Aerospace 4.0™

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"Aerospace 4.0™" is an integrated research, education and training program, created by AÉROÉTS, to respond to the needs of Industry 4.0.

Industry 4.0

"Industry 4.0", a simplified term for Cyber Physical Production Systems "CPPS", was introduced by the German in 2005 to represent the fourth revolution in the manufacturing industry. Industry 1.0 (1784) was characterized by steam power and mechanical production, Industry 2.0 (1870) by electric energy, mass production and the first assembly line and Industry 3.0 (1969) by electronics, Information and Communications Technology (ICT) and automation.

Industry 4.0 is characterized by automation and digitization, knowledge, optimization and management of assets, reliability, accuracy, variability, sharing and security of data, tracking part from cradle to grave: the "Digital Thread", data analytics and Artificial Intelligence (AI). Big data is the "raw material" of Industry 4.0. It is the transformation from: the physical to the digital (the "Digital Twin"), carbon to silicon, clusters to cloud computing, deterministic to probabilistic design and experimental to analytical certification. It is the "Democratization of Technology" where "humans, computers, machines and products collaborate digitally and communicate seamlessly through integrated and optimized processes across the total product value stream both within an enterprise, and upstream (suppliers) and downstream (customers) of an enterprise".

In two reports, Deloitte (2014 and 2015) highlighted the four challenges and solutions for Industry 4.0's digital transformation as: vertical networking of smart production systems, logistics and services, horizontal integration of business partners and customers across the globe, through-engineering throughout the entire product life cycle and acceleration through exponential technologies. They listed the five advanced technologies driving disruptive innovation as: advanced robotics, AI, networks (internet of things, data, services and people), advanced manufacturing (3D printers) and collaborative connected platforms (cloud-computing and crowd-sourcing). According to Deloitte, global CEOs pointed to talent, cost competitiveness and workforce productivity as the top three drivers of manufacturing competitiveness.

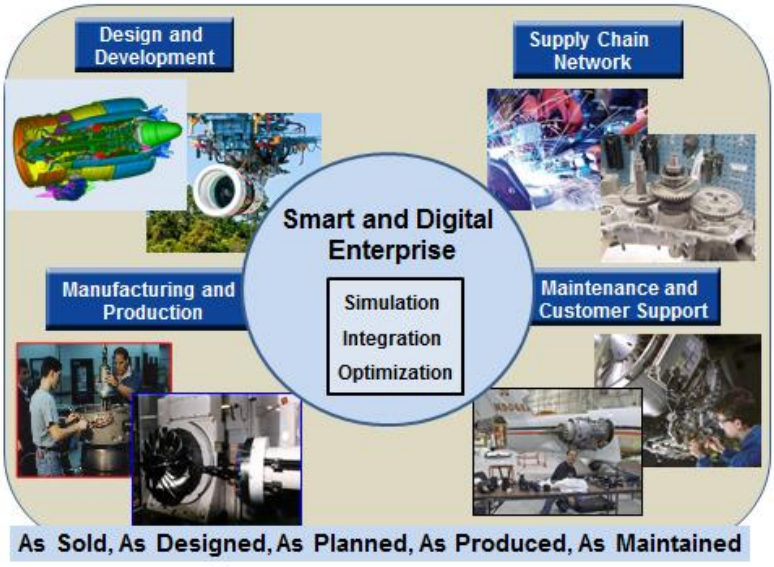
Over the past decade, several well-funded initiatives have been pursued for the implementation of Industry 4.0: Germany's Smart Factory (2005) and its Industry 4.0 Demonstrator, Siemens' Digital Factory (2012), GE's Brilliant Factory (2014), the EU

Factory of the Future (2013) and the USA National Network of Manufacturing Innovation (NNMI, 2013).

Industry 4.0: Nine Technologies

For Canada, it is worth mentioning that Pratt & Whitney Canada (P&WC) identified this need back in 2000 when they defined their vision for a "Digital Virtual Enterprise" integrating all aspects of design, manufacturing, supply chain, customer service, etc. In 2012, P&WC started their ICEMAN (Intelligent Cells Manufacturing) program, and in 2014 their Advanced Manufacturing Center (AMC) and Enterprise Product Lifecycle Management (EPLM) programs.

During the Aéro Montréal Innovation Forum's session on Industry 4.0 (April 2016), there was clear consensus that Industry 4.0 is not only about the "Factory" but rather the total "Enterprise": digital-smart-virtual design, factory and supply chain.



Enterprise Product Lifecycle Management (PLM)

Aerospace 4.0™

Mission

To mobilize the strengths of the academic institutions to address the industry needs for Industry 4.0 in terms of research, development, education and training, with primary focus on the aerospace industry. Industry 4.0 activities will include the total enterprise in terms of digitization, simulation and integration of design, manufacturing, maintenance, supply chain, customer support, resources, etc.

Objectives

- Build on existing strengths of academic institutions
- Respond to industry needs for the implementation of Industry 4.0
- Address all aspects: design, factory, supply chain, customer, etc., i.e. total enterprise
- Develop a comprehensive integrated research and developement program
- Build an academic digital-virtual enterprise lab with all needed software simulation tools
- Develop short courses and academic programs to prepare future HQP
- Partner with industry and software providers (Siemens, Dassault, etc.)
- Seek funding: CRIAQ, CARIC, MITACS, NSERC, etc.

Research and Development

Focusing on the total enterprise (marketing, engineering, operations, etc.) to achieve a "Digital Smart Enterprise", including the manufacturing-production aspect to develop a "More Intelligent Factory".

