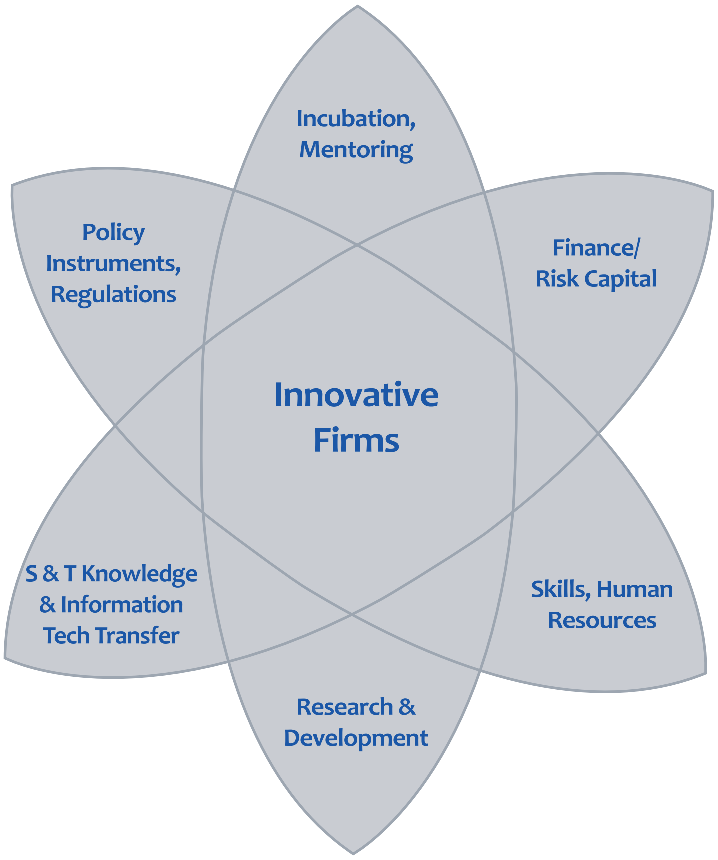
Canadian Aluminium Transformation Technology Roadmap

2006 EDITION
Complete version

National Research Council Canada
Conseil national de recherches Canada

Canada

RÉSEAU TRANS-Al



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POSITIONING, TRENDS AND STRATEGIC ISSUES OF THE CANADIAN INDUSTRY

Cover page: The six-pointed, star-shaped layout makes reference to a technical cluster concept, in which technical and human expertises are essential. Technology, expertise, research, funding, mentoring and political tools are the essence of innovation in aluminium industry businesses.

The present document is a joint effort of Réseau Trans-Al Inc. and NRC's Aluminium Technology Centre with the financial support of the following partners: Canada Economic Development for Quebec Regions, Aluminum Association of Canada and the Ministry of Economic Development, Innovation and Export Trade of Quebec.

Note: The Canadian spelling for the word "alum**i**nium" is used by choice throughout the text. However, readers may find "aluminum" when references are made to a document title or an association that uses this spelling.

ISBN 978-2-9809883-1-8

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ACKNOWLEDGEMENTS

The NRC-Aluminium Technology Centre, Réseau Trans-Al Inc. and its many partners would like to thank the following people for their assistance and contributions to this project.

CANADIAN ALUMINIUM TRANSFORMATION TECHNOLOGY ROADMAP (TRM) STEERING COMMITTEE MEMBERS

Boismenu, Marc	General Motors of Canada Limited
Boulé, Eric	Alcan Inc. *(Representing Aluminum Association of Canada)*
Deschênes, Jean-Pierre	Canada Economic Development
Dubé, Michael J.	Ontario Ministry of Economic Development and Trade
Dufour, Gilles	Alcoa Inc. *(Representing Aluminum Association of Canada)*
Duval, Maurice	Aluminium Research and Development Centre of Quebec (CQRDA)
Duval, Johanne	Industry Canada
Fedchun, Gerald B.	Automotive Part Manufacturers' Association
Houde, André	*Ministère du Développement économique, de l'Innovation et de l'Exportation, Québec*
Jackman, Jennifer	Natural Resources Canada CANMET
Lavoie, Robert	Canada Economic Development
Marceau, Daniel	Aluminium Research Centre REGAL
Martin, Jean-Pierre	NRC-Aluminium Technology Centre
Melhem, Nafez	NRC-Industrial Materials Institute
Paré, Jean	Alfiniti Inc. *(Representing Réseau Trans-Al Inc.)*
Pouliot, Jean-François	Réseau Trans-Al Inc.
Simard, Alain	NRC-Aluminium Technology Centre
Trindade, Carlos	Bombardier
Worswick, Michael J.	University of Waterloo

Everyone who contributed by their participation at the five workshops in Ontario and Québec:

Transportation Workshop	
Beaulieu, Denis	*Centre de recherche industrielle du Québec* - CRIQ
Boismenu, Marc	General Motors of Canada Limited
Border, Kerry	Toyota Motors Engineering & Manufacturing North America, Inc.
Chappuis, Laurent B.	Ford Vehicle Operations
Couture, Ghislain	Bombardier Recreational Products Inc.
Dufour, Gilles	Alcoa Inc.
Duval, Johanne	Industry Canada
Frise, Peter	AUTO21, Network of Centers of Excellence
Fuerst, Carl	General Motors of Canada Limited
Gattaz, Isabelle	*Ministère du Développement économique, de l'Innovation et de l'Exportation, Quebec*
Kennedy, Dan	Promatek Research Centre
Laplante, Jean-François	Alcan Inc.
Lasnier, Yves	Indev Inc.
Lemay, Claude	Mingan Industries Inc.
Martin, Jean-Pierre	NRC-Aluminium Technology Centre
Moore, David	Aluminium Consultant
Propeck, Jan	Alcan Inc.
Sherman, Andy	Ford Research & Innovation Center
Skszek, Tim	Physical Cosma Engineering
Smith, Philip E.	Alcoa Technical Center
Stephen, Gail	Bell Helicopter Textron Canada Limited
Worswick, Michael J.	University of Waterloo

Construction Workshop	
Beaulieu, Denis	*Centre de recherche industrielle du Québec* - CRIQ
Becker, Allan	Aluma Systems Canada Inc.
Biscaro, Alberto C.	*Institut de recherche d'Hydro-Québec* *Laboratoire des technologies de l'énergie in Shawinigan*
Brisson, Alex	Roche Ltée
Elmaraghy, Rachik	SAFI Quality Software Inc.
Kissel, Randolph J.	The TGB Partnership
Morin, Daniel	Kawneer Montreal Service Center
Morin, Jean-Luc	*Ministère du Développement économique, de l'Innovation et de l'Exportation, Quebec*
Nabhan, Fadi E.	NRC-Institute for Research in Construction
Perron, Jocelyn	*Les Volets Josuma Inc.*
Pronovost, Claude	Gentek Building Products Inc.
Sanders, Robert E.	Alcoa Technical Center
Tremblay, Pierre	Tectal Inc.

Shape Casting Workshop	
Ajersch, Frank	*École Polytechnique de Montréal*
Andrews, Neil	Breyer Casting Technologies
Bouchard, Dominique	NRC-Aluminium Technology Centre
Brochu, Christine	*Alixium Développement Inc.*
Gallo, Rafael	Foseco Inc.
Gupta, Kris (K.K.)	Fabrication Powercast
Hamel, François	NRC-Aluminium Technology Centre
Houde, André	*Ministère du Développement économique, de l'Innovation et de l'Exportation, Quebec*
Kennerknecht, Steven	Aluminium Consultant
Loong, Chee-Ang	NRC-Aluminium Technology Centre
Major, Fred	Alcan International Ltd.
Marin, Gheorghe	FluoroSeal Inc.
Martin, Jean-Pierre	NRC-Aluminium Technology Centre
Melhem, Nafez	NRC-Industrial Materials Institute
Morin, Guy	*Centre intégré de fonderie et de métallurgie*
Osborne, Mark	GM Powertrain
Rooy, Elwin	Rooy and Associates
Sahoo, Mahi	Natural Resources Canada CANMET
Shankar, Sumanth	McMaster University

Forming Workshop	
Border, Kerry	Toyota Motors Engineering & Manufacturing North America, Inc.
Gakwaya, Augustin	Laval University
Jahazi, Mohammad	NRC-Institute for Aerospace Research
Kennedy, Dan	Promatek Research Centre
Larouche, Sylvain	Alcan-Automotive Structure Plant
Martin, Jean-Pierre	NRC-Aluminium Technology Centre
Martin, Pierre	Natural Resources Canada CANMET
Moore, David	Aluminium Consultant
Quinn, John J.	Bell Helicopter Textron Canada Ltd.
Rahem, Ahmed	NRC-Aluminium Technology Centre
Smith, Philip E.	Alcoa Technical Center
Walters, Cam	Amino North America Corporation
Wilkinson, David S.	McMaster Manufacturing Research Institute

Joining, Surface Treatment and Machining Workshop	
Altshuller, Bernie	Welding Consultant Inc.
Arsenault, Bernard	NRC-Aluminium Technology Centre
Attia, Helmi	NRC-Institute for Aerospace Research
Beaulieu, Denis	*Centre de recherche industrielle du Québec*
Caya, Jacques	Industries Jaro
Courval, Greg	Novelis Global Technology Centre
Deveaux, Marlène	*RSM – Revêtement sur métaux*
Duval, Maurice	Aluminium Research and Development Centre of Quebec (CQRDA)
Gagnon, François-Olivier	NRC-Aluminium Technology Centre
Gougeon, Patrick	NRC-Aluminium Technology Centre
Hamel, François G.	NRC-Aluminium Technology Centre
McCleary, Sherri F.	Alcoa Technical Center
Paré, Jean	Alfiniti inc.
Perron, Jean	UQAC-Anti-icing Materials International Laboratory
Quinn, John J.	Bell Helicopter Textron Canada Ltd.
Simard, Daniel	*Groupe EDS*
St-Georges, Lyne	REMAC Industrial Innovators
Tan, Ayravuth	Bombardier
Thibaudeau, Jean-Philippe	Usimet
Tounsi, Nejah	NRC-Institute for Aerospace Research

TRM Project Team

Congratulations to the TRM Project Team for the successful completion of such an ambitious project within budget and for exceeding the expectations of Steering Committee Members.

Thank you to **Mr. Jean-François Pouliot** of *Réseau Trans-Al* for accepting the role of Project Leader and helping the Project Team stay focused on the objective, all the while respecting the opinions of each member. Mr. Pouliot has been the General Manager of Trans-Al since 2003. He has also been a privileged witness of the many achievements of Quebec SMEs in aluminium transformation. Every month, his duty is to meet with dozens of managers, engineers and entrepreneurs working in the aluminium transformation industry.

Thank you to **Mrs. Marie-Christine Gagnon** of *Réseau Trans-Al* for her flawless organisational skills and her unlimited and dedicated involvement as Project Coordinator for 18 months. Mrs. Gagnon has been working in the aluminium transformation industry since the early stages of her career. She has worked in various types of fields, including: research and development, product design, quality and control. She has also distinguished herself as a production, fabrication and construction project manager in the aluminium industry and numerous other aluminium markets. Mrs. Gagnon originally worked in small and medium-sized businesses where she held various kinds of management positions, in which she has a proven record of success.

Thank you to **Mr. Alain Simard** of *NRC-ATC* for his dedicated work and for using his numerous contacts within the Canadian aluminium industry and abroad to help the TRM project. Mr. Simard is presently working as ATC's Business Development and Communications Officer. At the beginning of his career, he played a leading role in the aluminium industry at ABB-Bomem in Quebec City, where he worked, in collaboration with ARDC in Jonquière, on the development of various types of molten aluminium analysis instruments. Over the past 20 years, he has held many positions at ABB-Bomem, Alcoa and NRC, including: Project Manager, Section Head, R&D Manager, After-sales Service Manager and Business Unit Manager.

