INO brief for pre-budget consultations

SUMMARY
The National Optics Institute (INO) proposes coordinating a Canada-wide cluster to mobilize the entire optics and photonics industry around three so-called "disruptive" technologies: the Internet of Things, 3D printing and advanced robotics. The Internet of Things alone could reduce global greenhouse gas emissions by 19%.[1] Establishing this cluster over a five-year period would require investments of $150 million to $170 million and could have an impact of up to $10 billion on the Canadian economy.[2]

TECHNOLOGY OPPORTUNITIES
A key report published recently on trends and questions to consider for the global consumer sector identifies the prevailing forces that will continue to affect this industry leading up to 2030.[3] These forces have had and will continue to have an impact on the consumer industry. In the short and medium term, their trajectory may not be very predictable or obvious.[4] There are also trends whose trajectories in the medium and long term are more difficult to predict.

According to the authors of this report, trends that have a higher impact on the consumer industry must be taken into consideration in innovation because they are the ones that will contribute significantly to wealth creation in the years to come. Ignoring them would mean condemning the Canadian economy to depletion. Similarly, trends whose trajectories are more difficult to predict should be priority areas for two reasons. First, the country would benefit from any resulting supplementary benefits that are not directly predictable. Second, the risk associated with the unpredictable nature of the trajectory would be mitigated. The best way to predict the effect of these trends, thereby mitigating the inherent risk associated with these trends, is to be involved.

In total, six of the 13 technological advancements identified by the Benson-Armer *et al*. study (2015) are in the highly unpredictable zone, and three are in fields that INO has key expertise in: the Internet of Things, advanced robotics and 3D printing. These three disruptive technologies feed a fourth: big data for development and operations. Therefore, INO is in a very good position to propose this structuring initiative.

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[1] Cullinen, M. (2013). *Machine to Machine Technologies: Unlocking the potential of a $1 trillion Industry*, 52 p. http://www.grahampeacedesignmail.com/cwr/cwr_m2m_down_singles.pdf [consulted on July 9, 2016].
[2] The European Commission estimates that the economic leverage effect of the optics and photonics industry is more than 1/50. See Butter, M., Leis, M., Sandtke, M. *et al.* (2011). *THE LEVERAGE EFFECT of Photonics Technologies: the European Perspective*, European Commission: Delft, 194 p.
[3] Benson-Armer, R., Noble, S., and Thiel, A. (2015). *The Consumer Sector in 2030: Trends and questions to consider*, 8 p. http://www.mckinsey.com/ [consulted on June 3, 2016].
[4] See Exhibit 2 of the study cited at note 7.

POLICY OPPORTUNITIES

The Government of Canada has recognized for a number of years the importance of industrial research and development in the optics and photonics industry, including through its contributions to the creation and development of INO. Recently, it has committed to maintaining Canada's position as a leader in the optics and photonics industry: "To support the [National Optics] Institute's work with Canadian businesses, Budget 2016 proposes to provide it with $50 million over five years, starting in 2016–17."[5] This noteworthy investment shows the government's political will to see the optics and photonics industry become a full partner in sustainable prosperity and the reduction of greenhouse gases in Canada. In addition to this investment, the government has other plans to develop a broader project for a Canadian cluster in optics and photonics.

Minister Bains has already indicated the government's intention to compete in the digital world: it is one of six areas for action identified in the Innovation Agenda,[6] which further explains that this will be accomplished by developing cloud computing and driverless cars. Both these technologies rely on developments in the optics and photonics sector.

By 2030, most countries, including our own, will have adapted and improved in response to various high-level technological advances that involve significant economic benefits, such as the optics and photonics industry.

AREAS FOR DEVELOPMENT

As part of this proposal, we would like to emphasize technologies that will have a bigger impact on the consumer industry and whose trends are less predictable in the medium and long term, which will cement Canada's key role as regards these technologies:

- the Internet of Things;
- advanced robotics;
- 3D printing.

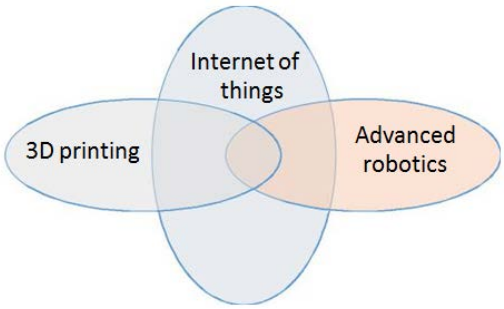

Figure 1 – The three disruptive technologies and how they relate to each other

This figure illustrates the relationship between these technologies and to what degree they influence each other.

[5] DFC (2016). *Growing the Middle Class*, p. 124. http://www.budget.gc.ca/2016/home-accueil-en.html [consulted on June 3, 2016].

The **Internet of Things** refers to physical objects that are part of our current digital world. Machinery, transportation, infrastructure and various devices are connected to a network that allows them to monitor their environment, record their status and act based on this information. People can also be equipped with networked devices.

Two major development streams are anticipated for the Internet of Things. **Photonic integration** is now recognized as being necessary for the Internet of Things to reach its full potential. Technologies such as silicon photonics and printable photonics and electronics, as well as heterogonous integration, have opened the door to miniaturization and to producing large quantities of devices at a very low cost. To succeed, the Canadian players in this field must consolidate. **Innovative sensors** are the second area for development as regards the Internet of Things. To achieve maximum efficiency, things must be able to collect relevant information, analyze it, share it and take action based on the analysis performed. The Internet of Things therefore requires the development of a plethora of sensors integrated into things. Physical, chemical and biological factors must be monitored on an ongoing basis.

