Automotive Centre of Excellence
(ACE)

From Ideation to Implementation: The ACE Research Plan

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Executive Summary

The Automotive Centre of Excellence (ACE) is a one-of-a-kind, world-class research and evaluation centre with a mandate to accelerate the investigation and development of new technologies for automotive, transportation and related environmental, energy and power industries in need of climatic or durability research, experimental development and innovation. The research, experimental development and innovation enabled by ACE will lead to a paradigm-shift in collaborative thinking. UOIT is poised to become a Center with the capacity to develop technology from ideation.

ACE is the only facility of its kind in Canada. It has an array of environmental and evaluation chambers, including one of the most sophisticated climatic wind tunnels (CWT) globally. The ACE CWT is the first with a variable nozzle allowing for wind speeds in excess of 240 km/h and the first CWT with a rotating index table for a high-powered dynamometer allowing products to be evaluated at yaw.

ACE is framed around integrating R&D that enables industry and university partnerships to emerge. As a centre of innovation and incubation, ACE builds on the principles of clustering of technology based companies, universities, government, and business support services. It will enhance the exchange of people, ideas and technologies leading to the development of real world products and processes. ACE is where truly innovative and transformative products will be developed, providing economic and societal benefits to Ontario and Canada.

ACE was developed in partnership with UOIT, General Motors of Canada Ltd. (GMCL), Partners for the Advancement of Collaborative Engineering Education (PACE), and the governments of Ontario and Canada.

ACE has two principal research, development and evaluation facilities:

- The Core Research Facility (CRF), and
- The Integrated Research and Training Facility (IRTF)

The IRTF and CRF create the environment in which highly innovative R&D will occur amongst teams of university and industry scientists and engineers. Through collaboration, they will develop, evaluate and transfer new methods and technologies from the bench to the marketplace.

ACE will be a model for effectively operating an industrial R&D and evaluation facility directly connected to university engineering and business schools. It is the combination of industry-led research and development with the university’s engineering capacity and the business analytics that make ACE a leading-edge centre for research development, innovation, incubation and cluster-formation, and the assessment of the innovation processes. Only the combination of highly trained personnel and sophisticated equipment and robust university-industry collaborations
will be able to capture the advances necessary to maintain a leadership position in innovative design and advanced automotive technology.

ACE is at the core of UOIT’s innovation strategy to provide outstanding undergraduate and graduate education to enhance the competitiveness of Ontario’s and Canada’s automotive industries. ACE is the nurturing environment in which UOIT will educate and mentor the next generation of technicians and engineers, the students of today who will create the jobs of tomorrow. Thus, the ACE partnership embodies UOIT’s commitment to its students: providing them with highly quality, industry-oriented academic and research experience embedded in the current environment while developing the skills to solve technological, business and societal challenges in the automotive, transportation, environment, and energy sectors.

ACE will facilitate UOIT research in three initial focus areas:

- Vehicle Thermal Management,
- Vehicle Dynamics and Performance (Vibration and Noise), and
- Hybrid and Alternative Fuel Technologies.

These foci build upon areas of strength within Canada’s automotive industry and the GMCL Engineering Centre of Excellence and UOIT’s research capabilities. These foci are central to the advanced technology development work being carried out by the Canadian automotive industry.

This Research Plan has six components:

1. ACE Vision and Research Mandate
2. ACE Facilities
3. Academic Research,
4. Industry Research (GMCL),
5. Applied Evaluation Research, and

This Research Plan is the first iteration of a dynamic and responsive research strategy. This document will evolve as ACE progresses, UOIT evolves and as UOIT and its industry partners identify new strategic research initiatives and projects. The research plan is built on the premise that UOIT will be a leader in automotive technology research, experimental development and innovation and education in Canada and internationally. The research plan focuses on UOIT’s core research competencies and ACE as an unprecedented toolbox to engage academic and industry researchers.
1.0 INTRODUCTION

On March 2, 2005, General Motors of Canada Limited (GMCL) announced a $2.5 billion initiative in partnership with the Ontario and Federal governments. The GMCL Beacon Project was the largest and most comprehensive automotive investment in Canadian history, reinforcing Canada’s leadership as one of the largest automotive producers in the world and Ontario as the centre of the Canadian industry.

A central element of the Beacon Project was the creation of an Automotive Centre of Excellence (ACE) at the University of Ontario Institute of Technology (UOIT).

ACE will make a major contribution to Canada’s automotive engineering R&D capacity and to the education of the next generation of engineers, innovators, and entrepreneurs. As a centre for automotive engineering research, development and evaluation, ACE will address the research, education, and advanced automotive design, development, and engineering analysis needs of Canada’s automotive sector. ACE is expected to complement GMCL’s Engineering Centre of Excellence in Oshawa. ACE will be the home to UOIT undergraduate and graduate students to work and learn beside university faculty and professionals in these industries. Students will be engaged from the idea stage, through technology implementation, to assessing consumer acceptance of innovation.

ACE will nurture Canada’s entrepreneurial spirit by introducing students to the commercial applications of research, and by supporting collaborative research and development between university and industry-based researchers aimed to bring new products to market. Engineering and business students will have exposure to real world engineering product and process, research and development. They will participate in an environment that assesses the benefits and manages the risks of accelerating technology adaptation in new product development. The UOIT environment is one that develops leaders who will shape Canada’s future.

2.0 THE ACE VISION

Nurturing Industry-University Relationships for Economic Prosperity and Productivity through Innovation

The Automotive Centre of Excellence is a world-class research co-laboratory for university, government and industry partners building towards an Ontario cluster of research, experimental development and evaluation for automotive and related industries. Academic and industry partners will be attracted to the learning, knowledge and advanced development represented by UOIT and ACE. Government research laboratories will view ACE as complementary to their R&D capacities and a
partner in industry-focused innovation. Industry partners will invest and participate in the growing pool of intellectual capital and available talent for their own engineering and commercialization efforts.

3.0 THE ACE RESEARCH MANDATE

ACE will be a destination – for academic, government and industry researchers. The UOIT strategic research foci and ACE’s unique capacities will be magnets for researchers and innovators. ACE will be a research and innovation centre that, for the first time in Canada, provides academic, government and industry partners with opportunities to conduct focused, leading edge and applied research that supports industry needs and fosters game-changing technologies. ACE will facilitate change in the automotive industry, integrating innovation into the production process and into the final product – high quality, technologically advanced automobiles for Canada’s and the international marketplace. Academic and industry researchers will focus on technological challenges – those that are intellectually and technically challenging and that offer benefits to the consumer.