Finally, thank you to **Mrs. Caroline Gaudreault** of *NRC-ATC* for the assistance she provided to the team in preparing the numerous documents, progress reports, charts, tables and survey booklets that were necessary to prepare the workshops, surveys and, of course, the document your are now holding in your hands.

Expert Consultants:

We would especially like to thank our two expert consultants who helped us have a better understanding of the aluminium industry and guided us in the development of a structured approach throughout this process.

To ***Mr. David M. Moore***, Vice President Alcan Automotive (retired). Thank you for your patience and always being there when needed. Mr. Moore generously accepted, on numerous occasions to read endless amounts of texts, explain concepts in more simple terms and share his point of view.

To ***Mr. André Girard***, President of GRI Consultants Inc. Mr. Girard is a former plant manager at Alcan Laterrière and a former vice-president of ABB Canada Inc. Thank you for your diligence and organisational skills that helped guide TRM workshops and also for respecting the ideas that were shared during follow-up activities.

We would also like to thank the following individuals for their valuable assistance: Mr. Jean-Paul Huni, Mr.Ghyslain Dubé (Alcan-ARDC), Mr. Denis Beaulieu (CRIQ), Mr. Fred Major (Alcan-KRDC), Nejah Tounsi (NRC-IAR), Mr. Bernie Altshuller (Welding Consultant), Mr. Bernard Arsenault (NRC-ATC), Mr. Julien Gendron (Alcan), Mr. Jacques Ménard (Alcan), Mr. Daryoush Emadi (CANMET), and Mrs. Virginie Bizier and Mrs. Marie-Thérèse Gagnon (Reseau Trans-Al Inc). Mrs. Lyne Bélanger and Mr. Luc Charron of Canada Institute for Scientific and Technical Information (NRC-CISTI) for the literature retrieval work they conducted for us. Mr. James F. King and Aluminium Association for using their data.

Very special thanks go to Mrs. Donia Bergeron and Mrs. Raphaëlle Prévost-Côté of *Les Presses de l'aluminium* (PRAL) for their generous contributions during the workshops.

We would like to express great thanks to all our survey respondents.

Translation: Les Traductions Québec-Amérique Inc. Alma, Quebec

Graphic Design: Eckinox Média, Alma, Quebec

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EXECUTIVE SUMMARY

The present Technology Roadmap (TRM) led us to three observations:

1- **The last 25 years of effort to transform more aluminium[i] has yielded some positive results. In particular, significant progress has been observed since the last Canadian aluminium roadmap in 2000. Critical mass required to have an impact and generate momentum is being reached, especially in Quebec.**

2- **Entrepreneurs in the transformation sector should concentrate on innovative processes and products that exploit advanced technologies and in-depth knowledge of aluminium.**

3- **The Canadian aluminium industry faces a brief window of opportunity to make its mark on the international aluminium transformation scene such that Canada is perceived to be the place where innovation and aluminium come together – where transformation technology is at the leading edge and thriving.**

Situation

The publication of the Canadian Aluminium Industry Technology Roadmap in 2000 brought positive, tangible results, one of them being the creation of the National Research Council's Aluminium Technology Centre.

Almost seven years after the TRM-2000, it is clear that the relative importance of Canada as a primary producer is decreasing in spite of increased production. This can be explained by massive production growth in countries such as China. The situation is the same for semi-finished products. In the next few years, we will lose our position as the world's 10th largest producer of rolled products. Meanwhile, we are importing more extruded products from overseas while only maintaining the status quo with respect to the production of shape castings, without necessarily being a major player.

The North American aluminium industry is largely vertically integrated, with the manufacturing chain distributed between Canada, the United States and even subsidiary operations in Europe. Thus Canada imports much of its semi-finished aluminium products despite its large primary metal production.

In order to resist the progressive leakage of finished product manufacturing to emerging economies, Canadian manufacturers are encouraged to invest in leading-edge design and manufacturing technologies rather than attempting to defend mature methods. Advanced modeling design techniques and fully-automated manufacturing, combined with a full awareness the capabilities of aluminium will facilitate customer acceptance and even preference for aluminium.

Markets

In tandem with the rise of worldwide production, aluminium consumption will grow significantly all over the world in the next ten years. By 2015, Asia is expected to consume twice as much aluminium as North America. These facts could mean an interesting windfall for the Canadian aluminium transformation industry. A prodigious array of possibilities will be distributed among markets.

*[i] The Canadian spelling for the word "alumin**i**um" is used by choice throughout the text. However, readers may find "aluminum" when references are made to a document title or an association that uses this spelling.*

Depending on social choices, the growth of aluminium consumption in the transport industry will be between 20% and 70% in North America. In any case, synergy is necessary to better control the technologies that allow us to develop winning applications, and greater potential for the creation of wealth. Several emerging and growing technologies now need a multi-material and systems approach to achieve increased usage. It is, therefore, necessary to develop an understanding of the mechanisms of material combinations and favour designer training. This would allow the Canadian industry to seize a multitude of opportunities that would be applicable in diverse markets.

The construction industry is continuing to expand. Over the next 10 years, a growth of 58% on the Asiatic continent should take place, with a comparative rate of 20% for Europe and North America. The lack of promotion and information to the public limits the introduction of a number of emerging and leading edge applications. The competitiveness of aluminium must be enhanced so that winning strategies in our own and world-wide niches can be deployed. This can be accomplished at several levels, whether taking advantage of systems approach, life-cycle analysis or through the combination of multiple materials.

Technologies

At the level of technology platforms, the needs for the aluminium transformation industry are striking. With the aid of state-of-the-art technologies, developing countries are gaining ground in the shape casting and forming sectors. Soon, these countries will do the same for products requiring leading edge and leading edge technologies, and the technological gap will be reduced ushering in fierce competition. Methods and techniques on aluminium-joining must be better deployed in Canadian industries. Methods respecting the environment and health of workers have also been called for in the surface treatment industry. Furthermore, offering surface treated alloys with improved properties could open the door to new niche markets. Promotion for machining and training support for new machining equipments and processes would revitalise this technology platform.

The most important technical issues are a) the development of new aluminum products having superior performance, produced using more efficient processes and b) better access to predictive and actual product performance testing facilities so as to meet the most demanding needs of the transportation, construction and energy industries.

Social and Economic Factors

Canada currently possesses knowledge at the most recent and advanced technological level and must continue to count on this technology. Nonetheless, it is necessary to consider human-based issues such as knowledge acquisition and training to be able to stay at the forefront of the industry. A rapid deployment of new production capacities will help ensure we remain competitive.

Canadian industry should immediately get together to rise up to the challenge. It is a bold commitment but a doable one. For example, technology deployment activities or collaborative R&D could well reduce risks and allow for optimal usage of equipment and resources.

According to specialists in workshops, several opportunities for successful aluminium promotion might be missed if support organisations and other institutions do not collaborate and cooperate amongst themselves. **Systematic coordination** of these collaborations, which is seen to be lacking at the moment, along with an actual commitment to work together is of the utmost importance to ensure the greater good.

Manufacturers and Specialized Equipment Suppliers

Canadian manufacturers and specialised equipment suppliers can count on favourable prospects worldwide. However, having a better idea of the production technologies used by their clients and targeted markets would make it possible for Canadian suppliers to offer the **best total solution** to their customers.

Result

From these observations come **four recommendations** that will allow the Canadian industry to consolidate its position. **Thirty-eight needs and opportunities** were also selected for their potential to create wealth, reasonable time frames and achievable technical challenges. Appropriation of these recommendations and opportunities by the stakeholders of the aluminium transformation field will allow Canada to step into a leading position.

Opportunities

Industry experts analysed the thirty-eight opportunities listed below and provided clear and concise summaries for each of them. Moreover, the benefits most likely to be generated by these opportunities are also presented in this document.The following opportunities were found to be particularly relevant:

Transportation

1. Offer integrated aluminium solutions to OEM manufacturers
2. Develop multi-material solutions
3. Research & Develop alloys with higher strength and heat resistance for diesel engine
4. Research & Develop high formability, low cost, high strength aluminium alloys
5. Design lighter structures for trucks, buses, and recreational vehicles
6. Invent methods to produce larger castings with thinner walls
7. Achieve a significant cost reduction for the various aluminium transformation processes
8. Improve wear resistance, tribology and lubrication of aluminium surface

Construction

9. Upgrade aging civilian infrastructures
10. Offer modular structures for easy on-site assembling
11. Offer large extruded shapes
12. Develop integrated design software for aluminium
13. Offer an Aluminium Design Solutions Centre

Shape Casting

14. Perform alloy development for semi-solid rheocasting of structural components
15. Develop a ''Best Practice Guide for Shape Casting''
16. Offer aluminium Casting Competitiveness Tools
17. Make products from readily available liquid alloys from Canadian primary plants
18. Offer non-competitive process optimisation
19. Improve real-time monitoring of products and processes with advanced sensors and systems
20. Improve and diffuse energy efficiency solutions for foundries
21. Offer larger castings with thinner walls

Forming

22. Create an aluminium life cycle cost/benefit body of knowledge
23. Design Aluminium multi-material flat panels
24. Research & Develop aluminium hydroforming
25. Improve process simulation of forming technologies
26. Invent new forming processes suitable to industry needs

Joining

27. Develop a body of knowledge on adhesives
28. Form an interest group on friction stir welding of aluminium
29. Develop or adapt sensing technologies for aluminium surface characterization

Surface Treatment

30. Offer prepainted sheet products capable of surviving forming operations
31. Develop chrome-free conversion treatment
32. Offer low-cost, decorative metal texturing
33. Develop a paint that can be applied to aluminium substrate without using conversion films
34. Research & develop a treatment to prevent the adhesion of ice to aluminium surfaces

Machining

35. Form an interest group on aluminium machining
36. Automate measurement systems to optimise part positioning and enhance equipment performance
37. Promote adoption of aluminium dry machining or MQL (Minimum Quantity Lubrication)
38. Develop analytical tools, numerical simulations, and software capabilities for aluminium machining

Recommendations

The information put forth by the many industry players that took part in TRM surveys, workshop plenary assemblies, and follow-up activities have lead to the following four recommendations:

1. **Ensure a systematic coordination and cooperation of all aluminium transformation industry players.**

2. **Develop the Canadian capacity to designing <u>for</u> aluminium instead of simply manufacturing <u>out of</u> aluminium.**

3. **Promote continuous training in the aluminium industry (architects, engineers, and designers).**

4. **Update the Canadian Aluminium Transformation Technology Roadmap.**

1. INTRODUCTION

Although aluminium stands out as a fairly young material, Jules Verne had already imagined an aluminium-made rocket in his 1862 novel *From the Earth to the Moon* [ii]. Today, almost 150 years later, aluminium has become a standard in the aerospace industry and a material of choice for an endless array of products in every market area.

The transformation of aluminium is a thriving and profitable industry with a bright future on the horizon. World consumption[iii] for aluminium and aluminium-based products has exceeded 44 million metric tons in 2005 for an economic activity that can be estimated at over $300 billion annually.

Aluminium has a number of unique properties that gives it an edge over the competition. It is very light, has great tensile strength, possesses a high degree of conductivity is resistant to corrosion and is infinitely recyclable. It is first used to manufacture various types of semi-finished, drawn/wire, extruded, shape cast and forged products. These products are then processed into finished products (consumer durable goods) intended for various markets, including transportation, construction, packaging, electricity, engineering, machinery and equipment, etc.

Aluminium is a powerful development tool for numerous Canadian businesses looking to secure a place among the global leaders presently working to satisfy the ever increasing demand of many countries. For instance, the United States, China and Japan, alone, consume seven times more of the metal than Canada's total production of primary aluminium.[iv]

Today, the Canadian aluminium transformation industry must clearly identify the trends and strategic issues that need to be addressed, so as to remain competitive in an ever-changing market where new materials are appearing regularly and well-established industries are battling to regain lost ground.

