



# **NRC capabilities in smart infrastructure and cities of the future**



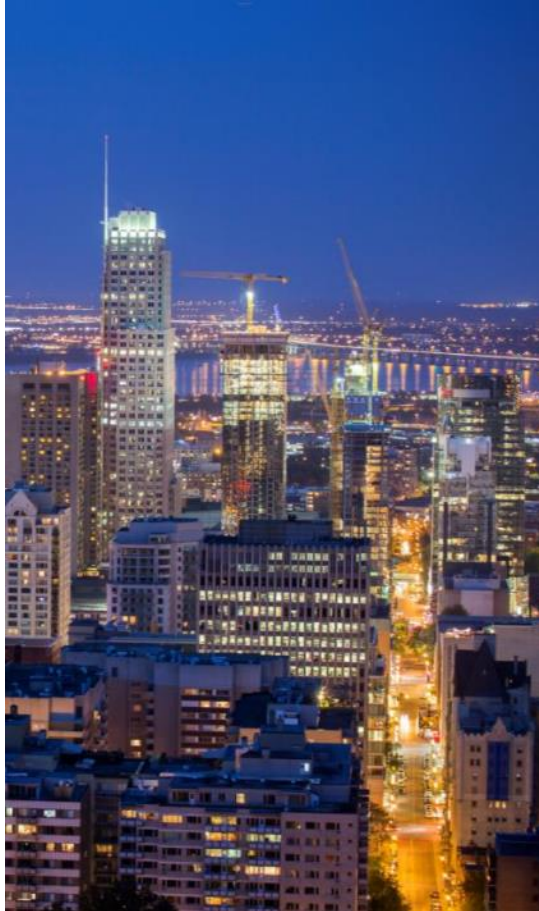


# Key opportunities for Canada



- North America is one of the most urbanised regions in the world (82 % living in urban areas in 2014).
- With growing urbanisation, sustainable development challenges will be increasingly concentrated in cities, requiring technology solutions.
- Smart cities are data-driven, relying on broadband and telecommunications, sensors, social media, data collection and integration, automation, analytics and visualization to provide real-time situational analysis.
- Most infrastructure will be “smart” by 2030 and transportation systems will be intelligent, adaptive and connected.
- Renewable energy, energy storage, power quality and load measurement will contribute to smart grid solutions that are integrated with transportation.
- “Green”, sustainable and high-performing construction and infrastructure materials are in demand.

# Canadian challenges



- High energy use: Transportation accounts for roughly 23% of Canada's total greenhouse gases (GHG) emissions, followed closely by the energy consumption of buildings, which accounts for 12% of Canada's GHG emissions (Canada's UNFCCC report).
- Traffic congestion in Canadian cities is increasing, contributing to loss of productivity, increased stress for citizens as well as air and noise pollution.
- Canadian cities are susceptible to extreme weather and events related to climate change (e.g., floods, storms).
- Changing demographics: aging population (need for accessible transportation options, housing, medical and recreational services) and diverse (immigrant) populations.
- Financial and jurisdictional issues: the inability of municipalities (who have primary responsibility) to finance R&D or large-scale solutions without other government assistance.

# Where the NRC can contribute

Key areas	Topics
<b>Infrastructure</b>	Physical infrastructure (roads, bridges, buildings, water treatment, waterways) and information and communication technologies (ICT) infrastructure
<b>Efficient transportation</b>	Public transportation, traffic management, parking, logistics, connected mobility and autonomous vehicles, integration with physical infrastructure and energy, and urban planning for the efficient movement of people and goods in urban and inter-urban environments
<b>Energy and environment</b>	Renewable energy, energy storage, food and urban agriculture, energy-efficient and low-emission transportation, waste management
<b>Community engagement and planning</b>	Technologies to enable community services (housing, recreation, emergency management) and urban planning (may include social studies on the interaction of people with the urban environment)

# Opportunities being examined

## LIVING LAB

- › Test bed for smart city technology in order to quantify and demonstrate the benefits of smart cities.
- › Multiple partnering opportunities (e.g. municipalities, other government organizations, industry association, universities, social sciences, urban planning).

