Navigating the Shift to Advanced Manufacturing

John Laughlin - Chief Technology Officer February 4th 2020



Manufacturing was a pillar of Canada's 20th century economy.

1944: 29% of Canadian GDP.

It delivered the prosperity that we used...



to make Canada a great place to live.

But in the 21st century...

Canadian manufacturing faces a new industrial revolution.

Greater global competition...

-3

and game-changing new technologies...

are upending the ways the world builds things.

Advanced Sensors.

Restaurrentere reations

STATISTICS SALES SALES

1

Additive Manufacturing.

Robotics.

\$20-\$30 STATION CONTROL PANEL

11

Artificial Intelligence, IIOT and more.

New technologies and platforms are creating the promise of next generation production...

that combines the physical and material world with the digital, virtual and cyber ones...

in which machines can talk to other machines...

and machines can talk to people.

This is advanced manufacturing.



At least 30% of Canadian manufacturers risk going out of business because of their failure to adopt advanced technologies.

Source: Jayson Myers Strategic Business & Policy Solutions

45% of manufacturers that invest in advanced technologies in Canada do not achieve their business objectives. Only 24% of Canadian manufacturers collaborate with other organizations on a regular basis.

Source: Jayson Myers Strategic Business & Policy Solutions

This threatens the competitiveness of Canadian manufacturing.

Yet great disruption also offers us a great opportunity.

Canadian manufacturing is well-positioned to succeed in this digital revolution.

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Our strong manufacturing companies...

and cutting-edge technology providers...

led by a highly-skilled workforce...

could make Canada a global leader in advanced manufacturing.

Canada's challenge?





Our strengths are not well-connected

& each sector has its own dynamics





Automotive Sector Trends

Emissions Legislation, Autonomous Vehicles & Localised Regulation





Source:- www.electricautonomy.ca/

Source:- www.ukmfgreview.com/





Emissions Legislation, Autonomous Vehicles & Localised Regulation

PASSENGER CAR





Driver set Driver predicted Solid bar represents >1% global marked adoption and is preceded by significant product and process R&D Source: UK Automotive Council

1 chevron = some uncertainty around timing of mass market adoption or phase out 2 chevrons = considerable uncertainty around timing of mass market adoption or phase out

Emissions Legislation, Autonomous Vehicles & Localised Regulation

THERMAL PROPULSION SYSTEMS

	/	air quality emission umits	/	Trend towards very low	CO2 and air quality emission	ns limits, zero emission zones, LC	~
TARGETS*	Current status		2025 targets			2035 targets	
ight duty brake thermal efficiency (%)	42 %		48 %			53 %	
eavy duty brake thermal efficiency (%)	47 %		55 %			60 %	
	Contract the second second second					¥ .	
HERMAL EFFICIENCY	Elevible CP and valve contro	ent and combustion systems des	signed for low neat los				
aht duty oriented	Efficient, clean cor	mbustion e.g. lean burn. HCCI. w	ater injection				
					Hybrid-focussed power uni	its e.g. camless engine, fuel cell	
	Reduced heat loss e.g.	coatings, thermal management,	, combustion phasing				
eavy duty oriented		Lower terr	nperature combustion	e.g. HCCI, PPCI, extreme le	an burn NG 💦 🔶 -	-	
cary daty offerfield				High eff. p	ower units with integrated	WHR, eg. split cycle, high temp	. fuel cell
	Exhaust heat recovery (e.ç	. turbocompounding, Organic R	ankine Cycle)	$\rangle \rangle \rangle$	Integrated heat recovery	y from multiple heat sources	
Jelling	Engine optimised for avail	able fuels i.e. diesel, gasoline, na	atural gas	Engine acce	oting to a wide range of fue	els e.g. synfuels, H2, advanced fo	ossil
	Flexible fuel syste	ms e.g. rate shaping, multiple inj	jection, nozzle geomet	<u>у</u>			
YSTEM EFFICIENCY	Advanced lubrication a	nd lightweighting via design/mar	nut. and Al, Mg, Ti	fuel evited		a board referming CO2 centure	
	Multi boost devices for v	wide map	Controller	air supply supporting hig	n efficiency combustion e	 a. e-boost and multi device 	
ngine systems and control	Advanced powertrain cont	rol >> Predictiv	ve control via V2X	Aggressive ZE	geo-fencing	Fully auto powertrain co	ntrol, Al
	Electrified light dut	y ancillaries (48v), reduced paras	sitic loads				
anh Eag debratenia eretaren	Hybrid systems	for effective recovery e.g. 48v, KI	ERS	$\overline{\rangle}$	Co-developed eng	jine and hybrid system	
labung unvetrain systems	Manual transmissions repl	aced by 10+ speed auto, shift mo	gmt. and e-clutch	$\rangle\rangle\rangle$ c	-developed HD-focused e	ngine and auto, no torque conv	ertor
ESIGN AND		Design for disassem	bly and recycling	\rightarrow	Design for low life cyc	tle impact i.e. incl. embedded in	npacts
IANOFACTORING		\rightarrow	Next ge	n. manufacturing incl. add	itive layer, metal injection r	moulding, metal foams	
DIVERS	xEV uptake. CO ₂ limits, air qu	ality regulation. ULEZs, charging	access Ver	v low CO2. zero emission z	ones. LCA, materials securit	v, rapid/opportunity charging inf	rastructure
RIVERS ARGETS*	xEV uptake, CO ₂ limits, air qu Current status	ality regulation, ULEZs, charging a	access Ver 2025 targets	y low CO2, zero emission z	ones, LCA, materials securit	y, rapid/opportunity charging inf 2035 targets	rastructure
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ELECTRICAL ENERGY STORAGE