In order to secure its growth and remain competitive, the industry has to be at the cutting edge of innovation and adapt quickly. Furthermore, it must target and use the technologies that will best suit its context, i.e. niche or mass markets, and be able to rely on a highly developed and effective innovation system that can be rapidly deployed.

The Canadian aluminium transformation industry will remain in the race only if it can be better and more efficient than its competitors around the world. Maintaining the status quo is the least acceptable strategy in this era of trade globalisation.

The Canadian Aluminium Transformation Technology Roadmap (TRM) is, first and foremost, a strategic tool enabling Canadians to identify their future needs and set up the plans required to satisfy them, thus creating greater wealth for our country.

The main purpose of this document is to analyse the Canadian aluminium transformation industry in accordance to technologies and markets. To this end, a large group of experts, in aluminium transformation technologies and markets, have provided a detailed picture of the Canadian industry's market position and identified the trends and strategic issues that need to be fully explored. This initiative paves the way for new types of collaboration, shows our nation's strong spirit of cooperation and fosters synergy among the industry's role players - three essential ingredients that will guarantee our success!

[ii] *Association française de l'aluminium*
[iii] *James F. King*
[iv] *Aluminum Association*

2. TECHNOLOGY ROADMAP 2006 CONTEXT

The Canadian Aluminium Industry Technology Roadmap was released in September 2000 and presented a general overview of Canada's production and transformation industry. The Roadmap put forth eight recommendations aiming to consolidate and expand markets, and featured 47 technological projects that were to satisfy the market needs and priorities of that time.

2.1 FOLLOW-UP TO THE CANADIAN ALUMINIUM INDUSTRY TECHNOLOGY ROADMAP 2000

In 2005, the initial production stages of the new Canadian Aluminium Transformation Technology Roadmap were deemed an excellent opportunity to assess the spin-off the Canadian Aluminium Industry Technology Roadmap had generated for the industry. A detailed analysis of the data has led to the following observations:

- Most of the recommendations made in the 2000 Edition of the TRM were implemented locally.
- Substantially all of the 47 technological projects were implemented, 17 of which yielded interesting technical results, and numerous others were still active during the assessment exercise.

2.1.1 TRM 2000 – 8 RECOMMENDATIONS

1. In November 2004, the National Research Council of Canada inaugurated the **Aluminium Technology Centre** in Saguenay. This major achievement met the first recommendation of the TRM – **To create a Canadian aluminium research and development institute**.

   The organisation presently includes 45 researchers and technicians. R&D activities conducted by NRC's ATC cover three main areas: advanced forming technologies, joining technologies and computer simulation methods.

   The NRC-ATC has built partnerships with numerous businesses (Alcan, General Motors and a wide array of SMEs), universities and other academic institutions. It has also regularly worked hand-in-hand with regional, provincial, national and international industry players to organise many symposiums and other types of events.

   Current studies carried out in Canada show that aluminium-based businesses are located in very specific regions – a trend that makes them much more competitive. These results were documented in certain studies and works (Wolfe 2003, Wolfe and Lucas 2004, Wolfe and Lucas 2005). The studies **highlighted the importance for public institutions to take part in these research clusters**, be they public-owned research laboratories, such as NRC centres, or universities[v].

2. The second recommendation stated the necessity to **ensure a follow-up to the technology roadmap on a yearly basis**. The initial follow-up activities took place in 2005 when the planning phase of the new Canadian Aluminium Transformation Technology Roadmap project began.

3. As far as the third recommendation was concerned, the TRM highlighted the need to **coordinate research and development activities**. It is clear that the province of Quebec continues to promote the development of aluminium in an effort to make it a competitive material in a wide variety of markets. Indeed, the development of efficient infrastructures such as the Aluminium Research and Development Centre of Quebec (CQRDA), Aluminium Research Centre (REGAL), Centre universitaire de recherche sur l'aluminium (CURAL) and NRC's Aluminium Technology Centre (ATC), has enabled stakeholders to work hand-in-hand on a regular basis on a wide range of projects. The remainder of Canada puts an emphasis on finished products aimed at very specific markets and takes advantage of the support provided by organisations such as Auto21 (transportation sector), which in turn benefits from support provided by various partners, including: the Centre for Research on Transportation, Centre for Automotive Materials & Manufacturing, Transport Canada, etc.

[v] *Hicking, Arthurs & Low, "Base study on technology cluster initiatives", NRC-CNRC, internal report, p. 35, 2005*

4. In its fourth recommendation, the TRM also emphasised the importance of **encouraging the development of equipment for the aluminium production sector and software for all areas of the industry**. Alliances of equipment manufacturers (SME) were formed, and many businesses are benefiting from the advantages provided by such networks, thus simplifying and enhancing the design and fabrication of parts for the aluminium production industry. Certain types of specialised industry-oriented software are presently under development.

5. The fifth recommendation recognised the need to **support the development of value-added products**. In Quebec, Federal and Provincial agencies and many other types of organisations, such as Réseau Trans-Al Inc., offer support to businesses specialising in secondary aluminium. Moreover, certain large-scale aluminium producers have accepted, through numerous agreements, to create jobs in the secondary aluminium sector. Concrete actions have been taken and are still in effect.

6. The necessity **to reinforce linkages among industries, universities and research centres** was the sixth recommendation put forth by the TRM. To that end, many activities, including Synergie-Al, CentrAl and the Trans-Al Congress have been organised to strengthen bonds between stakeholders. Moreover, the increased participation of industry players to COM2006 (Conference of Metallurgists) did not remain unnoticed.

7. The seventh recommendation demonstrated the need to **build specialised aluminium teaching/training curricula**. This was successfully achieved through the development of vocational, college and university undergraduate and graduate programmes presently being offered in selected academic institutions.

8. The eighth and final recommendation was to **conduct market surveys on various aluminium manufacturing sectors and disseminate the findings**. Even though a few studies are currently under way, this objective has only been partially achieved so far.

In light of the information stated above, it can easily be concluded that the full spectrum of activities resulting from the production of the Canadian Aluminium Industry Technology Roadmap 2000 have produced positive returns, while limited to Quebec, and visibly demonstrated that the needs identified during the process were indeed real.

2.2 THE CURRENT SITUATION

More than six years after the introduction of the Canadian Aluminium Industry Technology Roadmap 2000, the needs of businesses have become clear; since the production of primary aluminium will essentially be under the control of two companies in Canada from now on, they have asked us to make **the transformation of aluminium the focal point of the new Technology Roadmap**.

In 2002, NRC began the construction of a state-of-the-art research centre whose main task is to be a catalyser for the emerging aluminium cluster. The centre also provides numerous support services to cluster members seeking for the most cost-effective ways for various types of industries to transform aluminium into durable, lightweight products. Furthermore, to ensure the technology cluster focuses on the objectives that are the most likely to be successfully achieved and generate the highest payoffs, NRC has designed a strategic plan aiming to develop two major areas of the transformation industry; advanced forming technologies and joining technologies.

Businesses looking to use the potential of aluminium as a development enabler want information relating to the market trends and strategic issues they will be confronted with. Which technologies are sure to guarantee success? Which ones will be reserved for niche markets and which ones for mass markets? What are the stakes involved in the markets of major manufacturing industries that use aluminium? Which obstacles will need to be overcome? What challenges will have to be met? How can we access future development potentials? These are the questions Canadian entrepreneurs will have to deal with to remain competitive on today’s markets. Thereupon, it quickly became obvious that the present project should focus on conducting an analysis of aluminium transformation with regards to technologies and market requirements, instead of updating the original TRM of the Canadian aluminium industry, which largely dealt with issues related to aluminium production.

3. THE OBJECTIVE AND SCOPE OF THE TECHNOLOGY ROADMAP

The data collected during the Canadian Aluminium Industry Technology Roadmap 2000 process has helped to better define the main objective of the Canadian Aluminium Transformation Technology Roadmap. It was agreed to the following:

Provide the Canadian aluminium transformation industry with information on market trends in a global context and identify technology or commercial activities offering the greatest potential for the creation of wealth.

A steering committee, bringing together a representative cross-section of aluminium industry members, was created to define the basic technical issues involved in this exercise. With representatives from such a wide array of sectors, it was relatively simple to understand the expectations of industry stakeholders and recognise the legitimacy of such a process. From then on, it was possible to join forces to meet common essential needs, overcome major strategic issues and set adequate performance requirements that reach targeted objectives. Numerous financial partners, wanting to do their share to help advance the Canadian aluminium transformation industry, also took part in the process.

3.1 METHODOLOGY

This edition of the Canadian Aluminium Transformation Technology Roadmap is the result **of a process that took a little over two years**. In order to provide quality work that meets the expectations of industry players, a rigorous procedure was followed by professionals to ensure the validity of the information contained in the new TRM right from the very beginning.

3.1.1 PHASE A: PRELIMINARY STEPS

The first phase included the four steps required to plan the process from beginning to end, thus making it possible to anticipate any difficulty that could have arisen throughout the course of the project. These key steps are described as follows:

- **To have a preliminary study conducted by the NRC** on the technology manufacturing platforms used to produce aluminium-based products
- **To create a steering committee** comprised of members of the organisations that participated in the Canadian Aluminium Industry Technology Roadmap 2000 process. The steering committee was initially made up of 10 members but was expanded to include an additional 19 members when funding arrived - thereby ensuring true Canadian representation
- **To draw up a work plan and funding applications** to be submitted to Canada Economic Development (CED), the Aluminium Association of Canada and Quebec's *Ministère du Développement économique, de l'Innovation et de l'Exportation*
- **To develop a project team and choose the various technical experts** required to develop a TRM that meets the objective, overcomes technical obstacles and stays within allocated budgets. Project team members and technical experts had to be recognised professionals and key figures in their respective fields.

3.1.2 PHASE B: DEVELOPMENT OF THE TRM

After the completion of the first phase, three new steps made it possible to gather the information required to develop the technology roadmap.

- The first step included two objectives: to use various types of informational sources (literature review and other relevant analyses) to **assess the spin-off generated by the first TRM (2000) and table an updated portrait of the industry**. A progress report weighed the status of the 8 recommendations and 47 technological projects of the TRM 2000. Moreover, the report presented the overall performance of the industry, in terms of global aluminium production, markets and aluminium transformation technologies.

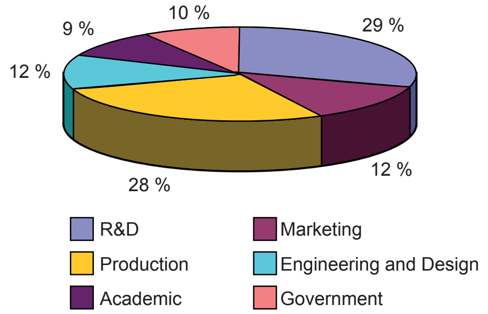
- In the second step, research efforts were put forth to achieve the following:

  - Use the views of specialists and large-scale users of aluminium to **table a comprehensive portrait of the industry** in two main areas: technologies and markets;

  - Have industry manufacturers and scientists **use pre-selected themes to build a list of the opportunities and technological and commercial needs** holding the greatest potential for the Canadian industry.

These two objectives have led to the creation of a 50-plus-page survey, written in both official languages, covering a variety of fields, including: technologies, markets, goods and services suppliers and generic requirements. **The survey was filled out by 106 specialists from a full range of specialty fields** (see Figure 1) and industry sectors. The majority of respondents were from Canadian-based organisations, while the remainder were from various other regions around the world.

