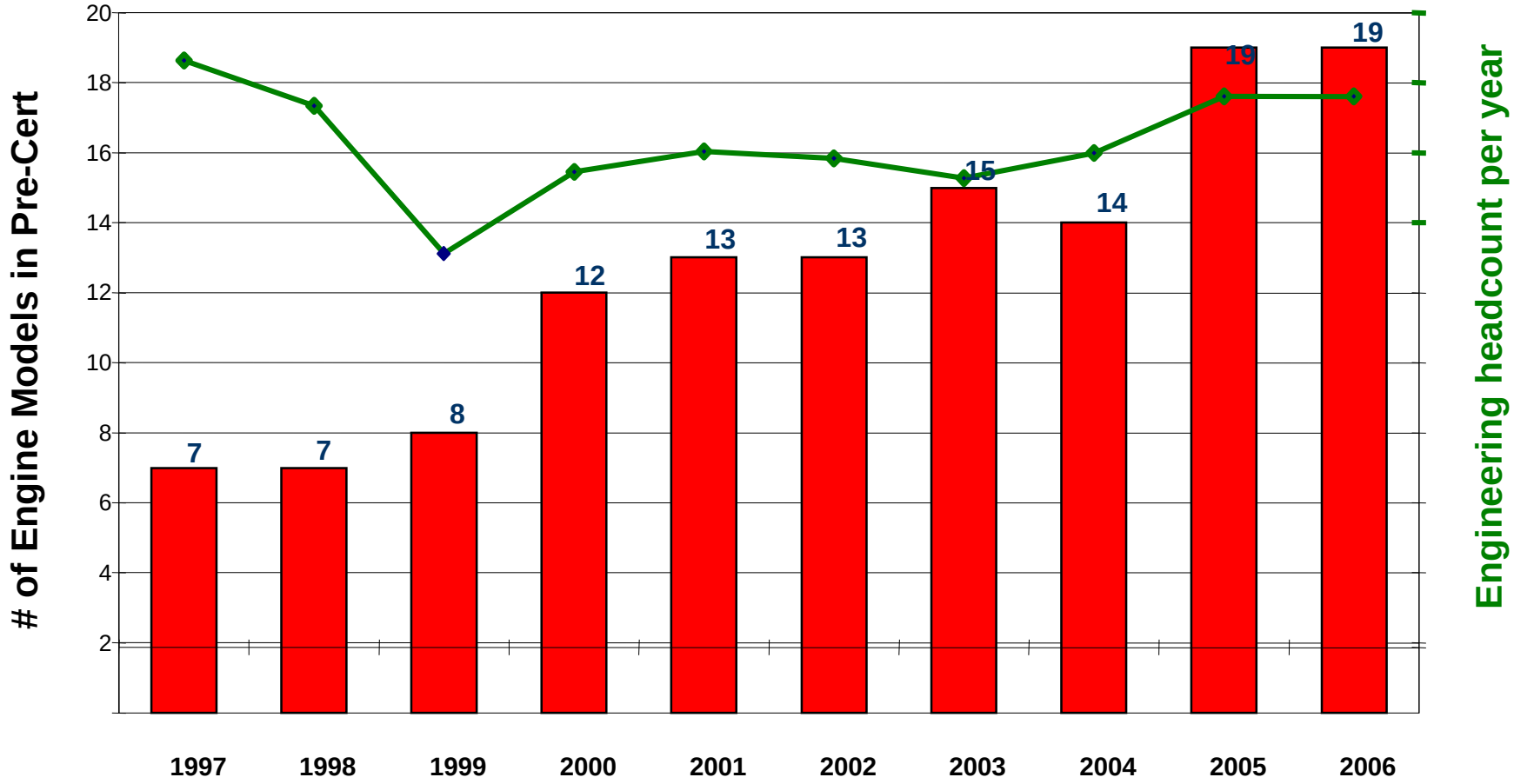
Technological Unemployment Theory (Keynes, 1930)
Economizing the use of labor is outrunning the pace at which we can find new uses for labour

- 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

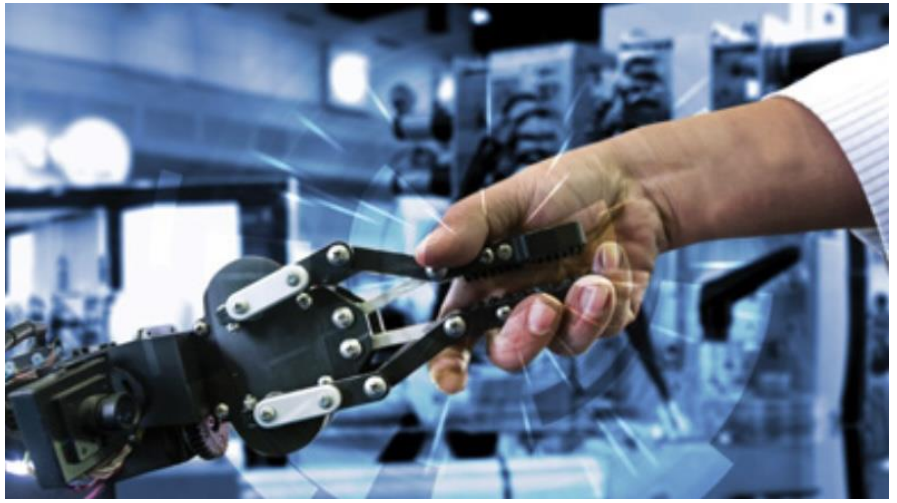
Technology-Productivity-Growth

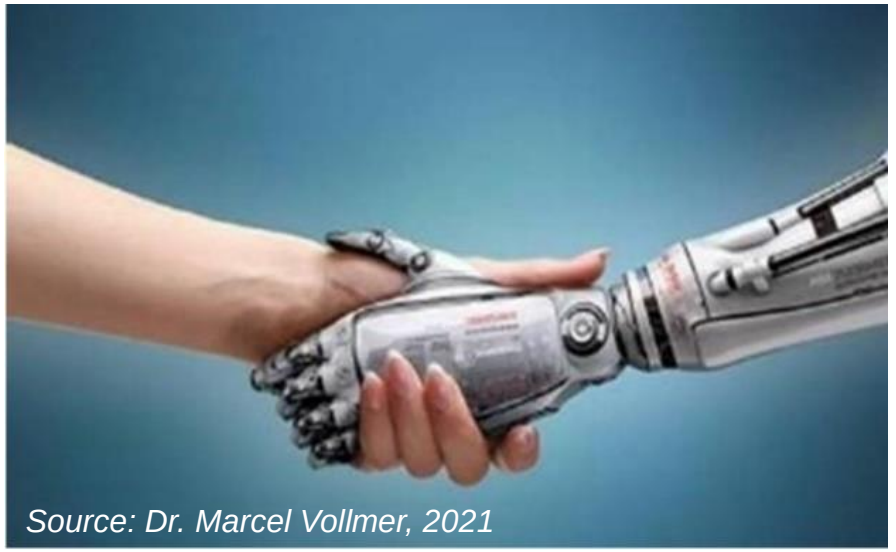
From 2 Engine Families in 1978 to
12 Engine Families in 2018
With same headcount and budget



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

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

INDUSTRY 1.0 – INDUSTRY 5.0

Industry 1.0	Industry 2.0	Industry 3.0	Industry 4.0	Industry 5.0
Mechanization	**Electrification**	**Automation**	**Digitalization**	**Personalization**
Time: 18th C.	Time: 19th C.	Time: 20th C.	Time: 20th/21st C.	Time: 21th C.
Keywords: Water, Steam	Keywords: Electricity, Assembly line	Keywords: Computers, Automation	Keywords: Networking, Communication	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 – source and courtesy infographic EC

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 (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 Home, Transport, City, Hospital, Universities, Etc.