DRIVERS	xEV uptake, CO ₂ limits, air quality regu	lation, ULEZs, charging access Very low CO2,	zero emission zones, LCA, materials	ecurity, rapid/opportunity charging infrastructure
ARGETS*	Current status	2025 targets		2035 targets
	280 \$/kWh	150 \$/kWh		100 \$/kWh
nergy Density (Wh/l)	280 Wh/l	550 Wh/l		1000 Wh/l
ower Density (kW/kg)	3 kW/kg	7.5 kW/kg		12 kW/kg
				V
VOLUTIONARY TECHNOLOGY	Advanced lead battery and Ni	Mh solutions	the database to see	- description for the law the law (1.4)
	Optimised liquid electrolytes for Li-	-ion (e.g. additives and high voltage)	Liquid electrolytes for new	v cnemistries (e.g. Na-Ion, Mg-Ion, LI-S)
ectrolytes, separators,	Conceptore with and used shield and	nd and avidation excitation hast discussion	perature solid state electrotytes wit	
nders and solvents	Solvent replacements for NMR (e.g. N	Acabul R) Next gen binders (e.g. k	wheid celf.healing)	Bindeders susteme
	Ontimised Livion anode materials	and structures (e.g. Silicon ITO, bard carbon)	iyond, sett-neating)	Dirivertess systems
	Optimised chion anote materials	and structures (e.g. stricon, cro, nard carbon)	Next gen anodes (e.g. transition n	etal ovides metallic anodes and novel additives)
odes and cathodes	Ontimised Livion cathode materi	als and structures (e.g. LEP, NMC, NCA, LMO)	Next gen, anodes (e.g. d'ansidon n	etal oxides, metallit anodes and novel address
	Optimised Er-fort catrioue materia	as and structures (e.g. Er), twice, they, they	Cathode materials for new cher	stries (e.g. Nation, Mation, Li-S)
		Embedded sensors in cells		Cells that eliminate thermal runaway
rmats and casings			Cross-OFM standardis:	tion of cell formats
	Advanced pack designs for performan	ice and manf Mixed cell packs (high e	nerov and power)	New cell-module-pack concepts
MODULES, PACKS AND BATTERY MANAGEMENT	Smart and connected BMS enabling ac	curate SOC and SOH monitoring and life prediction	Distributed	3MS enabling individual cell monitoring
	Advanced thermal manageme	nt strategies (e.g. integrated with vehicle cooling)	Passive then	nal management (e.g. phase change materials)
CYCLING AND	Pack designs that extend 1st life and e	nable 2nd life	Deployment of 2nd life batteries	with flexible applicability
E CYCLE MANAGEMENT	Processes for end-of-life recover	v of cell material/electrode	Industrial scale up of hi	ah efficiency recycling processes
DRIVERS	xEV uptake, CO ₂ limits, air quality i	2025 targets	CO2, zero emission zones, LCA, mai	erials security, rapid/opportunity charging infrastructur
Cost (\$/kW)	5 \$/kW	4 \$/kW		3 \$/kW
Power Density (kW/kg)	15 kW/kg	22 kW/kg		50 kW/kg
Power Density (kW/l)	12 kW/l	15 kW/l		60 kW/l
		v		*
	Optimised Si sen	niconductor devices		
EMICONDUCTOR	_	SiC semicor	ductor devices	
MATERIALS	-	GaN semic	onductor devices	\rightarrow \rightarrow \rightarrow
				a-wide band gap materials (e.g. Ga203, Diamond)
COMPONENTS	High temp., lower loss, more	robust materials for power modules and discrete devic	es	
Semiconductor packaging		Power modules with integrated little	s, sensors and gate drives	arter in package devicer
 Passive components	Higher energy dep	sity and hinher temperature canable passives	Next or	neration dialactric and mannetic materials for nassive
	Low loss high temp, and accura	ite sensors	Sensorless and wireles	health management
sensors and fault nechanisms	Reactive fail-safe mechanist	ms Self-diagnostic and fault t	olerant control	Self-healing and reconfigurable power electroni
	Si converter topologies for	increased eff. and power density		
CONVERTER ARCHITECTURES		High frequency, multi-level	and soft-switching converters opt	imised for wide band gap materials
	Multi	-functional and modular blocks (e.g. integrated DC-DC	/овс)	Integrated DC-DC, inverter and OBC
		Fully integrated drives (motor, power el	ectronics, control)	Power electronics embedded in motor
	Embedde	d power electronics software and control	\rightarrow	Self learning software optimised for drive cycle
	Glycol/water/oil/air cooling of PE	Integrated motor and PE therma	al management	Single vehicle thermal management
		Leveraging advanced manufacturing pro	cesses to improve power electroni	cs performance or lower cost
	a ti	2025	2070	2075
	202	2023	2050	2030

Source: UK Automotive Council

Emissions Legislation, Autonomous Vehicles & Localised Regulation





What Game Are You In?