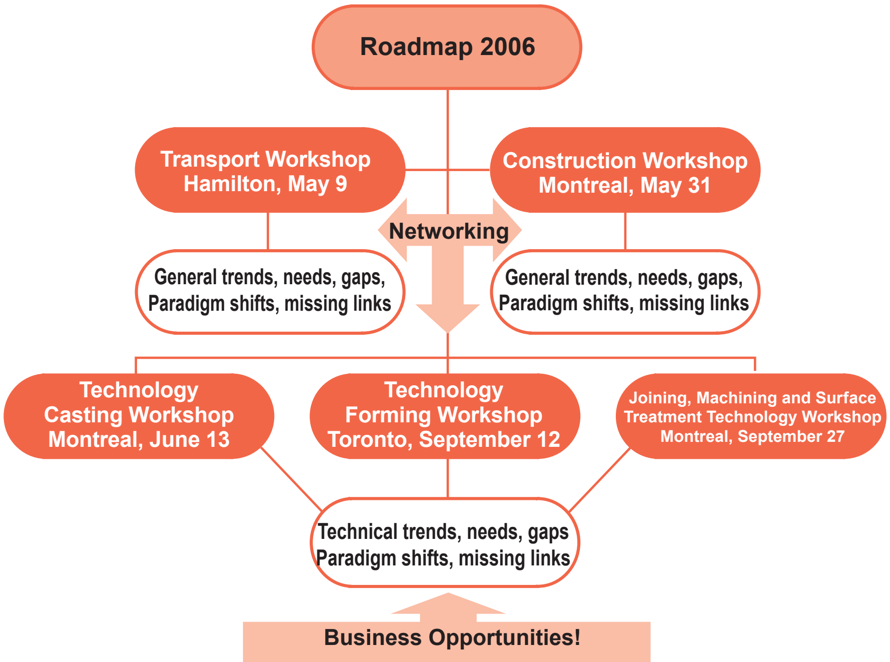
Figure 1: *Area of Expertise of Respondents*



Source : Compilation of the survey results presented in the Canadian Aluminium Transformation Technology Roadmap

Furthermore, five workshops were organised to explore current needs and trends in the transportation, construction, shape casting, joining, surface treatment and machining sectors (see Figure 2). This consultation process, which took place over several months, gathered the opinions of 84 experts on 3 main topics: the status of technology and markets, strategic issues involved in aluminium transformation and identification of opportunities liable to generate wealth.

Figure 2: *TRM Workshops Flowchart 2006*



- The third and last step in the development phase of the Technology Roadmap consisted in **synthesising all the information gathered during the activities**, integrating the data and writing the final draft. Among other things, this synthesis offered an interesting cross-section of technological and commercial opportunities chosen among the **270 that were initially suggested and also permitted to table overall recommendations**. With regard to the needs and opportunities that were chosen, a pre-selection process was carried out by workshop participants who had received a detailed list beforehand. The experts used the following criteria to conduct the assessment:

  - Priority level;
  - Economic spin-off;
  - Technical challenge;
  - Time frame.

Each expert could also add comments and make new suggestions. The data compilation process, as well as the transfer of results into tables, helped determine the most promising opportunities and then submit them to a joint panel in charge of enhancing the information obtained.

3.1.3 PHASE C: PROMOTION

The objective of this last phase is to ensure the promotion of the Canadian Aluminium Transformation Technology Roadmap and encourage the industry to use it. Hence, it is mandatory to plan a fixed and flexible Web hosting solution that will make this tool available to Canadian stakeholders as quickly as possible and set up promotional campaigns and presentations for industry players.

4. GLOBAL STRUCTURAL TRENDS AND ISSUES

The three sections covered in this chapter explore the structural tendencies that affect our environment and our capacity to turn aluminium transformation into wealth. This section provides only a brief overview. However, readers desiring additional information can consult the three references provided at the bottom of this page.

Worldwide trends need to be taken into consideration because they bring us to reflect on fundamental strategic issues. They give us greater insight into global issues while we are busy transforming products and earning a living. The world is in constant evolution, and it can take years before certain changes become deeply rooted. However, even if this process can sometimes be long, we must focus on future results because they may very well have a major impact on our lives.

4.1 ENVIRONMENT AND CLIMATE CHANGE[vi]

The Earth's climate system has demonstrably changed on both global and regional scales since the pre-industrial era, with some of these changes attributable to human activities.

An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.

There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

Observed changes in regional climate have affected many physical and biological systems, and there are preliminary indications that social and economic systems have been affected.

Projected climate change will have beneficial and adverse effects on both environmental and socio-economic systems, but the larger the changes and rate of change in climate, the more the adverse effects predominate.

Adaptation has the potential to reduce adverse effects of climate change and can often produce immediate ancillary benefits, but will not prevent all damages.

Numerous possible adaptation options for responding to climate change have been identified that can reduce adverse and enhance beneficial impacts of climate change, but will incur costs.

Unlike the climate and ecological systems, inertia in human systems is not fixed; it can be changed by policies and the choices made by individuals.

The development and adoption of new technologies can be accelerated by technology transfer and supportive fiscal and research policies.

4.2 TRENDS IN CANADIAN MANUFACTURING[vii]

The well-being of all Canadians depends on a prosperous economy. Our ability to create wealth generates the jobs and incomes that pay for the goods and services we use as consumers. It allows us to pay for our public services, our health care, education, income and social support systems.

[vi] *(Reference: **IPCC**, 2001: Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 398 p.*

[vii] *CME 20/20: The future of manufacturing in Canada, February 2006*

Our ability to sustain and improve our standard of living ultimately rests on our capacity to generate new opportunities for Canadians – in other words, to continually grow the Canadian economy. **A strong manufacturing sector has been and must continue to be a critical element of Canada's economic success.**

In recent years, other countries have been gaining on Canada in terms of their ability to generate economic wealth. Canada has dropped from fifth to ninth most prosperous country in the OECD (Organization for Economic Co-operation and Development) over the past 15 years. **Per capita income levels are now 22% higher in the United States than in Canada.**

Other countries have been doing better in raising their economic standard of living because they have found more effective ways of building capital and workforce capabilities, capturing knowledge, and expanding business on a global scale. Canadians must strive to do the same if we are to maintain or improve our standing among the most prosperous nations of the world.

Today, manufacturing is a business system encompassing all the activities that are required to deliver products that meet customer needs – a system that extends from research and development, design and engineering, to production, logistics, finance, sales and marketing, and after-sales service. It is a system that extends beyond any single enterprise, across supply chains and business networks that are increasingly global in scope and that incorporate services as well as production activities.

A number of significant challenges lie ahead – an ageing workforce, the emergence of China as an industrial powerhouse, an intensification of competition in international markets, the appreciation of the Canadian dollar, escalating business costs, increasing constraints on the supply of energy, trade and border problems with the United States, an erosion in the quality of Canadian infrastructure, and mounting competition with other countries around the world for investments and product mandates.

How companies respond to these challenges will fundamentally change the nature of manufacturing in Canada over the next 10 years. Manufacturers will have little choice but to be world-class in a new era of global competition, global supply chains, and new global market opportunities.

Innovation will be key in driving higher value and productivity improvements. **International trade and business partnerships** will be an integral part of business development. **New investments** will be needed to keep pace with technological change. **New skills** will be required in a more knowledge-intensive workplace. Time, agility, and customer focus will be important differentiators of competitive success.

Canadian manufacturers are restructuring their businesses in response to the challenges they face in the global marketplace. However, they are not alone. The emergence of new markets and disruptive low-cost competition, the rapid development of new technological capabilities, more demanding customers, a more discerning public, and intense bottom-line pressures are changing the nature of manufacturing around the world.

The business of manufacturing has already undergone extensive change. We are a long way from the world of smoke-stack industries, mass production, heavy machinery, and manual labour that characterized manufacturing in the past. **Modern manufacturing is highly automated, heavily dependent on technological knowledge and skills, ever more customized and service oriented, and increasingly integrated in international markets and global supply chains.**

The future for manufacturers is one of global customers, global supply chains and business networks and the potential to source from the best companies, the best technologies, and the best skills from around the world. **Growth will be driven by innovation and the ability to respond to rapidly changing customer needs**. It will be built on sophisticated information and production technologies with powerful capabilities to revolutionize products, businesses, and production processes. It will require ever greater degrees of precision and flexibility. And it will need new knowledge and highly skilled people to make it work.

4.2.1 CRITICAL SUCCESS FACTORS FOR MANUFACTURING IN CANADA (CME 20/20)

Canada's manufacturing success will depend on the ability of the industry to restructure in response to the challenges and opportunities that lie ahead.

Seven factors will be critical to sustaining the competitive success of Canadian manufacturing and achieving the goal of enhanced prosperity for all Canadians:

Leadership - Business strategies, public policies and programs, must be coordinated and aligned to strengthen Canada's economic growth potential in the global markets of the future.

Workforce capabilities - Canada's workforce must be prepared to meet the future requirements of manufacturing. Careers in manufacturing must be viewed as attractive opportunities for young people. Employees must possess the basic skills required to work in a responsible, innovative, highly flexible, and internationally networked business environment, and take every advantage to improve their capabilities.

Innovation - Canadian manufacturers must be recognized as the benchmark of the world for innovation, flexibility, and continuous improvement. Innovation must be an integral part of business strategies aimed at managing change. Lean business principles aimed at perfecting process efficiencies must be applied throughout enterprises and across supply chains.

International business development - Canadian businesses must have the capacity to operate on a global scale. There must be a more integrated market framework between Canada and the United States, and within the NAFTA as whole. The Canadian government must make it a strategic priority to maintain and improve access for Canadian businesses in the U.S. market.

Business and financial services - The changing financial and servicing requirements of manufacturing must be met in a cost effective way. Manufacturers will continue to source the best in services from around the world. However, there will be an advantage in sourcing local services that are customized and competitively priced, and that offer specialized knowledge and expertise. Business and financial services must provide the specialized expertise and customized applications needed by manufacturers that are themselves focusing on more specialized products and knowledge-intensive activities to grow their business.

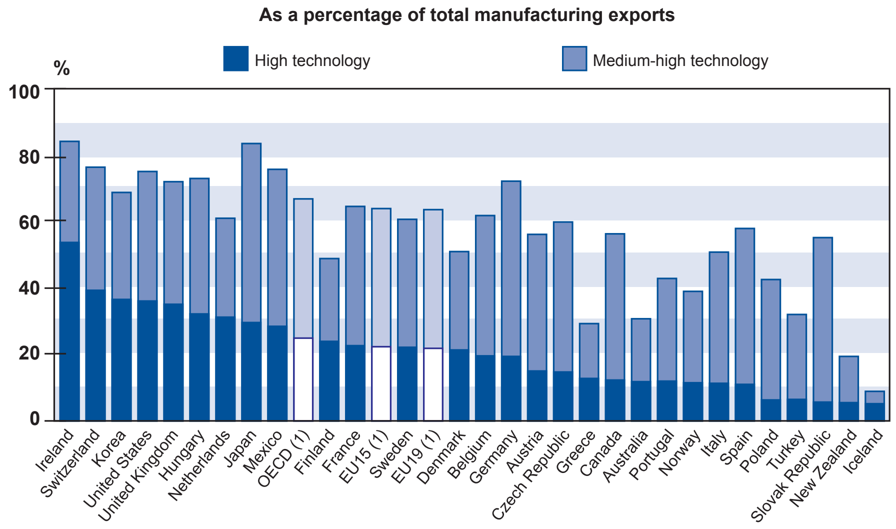
Infrastructure - The capacity of Canada's transportation, telecommunications, and energy infrastructure to meet the future requirements of manufacturing and global business must again become a driver of business investment and economic growth. Manufacturers, other shippers, transportation and logistics companies, together with all levels of government, must develop an integrated logistics strategy for the country to ensure that future shipping needs are met on a just-in-time basis and at competitive costs.

A competitive business environment - Canada must become the preferred location in North America for businesses to locate, invest, manufacture, export from, employ, and grow. Governments must make wealth creation a policy priority and recognize the importance of sustaining a prosperous manufacturing sector. Canada requires a more coherent and integrated approach – involving all levels of government – to improve the business environment for manufacturers, and attract and retain manufacturing investments in Canada. There is also a need for better dialogue between business and all levels of government.