ACE will build capacity for university-industry relationships. UOIT faculty and students, government researchers, and industry will access ACE facilities for research that ranges from discovery-oriented research through to short- and medium-term applied research and development focusing on industry needs, and immediate engineering, development evaluation requirements (Appendix 4.)

The ACE research mandate is underscored by the idea that by attracting clusters of university researchers, government research scientists, and industry colleagues. It will create new knowledge development, technology and human capital mobility opportunities, and innovation that builds existing industry strength, creates new companies, and enhances Ontario’s and Canada’s economic competitiveness and prosperity. (See Appendix 3: University-Industry Business Model.)

4.0 ACE FACILITIES

To support advanced engineering and scientific research and applied research and evaluation, ACE’s R&D infrastructure will accommodate a full range of automotive research and evaluation facilities, educational and research labs, and offices for academic and industry partners. ACE will be a secure and controlled access facility, ensuring the security of proprietary research conducted by industry and academic partners.

ACE has two principal facilities:

- The Core Research Facility (CRF) and
- The Integrated Research and Training Facility (IRTF).
4.1 Core Research Facility (CRF)

The CRF comprises multiple facilities that support advanced research and development. The CRF has secure and controlled access to the industry partnered work environments. The CRF is able to handle complete vehicles and a wide range of components. The CRF has the following chambers and work areas:

1. Climatic Wind Tunnel (CWT)

   The CWT is a closed-return circuit layout that provides environmental control and enables a dynamic simulation for the evaluation of cars, buses, trucks and other vehicles. The (CWT) can provide simultaneous simulation of air speed, temperature, humidity, solar loading, rain and snow, and road load conditions to the vehicle via a 4-wheel drive chassis dynamometer. The CWT includes two unique features: an adjustable nozzle that provides variable flow area and wind speed, and a high power dynamometer that rests on an indexing turntable. These two features when coupled together allow for simulation of crosswind vectoring, thereby eliminating the head-wind restriction of contemporary CWT’s. This sets a new world benchmark on thermal test capability for automotive vehicles. Cross coupling of external-body flow and under-body flows with under hood convective heat transfer can now be properly investigated. This cross-coupling in conjunction with full road dynamic loads provide investigations to a broader spectrum of temperature and environment sensitive ride and aero effects to noise, vibration and harshness investigations of whole vehicle, full ride, load conditions.

2. Environmental Chambers

   ACE has three environmental chambers that provide static simulation of cars, buses, and trucks with the same temperature and humidity control as the CWT.

   Two of these may be used separately, or together and will provide a cost-effective ‘pre-soak’ capability for the CWT. Both chambers can accommodate multiple vehicles and can be converted into a specialized facility with the addition of a test bench that straddles both chambers. This specialized three-zone test bench configuration will facilitate advanced development of energy battery packs for use in electric vehicles. The larger chamber is outfitted with an input dynamometer and overhead solar array and can accommodate larger test vehicles such as a bus or coach. This readily allows for “in-Lab” simulation of vehicle normalization and whole vehicle engine development to facilitate cold and hot start engine calibrations, drivability, and idling development.

   The third chamber has a ‘drive-on’ Four-Post Shaker. The uniaxial motion of the posts is variable and controllable and can simulate road conditions and allow severe stressing of test vehicles. This chamber will enable a test property to be exposed to an extreme environmental condition, such as driving in a snowstorm, and then be easily moved into the 4-post shaker
chamber with the same temperature and humidity conditions. This configuration sets a new benchmark for development of automotive vehicles. The influence of the environment now can be investigated for full road loads in the CWT and full chassis road load input in the climatic Four Post Shaker. This will enable the development of routines and algorithms to investigate whole vehicles for structural durability, ride, comfort, squeak and rattle, vibration, harshness, and other outcomes.

3. Multi-Axial Simulation Table (MAST)

The MAST enables component and sub-system structural evaluations in a hemi-anechoic chamber environment. The motion simulations and data analysis suite will handle structural durability and analysis correlation; buzz, squeak and rattle detection; and, noise, vibration, and harshness R&D.

4. Ancillary facilities:

- Work bays and support areas to enable on-site physical modifications to vehicles and systems as required to maintain operational efficiency.
- Test and IT infrastructure such as control rooms to support wind tunnel, soak room and test chamber requirements and test condition data.
- Full test fueling support equipment that includes gas, diesel and hydrogen fueling, and charging power supplies.

5. Future Facility Development

The automotive industry faces consumer demand for increased passenger comfort to keep pace with advanced vehicle propulsion system developments. This means better climate control and internal acoustics must accompany green technology developments. All improvements will be incrementally smaller, which will demand more precise experimental techniques that are coupled with improved computing analysis capabilities.

ACE will keep pace with these demands and stay ahead of other test centres' capabilities. The plan includes the development of test techniques and climatic simulation capabilities. New test techniques will be established to establish critical simulation improvement needs as well as providing valuable reference data for parallel development of computational analysis techniques.

In the case of the CWT, there are three simulation capabilities that can build on capabilities already in place.

- First, improved under-body flow simulation while the chassis dynamometer is in use. This involves further reduction of ground boundary layer thickness to more closely mimic the relative motion between the ground and a vehicle. The dynamometer provides the necessary rotating wheels and incorporation of a ‘fluid belt’ will provide the boundary layer reduction. This robust approach to design allows for
an unprecedented full climatic range of air stream effects and boundary layer reduction.

- The second improvement is an aero-acoustic simulation capability to enable evaluation of passenger compartment noise levels. The CWT has an acoustic treatment that is able to detect ‘drive-away’ anomalies of the engine and drive train and an anechoic wall treatment in the test chamber. Implementing this improvement, together with a reduction in main fan generated noise, using active noise cancellation, will complete the upgrade.

- The third improvement is the addition of an adaptable, dry climatically neutral, model balance. This would enable scaled climatic aerodynamic evaluations for teaching, and smaller scale aerodynamic research and development in varying temperature and humidity conditions.

These improvements would continue on the path to keeping the CWT unique and highly sought after worldwide.

4.2 Integrated Research and Training Facility (IRTF)
The IRTF comprises five floors for research, education and training, and evaluation. IRTF supports automotive-related undergraduate and graduate teaching. The IRTF has meeting rooms, teaching/ research labs and specialized research-seminar rooms. The IRTF creates a collaboration environment for university and industry researchers. The IRTF has secure and controlled access to the industry partnered work environments. Facilities include:

1. Machine shop, prototyping and concept build areas along with other facilities shared by both industry and academics (Floor 1)
2. University space – Offices for UOIT faculty members involved in automotive-related research and training initiatives. (Floors 2 and 3).
3. Collaborative and industry sponsored research laboratory space – Secure and flexible research space available to UOIT and industry research, development and evaluation. Automotive partners and tier suppliers will have access on a contractual basis to conduct research projects. (Floor 4).
4. A dedicated GM research facility for the first two years of operation (Floor 5).