## THE INTEGRATED CITY

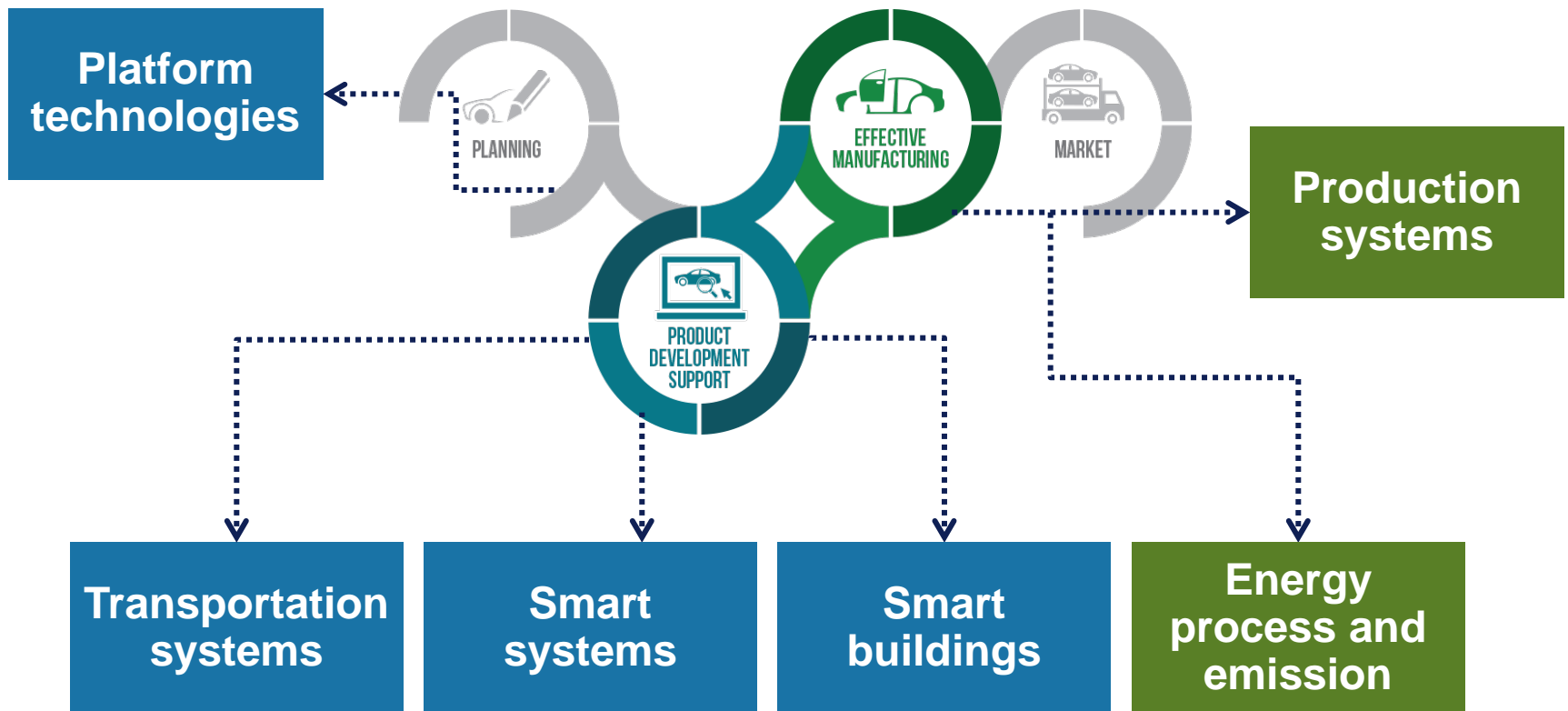
- › Efficient transportation: integration of personal mobility and freight movement as key city and inter-city infrastructure.
- › Efficient and integrated transportation systems linked to city infrastructure.
- › Planning urban environments for mobility while repurposing redundant infrastructures (parking to food-water-energy) as population shifts away from personal transportation.

## FOOD-WATER-ENERGY NEXUS

- › Sustainable urban bio-cycling.
- › System approach to the development of the technology platforms required to address the nexus.



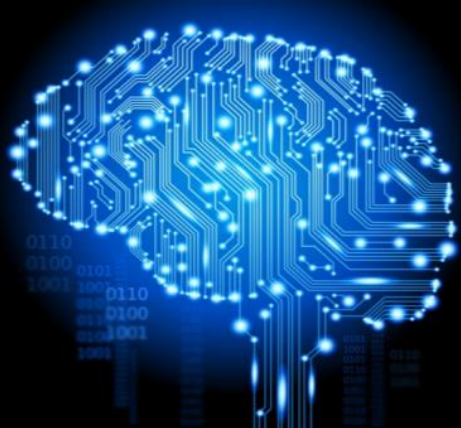
# NRC R&D groupings



# Key enabling platform technologies



## Artificial intelligence (AI)



- *Computer vision and image understanding*
- *Adaptive robots; future robotic platforms for part manufacturing*
- *Understanding human emotions from language*
- *Next generation information extraction using deep learning*
- *Speech recognition*
- *AI to optimize talent management for human resources*

## Nanomaterials



- *Nanoelectronics*
- *Nanosensing*
- *Smart materials*
- *Nanocomposites*
- *Self-assembled nanostructures*
- *Nanoimprint*
- *Nanoplasmonic*
- *Nanoclay*
- *Nanocoating*