4.3 THE CHANGING NATURE OF MANUFACTURING IN OECD ECONOMIES[viii]

OECD countries differ considerably in the composition of manufacturing trade and in their relative comparative advantage. **Only a few OECD countries, notably Switzerland, Ireland, the United States and the United Kingdom have a strong comparative advantage in high-technology manufacturing**. Several others, notably Japan and Germany, are particularly strong in medium-high technology industries, such as machinery, electrical equipment and cars.

Figure 3: *Share of high and medium-high technology industries in manufacturing exports, 2003*



(1) Excluding Luxembourg.

Source : OCDE, STAN Indicators database, June 2005.

- **The share of the manufacturing sector in total economic activity continues to decline in OECD countries and is likely to do so in the future.** The relative decline in the share of manufacturing in production and value added results primarily from relatively slow growth in demand for manufacturing products, as demand for services is growing more rapidly. The relative and absolute decline in manufacturing employment is primarily due to strong productivity growth, but is also affected by the growth of manufacturing capacity in non-OECD countries.

- **The character of manufacturing production in OECD countries is changing.** The distinction between high-technology and low-technology sectors is becoming less relevant, as certain components of high-technology production can also be carried out in non-OECD countries. Manufacturing activity in OECD countries increasingly incorporates high-value added services. This change seems due to business models that increasingly emphasizes intellectual assets and high-value added activities (OECD, 2006), such as research and development, financial and after-sales services, instead of manufacturing production as such.

- **Manufacturing production has become more and more integrated at the global level.** Manufacturing companies increasingly explore which part of production can be carried out at arms length, either within their own country or abroad, or by their foreign affiliates. This leads to a growing fragmentation of production, notably in those industries where production can be fragmented (e.g. electronics) and to growing inter-industry and inter-firm trade. Due to these changes, trade patterns and patterns of comparative advantage across countries are increasingly complex as they are heavily influenced by location choices of multinational enterprises.

[viii] *THE CHANGING NATURE OF MANUFACTURING IN OECD ECONOMIES STI WORKING PAPER 2006/9, Dirk Pilat, Agnès Cimper, Karsten Olsen and ColinWebb, Copyright OECD/OCDE, 2006*

- **Innovation in manufacturing remains dominated by OECD countries.** The emphasis on high value added activities translates in a growing importance of innovation. Research and development in non-OECD countries is growing, notably in China. Thus far, growth of R&D in non-OECD countries has not translated into much new innovation, as measured by triadic patents. OECD countries continue to account for the bulk of global patenting activity. That being said, the R&D intensity of OECD countries has not grown significantly in recent years, even if there appears to be a growing emphasis on innovation in national policies.

4.4 HOW IS IT GOING TO IMPACT ME? WHAT CAN I DO?

You are maybe asking yourself, how is this going to impact me or what can I do? The answers are not obvious, but the questions are relevant.

The first thing you can do is to **be aware of these trends** and **try to stay abreast of current developments**. Individually, entrepreneurs will have little impact on the structural trends that are present in today's environment. However, you can better adapt your business and your market offering by knowing and understanding them well. You could also leverage your capabilities with others that possess complementary ones.

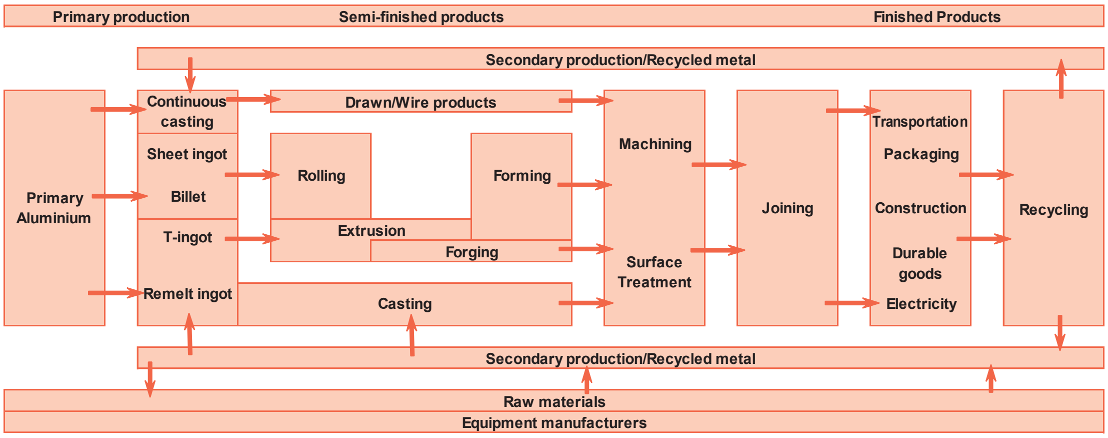
The world is your market place, regardless of whether you agree or not. We are influenced everyday by the global economy because of what we consume or produce. For instance, the base price of aluminium is set in England at the London Metal Exchange. Furthermore, when it comes to the environment, we are all in the same boat even though we may have a better place for the moment in our northern country. Indeed, there are many arising opportunities related to this ever changing reality. **The global market and its effects on our lives and the industry are the new reality.**

The world is changing every day, but some changes are more difficult or slower to implement. Structural trends help you read ahead of time in a context where your environment is constantly evolving. They provide you with a detailed picture of what is happening around the world while you are busy transforming aluminium.

5. OVERVIEW OF THE ALUMINIUM INDUSTRY

This chapter aims to provide a **brief summary of the aluminium industry**, both from international and Canadian perspectives. Five major aspects of the industry are described: **production, semi-finished products, equipment manufacturers and specialised service suppliers, end products by market type, as well as technology platforms**. All these elements are closely related and make up the logical process (see Figure 4) leading to the design or manufacturing of a product.

Figure 4: *The Aluminium Industry*



Source : David M. Moore

**The technical terms used above are defined in the glossary provided at the end of this document.*

5.1 ALUMINIUM PRODUCTION

5.1.1 PRIMARY ALUMINIUM PRODUCTION

Paul-Louis Toussaint Héroult and Charles Martin Hall discovered the industrial process of aluminium electrolysis in 1886. The process, which has undergone continuous improvements over the years, is mainly based on sending a strong electric current to decompose alumina. This reaction occurs within large cells subjected to a powerful continuous electrical discharge. The bottom of each cell acts as a cathode, while carbon blocks are suspended over the cells as anodes. Inside the cells, alumina is dissolved in both a cryolite and aluminium fluoride electrolyte. The desired effect is achieved by passing an electrical current through the mixture, i.e. from the anode to the cathode. The molten aluminium thus settles to the bottom of the cells, while the oxygen mixes with the carbon of the anode. Today's electrolysis processes require an electrical current exceeding 300,000 amperes and the next technology cycle will use 500,000-ampere processes. Hence, enormous quantities of electrical power varying from 13 to 17 kilowatt-hours per kilogram of metal are needed. The resulting aluminium is then drawn into crucibles at regular intervals and transferred into a holding furnace where alloys are prepared. Following an analysis of its composition, the aluminium will usually be turned into ingots and given a specific shape to meet the specifications of the future transformation process it was made for.[ix]

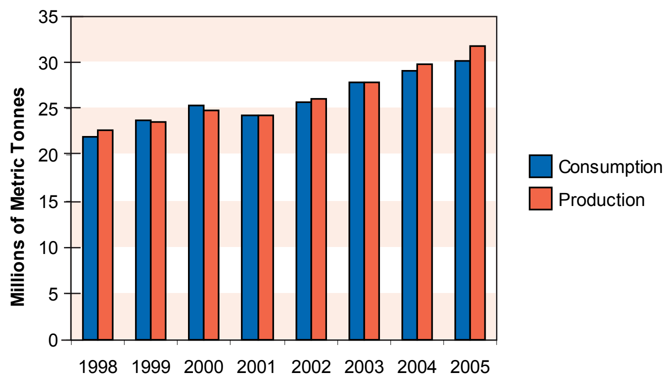
5.1.1.1 WORLD PRODUCTION

World production and consumption of primary aluminium has been constantly on the rise. Between 1995 and 2005, global primary aluminium production experienced steady growth at a Compound Annual Growth Rate (CAGR) of 4.5 percent (see Figure 5); the most significant increase being in China. In 2005 alone, 31.8 million tonnes of aluminium were produced, a 35% increase since 1999; the reference year taken for the Canadian Aluminium Industry Roadmap[vii].

[ix] *Canadian Aluminium Industry Technology Roadmap 2000*

Since 2000, virtually all of the aluminium produced every year has been sold. Based on forecasts, the demand should always exceed global production by 2012 and reach 42.2 million metric tonnes per annum; a major increase compared to the 39.4 metric tonnes originally projected. Based on this data, and assuming that no economic recession will disturb future performance, the aluminium industry should continue its overall positive trend.

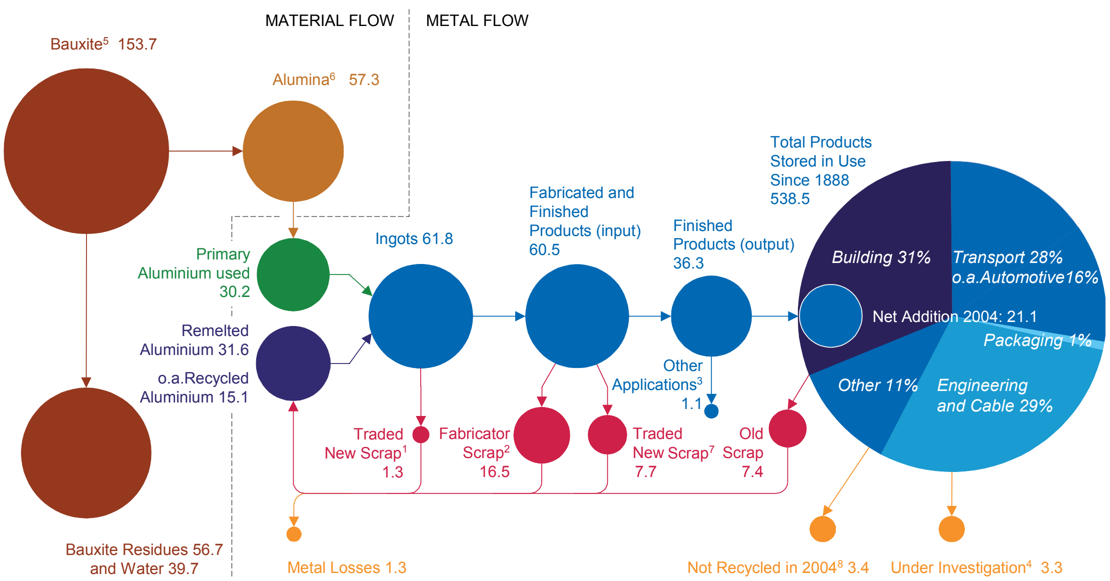
Figure 5: *World Production and Consumption of Primary Aluminium*



Source : Natural Resources Canada and Aluminum Statistical Review for 2005, Aluminum Association

Figure 6 presents an overall view of the aluminium cycle and provides a clearer picture of current production branches. The aluminium industry is presently experiencing continuous growth and should generate significant wealth. Consequently, the Canadian aluminium transformation industry can successfully position itself on world markets and take advantage of this growth by immediately deploying a long-term market penetration strategy.