4.3 Design Engineering Commons
ACE is contiguous to the Design Engineering Commons (DEC), the teaching and learning centerpiece of the Centre for Innovative Design Engineering and Research in the Faculty of Engineering and Applied Science at UOIT. DEC facilities include principal design engineering and teaching laboratories:

- Computer Aided Design Laboratory;
• Component Design Laboratory;
• Rapid Prototyping and Manufacturing Laboratory.
• An automotive teaching laboratory.

5.0 ACADEMIC RESEARCH AGENDA: DISCOVERY AND IMPLEMENTATION

Fundamental to ACE’s research mandate is the building of research capacity at UOIT and other Ontario universities in automotive science and engineering, business, and associated fields of transportation, energy and environmental sciences. This research mandate covers discovery research, applied research and technology development, and near-to-market and proof-of-concept research.

UOIT’s three strategic automotive R&D focus themes (see Appendix x) complement those of industry and the automotive research capacity of other Ontario universities.

• Vehicle thermal management and control systems;
• Vehicle dynamics and performance;
• Hybrid and alternative fuel vehicle technologies;
• Business and Innovation systems.

These research themes will be reviewed and refined and evolve as UOIT recruits additional research faculty and the needs of industry and consumers change. Each thematic area includes predictive tools, analysis, experimental work, and manufacturing techniques.

UOIT has built capacity in these strategic areas (Appendix 4). Through industry and academic research partnerships, UOIT faculty members identify areas of research where they have the opportunity to advance technological capabilities. Implicit in our research strategy is a shift towards “green” technologies that will grow the economy.

5.1 Vehicle Thermal Management & Controls Systems
This research area includes: climate comfort, under hood and under body thermal management, solar loading, including airflow, heat transfer characteristics, energy management, control systems and impacts of alternative propulsion/fuels.

5.2 Vehicle Dynamics and Performance
This research theme includes vehicle structures, chassis systems, chassis control systems, noise, structural vibration & harshness (NVH), driving dynamics and durability over a range of environmental conditions.

5.3 Hybrid and Alternative Fuel Vehicle Technology
This research area includes: vehicle systems, component technology and fuel systems. Details of the individual UOIT research projects under these three focus areas, and of complementary research projects, are given in Appendix 4.

5.4 Business and Innovation Systems
This emerging area of research will bring together researchers from the Faculties of Engineering and Business and Information Technology to investigate, document and analyze the ways in which collaborative research and experimental development occur within a highly specialized research and evaluation centre and how innovative processes and discoveries move from the laboratory to the market place.

6.0 VALIDATION AND EVALUATION RESEARCH

Industry partners will have proprietary evaluation research that needs to be undertaken solely by themselves or in collaboration with other industry, college or university research support. The breadth of evaluation research in this focus area is broad and will not be solely limited to the automotive and transportation industry.

6.1 General Motors of Canada

For GMCL, ACE is a strategic asset that complements its Canadian Regional Engineering Centre in Oshawa and investments at McMaster and Waterloo. GMCL will lever ACE’s capacity to expand its R&D capability in seven core areas.

6.1.1 HVAC, Powertrain Cooling and Vehicle Thermal Evaluation

GM will advance the integration of innovative technologies and control solutions by evaluating and applying new theories and hypotheses validated through experimental data acquired through rigorous environmental and engineering studies conducted within ACE. Data generated through benchmarking activities will enable engineers to develop best in segment technical solutions for future vehicles. New model development and quality improvement through the life cycle of the vehicles will be conducted in the facility.

6.1.2 Refrigerant Development

New refrigerant development and evaluation will be conducted to optimize cooling capacity, charge reduction, oil migration and coefficient of performance optimization. Use of the IRTF and CWT will provide engineers physical data to migrate to new refrigerant technologies and delivery methods in an effort to minimize impacts related to global warming.

6.1.3 Hybrid Systems Controls Development

Hybrids and advanced battery technology is developing at a rapid pace. Engineers require physical conditions provided in a CWT to simulate environments to which vehicles are exposed. GM will use ACE for hybrid vehicle battery thermal calibration. Complex controls strategies are necessary to ensure the driver and vehicle interfaces are seamless.

6.1.4 On Board Diagnostic Test and Development

New Product Development with internal combustion engine, hybrids and battery electric vehicles require development of On Board Diagnostic (OBD) algorithms. Vehicles must be functional under a range of temperature conditions to develop and validate OBD requirements.
6.1.5 Simulated Cold Weather Development
Complementing the GMCL Cold Weather Development Centre, GM engineers will employ ACE to simulate cold weather conditions to complete required validation milestones. The CWT allows engineers to schedule vehicle development and research in vehicle operation under harsh conditions on a year-round basis, thereby shortening development cycles.

6.1.6 Alternative Fuels
Development of alternative fuels including diesel, CNG or LPG will be enabled at the ACE facility. Simulation of Max Ice conditions in diesel urea injection systems is one example of climatic evaluation required.

6.1.7 Complementary Areas
General Motors will employ ACE in areas such as Electrical, Battery Development, Chassis, Powertrain and Diesel Exhaust. Advanced research engineers will employ the Climatic Wind Tunnel, MAST and 4 Post as well as the available test lab space.

7.0 IMPLEMENTATION OF THE RESEARCH PLAN
The following five strategies are proposed to advance ACE goals and objectives:

1. Develop ACE facility human capital;
2. Develop automotive research capacity in partnership with other universities;
3. Develop grant and contract research in partnership with the automotive industry;
4. Develop grant and contract research with other related industries; and
5. Define and develop a physical and virtual cluster of automotive innovators by establishing and nurturing an Automotive Innovation Network (AIN).

7.1 Develop ACE Facility Human Capital
Only the combination of highly trained personnel (HQP) and sophisticated equipment will allow Ontario to capture the advances necessary to maintain a leadership position in an industry focused on advancing greener propulsion technology. UOIT and ACE will contribute to Ontario’s and the automotive industry’s need for highly qualified personnel in three ways: attraction and retention of research faculty members, education and training of the next generation of HQP, and attraction and training of specialized professional and support staff. The presence of a full OEM specification research and commercial evaluation facility linked to a university Engineering Faculty provides opportunities for collaborative research and R&D and specialized education and training not found elsewhere in North America.