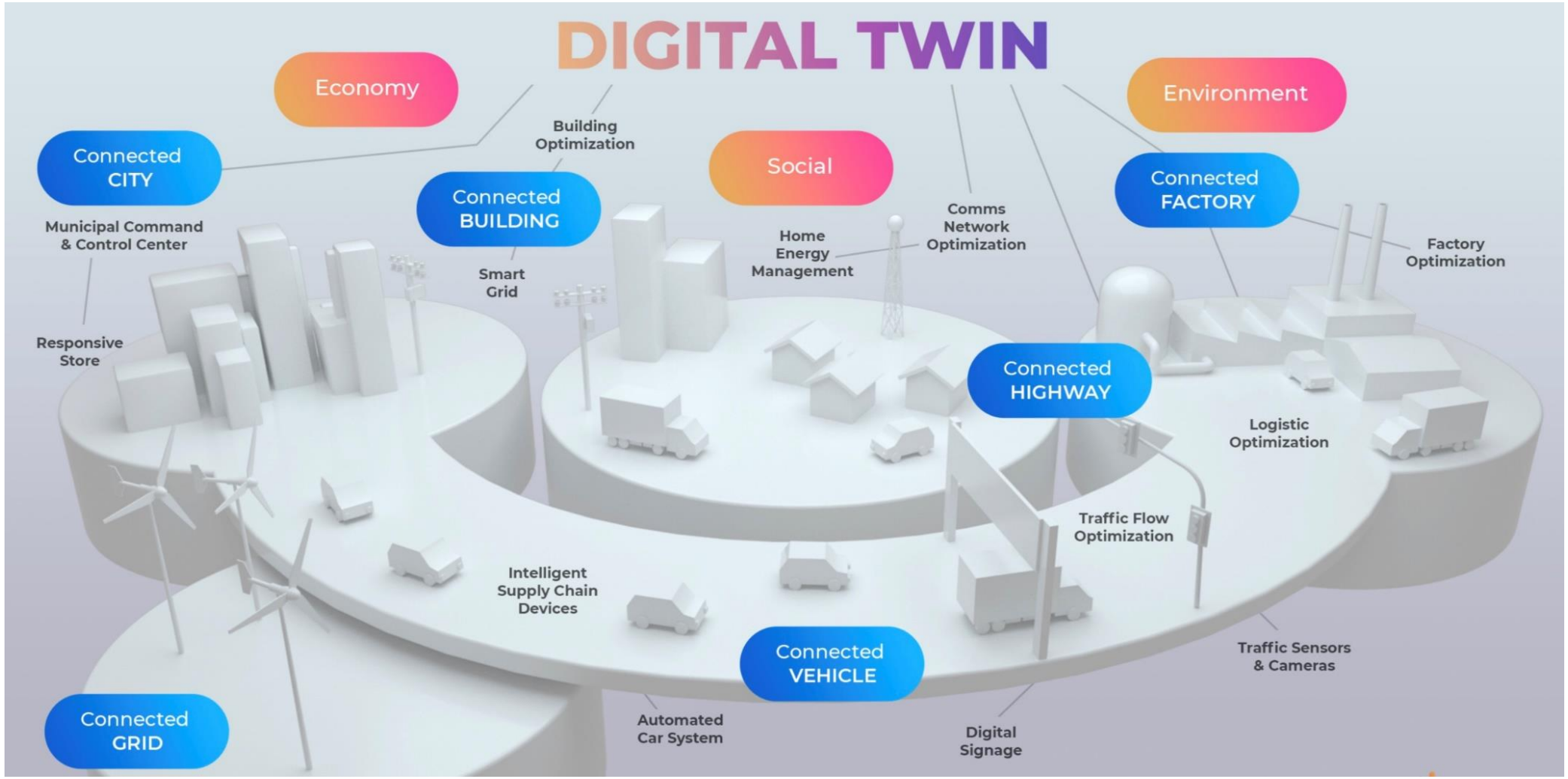
Smart Digital Green “SDG” Society

- 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

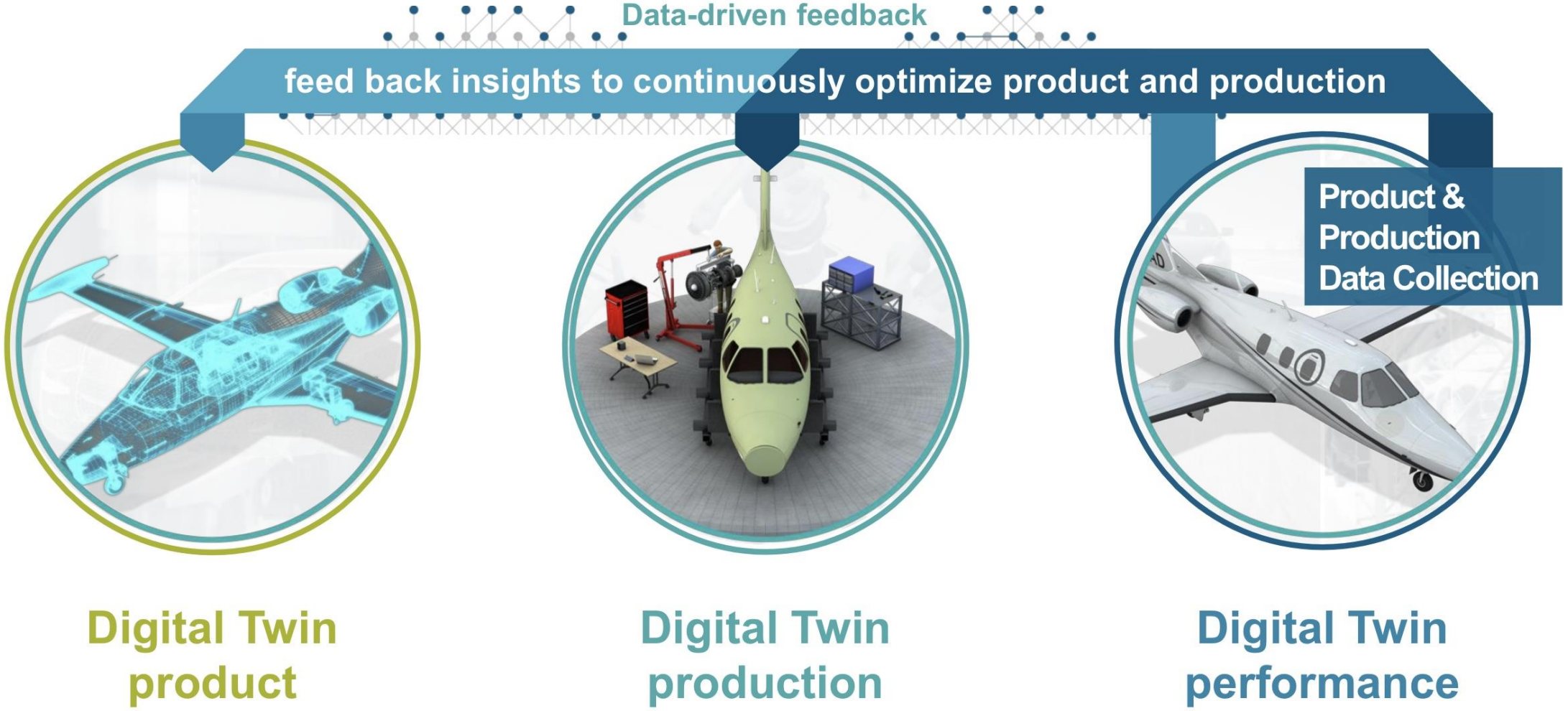


(Sources: CAE)