Advanced Manufacturing Allows Us to "Change the Game"





Automotive Sector Trends

Whole Life Cycle Regulation

Impact Today





By Wikipedia-User: Ra Boe https://commons.wikimedia.org/w/index.php?curid=51380859



Automotive Sector Trends Whole Life Cycle Regulation

Impact Tomorrow





Automotive Sector Trends Whole Life Cycle Regulation

Impact Tomorrow



40°37'32.9"N 109°40'10.1"E

Baotou toxic lake Inner Mongolia





Whole Life Cycle Regulation

The CO₂ balance of the Mercedes-Benz EQC – dependent on power generation

The life-cycle CO_2 balance of the EQC 400 4MATIC (combined power consumption: 20.8 - 19.7 kWh/100 km; combined CO_2 emissions: 0 g/km)* varies depending on the source of the electricity used for driving.





Aerospace Trends

- A cap on net aviation CO2 emissions from 2020 (carbon-neutral growth)
- A reduction in net aviation CO2 emissions of 50% by 2050, relative to 2005 levels
- Targets for reduced NOx, reduced noise.
- Opportunities of huge market growth.
- Global commercial pressures.







Aerospace Manufacturing Impact



AEROSTRUCTURES ROADMAP



SYSTEMS ROADMAP



PROPULSION AND POWER ROADMAP





Aerospace Manufacturing Impact

- Opportunities with additive manufacturing and composites in aerostructures.
 - Creating greater component functionality, lighter and stronger structures and greater efficiency from the overall airframe.



 Advanced Manufacturing techniques enables new concepts for components to be manufactured and assembled.







Aerospace Manufacturing Impact

- Manufacturing precision and repeatability is essential to remain competitive.
 - By developing the next generation of smart automated assembly processes, tools and flexible assembly cells.
- High-fidelity learning models will enable highly precise and repeatable assemblies.
 - Dynamic models will depend on connected assembly machines, factories and ultimately entire supply chains.

N®en





Why NGen

Canada's Advanced Manufacturing Supercluster

NGen connects Canada's strengths in manufacturing and technology with its skilled workforce to build a world-class advanced manufacturing ecosystem.



\$200m funding available

Helping companies: de-risk, accelerate or be more ambitious.

Why the industry collaboration model

- European Cluster Excellence Scoreboard.
 - Employment. 33.3% of firms in clusters showed employment growth greater than 10%.
 Compared to only 18.2% of firms outside clusters.
- Innovate UK collaborative projects grant recipients vs non recipients.
 - **Turnover**. Showed a 12% increase on average over 4 years.
 - Employment. Higher employment levels compared equating to an increase of between 11%-14% within 2-4 years.
 - Survive. 95% of companies supported survived for three years after receiving a grant, compared to 84% of the similar companies which didn't receive a grant. After five years the gap grows to 16 percentage points.



6 Funding Streams



\$430m

\$12m of grant available matched creating \$24m of projects

NGen Project Types

Pilot Project

Supercluster Project

50%	NGen Reimbursement	44.4%	
\$100k - \$500k	Total Project Size	\$1M - \$20M	
2 or more SMEs	Partners	3 or more partners (at least 1 SME)	



How it works



Step 1: Join NGen

Become a Member at www.ngen.ca/join Membership is free.



Step 2: Contact us

Capacity@ngen.ca

Project@ngen.ca

We can help:-

- Explore ideas,
- Identify partners,
- Offer presentation opportunities,
- Navigate the funding process
- Review proposal drafts



Strategic Evaluation Criteria

Transformative

Positioning Canada as a global leader in advanced manufacturing.

Applied

Involving later stage technology and manufacturing readiness with a potential to generate significant commercial benefits.

Collaborative

Involving the participation of industry partners, co-investors, academic and research institutions.

Enduring

Leaving a legacy in skills development, tools, testbeds, IP, business knowledge for Canada's advanced manufacturing ecosystem.





Application 10 questions

- 4 Qs Business case
- 4 Qs Project & delivery
- 2 Qs Funding and adding value



Project Size Determines the Process

\$100k - \$500k





\$10M - \$20M

Single Application

10 Questions

400 Words / Question c8 pages Single Application

10 Questions

900 Words / Question c18 pages 2-Stage Application

10 Questions

Stage 1: 900 Words / Question

Stage 2: 2000 Words / Question 2-Stage Application + Partner interview

10 Questions

Stage 1: 900 Words / Question

Stage 2: 2000 Words / Question



Collaboration days Save the date 28th April 2020 at LOT42 Free to attend

Manufacturing. Revolutionized.

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Tell us how we can support your transformation.

<u>Get involved Join - www.ngen.ca/join</u>

Major Project - project@ngen.ca

Capacity building project capacity@ngen.ca

John.Laughlin@ngen.ca

Thank you