ACE will provide both industry and UOIT with exceptional research, development and innovation opportunities. The opportunity, for example, for research faculty and
their trainees to interact with and capitalize on the presence of industrial clients who will identify knowledge gaps and technical needs will provide outstanding research directions for faculty and training opportunities for students. The industrial partners gain access to leading-edge facilities, new ideas and knowledgeable experts and students, who can develop new technologies and value-added solutions,

7.1.1 Core Faculty

UOIT’s researchers’ engagement with the ACE facility represents a change in paradigm. Modeled after European technical universities, UOIT’s engineering professors hold significant industry experience prior to joining academic ranks. This experience ensures that our faculty members’ research is directed to critical long term and applied research needs of industry.

UOIT currently has two dedicated automotive faculty members who provide a direct fit with the thematic areas and 12-15 in mechanical and manufacturing engineering whose expertise complements automotive engineering (Appendix 4). UOIT will hire 5-6 additional faculty members in UOIT’s three strategic automotive R&D focus areas. These new hires will be hands-on researchers, engage with industrial clients and mentor graduate students, research associates, post-docs, resident engineers, and skilled technicians.

7.1.2 Professional and Support Staff

ACE has three professional leaders

- A Director, Engineering and Operations is responsible for management of the facility
- A Director, Business Development, and
- The ACE Academic Director is responsible for academic research and education programs.

These individuals provide an industry-oriented focus for ACE and an articulation with the research and academic programs of UOIT.

ACE will have a cadre of experienced technicians and support personnel who will assist university and industry researchers utilize the facilities efficiently and effectively.

7.1.3 Student Training

Attracting and retaining top tier undergraduate students in UOIT’s automotive engineering program and enticing them to pursue graduate studies is a primary objective of UOIT and our industry partners. We are committed to engaging 3rd and 4th year engineering students, as research assistants, co-op students and interns in design and research assignments directly related to automotive research. Undergraduate co-op students and interns will train with engineers, technologists, support staff and faculty researchers or assist graduate students and engineers to design and run experiments. This experience puts young minds and their creativity to work in developing methods to overcome technical challenges and experience
success. It allows practice of engineering skills, reinforces use of design tools, and inspires students to reach for higher levels of understanding in engineering.

7.1.4 Automotive Design Chair

UOIT is committed to maintaining the Automotive Design Chair as an essential position for ACE-related research and attraction and retention of HQP. The Automotive Design Chair is critical to UOIT’s research and education programs in automotive engineering. The Automotive Design Chair will become a catalyst for other automotive-related research chairs.

7.2 Develop Research Capacity in Partnership with Other Universities

There are four Ontario universities (UOIT, McMaster, Waterloo and Windsor) with high levels of automotive research and others (UWO, Queen’s, Guelph) that conduct research of interest to the automotive industry. McMaster has expertise in lightweight materials development and corrosion research. McMaster has co-located the CANMET laboratories and received a CECR in power train research. Waterloo has established linkages to GMCL on vehicle controls, battery chemistry, and fuel cells. Windsor is the centre of the AUTO 21 initiative and has significant capacity in manufacturing engineering. These universities are within traveling distance from ACE. Projects will be targeted that can effectively lever the ACE infrastructure.

Through its membership in Partners for the Advancement of Collaborative Engineering Education (PACE), UOIT will engage research partners from other Canadian (UBC, Toronto, Dalhousie) and international universities to focus on the automotive product lifecycle management (PLM) research. This global approach to research, experimental development and innovation contributes to our goal of increasing the quality of industry’s human capital and the international competitiveness of Ontario’s automotive industry.

7.2.1 Automotive Innovation Network (AIN)

The formation of an Automotive Innovation Network (AIN) will link university researchers, manufacturers and suppliers for the advancement of automotive engineering, development, training and commercialization of R&D in Canada.

One outcome of the collaboration among these groups is the acceleration and commercialization of R&D in Canada’s automotive and technology sectors. The demonstrated success in university-industry technology and knowledge transfer and the commercialization of research outcomes will encourage Canadian suppliers to take advantage of the network while effectively managing risks and reducing the cost of development through the cluster and partnership approaches facilitated by ACE. The members of AIN will influence the direction of investment, establish coordination amongst institutions and industry to minimize overlap, and establish thematic focus areas to help move the industry forward. An AIN sponsored an annual conference will make known the work of network researchers and expand its reputation for automotive R&D in Canada.
7.3 RESEARCH PARTNERSHIPS

7.3.1 Partnerships with the Automotive Industry
The ACE facilities are developed with the specific goal and focus of increasing the expertise and competitiveness in the Ontario automotive industry internationally. ACE will facilitate strong research partnerships with the automotive industry. These partnerships include close ties with the founding industry partner, GMCL, parts manufacturers and assembly companies (Magna, Linamar), and service industries (Aiolos, Multimatic). These research partnerships span the breadth of research relationships: from blue sky research seeking to answer the big and unknown questions through to highly targeted, company focused linkages. Funding arrangements will range from grants through to contract research (Appendix 3). In all cases, these research arrangements will provide training of HQP: undergraduate and graduate research students, postdoctoral fellows and research scientists who will become the employees of industry partners and future entrepreneurs.

7.3.2 Partnerships with associated industries
UOIT recognizes that industry partners extend beyond automotive-related industries. Transportation, energy and environmental sciences companies are potential users of ACE. UOIT recognizes that innovation for the automotive industry does not always come from within and, conversely, developments in the automotive industry may have applications that go beyond vehicles. There exist industries outside of automotive or ground transportation sectors, such as aviation, rail, nautical, military, agricultural equipment, mining/petroleum, wind and solar power, outdoor survival equipment, power line, and packaging industries that can be served. ACE will become a hub for research collaborations between UOIT faculty members and these other industry partners, advanced education and training of HQP, and innovation.

8.0 RESEARCH PLAN METRICS
In the next 10 years, ACE will make a major impact on Ontario’s economic prosperity and productivity by fostering sector specific R&D and training of the next generation of engineers, innovators and entrepreneurs. Measuring such impacts is difficult. UOIT has identified three key areas (Human Capital Development, Facility Development & Research Outputs/Commercialization/Business) in which success indicators will be compiled annually.

8.1 Human Capital Development
- HQP, by level, who have substantially enhanced their knowledge / skills
- Degrees earned by research team members
- Number of UOIT faculty members engaged in the focus areas
- UOIT faculty in supporting fields working in ACE
- Visiting professors, adjunct faculty, resident engineers, post-docs
- Number of student internships, level, duration
- Number of support staff, level, progression
• Facility management (manager, director, advisory bodies established);
• Workshops
• Number and location of undergraduate and graduate students working in the automotive industry (HQP education and knowledge mobilization).