Digital Twins are the building blocks of Industrie 4.0 capabilities

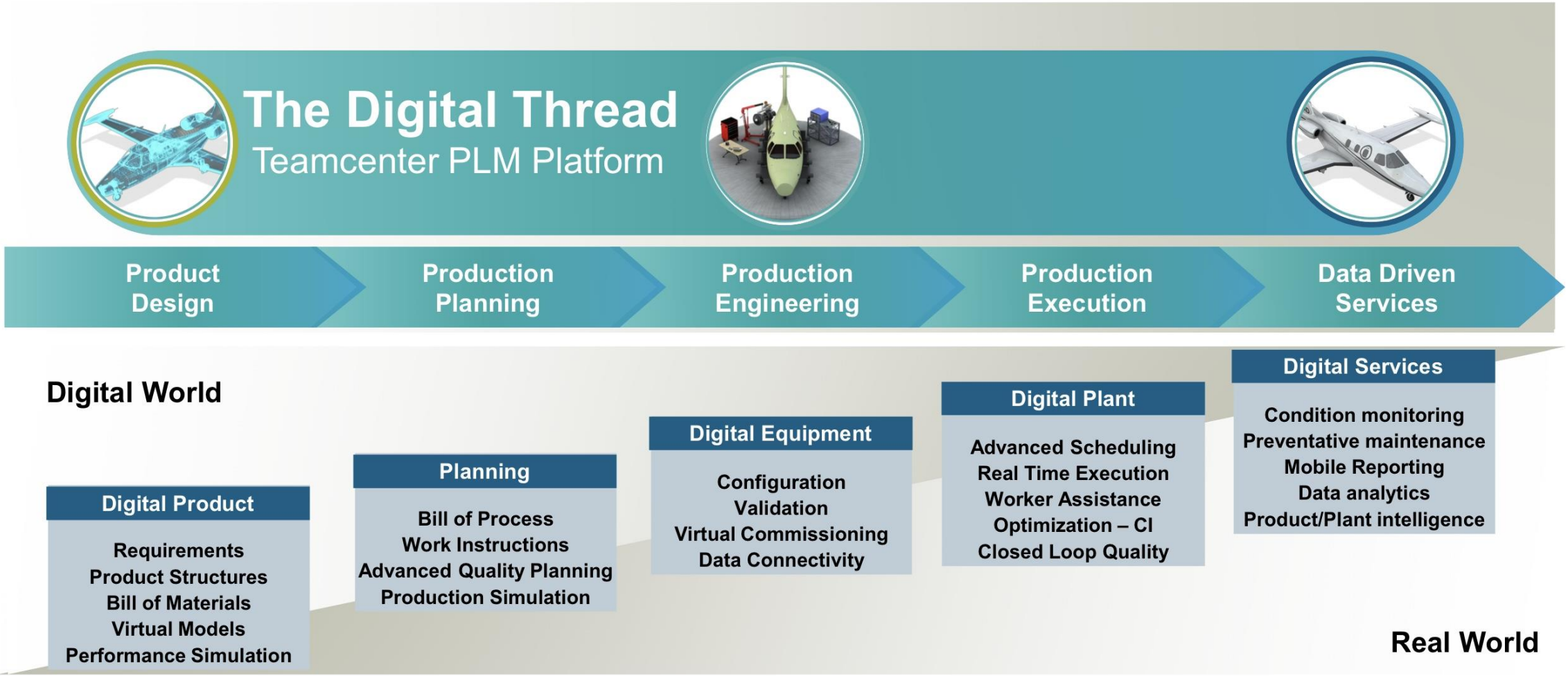
SIEMENS

Digital Replication of a Physical Entity



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

SIEMENS



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)

Université Concordia University

ÉTS Le génie pour l'industrie

Université Laval

McGill

Polytechnique Montréal – Université d'ingénierie

Université de Sherbrooke

UQÀM

UQTR Université du Québec à Trois-Rivières

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

Québec

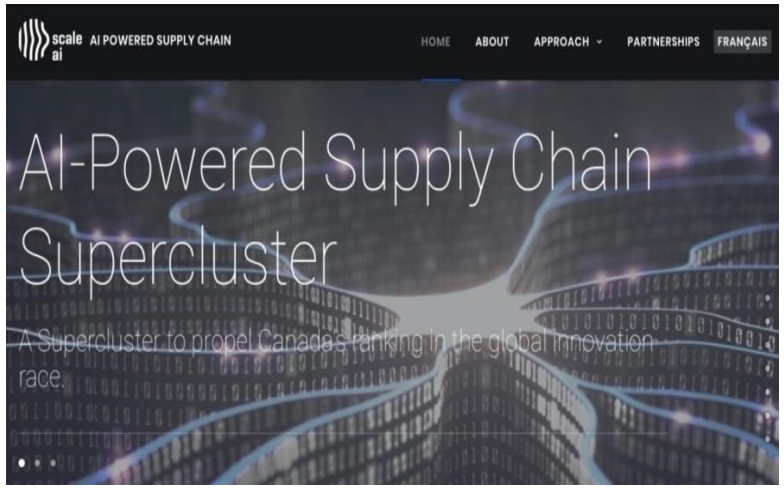
ALSTOM · mobility by nature ·

Pratt & Whitney – Moteurs haute fiabilité – SE DÉPASSER

SIEMENS Ingenuity for life

CAE

Clusters – Infrastructures – Financing – Etc.



$3B Clusters

NGen Next Generation Manufacturing Canada

ENCQOR 5G

IVADO

HOMEPAGE IVADO RESEARCH TRAINING PARTNERS

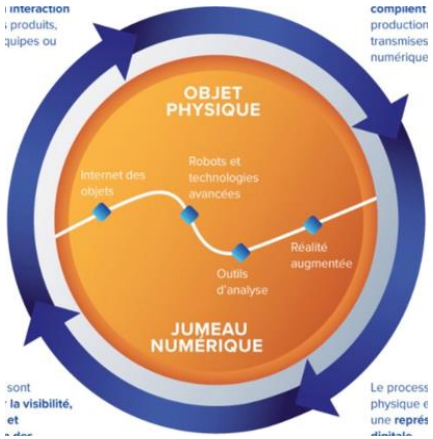
THE INSTITUTE FOR DATA VALORIZATION: A SCIENTIFIC AND ECONOMIC DATA SCIENCE HUB

Yoshua Bengio named 'Scientist of the Year' by Radio-Canada

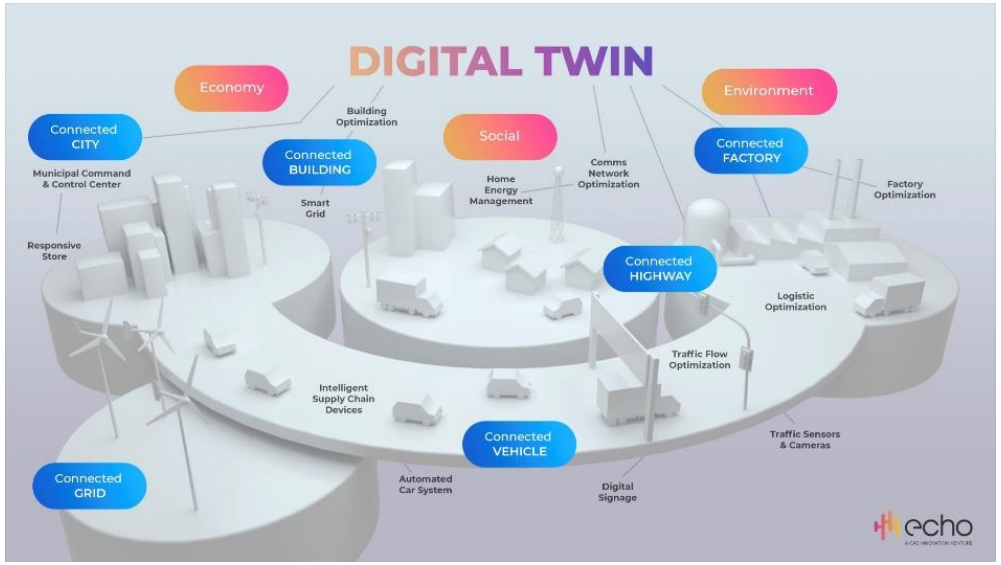
For his outstanding contribution to the advancement of artificial intelligence in Canada.