Advanced robotics promotes a world with a limited need for physical human labourers, in which roboworkers working with humans could lead to a huge increase in productivity and a higher life expectancy for humans.

Work on **advanced robotics** would focus primarily on the robot's vision, comprehension and interaction with its surroundings. The robot's mobility and autonomy rely on analytical video. All aspects of analytical video will be developed, including camera mobility and calibration,[6] telemetrics, sensor fusion, and intelligent sensors. For all practical purposes, a driverless car is a specialized transportation robot.

Lastly, **3D printing** involves machines printing real objects the same way a printer creates images on paper. The field of 3D printing is progressing rapidly.

3D printing is revolutionizing the manufacturing industry by customizing production (made-to-measure and just-in-time) and rewriting the rules of mechanical design. Just as laser machining revolutionized the automotive industry by changing how pieces were designed, thereby reducing vehicle weight by around 30%, 3D printing will revolutionize the industry because it can combine a sub-assembly of 70 pieces into one.

INITIATIVE

These technologies are among those that are predicted to have the highest impact on the consumer industry by 2030. They are the most promising, not only in economic terms, but also in terms of sustainable social and economic prosperity. Recent studies show that the Internet of Things alone will reduce global carbon emissions by 19%[1] and will have an economic impact of between US$2.7 trillion and US$6.2 trillion around the world.[2]

INO proposes taking on a leadership role in developing a Canada-wide development project that would bring all stakeholders in the optics and photonics industry together in a cluster, with a focus on

[6] The following example, provided by one of our partners, highlights the importance of calibrating mobile cameras. The company had a group of robots at Ground Zero in New York in 2001. During the search, a robot with uncalibrated cameras identified what appeared to be a human skull. Following procedure, a team was deployed to the site to recover the remains. However, it turned out that the object in question was a small pebble (1 cm) in the shape of a skull. This shows the importance of being able to identify the size of an object in an image (calibration).

disruptive technologies with a significant economic impact. Over a five-year period, the Government of Canada's investment would be between $150 million and $170 million and would have an economic impact of roughly $10 billion.[1]

STRUCTURAL ELEMENTS

As government officials already know, the most effective international innovation strategies are developed and established by stakeholders that exhibit four types of behaviours.

1) They understand that innovation is a multi-step process with many stakeholders that transform ideas and knowledge into products or services that are commercially attractive and viable.
2) They target specific strong industries.
3) They identify key generic and enabling technologies.
4) They favour groups that bring together all stakeholders.

Figure 2 gives a representation of this type of strategy over the long term. The matrix shows how the technology penetrates over time and can be applied to a number of economic sectors.

[ROWS]: OPTICS AND PHOTONICS, DIGITAL, …

[COLUMNS]: ENERGY, RESIDENTIAL, INFRASTRUCTURE, TRANSPORT, MANUFACTURING, AGRI-FOOD, HEALTH, …

Figure 2 – An effective international innovation strategy in matrix format

More generally speaking, the optics and photonics industry must be tied to markets. This natural closeness and cohesion is what shapes a cluster. For example, leading-edge infrastructure in the areas of silicon photonics, electronics, photonic printing must be integrated in order to create a powerful world-class entity.

The close relationships INO has built across Canada in a variety of fields, based on needs the optics and photonics industry can meet, have put INO in a position to achieve the growth goals in question. As Minister Bains said in his speech on June 14, 2016, to launch the Innovation Agenda,[7] fostering an entrepreneurial and creative society that will focus on sustainable growth and social and economic prosperity means recognizing the interconnectedness of science, insight and innovation. In the optics-photonics industry, INO aspires to be and is well positioned to play this connecting role.

The planned structure of an industrial cluster would bring together all the relevant stakeholders to accelerate the transformations stemming from progress in the optics and photonics industry. Regional offices with laboratories and implementation areas would be established near industry and other market players.

The cluster activities would be as follows:

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[7] http://news.gc.ca/web/article-en.do?crtr.sj1D=&crtr.mnthndVl=6&mthd=advSrch&crtr.dpt1D=&nid=1084709&crtr.lc1D=&crtr.tp1D=&crtr.yrStrtVl=2016&crtr.kw=&crtr.dyStrtVl=14&crtr.aud1D=&crtr.mnthStrtVl=6&crtr.page=2&crtr.yrndVl=2016&crtr.dyndVl=14&_ga=1.32274550.913366849.1454081339

- Mobilizing, pooling knowledge and coordinating activities for the entire Canadian optics and photonics community so that the Canadian economy can fully benefit from the growth stemming from the Internet of Things, 3D printing and advanced robotics;
- Selecting, organizing and carrying out strategic innovation projects in the optics and photonics field, in partnership with other industries and market players;
- Implement linkage activities;
- Establishing forums for sharing knowledge, such as *Photonics North;*
- Organizing joint symposia on optics and photonics between target industrial sectors;
- Distributing the potential of the optics-photonics industry across various sectors;
- Establishing an intellectual property market.

Beyond the first five years, the Canadian economy will reap the benefits from the initial careful investments—not only economic benefits, but also social, environmental and political benefits.