Figure 6: *Overall Aluminium Cycle 2004*



Values in millions of metric tonnes. Values might not add up due to rounding. Production stocks not shown

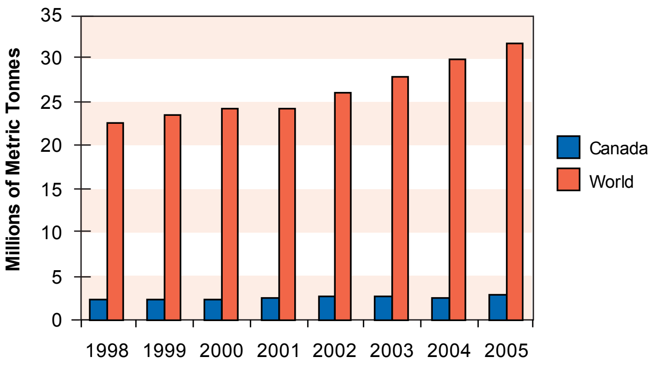
1 Aluminium in skimmings; **2** Scrap generated by foundries, rolling mills and extruders. Most is internal scrap and not taken into account in statistics; **3** Such as powder, paste and deoxidation aluminium (metal property is lost) **4** Area of current research to identify final aluminium destination (reuse, recycling or landfilling); **5** Calculated. Includes, depending on the ore, between 30% and 50% alumina; **6** Calculated. Includes on a global average 52% aluminium; **7** Scrap generated during the production of finished products from semis; **8** Landfilled, dissipated into other recycling streams, incinerated, incinerated with energy recovery.

Source : 2004 Global Aluminium Recycling, IAI, EAA et OEA

5.1.1.2 CANADIAN PRODUCTION

Canada's production of primary aluminium has been growing significantly in recent years with a Compound Annual Growth Rate rising to 2.6% from 1995 to 2005. In 2005, the Canadian production of primary aluminium reached 2.9 million metric tonnes, accounting for 53% of the North American production (see Figure 7).

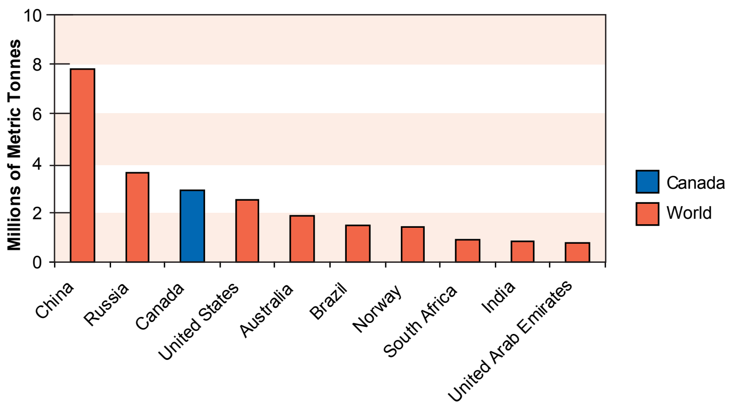
Figure 7: *Canadian Production of Primary Aluminium vs World Production*



Source : Aluminum Statistical Review for 2005, Aluminum Association

Also in 2005, Canada remained third among the world's top ten primary aluminium producing countries (see Figure 8), by increasing its production by more than 33% over the past ten years (see Figure 9). With a production of 2.9 million metric tonnes, Canada accounted for 9.1% of total world production. Abundant electrical energy at competitive prices, the will of governments to stand behind the industry, as well as a positive social and economic environment, are the key elements that have encouraged aluminium producers to make the investments required to increase the production of primary aluminium in Canada. It must be stated, however, that the production of countries such as India, the United Arab Emirates and South Africa has increased substantially more than that of Canada, thus strengthening their standing among the most significant producing countries.

Figure 8: *Top 10 Primary Aluminium Producing Countries - 2005*

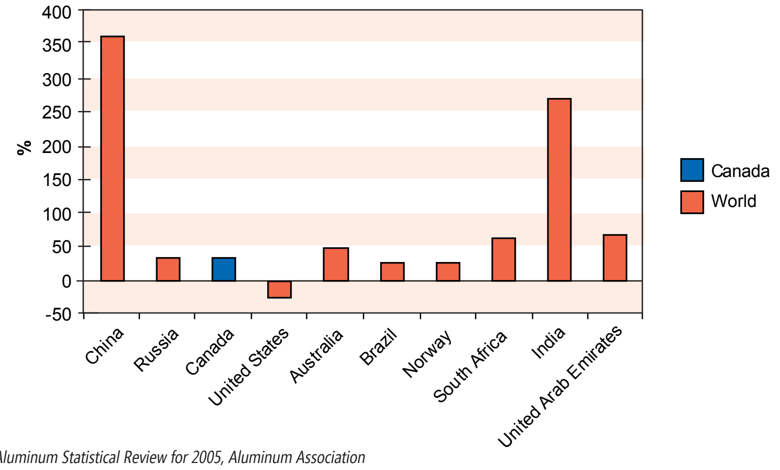


Source : Aluminium Statistical Review for 2005, Aluminum Association

5.1.1.3 SIGNIFICANT CHANGES

The portrait of the top ten primary aluminium producers has changed over the past ten years. China has taken the lead with a 364.3% increase, sending the United States to fourth place, down 26.5% since 1995 (see Figure 9). Like Canada, other countries such as Russia, Australia, Brazil, Norway and South Africa were able to keep their positions due to unfailing continuous growth. On the other hand, India, boasting a 271.2% increase, climbed into the top ten circle of primary aluminium producers by taking ninth place, just ahead of the United Arab Emirates.

Figure 9: *Growth of Top Ten Primary Aluminium Producing Countries (1995-2005)*



Source : Aluminum Statistical Review for 2005, Aluminum Association

5.1.1.4 THE FUTURE

For 2015, current trends show that China, Russia, Canada, the United States, Australia and Brazil should hold the same rank among the leading primary aluminium producers. Venezuela's production should experience significant growth and rank seventh ahead of India, South Africa and Norway[8]. Six out of the top ten primary aluminium producing countries will achieve a growth rate higher than Canada's, including the United States and Australia, which presently rank in fourth and fifth place respectively.

At first glance, China's rapid growth is impressive. However, it is important to keep in mind that this increase is relatively small per capita compared to countries with a more sophisticated aluminium industry. Equally, the growth rate of aluminium production should become stable due to a major obstacle: the limited availability of energy resources at competitive prices. As a result, over the next ten years, China will remain a high-potential market for producers and transformers aiming to supply various types of aluminium-based products to the country's large and growing population.

To maintain its rank, the Canadian aluminium production industry must continue to develop technology projects in order to further increase its production potential, reduce costs and enhance the quality of crude aluminium. Creating a solid synergy among stakeholders is the key to deploying the strategies required to ensure success and achieve optimum objectives.

5.1.2 SECONDARY AND REMELT PRODUCTION

In all, there are **four main types of organisations in secondary and remelt production**: large-scale casting centres, secondary billet plants, beverage can recycling plants and secondary smelters.

Large-scale casting centres, rolling mills and secondary billet plants receive production scrap which is mixed with remelt ingots (pure aluminium) to produce complete lines of sheet or extrusion ingots made of different types of alloys.

Secondary billet plants are casting centres designed to receive different qualities of scrap aluminium, mainly extrusion scrap, to which remelt ingots are added to ensure better quality and make billets.

Beverage can recycling plants receive and mix scrap aluminium cans with remelt ingots to make better quality recycled aluminium and produce sheets used to make the body of beverage cans.

Secondary smelters receive and mix scrap of different qualities, which is mainly used to produce secondary alloy remelt ingots for shape casting foundries.

As shown in Figure 10, secondary production is only a small fraction of Canada's total aluminium production, compared with the United States, which began in the 1940s (see Figure 11).

Figure 10: *Canadian Production of Secondary Aluminium 2000-2005*

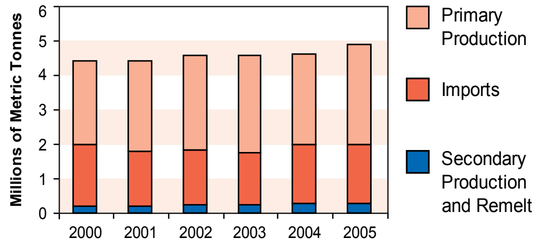
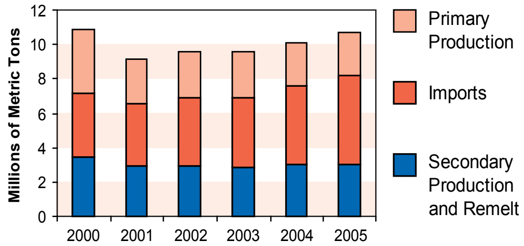


Figure 11: *American Production of Secondary Aluminium 2000-2005*



Source of both charts : Aluminum Statistical Review for 2005, Aluminum Association

In 2005, the estimated Canadian secondary and remelt production was 285,000 metric tonnes for about 24 plants; about twice that of 1995. In comparison, production in the United States was ten times higher than in Canada. We believe this difference is directly proportional to the relative size of the two countries' economies.

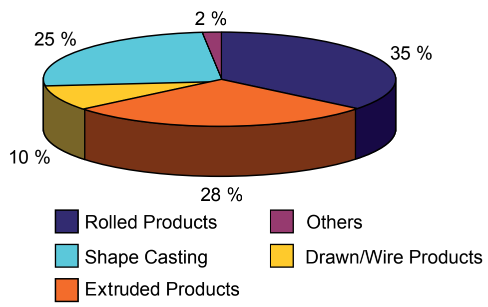
There were a little over 2,000 secondary aluminium producers in China during the same period, most of which have an annual output that is limited to a few thousand metric tonnes or less.[x]

5.2 SEMI-FINISHED PRODUCTS

The fabrication of semi-finished products involves a transformation process in which primary and remelt (recycled) aluminium are mixed together. The products obtained come in a wide variety of shapes and sizes, including cables and wire as well as rolled, extruded, forged and shape cast products. They are specifically made for final processing markets.

The fabrication of semi-finished products has risen with the growth of aluminium production. **Indeed, more than 44.3 million tonnes of all types of finished products were marketed worldwide in 2005[xi].** In contrast, the North American production was 11.6 million metric tonnes in 2005 - the equivalent of one-third of total world production – helping push its Compound Annual Growth Rate up by 3.2% since 2001[xii]. On a worldwide basis, rolled products (see Figure 12) had the highest production volume with 35% of the market, followed by extruded products and shape castings. Canadian semi-finished production was 1 million tonnes, thus accounting for 2.3% of world production.

Figure 12: *World Production of Semi-finished Products by Product Type - 2005*

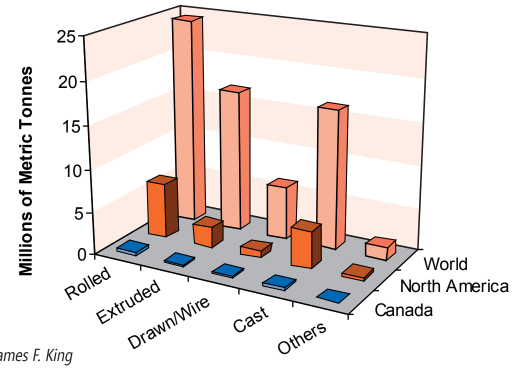


Source : James F. King

In 2015, world production of semi-finished products should reach over 49 million tonnes. As for Canada, this type of production should be somewhere around 1.4 million tonnes (see Figure 13). Additionally, the Canadian production of semi-finished products should represent 10% of North America's total production during this period.

[x] *Light Metal Age, August 2006*
[xi] *James F. King*
[xii] *Aluminum Association (AA)*

Figure 13: *Forecast of Production of Semi-Finished Products - 2015*

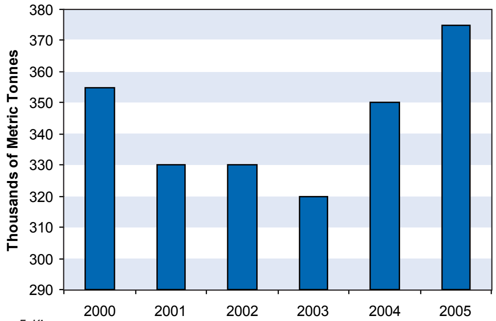


Source : James F. King

5.2.1 ROLLED PRODUCTS

Rolling consists in thinning a thick ingot of primary aluminium. The first step of the process is to preheat the ingot in order to soften it and ensure its homogeneity. Once heated, the ingot undergoes a multi-pass process where it is rolled between pressure cylinders with a decreasing gap between each roller. As a result, the plate lengthened, without altering its width. This rolling process generally continues until the plate has gradually been transformed into sheets of various thicknesses.