A Digital Smart Enterprise

To achieve "A Digital Smart Enterprise", companies need to develop a fully integrated seamless workflows, data and systems from inception to aftermarket. This transformation will touch every organization in a company affecting the "Product Value Stream": marketing, engineering design, development testing, manufacturing, supply chain, customer support, service center, etc. It is a transformation from the traditional silo-centric optimized business unit to an enterprise value-stream optimized. In addition, exponential, multidisciplinary and cross-sectional technologies need to be developed in each business unit.

The four main Research and Development (R&D) areas to achieve a Digital Smart Enterprise are:

1. Vertical Integration: This is the ability of a smart enterprise to be highly responsive to changes in supply, demand, delays and defects through "CPPS". To achieve this, various hierarchy levels in a company should be networked using integrated IT systems. Projects include: condition monitoring and predictive analytics, swarm intelligence models for decentralized autonomous transport, big-data statistical quality control.

2. Horizontal Integration: This is the networking of all the process steps in the value chain, including external partners and customers. Projects include: priorities management in product development, smart supply chains, responsive supply

network design, real time project sequencing and scheduling, risk aware decisions, etc.

3. Through-Engineering: Focus on the entire product life cycle, where design, development and manufacturing are integrated and coordinated with the life cycle, and data and information are available at all stages. Projects include: multi-criteria study of product development performance post PLM implementation, intelligent collaborative agents and distributed dynamic priorities, management for enhanced product development performance, etc.

4. Breakthrough Technologies: "Multidisciplinary Design Optimization" (MDO). "Multidisciplinary Factory Optimization" (MFO) platform where all manufacturing disciplines: materials, forming and joining processes, tooling, machining, robotics, material handling, additive manufacturing, etc. can be modeled, simulated and integrated. Artificial Intelligence (AI). Networks integrating intrinsic sensors. Intelligent Manufacturing Systems (IMS): closed door machining, in process measurement, dynamic compensation, trend and process monitoring, traceability of quality and process data, machine performance data capture, etc.

Several projects have been carried out since 2008 and new projects are planned and in discussion with our industrial and academic partners. Examples: establish a maturity index and KPI for "Aerospace 4.0", integrated systems modeling and simulation, intelligent and virtual development testing and product development simulation, smart logistics planning, precision robotics, Human Robot Interaction (HRI) and collaborative robots (cobots), additive manufacturing, modeling and simulation of machining, predictive maintenance systems and "MACHFab4.0", a partnership program between Aéro Montréal, AÉROÉTS, CEFRIO and STIQ, designed to provide Québec aerospace SMEs with the necessary processes, tools and training to automate and digitize their facilities.

Education and Training

Industry 4.0 will drive a major change in tomorrow's workforce as highlighted by the Boston Consulting Group's (BCG) 2015 report. Despite the greater use of robotics and computerization, there will be a net increase in jobs. The focus will be on retraining the workforce, revamping organizational models and strategic recruiting and work planning.

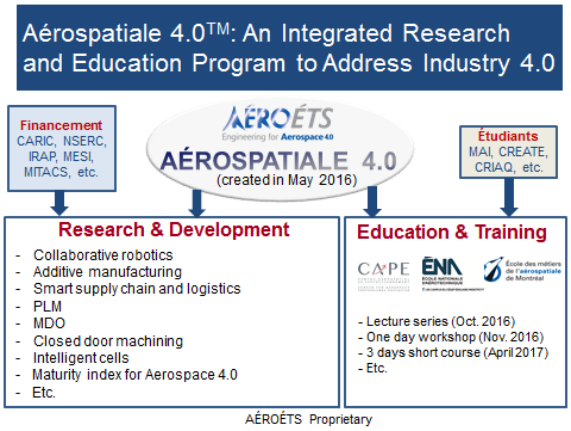
Educational institutions need to respond to Industry 4.0 needs, provide broader skill sets and close the gap in ICT skills. The BCG report highlighted the following ten effects of Industry 4.0 on the workforce.

1. Big-data-driven quality control: algorithms based on historical data identify quality issues and reduce product failures;
2. Robot-assisted production: flexible humanoid robots perform other operations such as assembly and packaging;
3. Self-driven logistics vehicles: fully automated transportation systems navigate intelligently within the factory;
4. Production line simulation: novel software enables assembly line simulation and optimization;

5. Smart supply network: monitoring of an entire supply network allows for better supply decisions;
6. Predictive maintenance: remote monitoring of equipment permits repair prior to breakdown;
7. Machines as a service: manufacturers sell a service, including maintenance, rather than a machine;
8. Self-organizing production: automatically coordinated machines optimize their utilization and output;
9. Additive manufacturing of complex parts: 3D printers create complex parts in one step, making assembly redundant;
10. Augmented work, maintenance and service: fourth dimension facilitates operating guidance, remote assistance and documentation.

There will be a need for "Industrial Data Scientists" with strong ICT and AI skills, user interface design, advanced analytics, root-cause-analysis skills and statistical programming. In addition, there will be a need for "Robot Coordinators" to oversee robots and respond to malfunction and emergency maintenance tasks. Embedded E-Learning tools to be used in real world situations and ICT skills need to be integrated in all technicians, engineering and business curricula.

All of the above will be addressed by "AeroFormation", a consortium between École des métiers de l'aérospatiale de Montréal (EMAM), École nationale d'aérotechnique (ENA) and the Centre for Aerospace Professional Education (CAPE of McGill University and ETS), in partnership with Aéro Montréal and CAMAQ. The objective is to develop short courses for specialized workers, technicians and engineers to prepare them for the Industry 4.0 skills requirements. Two short courses on "Aerospace 4.0 are planned for November 2016 and April 2017. These courses will also be offered to students of the Montreal Aerospace Institutes (MAI) and of the NSERC Collaborative Research and Training Experience (CREATE) Program in aerospace manufacturing.



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