8.2 Facility Investment
• Grants and project investments, Federal, Provincial, Industrial
• Infrastructure additions / upgrades, major equipment (financial value)
• Number of research contracts (financial value)
• Major facility operational support.

8.3 Research Outputs/Commercialization / Business
• Faculty and Student Publications and Conference Presentations
• Research Citations
• Research Collaborations (U2U, U2I, I2I)
• Patent disclosures, patents filed, patents granted
• Industry-specific commercialization of ACE facilitated technology
• Licenses negotiated
• Spin-off companies established, employees and business scale
• Number of industrial collaborators/partners (new, ongoing)
• AIN academic and industry membership
• Industry sectors served
• Clustering of industry and academic partners in UOIT Research Park
• Marketing awareness – website hits, survey of industry partners.

9.0 CONCLUSION
The Automotive Centre of Excellence opens up a world of possibilities. Located in the heart of the UOIT campus, ACE will attract academic, government and industry researchers, the best students and scientists, and industry leaders to collaborate, create, test and validate paradigm-shifting innovations. They will develop “the next big thing”. ACE will position UOIT as an international leader in advanced engineering education, research and innovation for the benefit of Ontario’s and Canada’s automotive industry and economic prosperity and productivity.
### Appendix 1
**UOIT Research Expertise**

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<th>Core Focus 2 (Vibration / Structural)</th>
<th>Core Focus 3 (Hybrids / Alternative Fuels)</th>
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APPENDIX 2

University-Industry Partnership Model

Figure 1, The numerous grant leveraging opportunities of Industry-University partnerships
Appendix 3
University-Industry Business Model

Figure 1, University Industry business model

Thanks to a Venn diagram approach, Figure 1 illustrates the various types of financial models enabling access to ACE, with a focus on industry-university relationships. The various types of financial arrangements relate to whether or not the industry-university relationship is leveraged by means of opportunities available in the Canadian research grant environment. This figure also shows the connection between the various types of industry-university interactions and the ACE business model.
Appendix 4
Automotive Related Research at UOIT

CORE AUTOMOTIVE RESEARCH

Focus Areas – Summary Overview of UOIT Faculty Members & Capabilities

Core automotive related research at UOIT is focused in three areas:

- Vehicle thermal management and control systems;
- Vehicle dynamics and performance;
- Hybrid and alternative fuel vehicle technologies.

**Focus Area 1: “Vehicle Thermal Management & Controls Systems”**

This focus area includes the following: climate comfort, under hood and under body thermal management, solar loading, including airflow, heat transfer characteristics, energy management, control systems and impacts of alternative propulsion/fuels.

**HVAC Interior Systems**

Today’s vehicles contain several thermal management loops to meet a wide range of subsystem needs. A key area of development is to use coupled system layouts that effectively manage these thermal loops and improve overall vehicle performance by reducing energy use. Modeling and experimental studies will be conducted to improve the HVAC systems of electric powered and hydrogen fueled vehicles. This will lead to newly developed components, specifically to meet the unique HVAC performance, durability, reliability, compactness and regulatory requirements of EREV (extended range electric vehicles) and hydrogen fuel cell vehicles in the development phase.

A large research program led by Dr. Rohrauer and funded through Automotive Partnerships Canada (APC) will develop new technologies for integrating high-voltage heaters into the HVAC systems, while meeting heating and defog/defrost requirements over a range of weather conditions. Another example of a sub-system to be incorporated into the HVAC design is the battery thermal management loop. This is the central theme of the project.

New thermodynamic optimization methods will also be developed for HVAC interior systems, based on the method of exergy analysis. Exergy losses are a measure of the irreversibility at selected points in a thermal loop. By formulating and modeling the HVAC system components with respect to such losses, the efficiencies can be identified, and improvements incorporated to reduce the power consumption and parasitic power losses. A range of new design tools that utilize exergy methods to extend the driving range and performance of electric and hydrogen powered vehicles, as well as to extend the fuel economy derived from conventional power train systems, will be pursued.

**Vehicle Aerodynamics / Thermodynamics**

This research program will utilize the climatic wind tunnel and static test cells to assess how varying weather conditions affect the thermal sub-systems of vehicles. From the extremes of
frigid winters with snow, ice and freezing rain, to the intense heat of southern climates, factoring not only hot and humid ambient conditions, but also intense solar radiation, the next generation vehicles must maintain their good performance and driving range over a wide diversity of exposures.

In the aforementioned APC project, experimental studies will monitor the temperatures, internal circulation patterns, and radiative, conductive and convective heat flows within vehicles that experience this simulated range of weather. Using precisely measured data, new predictive models will be developed and validated to improve key system components constituting the next generation of vehicles, particularly those designed to operate on an electrified vehicle architectures (hybrids, PHEV, EREV, Fuel Cells) where much opportunity for improvement remains.

**Thermal Modeling and Energy Management**

Numerical and experimental studies to evaluate the heat transfer and thermodynamic performance of system components, especially within electric powered and hydrogen-fueled vehicles, will be performed. New technologies for improved efficiency will be assessed and then consolidated based upon the feasibility of implementation. The areas of investigation include advanced fan and blower design; higher efficiency heat exchangers; pulse width modulation fan / blower controls; higher strength magnet electric motors, refrigerant loop internal heat exchangers for optimized sub-cooling; and electronically controlled expansion valves.

**Battery Thermal Management**

A key area of research involves battery thermal management for electric vehicles. This research will examine independent battery thermal management systems. New specifications and criteria for such systems, strategies for component sizing, better thermal predictive modeling capabilities, and incorporating controls and diagnostics to meet regulatory requirements, are some of the main goals of this research.

Such research will also investigate PCMs (phase change materials) for battery thermal management. Using a PCM as a heat sink/source has advantages such as compact size, inexpensive, low maintenance and no parasitic power consumption. Li-ion batteries with PCMs for thermal management can reduce or eliminate the need for conventional heating / cooling systems, especially if they are deployed in combination with insulation strategies, and thus increase available power for other thermal loads in the vehicle. This research will conduct experimental studies and modeling of Li-ion cells surrounded by a high conductivity graphite “sponge”, which is saturated by a wax-type PCM. Good temperature uniformity can be maintained without the need for a manifold, fans or pumps. Experimental facilities to acquire heat transfer measurements of Li-ion batteries immersed in a PCM matrix will be developed. Such data will permit validation of new predictive models, to develop the optimal matrix dimensions, PCM mass, spatial distribution, melting temperature, and strategy for PCM integration with other HVAC systems.