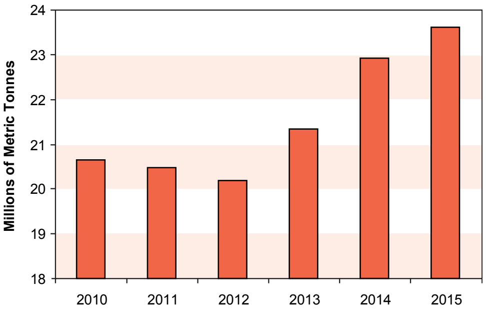
Figure 14: *Canadian Production of Rolled Products*



Source : James F. King

As shown in Figure 13, Canada accounted for 375,000 tonnes of rolled products in 2005, compared to world production, which was 16.1 billion metric tonnes. Consequently, Canada's growth rate was three times slower than that of world production, which was in the order of 51.3% during the same period. As a result, the Canadian industry accounts for 1.6% of the world's production of rolled products. In 2005, the world's top 3 producers were the United States (29%), Germany (10.3%) and Japan (9.5 %). The Compound Annual Growth Rate of the Canadian industry between 2006 and 2015 is expected to hit 1.3% vs. a worldwide CAGR of 3.1%. In light of these figures, it is foreseeable that this situation will likely remain stable in the future. World production should reach 23.6 million metric tonnes in 2015 (see Figure 15).

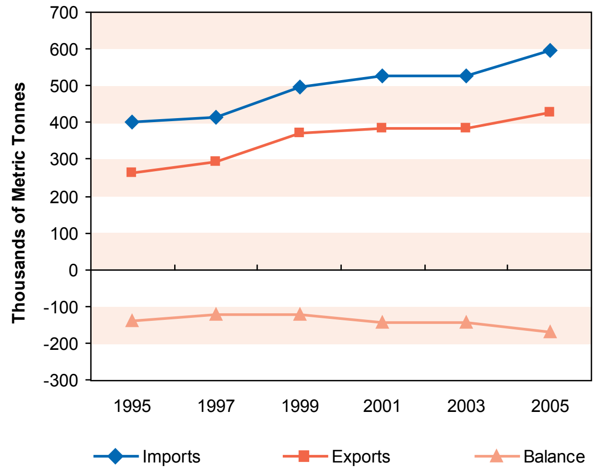
Figure 15: *Forecast of World Production of Rolled Products 2010-2015*



Source : James F. King

As a result, Canada remains an importer of rolled products. More importantly, the range of exported products differs from the range of imported finish-products, the latter being much more diversified. In 2005, the difference between exported and imported products amounted to about 169,000 metric tonnes (see Figure 16).

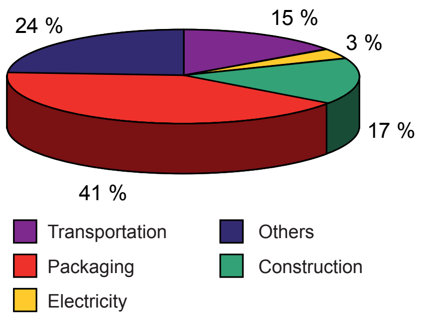
Figure 16: *Canadian Imports and Exports of Rolled Products 1995-2005*



Source : James F. King

As shown by Figure 17, rolled products are mainly used in the packaging, transportation and construction industries.

Figure 17: *Rolled Products Consumption by Market - 2005*



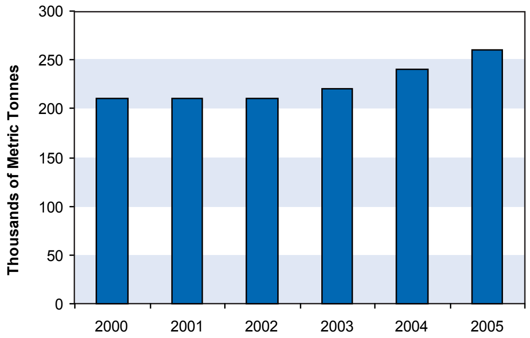
Source : James F. King

5.2.2 EXTRUDED PRODUCTS

Extrusion is a processing operation by which pre-heated billets are pushed through a steel die. Incoming aluminium is given a specific shape along its entire length as it passes through a die profile. To obtain extruded tubing and hollow profiles, it is necessary to add a mandrel at the orifice of the die. As the metal is pressed between the mandrel and the die, it assumes the shape of the mandrel on its inner surface and that of the die on its outer surface.

As shown in Figure 18, Canadian extrusion production reached 260,000 tonnes in 2005. Between 2000 and 2005, Canada's Compound Annual Growth Rate was 3.6%. This large decline in the output growth rate must be taken into account, considering that Canada's CAGR was 10% between 1995 and 2000. The world's top three producers of extruded production for the 2005 reference year were: China (27%), the United States (13%) and Japan (11%). Therefore, China took the honours as the producer with the highest growth rate since 2000, achieving a CAGR of 16.2%, while those of the other two countries remained relatively stable.

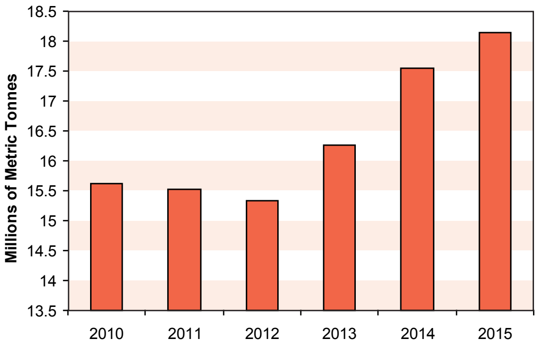
Figure 18: *Canadian Production of Extruded Products*



Source : James F. King

In 2015, world production of extruded products should be around 18.1 million metric tonnes (see Figure 19).

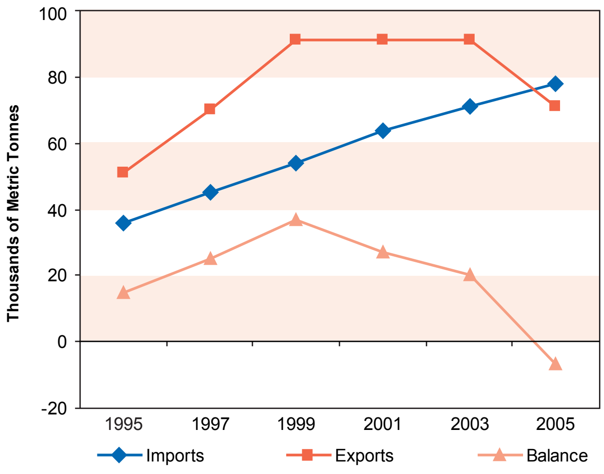
Figure 19: *Forecast of World Production of Extruded Products 2010-2015*



Source : James F. King

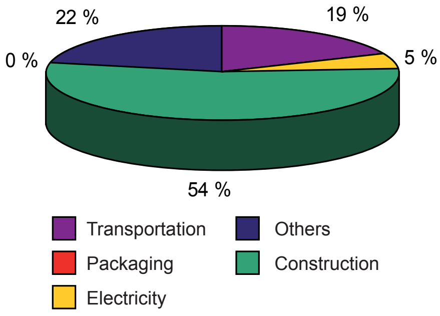
The tide has turned over the past years, and Canada has become an importer of extruded products. In 2005, the difference between exports and imports was 7 metric tonnes (see Figure 20). The Compound Annual Growth Rate of Canadian production for the period between 2006 and 2015 should be 2.4% (above the growth rate of rolled products) which, in turn, is below the 3.6% CAGR forecast for world production.

Figure 20: *Canadian Imports and Exports of Extruded Products 1995-2005*



Source : James F. King

Figure 21: Extruded Products Consumption by Market - 2005



Source : James F. King

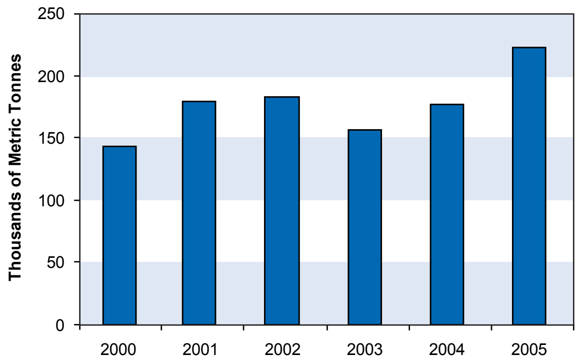
Around the world, extruded products are mainly used by the construction industry. The remainder of the demand for this type of product was generally divided among other markets - including transportation (see Figure 21).

5.2.3 SHAPE CASTING

During a shape casting operation, molten aluminium is poured into moulds to fabricate products of various shapes. Current techniques include high- and low-pressure die casting, permanent mould casting and sand casting.

In 2005, Canada fabricated 222,400 tonnes of shape cast products; up more than 35,000 tonnes since 1997 (see Figure 22). This output corresponds to 2% of world production, which rose to 10.9 million tonnes. The Compound Annual Growth Rate for Canadian shape castings went from 9.5% for the 1993 to 1997 period to 7.6% for the period between 2000 and 2005. Once again, the United States (22.8%), China (14.9%) and Japan (12%) ranked as the top three producers of shape castings in 2005, respectively.

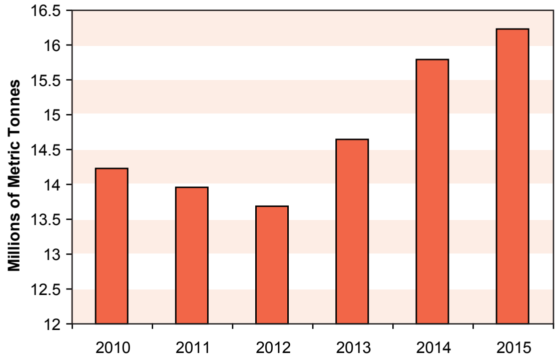
Figure 22: Canadian Casting Production



Source : James F. King

China's annual shape casting production growth rate has literally exploded since 2000, with a CAGR of 12.6%, while the production of the other two countries basically remained stable. The Chinese production growth rate should virtually double by 2015. On the other hand, world production should rise from 14.2 million tonnes in 2010 to 16.2 million tonnes in 2015 (see Figure 23), thus achieving a CAGR of 2.2%.

Figure 23: *Forecast of World Casting Production 2010-2015*

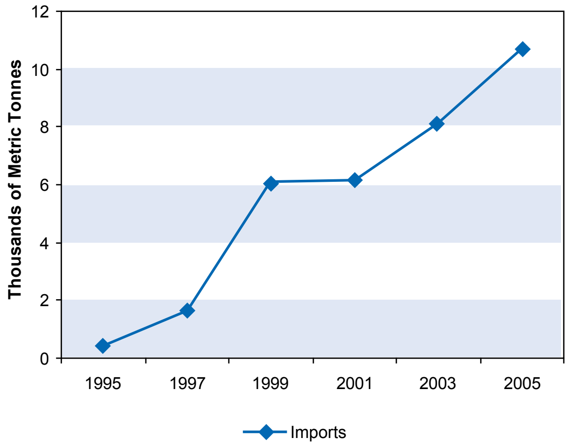


Source : James F. King

In 2015, Canada should produce 370,000 metric tonnes, which should account for 2.3% of world production.

Canadian casting imports presented a CAGR of 20.6% for the 1995-2005 period (see Figure 24). Results pertaining to Canadian exports were not available. Therefore, it was not possible to calculate the balance of trade for this type of semi-finished product.