$50M Infrastructures

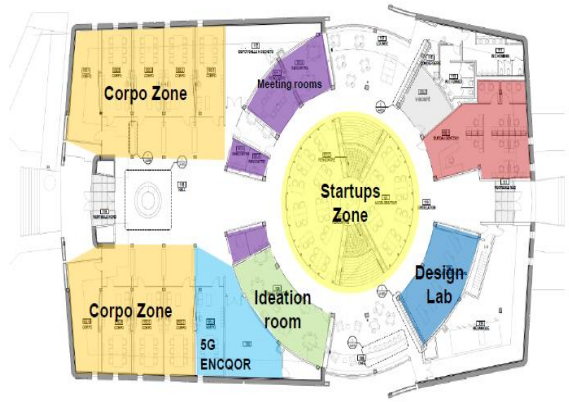
Physical Entity



Digital Twin



Collision center Incubator 4.0



CAE

CENTECH POWERED BY ÉTS

ÉTS-CENTECH Ecosystème d'innovation et d'entrepreneuriat

ÉTS

Évolution de l'écosystème 5.0 universitaire

Les initiatives académiques 4.0 au Québec

Réseau Innovation 5.0 Network

Towards a Smart, Digital & Green Society

qui ont amenées à la création du Réseau Innovation 5.0 et à l'octroi de la FCI4.0

Le Réseau Innovation 5.0

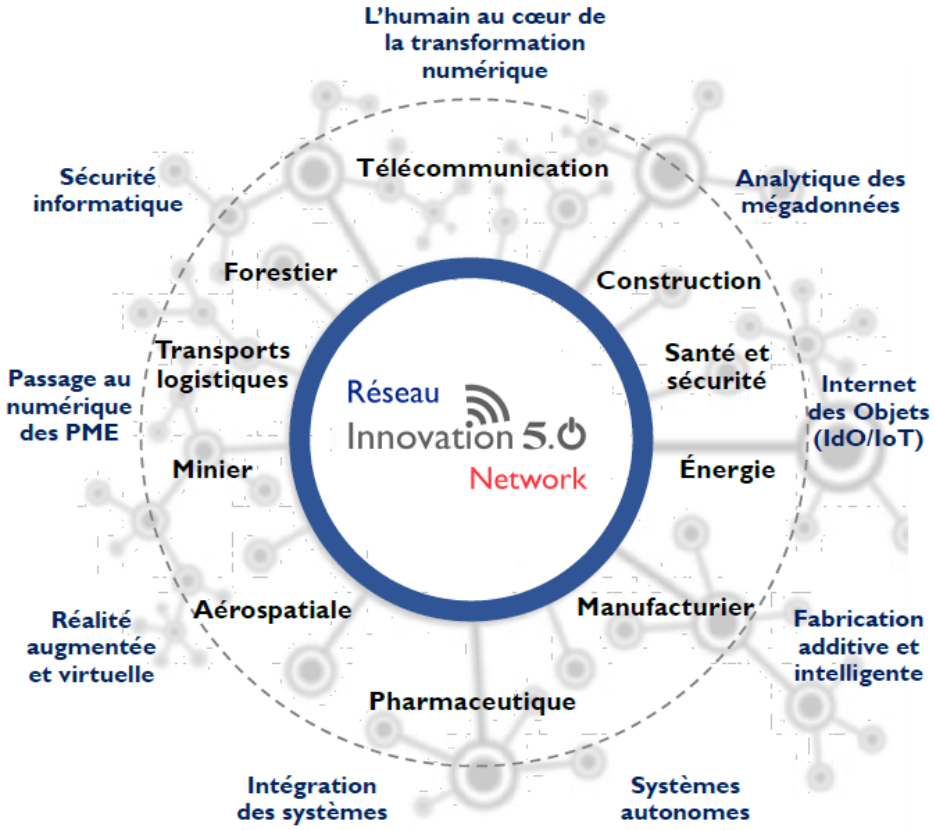
(créé en janvier 2019)

Nos universités: des catalyseurs pour l'Industrie 5.0

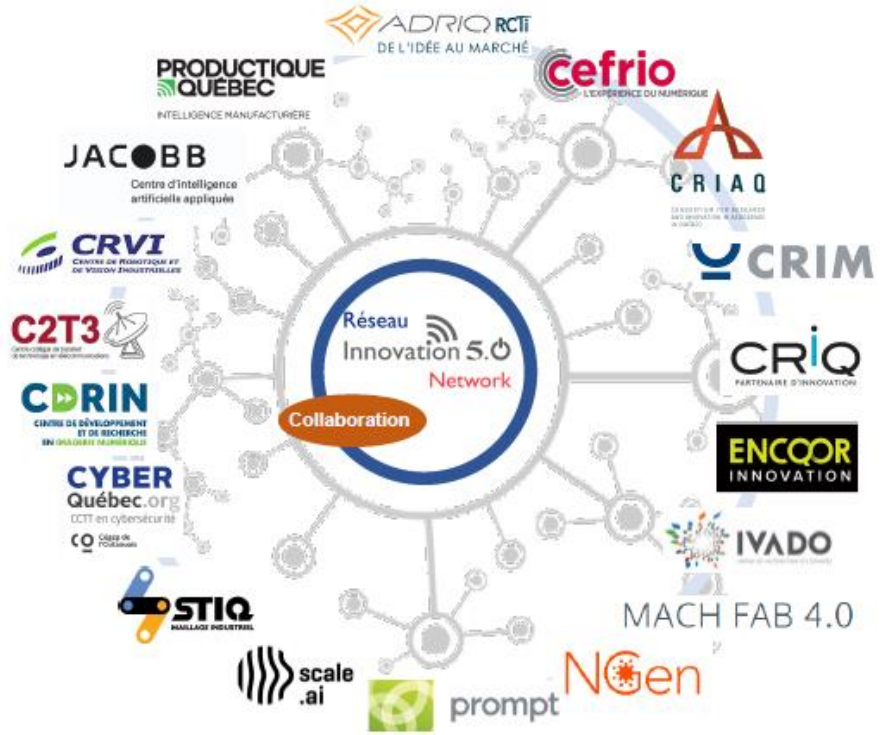
Réseau Innovation 5.0 Network

Towards a Smart, Digital & Green Society

Secteurs et domaines de recherche



Collaboration



Industrie, CCTT, Consortia, National, International

Réseau Innovation 5.0 (crée en Janvier 2019)

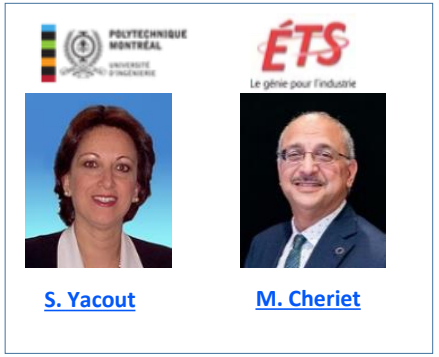
8 universités: des catalyseurs pour l'Industrie 5.0

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)**

Leaders RI5.0 (prof.)