## Big data analytics



- *Predictive equipment maintenance*
- *Energy management*
- *AI for optimizing energy storage and distribution*
- *Understanding and tracking of hazardous chemical elements*
- *Process and design optimization*

## Printed electronics for Internet of Things (IoT)



- *Inks and materials*
- *Printing technologies*
- *Large area, flexible, stretchable, printed electronics components*
- *Applications: sensors for IoT, wearables, antenna, Radio-frequency identification (RFID) tags, smart surfaces, packaging, security, signage*

# IT - smart systems competencies

## Clean technologies



- *Predictive equipment maintenance, e.g., train wheels*
- *Energy management for buildings or vehicles*
- *Optimising energy storage and distribution*
- *Understanding and tracking of hazardous chemical elements*

## Machine vision



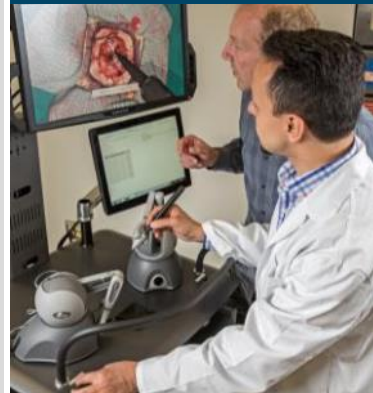
- *Understanding body shape, body landmarks and movement from camera images*
- *Understanding multi-spectral images to discover defects or disease*
- *Combining multiple images to gain an overall understanding of objects in space, including notably a high resolution human brain*

## Human communication



- *Superior machine translation with deep learning (Facebook)*
- *Understanding human emotions from language*
- *Next generation information extraction using deep learning*
- *Speech recognition*
- *Optimising talent management for human resources companies*
- *Aboriginal language understanding*

## Medicine



- *Automating medical research from electronic medical records.*
- *Understanding medical images for diagnosis*
- *Fusing very large data sources and detecting outbreaks*
- *Understanding large-scale data from biological experiments to discover diagnostic signals and potential drugs*

# IT - smart systems competencies



## Manufacturing



### **ROBOTICS**

- *Future robotic platforms for assembly, finishing and joining*
- *Future robotic platforms for part manufacturing*
- *Adaptive robots*

### **MACHINE VISION**

- *Vision systems*
- *Image sensors*
- *Big data analytics*
- *Processing and analysis software*

## Agriculture



- *Genomics for breeding improved crops*
- *Resistance to pathogens with naturally derived antifungals*
- *Analysis of crop/pathogen interactions in changing climate*

# Smart buildings

## Functional materials



- *Site-built wall and floor assemblies with improved wood-based products*
- *Renewable, biocompatible, biodegradable value-added nanomaterials*
- *Solid-state lighting (LED) metrology: enabler for high energy efficiency lighting solution to achieve significant energy savings while providing critical lighting solutions to green infrastructure*

## Codes and standards



- *Codes and standards advice and support: National Energy Code of Canada for Buildings, Setting out technical requirements for the energy efficient design and construction of new buildings ; National Building Code's requirements also apply to retrofit of existing stock.*
- *Development of detection (e.g. nanoparticles in water and food supply) and characterisation tools, reference materials*
- *Standards development assistance to facilitate Environmental Health and Safety (EHS), and regulatory work as well as commercial development*

## Building envelope



- *Façade technologies to make buildings more thermally efficient while harvesting energy, managing solar load and performing requirements for natural light, durability and moisture management*
- *Low energy solutions and technologies*
- *Human factors research to define control strategies for improved energy efficiency and organizational productivity*
- *3D image metrology to enhance processes and minimise waste and to evaluate building structures for repair to extend service life*

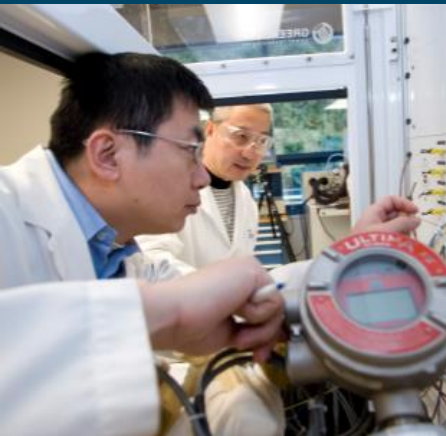
## ICT and grid integration



- *Intelligent environmental control*
- *Interactive platforms, standardised communication and management solutions*
- *Connecting and integrating building energy systems, vehicle charging stations and smart grid*
- *Components targeting high data-density, short reach applications, to alleviate congestion in access networks and data centers*
- *Grid impact analysis, big data analytics (smart meters, network analysis), systems modeling and integration*