The use of thermoelectric and solar power in conjunction with super insulation is also being explored to maintain an environment where the battery system can be packaged to survive for the life of the vehicle, while maintaining optimal performance through all climatic exposures.
Focus Area 2: “Vehicle Dynamics and Performance”
This focus area includes the following: vehicle structures, chassis systems, chassis control systems, noise, structural vibration & harshness (NVH), driving dynamics and durability over a broad range of environmental conditions.

Active Suspension and Steering
Ongoing research (led by Dr. He) aims at developing an improved method for the automated design synthesis of vehicles with active suspension systems. The object is to simultaneously optimize mechanical and control subsystems. To evaluate this design synthesis approach, the resultant prototypes and full scale active suspension systems will be tested and investigated using the Four-Poster Shaker and Multi-Axial Simulation Table (MAST) in ACE. To this effect, a recently awarded CFI grant for a driving simulator will be reconfigured for use in modeling different vehicles, and subjecting the driver to actual climatic environments and vibratory motions representative of cues available to the driver inside a “vehicle cab”.

Driver Focus
Many vehicles crash every day due to a lack of focus while driving. With an increasing number of electronic devices in vehicles, attention can be shifted away from driving, making it more dangerous. Dr. Ren is proposing to test a new design of haptic controls that use a "sense of touch". A peculiar set of distinguishable haptic feedback signals which link to a corresponding device, like the steering wheel, allows the user to operate partially through "sense of touch" and reduce the total reliance on visual interaction. Such designs can also help to reduce a driver’s distraction through alerts, thereby ensuring greater safety.

Heavy Articulated Vehicles
Active safety systems development for heavy articulated vehicles (HAVs) is a related effort. Due to large sizes and a high centre of gravity, these vehicles have poor low-speed maneuverability and low high-speed stability. Canada’s long and severe winter weather patterns further degrade HAVs safety. The climatic facilities in ACE, especially the HD chassis dynamometer, will provide an experimental capability to test and validate the proposed active safety systems for such heavy articulated vehicles. A research grant has been awarded (Dr. He) to commence this work.

Advanced Structural Evaluation and Materials
Other research areas under discussion with GM are the use of the shaker systems as part of a program for validating lightweight cast magnesium engine cradles. Here, the planned activity would encompass the MAST facility to subject these assemblies to fatigue loading representative of recorded acceleration profiles taken at the proving grounds. Additionally, high strain rate crash evaluation under simulated crash is an additional objective that would be carried out, in conjunction with a bumper impact test rig acquired by Dr. Rohrauer. This project initiative is currently in the planning phase.

Focus Area 3: “Hybrid and Alternative Fuel Vehicle Technology”
This focus area includes the following: vehicle systems, component technology and fuel systems related R&D.

EcoCAR, NeXt Challenge
This activity involves a strong educational and community outreach component. It is sponsored by the US Department of Energy and General Motors, and is organized by
Argonne Labs with financial and organizational help from Natural Resources Canada, Transport Canada and a large contingent of automotive suppliers. UOIT is one of only three Canadian schools selected to participate; the UOIT EcoCAR effort, led by Dr. Rohrauer, is unique in terms of architecture selection – a full function electric vehicle. Through this approximately four year effort, 17 selected engineering schools across North America were tasked with transforming a pre-production 2-mode hybrid Saturn VUE into even lower petroleum energy use and well-to-wheels greenhouse gas vehicle. Advanced engineering design tools, hardware in the loop modeling and annual competitions at GM vehicle proving grounds, along with numerous workshops, are requisite. The activity supports graduate students via dedicated scholarships, and complements research projects already underway at UOIT, employing alternative transportation technology. The number of undergraduates participating in this initiative as their capstone design project is significant (approximately half the class). It fulfills some of the promise to integrate ACE activities across the automotive curriculum.

Battery Environmental Performance Lab
At the development stage is the establishment of a battery performance lab for sub and full-scale evaluation of vehicular energy storage systems. ACE already incorporates many essential elements, namely a regenerative braking capable chassis dynamometer, and cold and hot test cells where battery systems can be subject to both vibration and thermal loads. Vehicular charging outlets, large laboratory environmental chambers, battery cycling equipment and sophisticated chargers are already in use by Dr. Rohrauer, complemented by the HVAC thermal load test benches recently acquired through the APC project “Thermal Management System Technology Development for Extended Range Electric Vehicles”. The activities and thrust under this project are to further develop elements of a battery energy storage system, in order to isolate it from extreme environments and make it survive the expected life expectancy of the balance of vehicle.

As a result of having Canada’s largest fleet of road licensed fully electric vehicles, and a number of years of experience acquired through servicing a range of battery technologies in daily use on this fleet, the initiative on battery performance evaluation has grown rapidly. Developing advanced technology implementations of the same type of experimental vehicles, like that being developed under the EcoCAR project, ties this research theme together with other elements of the integration work necessary to bring forth advances in electrified vehicle architectures, and promote their widespread public adoption.

Vehicle to Grid Communications
Through two Auto21 projects, “Hybrid Active Safety Systems and Grid Interfacing” and "Design of a Regenerative Braking System," Dr. Rohrauer has explored the elements of an alternate fuel focus area. Current work, carried forth in conjunction with the local electric utility Veridian Connections, is examining how to best bring vehicular charge point information into a database that a utility and customer can access. Wireless communication to a smartmeter via Ziggyb HAN protocol and implementing remote charger controls responding to price signals are being explored and prototyped. Elements of this project are under review for expansion with other partners (Whitby Hydro, Durham College, Intellimeter Canada, etc) through the LDC Tomorrow fund. This research also involves Dr. Sood (see below).
Power Grid Interconnection
Research plans are in development for the modeling and simulation of the grid interconnection of charging stations for electric / hybrid vehicles. There is also a related body of knowledge on drive train systems for the propulsion of large vehicles, as used in rail transport (Dr. Sood). The future grid interconnection of charging stations will occur at both residential and commercial locations. Two-way flow of power (for charging and generation) will be feasible and implications for AC-DC and DC-AC power conversion techniques will be investigated. The electrical system of future electric vehicles resembles a micro-grid power system with distributed generation and loads. Many of the loads are non-linear and they create harmonics and other power quality issues. Metering and other issues with regards to harmonic pollution and system interactions will be studied. The charging and discharging of batteries are often unbalanced and require electronic converters for protection and control.