Leaders FCI4.0 (prof.)



Smart-Digital-Green R&D Projects

Energy OEMs
Industry 4.0 Technology Integration ($5M)

Advanced Manufacturing Automation, Digitization and Optimization "AMADO"

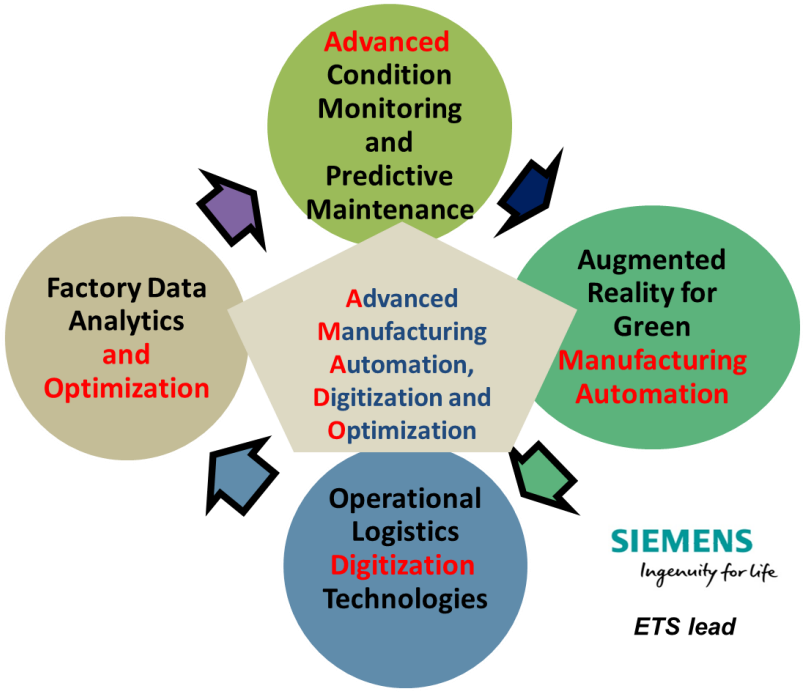
A Digital Technology Platform for Supply Chain "DTPSC"

SIEMENS energy

ÉTS
Le génie pour l'industrie

McGill

Université Concordia University

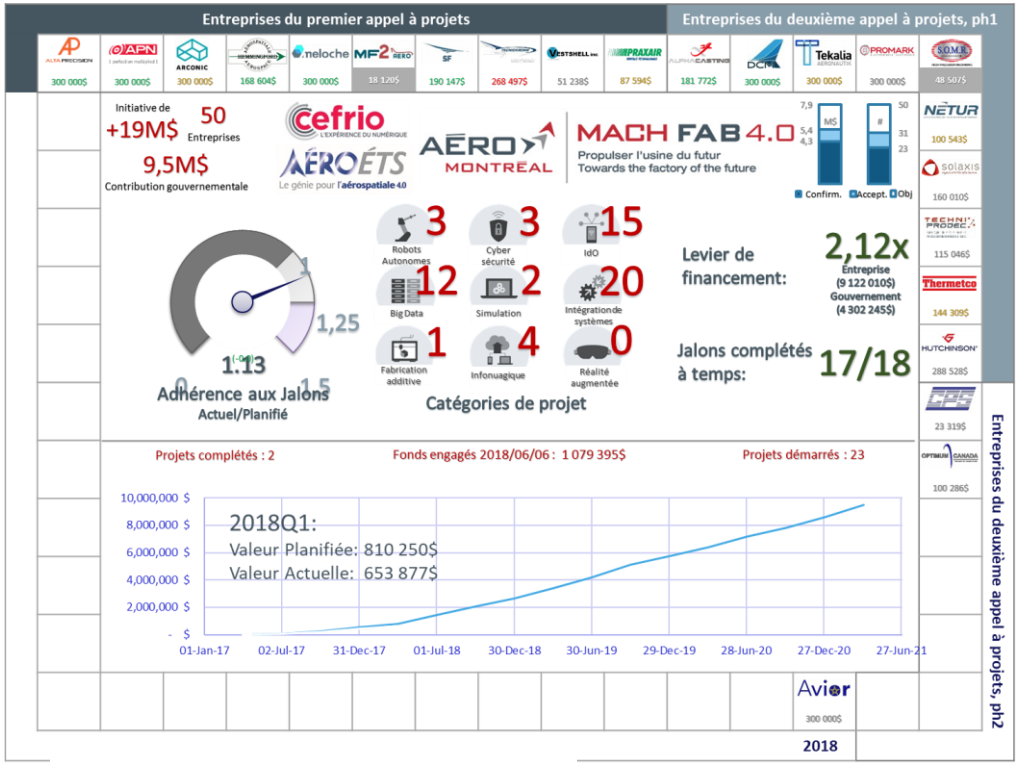


SIEMENS
Ingenuity for life

ETS lead

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

Aerospace SMEs
MACHFab4.0 ($19.5M)



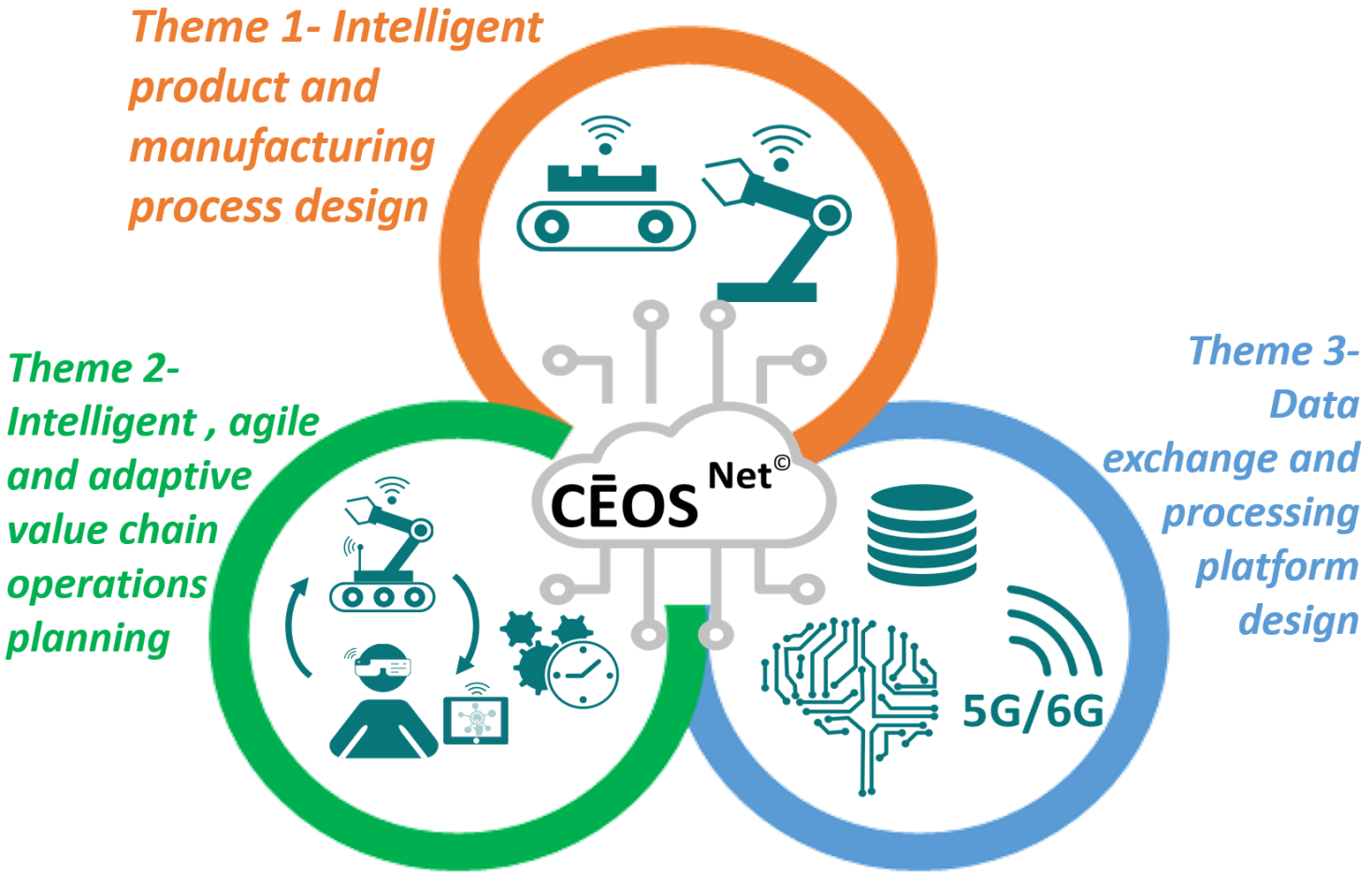
AÉRO MONTRÉAL | MACH FAB 4.0
Propulser l'usine du futur
Towards the factory of the future