# Energy processes and emissions

## Clean hydrogen (H<sub>2</sub>)



- Custom H<sub>2</sub>-certified facility
- Codes and standards expertise and support
- Catalyst and membrane materials development, design, testing
- Electrochemical energy conversion: H<sub>2</sub>, fuel cells, electrolyzers
- H<sub>2</sub> storage

## Process efficiency



- Process development and optimisation: sensors and materials to improve mining process efficiency
- Microbial electrochemical technology (MET): produce direct current from biodegradable materials for energy-neutral / energy-positive wastewater treatment

## Emissions reduction



- Measurement methods and standards for black carbon (BC) and other emissions for aviation, marine, on-road, upstream oil and gas sectors
- Support development of new emission certification standards
- Ground-based and airborne monitoring of environmental & air pollutants
- Algae cultivation using industrial carbon dioxide (CO<sub>2</sub>) emissions as feedstock and processing of algal biomass into sustainable products including biofuels

# Production systems

## Flexible manufacturing cells and adaptive manufacturing



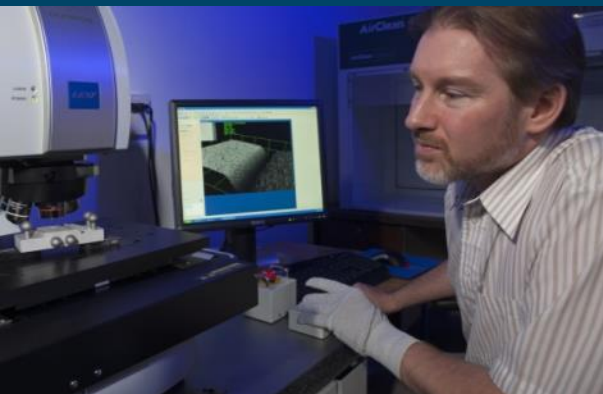
- *Autonomous and semi-autonomous robots*
- *Collaborative and human-assisted robots*
- *Mobile and reconfigurable manufacturing systems*

## Robotics and mechatronic systems



- *Future robotic platforms for assembly, finishing and joining*
- *Future robotic platforms for part manufacturing*
- *Adaptive robots*

## Metrology and sensing



- *Sensing technologies and sensing systems*
- *In-line measurement*
- *Non-destructive testing*
- *Quality assurance*

## Additive manufacturing



- *Cold spray*
- *Electron beam powder bed*
- *Laser powder bed*
- *Material characterisation*
- *Formulation of high-performance polymers and composites for additive manufacturing*

# Efficient transportation systems

## Energy efficiency



- *Electrification of transport*
- *Fuel efficiency of vehicles*
- *Energy systems development, evaluation and performance optimisation in Canadian context*

## Urban fleet optimization



- *Integration of multi-modal urban fleets for efficient movement of people and goods*
- *Route planning and optimisation to minimize operating cost, emissions and improve user experience*
- *Testing and validation of new smart technologies within fleets*
- *Technologies connecting vehicles to infrastructure (V2I)*

## Energy integration



- *Energy distribution infrastructure for transportation*
- *Integration of vehicles to grid (V2X)*

## Interurban transport



- *Inter-modal efficient supply chains*
- *Evaluate and develop technologies to reduce drag and reduce fuel consumption*
- *Influence the development of greenhouse gas regulations for light duty vehicles (LDV) and high duty vehicles (HDV)*

# NRC collaboration platform locations



## London, ON

- Additive manufacturing
- Product development
- Laser consolidation
- Micro-machining
- **NEW (Automotive advanced manufacturing solutions centre)**



## Edmonton, AB

- National institute for nanotechnology (NINT)



## Winnipeg, MB

- **NEW (Advanced manufacturing centre)**
- Process design, modelling, simulation
- Manufacturing systems engineering and integration
- Flexible manufacturing pilot laboratory



## Ottawa, ON

- Machine vision
- Big data analytics
- Metrology
- Materials characterisation and testing
- Canadian Photonics Fabrication Centre



## Mississauga, ON

- **NEW (Canadian campus for advanced materials manufacturing)**
- Advanced materials for digital manufacturing, printed electronics, smart objects, devices, sensors, etc.



- ▼ IRAP
- Research Facilities



## Saguenay, QC

- Lightweighting structural
- Aluminium joining and forming
- Aluminium and multi-materials assembly
- Hybrid manufacturing (extrusions, forgings, castings)



## Montreal/Boucherville, QC

- Intelligent machining processes and tooling
- Robotics and automation
- Modelling and simulation
- Advanced materials
- Medical devices
- **NEW (Aerospace advanced manufacturing solutions centre)**



## Montreal - Royalmount, QC

- Biomanufacturing pilot plant
- Advanced biologics analytics



For further information on how the NRC can support your **smart infrastructure and cities of the future** needs, contact:

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