Electric Transportation
Unique to UOIT is the electric vehicle fleet acquired by Dr. Rohrauer. For purposes of familiarizing itself with the best of technology developed by OEM's, community outreach requirements under the EcoCAR program, and as a rolling test-bed to develop and implement technology improvements, this electric transportation fleet has been invaluable. With diagnostics for items such as the battery management system, battery pack repairs and upgrades, and building up a detailed vehicle modeling simulation with Argonne’s Powertrain Systems Analysis Toolkit (PSAT), this research initiative spearheaded the launch of other programs such as EcoCAR and the APC work with GM Canada. Further plans are to increase the visibility of UOIT in the sustainable energy sector by implementing a shuttle service between campus locations with the electric buses using solar charging, and deploying existing electric vehicles to campus services like grounds keeping. Vehicle instrumentation using wireless technology to generate a database that monitors and assesses their performance is in the planning stages. This is leading to potential collaborations with bus manufacturers, Transport Canada and other parties.

Life Cycle Engineering and Greenhouse Gas Emission Measurements
Life Cycle engineering (LCE) refers to engineering activities that use new technologies and scientific principles to design and manufacture products with the goal of protecting the environment. This conserves resources, extending the product's useful life, making it easy to repair or recycle, and minimizing pollution and waste during the manufacturing, useful life, and disposal periods.

A basic question posed by a customer is: "How much CO₂ has been emitted in making this product?" Currently this information is not adequately available. The objective of this research is to develop simpler, more basic models that can be used by a manufacturer to determine the greenhouse gases emitted for a specific product, or product part, using a local electrical power grid and process specific material consumption inputs. The proposed research (led by Dr. Ham) will make a direct connection between the energy used to make an automotive product with power from a local power grid and the CO₂ emitted in making the product.

Hydraulic Launch Assist
Funding has been applied for a project entitled “Development of Hybrid Vehicles with Hydraulic Launch Assist Systems” that is led by Dr. He. This project aims to develop efficient hydraulic launch assist (HLA) systems and optimal energy management and control strategies for large hydraulic hybrid vehicles (HHVs). Hydraulic launch assist systems can
help boost the engine with hydraulic motors and provide regenerative braking during deceleration. The HLA system is one of the most effective technologies for reducing engine emissions, improving fuel economy and enhancing vehicle acceleration performance, in particular, for heavy duty vehicles such as refuse trucks whose driving cycle includes many stops. HLA systems enable regenerating and reusing significant amount of braking energy through a hybrid power-train configuration. The heavy-duty chassis dynamometer installed in ACE will provide an excellent test platform to carry out the proposed research project.

**COMPLEMENTARY AREAS OF STRENGTH**

UOIT is engaged in research areas that are complementary to ACE focus areas. These include automotive manufacturing techniques and the development of predictive tools and methods of analysis.

**Machining (Dr. Kishawy)**

High speed machining lightweight vehicle components: The objective is to expand the current effort to develop/improve machining methods and machinability for automotive parts that will constitute essential components in lightweight vehicles. These parts will be manufactured from aluminum and magnesium alloys that will foster growth in the evolving field of high speed and ultra high speed machining.

Dry machining: The costly recycling price of coolant and its associated health hazard have generated a large potential for the applications of dry machining. As it becomes more challenging to apply dry machining in industrial activities, the minimum quantity of lubricant has become an alternative solution for environmentally friendly manufacturing processes. The objective is to further develop this technology for automotive applications.

Control of automotive part surface integrity: Although achieving the desired part surface roughness and surface flatness are important aspects of manufacturing automotive parts, machining-induced residual stresses constitute an important aspect of the machined surface integrity. The objective of this research is to develop models to predict machining-induced residual stresses, and use the models to eliminate or reduce the harmful machining-induced tensile residual stresses.

**Automated Super Finishing (Drs. Zhang and Kishawy)**

Manual surface deburring and super finishing operations using hand-held tools may lead to health and safety problems. Carpal tunnel syndrome and "white fingers" (permanent numbness) are common symptoms of workers subjected to constant vibrations emanating from hand-held tools. Also, the tedious manual deburring task often results in inconsistent finish quality. The objective of this research is to develop automated deburring / finishing system using a parallel robotic machine which will operate through an optimized tool path planning routine.

**Single Point Incremental Sheet Metal Forming (Dr. Ham)**

Asymmetrical incremental forming or single point incremental forming (SPIF) is a modern sheet metal forming process that requires no dies in the manufacturing process. SPIF utilizes equipment found in standard machine shops, a CNC mill and computer aided design and manufacturing software (CAD/CAM). As there are no dies in the process, SPIF is highly flexible and can be used as a rapid prototype method. This field of research is new and investigation for potential applications is on going. Areas of interest in the automotive
industry are in the development of early prototypes and post-production, at times when dies are not available.

**Statistical Quality Control / Dimensional Accuracy (Drs. Ham and Kishawy)**

Statistical quality control (SQC) is a specialized field of applied statistics used by industries where statistical quality control is used in everyday processes. Developing research will allow for more collaboration with manufacturing companies. The study of dimensional accuracy goes beyond the study of the actual parts/vehicles that are being measured, and it becomes a systems engineering problem. Dimensional studies require understanding of the whole body-in-white (BIW) structure of an automobile. Understanding of the cause and effect of each process within the build allows the result of some of the investigations to entail part re-designs.

**Wireless Communication (Drs. Shahbazpanahi, Dong, Wang, and Grami)**

Under the APC program, the “Cognitive Car” topic lists the following three priorities:

- Vehicular Software;
- Electronics and Mechatronics for Safety and Performance Enhancement;
- Wireline and Wireless Communications for Vehicular Applications.

The ever-increasing demand for connectivity anywhere, anytime, has fueled the rapid growth of technology in wireless communications during the past three decades. The focus of research on wireless communications is expanding to include communications between moving vehicles, and between vehicles and road infrastructure. This emerging area within information and communications technologies has gained considerable attention for it can bring about an array of diverse new applications, mainly motivated by safety issues. Industrial and governmental efforts are underway in the EU, US and Japan to accelerate the research leading to the design, development, and deployment of technologies and networking functions in vehicles and highway infrastructures.