60 projects
50 SMEs

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

Réseau Innovation 5.0 Network

Towards a Smart, Digital & Green Society

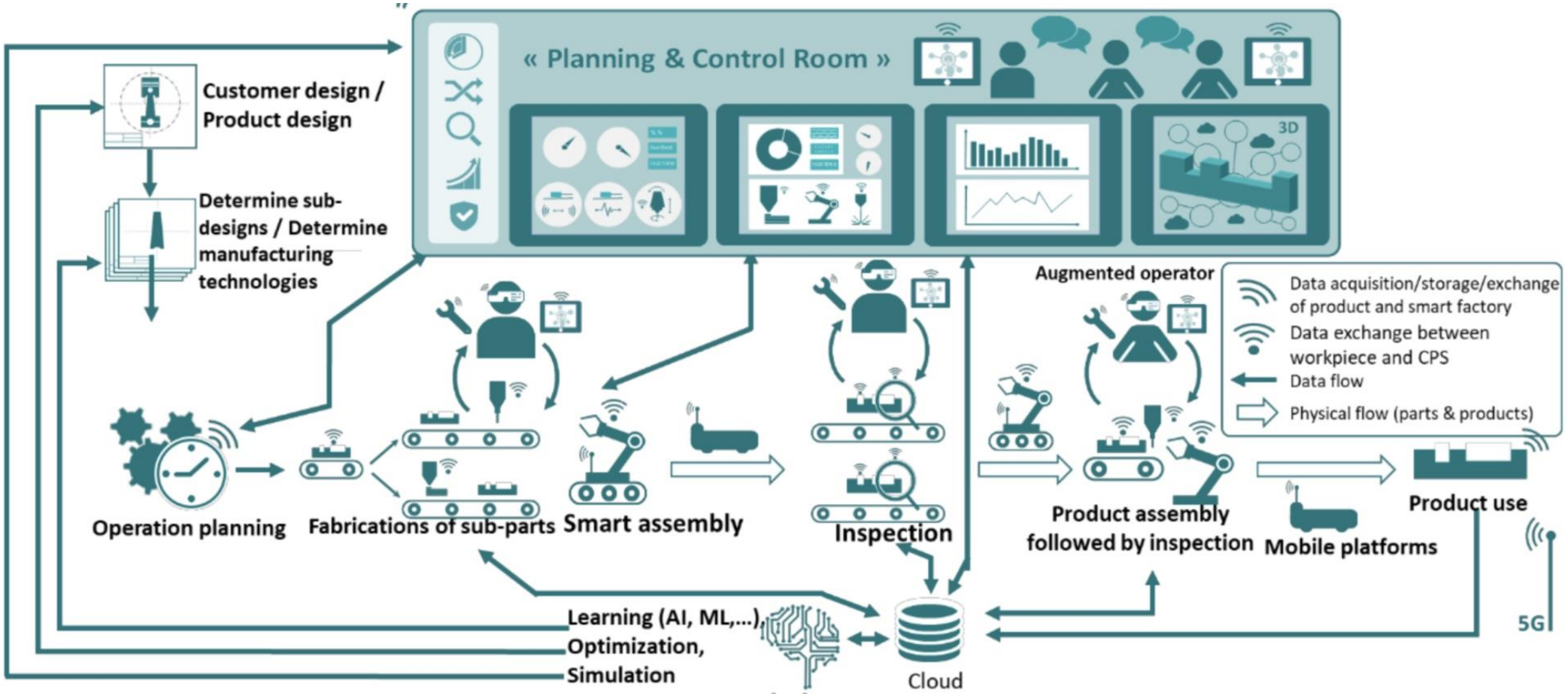


Intelligent Cyber Value Chain Network (CĒOS^{Net})

FCI5.0 ($12M): Support au Projets PMEs

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

(CĒOS^{Net}) *Interactions among the research nodes*



FCI5.0 ($12M)

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

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

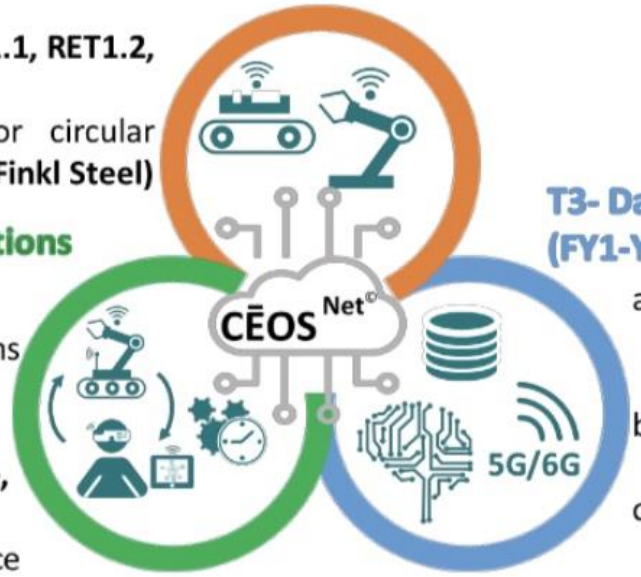
Research Program Overview

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, Innovmetric)**
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)**



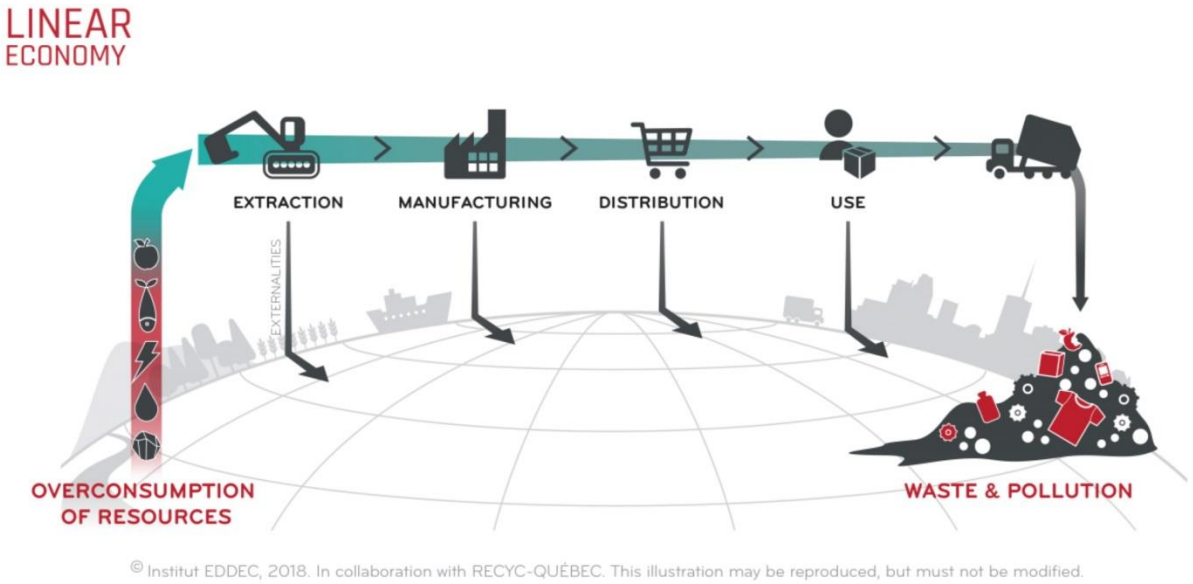
Legend:
Tx: Research Theme x; x= {1, 2, 3}
FY: Forecast Year
TRL: Technical Readiness Level
EETx: Existing Equipment & Retrofit for Theme Tx
RETx: Requested Equipment for Theme Tx

T3- Data exchange and processing platform design (FY1-Y5, EET3)

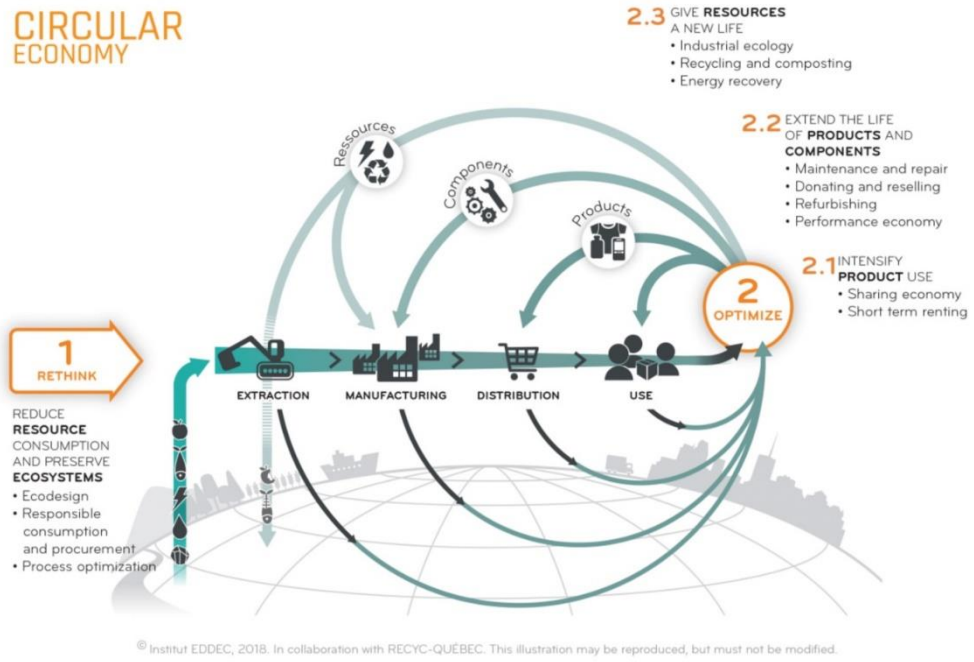
a) Ultra-low latency communications and network slicing for federated production centres **(TRL3, RET3.3, RET3.4, Ericsson Canada, Kaloom)**
b) Emergent intelligence for federated cloud **(TRL2, RET2.2, RET2.8, RET3.1, Ciena, Katti LLC)**
c) Computational efficiency for real-time massive data processing **(TRL3, RET2.8, RET3.1, NetGear, Cisco, Intel)**
d) Security and interoperability of the communication network **(TRL3, RET2.1, RET2.13, RET3.1, RET3.2, Texas Instruments, ID Quantique)**

Research Centers for Circular Economy and Sustainable Development ($5M)

CERIEC
Centre d'études et de recherches intersectorielles en économie circulaire



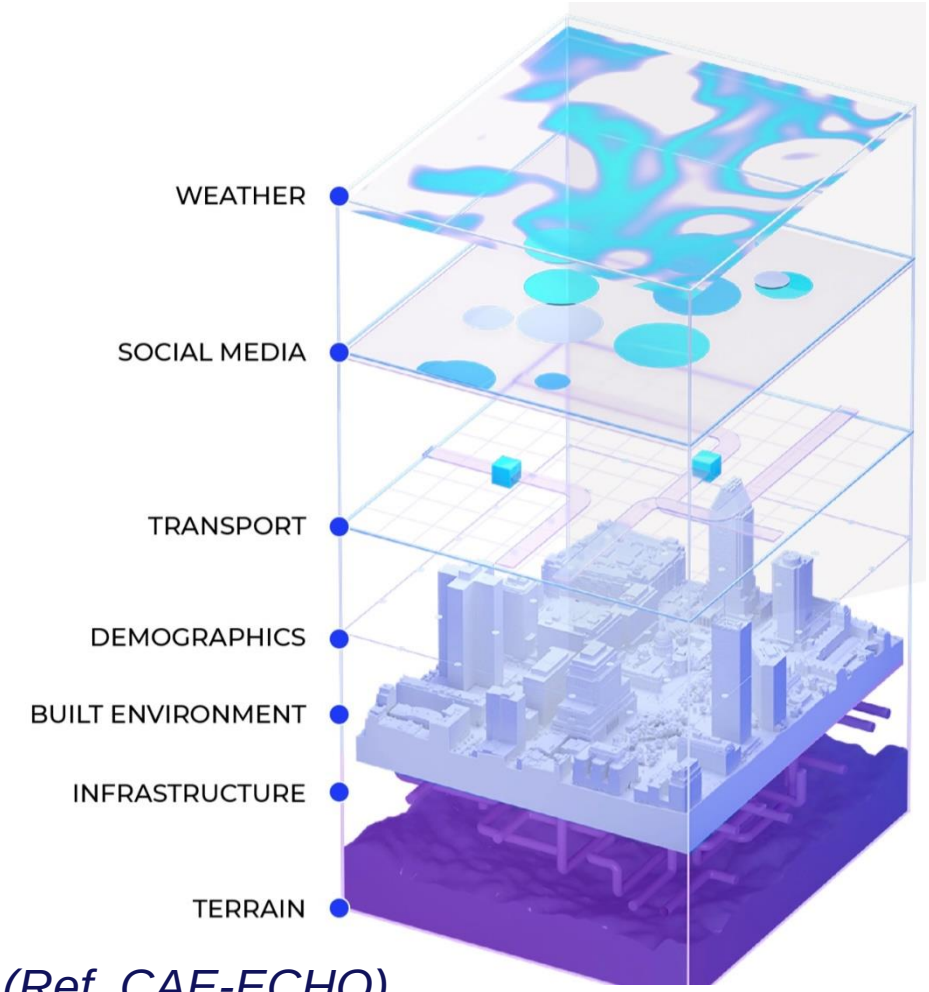
cirodd
Centre interdisciplinaire de recherche en opérationnalisation du développement durable