Research topics to be investigated include: design of vehicular and mobile ad-hoc and sensor networks, broadband wireless mesh networks, intelligent transportation systems, physical wireless layers, multiple antenna systems, access protocols, navigation and positioning systems, security and trust models for vehicular networks, and quality (reliability) of service. Intelligent transportation systems that integrate wireless communication-based information technology into vehicles and infrastructures to enhance driving safety, efficiency, vehicle wear, and fuel consumption are target areas. Realization of such benefits face many challenges including characterization of vehicular communication environments, traffic modeling, and effectively integrating wireless communications, computing, and sensor technologies into vehicular systems. The goal is to develop enabling technologies and methodologies for vehicle-to-vehicle (V2V), vehicle-to-roadside (V2R), or vehicle-to-infrastructure (V2I) communications, for reliable communication and wireless access that is adaptive to roadway conditions and serves to increase passenger security and safety. Specific research topics for investigation include the design of signal transmission and access protocols for short-range V2V communications through ad-hoc or sensor networking using cooperative communication techniques, and long-range communications with next generation broadband technologies and infrastructures with cognitive sensing and spectrum access.
APPENDIX 5
Automotive Engineering at UOIT

The Automotive undergraduate engineering program commenced with its first intake of students in September 2005. This cohort graduated in the spring of 2009. The Automotive program attracted 69 students in its initial year and continues to attract a healthy number of applicants since.

Undergraduate Programs and Enrolment
In addition to offering more traditional engineering programs such as Mechanical Engineering and Electrical Engineering, UOIT’s Faculty of Engineering and Applied Science has created two programs designed to provide more direct support to the automotive industry: Automotive Engineering and Manufacturing Engineering. UOIT offers the only accredited Automotive Engineering undergraduate program in Canada. In addition, UOIT’s engineering programs also have a one-year Management option. This range of engineering programs represents a comprehensive set of disciplines, which addresses the present and future needs of the automotive industry.

Enrolment in Automotive Engineering (Table 1) has been strong since its inception. Currently, there are over 170 undergraduate Automotive Engineering students at UOIT. In 2009, the Canadian Engineering Accreditation Board (CEAB) accredited the program. Table 2 provides historical enrolment data on engineering programs that have a relation to the automotive industry.

Table 1, Undergraduate Engineering Headcounts Current, (September 2009)

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Table 2, Undergraduate Engineering Headcounts, Historical

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Graduate Programs

Shortly after inception of the undergraduate curriculum, graduate programs in automotive-related areas were rapidly developed and approved. Master programs in Mechanical Engineering, Electrical and Computer Engineering, and Automotive Engineering began in September 2006, September 2007 and January 2008, respectively. The Mechanical Engineering PhD program, including an automotive field, commenced in September 2008. Enrolment is projected to increase enrolments by a multiple (~4) as the number of faculty members engaged in a particular area. There are 2 faculty members dedicated specifically to Automotive Engineering this a number of others collaborating in automotive-related areas.
1.1 Faculty Members and Space

UOIT has 14 core faculty members linked to Automotive, Manufacturing and Mechanical Engineering. In addition, UOIT has 14 professors in Electrical, Computer and Software Engineering areas. Fields such as Electrical, Computer and Software Engineering add value to the automotive industry. These faculty members will have a home in the same complex as the automotive-focused researchers.

It is expected that seven to ten full-time core faculty will have offices in the ACE facility. The remaining academic spaces will become the home of the manufacturing and mechanical engineering professors, when these areas are completed. Opportunities will be provided for industry engineers to be appointed as adjunct faculty at UOIT. Dedicated space for industry in the collaborative research areas exists, on the 5th floor for those linked directly to GM, and on the 4th floor for faculty members and their industrial partners working on collaborative projects directly related to the objectives of ACE. This space is meant to be very dynamically adjustable, based on project duration and associated needs.
Appendix 6

View Towards the Future of Test and Development Facilities

Some futurists have suggested that there is no longer need for test facilities for performing advanced technology work in automotive engineering due to advances in modeling and simulation that might replace this need. This is a myopic view, simply considering that even the military-aerospace industry, employing computer systems running at petaflops ($10^{15}$) scale throughput, aren’t yet close to using CFD as a design tool without validation. Typical test programs run 22,000 hrs for wind tunnel evaluation, a number that has been nearly constant for many decades and is not expected to decline for the next 25 years. The amount of data collected and its sophistication increases in pursuit of ever-higher performance requirements. Although for vehicular climatic evaluation, 220 hours might be more representative of one program, the trend and demands are shared. Bringing outdoor evaluation into the laboratory with a very high level of sophistication, such that it can truly be referenced and correlated to real world data, is paramount. Enjoying the consequent shortening of the design cycle that this brings to the industry is the true driver for facilities like the ACE complex from a competitiveness standpoint.

The role to be served by a high end climatic / aerodynamic capable wind tunnel, immersed in a research environment, is to establish leadership as a reference standard for all other facilities to calibrate against, and devise new and better ways to assess performance gains, as these keep getting smaller. A parallel development has to take place in the modeling and simulation fields. Although it has become much easier to produce more data in shorter periods, knowing and recognizing where to look for problems and sifting through reams of data quickly to extract relevant information, is crucial. This requires a shift to investing more in the skill set of the test engineers and operators. It also requires building on the “value-added” aspects of operating within a research environment so as to effectively deploy the latest visualization and instrumentation techniques necessary to comprehend the underlying phenomena. The emphasis must extend well beyond “evaluation according to the standard routine”. Rather, developing methods that evaluate the integrated system performance accurately in the most time efficient manner are essential.
Title of Proposal:

Thermal Management System Technology Development for Extended Range Electric Vehicles

Summary of Proposal for Public Release:

Extended Range Electric Vehicles (EREV's) represent a promising new era in automotive transportation. However, EREV's are currently limited by the lack of energy efficient and cost effective heating and cooling systems. Because the thermal management systems are electrically powered, vehicle range is reduced when the heating - ventilation -air -conditioning (HVAC) system is operating. In addition, battery thermal management is critical to the long-term cyclic durability of the battery system. It is necessary to devise new approaches that significantly reduce the HVAC energy requirements, reduce cost and control battery thermal environment over the widest range of external conditions.

This research proposal details a collaborative innovation project between University of Ontario Institute of Technology (UOIT) and General Motors of Canada, to advance technology of interlinked thermal management systems (HVAC) and power train cooling (PTC) for the next generation of EREV's. This research will build upon experience gained from the landmark first generation EREV, the Chevrolet Volt, in the areas of performance and durability, cost, and efficiency of the thermal management loops, to enable widespread commercialization of this technology.

The technology development will be focused in related disciplines, including: battery thermal management systems, thermal management architecture for EREV's, cost reduction in cabin heating, power train electronics cooling, condenser radiator fan module configuration, and finally, overall system efficiency improvements through intelligent interconnection and control of normally distinct loops.

Keywords:

Vehicle Thermal Management, Batteries, Electric Vehicle, Heating Efficiency, Cooling, HVAC, Controls, Onboard Diagnostics

Research Subject Codes:
Primary, 2108
Secondary, 2107

Area of Application Codes:
Primary, 305
Secondary, 306