And Four Québec Centers of Excellence for Industrie 4.0

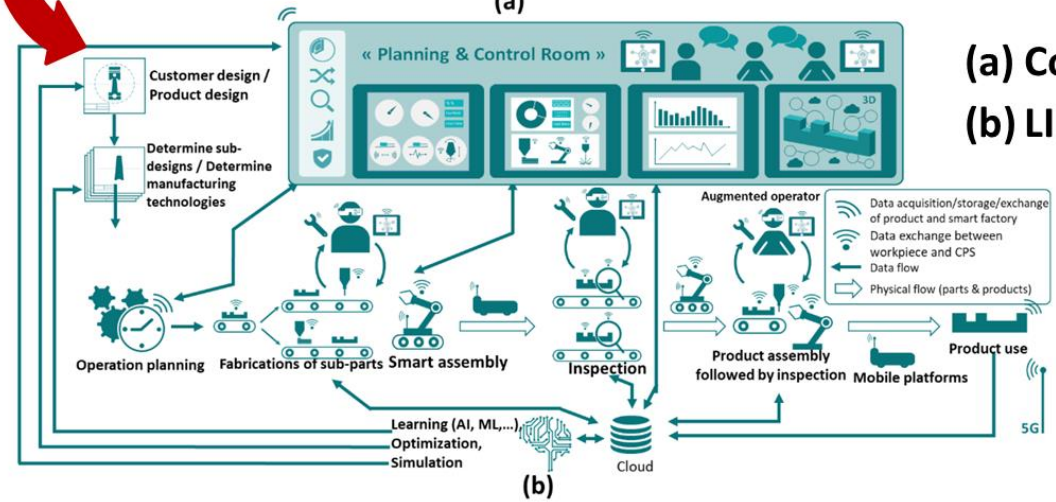
Digital Twin Platforms

Collaborative Innovation Lab (Decision Theater)



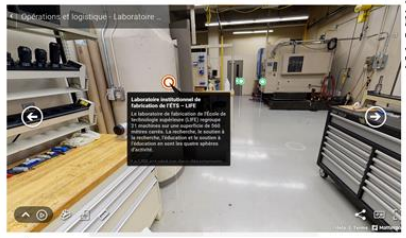
(Ref. CAE-ECHO)

(a)



(a) ColLabInnov

(b) LIFE / Usine du futur



Fabrication manufacturière

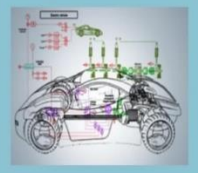
[1] ASU: Arizona State University. https://dt.asu.edu/. Last accessed n July 2016.

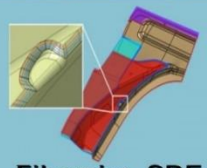
Smart-Digital-Green Technologies Enablers

Siemens Industry 4.0 Software at Universities

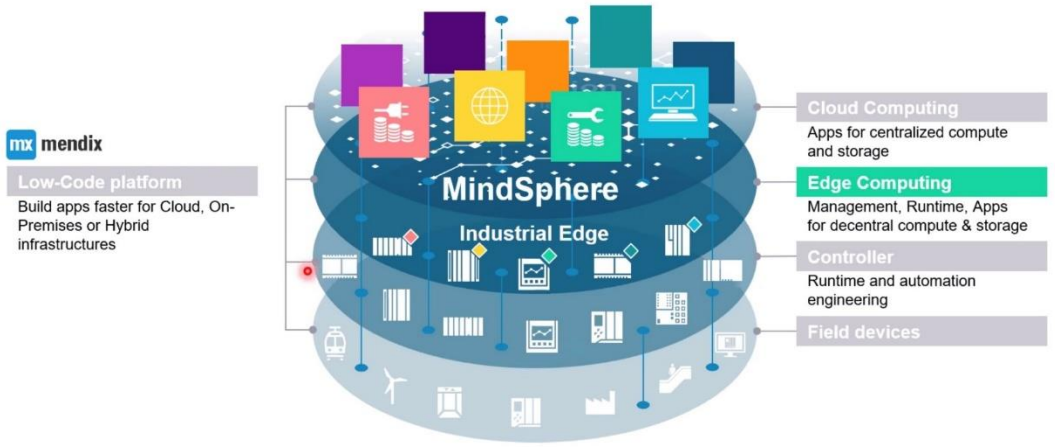
SIEMENS

Siemens PLM Software Business Segments

Product Engineering	Lifecycle Collaboration	Simulation and Test	Manufacturing Engineering
			
NX	Teamcenter	LMS	Tecnomatix

Specialized Engineering	Mainstream Engineering	Product Driven Services	Digital Enterprise Realization
			
Fibersim, SDE Syncrofit, QPE	Femap, CAM Express	Advantedge	SIMATIC IT, IBS, Preactor, WinCC

The big picture –
We enable our customers to deploy applications everywhere based on their needs



Applications with a strong need for responsiveness, privacy, reliability and cost-efficiency can now be additionally deployed **on-premise** with Edge Computing, while still benefitting of the available IT and OT-technology.

SIEMENS

MindSphere
Cloud Based Open IoT Operating System

(Ref. Siemens, 2019 and 2021)

Training - Networking

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

- **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"

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

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

Training Short Courses in Preparation for 4-6 months
Digital Work Integrated Learning « D-WIL »

Digital Enterprise Program

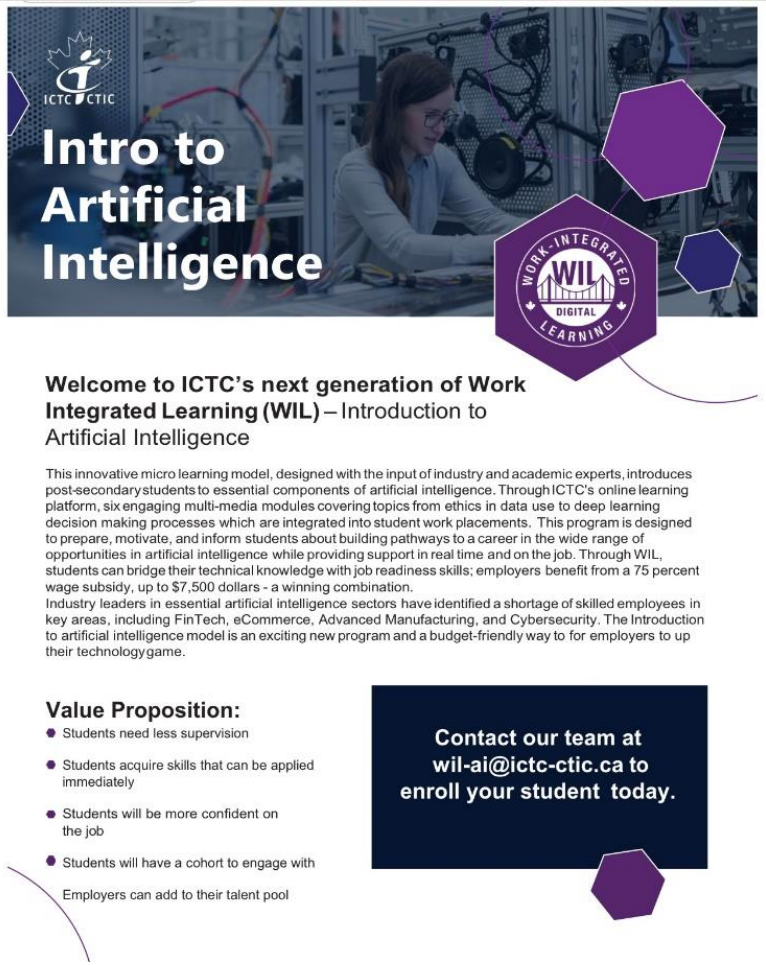
Introduction to digital technologies for the manufacturing sector

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



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