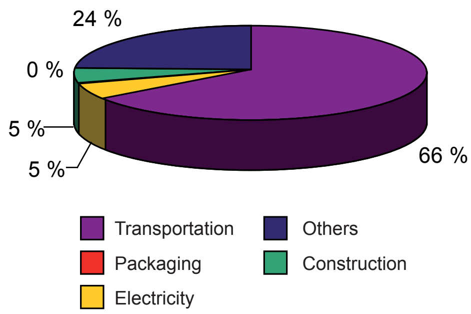
Figure 24: *Canadian Casting Imports 1995-2005*



Source: Aluminum Statistical Review for 2005, Aluminum Association

The transportation industry ranks as the largest consumer of shape cast products accounting for 66% of the demand (see Figure 25).

Figure 25: *Shape Casting Products Consumption by Market - 2005*



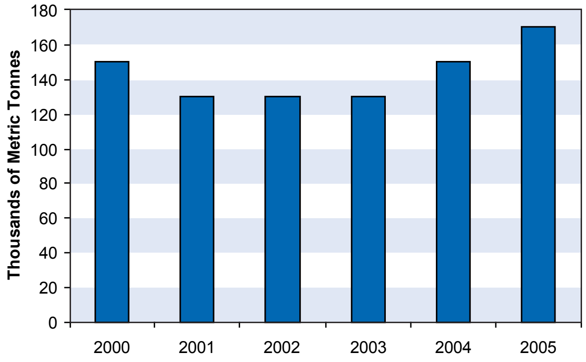
Source : James F. King

5.2.4 DRAWN/WIRE PRODUCTS

Drawing is a production process used to fabricate aluminium wiring, tubes and bars. It basically consists in passing a rough rod through dies of decreasing dimension until the desired size is obtained.

In 2005, Canada's output of drawn/wire products reached 170,000 metric tonnes (see Figure 26), while world production yielded 4.3 million metric tonnes for the same year. Despite the fact that the Canadian production was stable during the 2001 to 2003 period, it still accounted for 3.9% of world production.

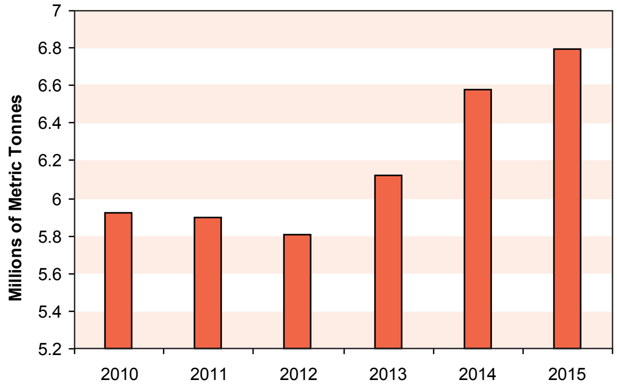
Figure 26: *Canadian Production of Drawn/Wire Products*



Source : James F. King

In 2005, the world's 3 leading producers of drawn/wire products were China (39.2%), the United States (11.9%) and Russia (6.9%), while Canada ranked 5th. In 2015, total world production should be close to 6.8 million metric tonnes with China yielding 44.8% (see Figure 27).

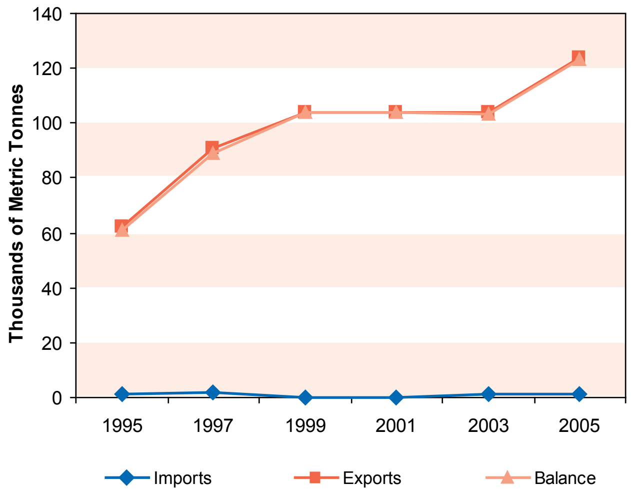
Figure 27: *Forecast of World Production of Drawn/Wire Products 2010-2015*



Source : James F. King

Canada is an exporter of drawn/wire products. In 2005, the trade balance between exports and imports was 187,475 metric tonnes, compared to the 42,175 metric tonnes yielded ten years before (see Figure 28). The Compound Annual Growth Rate of the Canadian output for the 2006 to 2015 period should be 1.4%, while worldwide output should account for 3.5%.

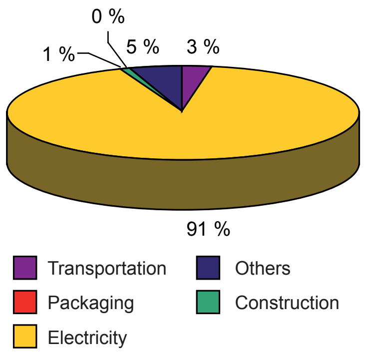
Figure 28: *Canadian Imports and Exports of Drawn/Wire Products 1995-2005*



Source : James F. King

Most drawn/wire products are made for the electricity industry which consumes 91% of the production (see Figure 29).

Figure 29: *Drawn/Wire Products Consumption by Market - 2005*



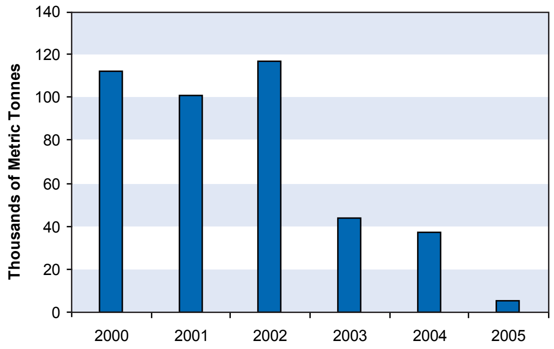
Source : James F. King

5.2.5 OTHER PRODUCTS

This section covers aluminium powders, pastes and forged products. For the moment, however, detailed information pertaining to this product category is quite limited. Therefore, only a brief description will be presented.

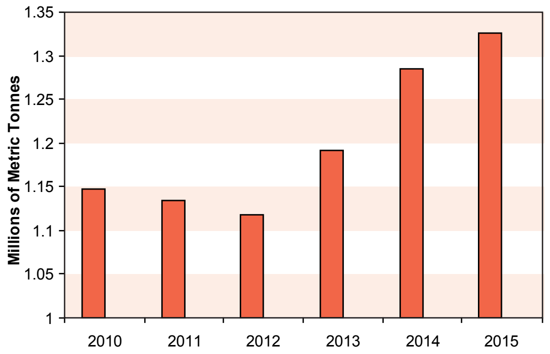
Canada produced 5,000 tonnes of other types of products in 2005 (see Figure 30), thus accounting for 0.6% of world production (780,000 metric tonnes). Future projections show that the Canadian industry should have a CAGR of 1.6% for the 2010-2015 period, while world production should reach 2.4% for the same period. Furthermore, total world production should reach 1.3 million tonnes in 2015 (see Figure 31).

Figure 30: *Canadian Production of Other Products*



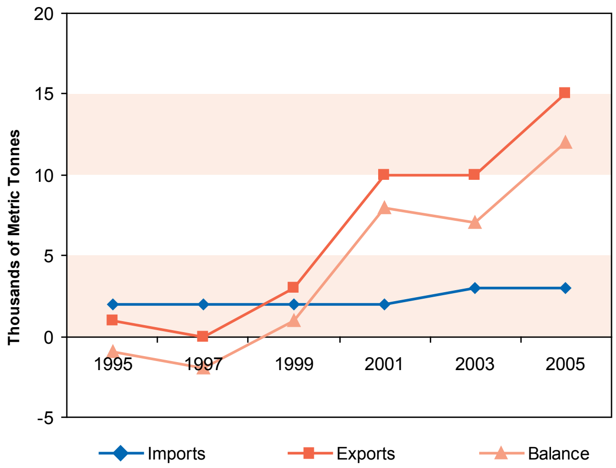
Source : James F. King

Figure 31: *Forecast of World Production of Other Products 2010-2015*



Source : James F. King

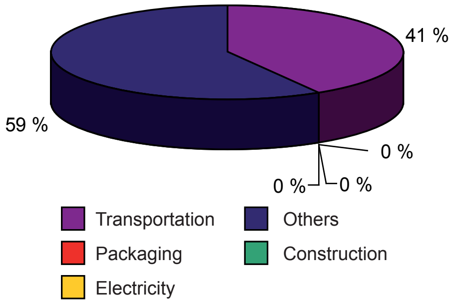
Figure 32: *Canadian Imports and Exports of Other Products 1995-2005*



Source : James F. King

As shown in Figure 33, the transportation industry and other markets are the main consumers of other types of products.

Figure 33: *Other Products Consumption by Market - 2005*

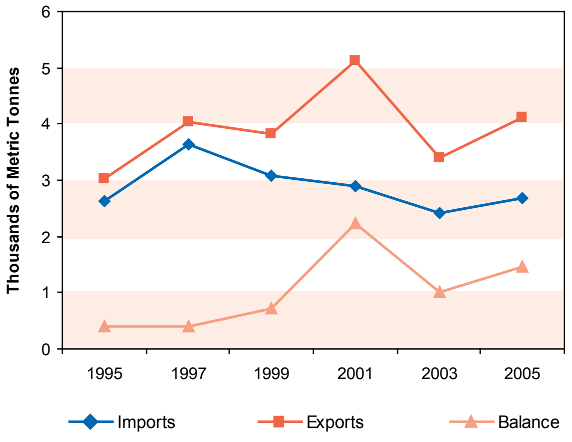


Source : James F. King

5.2.5.1 ALUMINIUM POWDERS AND PASTES

Aluminium powders are aggregates of discrete particles of aluminium, substantially all of which are finer than 1,000 microns. In contrast, aluminium paste consists in blending powder or flakes with a thinner or plasticizer. The main uses for powders and pastes are in the explosives and paint industries.

Figure 34: *Canadian Imports and Exports of Powders and Pastes 1995-2005*



Source : Aluminum Statistical Review for 2005, Aluminum Association

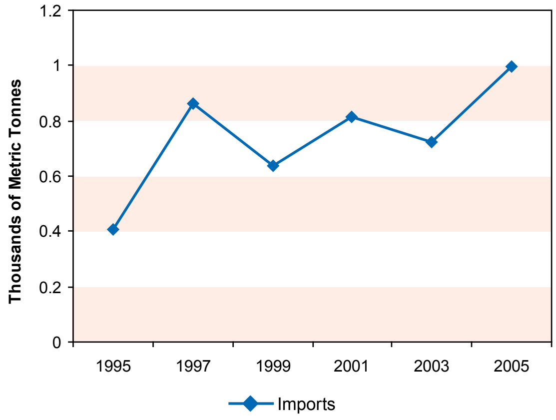
Canada is an exporter of aluminium powders and pastes. Its Compound Annual Growth Rate grew by 2.6% between 1995 and 2005. In 2005, over 4.1 million metric tonnes of aluminium powders and pastes were exported. On the other hand, only 2.6 million metric tonnes were imported during the same period (see Figure 34). Since 1995, exports of this type of product have increased by 35 %.

5.2.5.2 FORGED PRODUCTS

During a forging process, the desired aluminium part is formed in a confining die from a hot metal slug. In other words, a high-pressure confining die is used during this operation to give the slug its final shape. The main uses for forging are in the automotive and aerospace industries.

In 2005, Canada imported 997 metric tonnes of forged aluminium products. This yielded a Compound Annual Growth Rate for imported semi-finished products in the order of 7.5% since 1995. Results pertaining to Canadian production and exports were not available. Therefore it was not possible to carry out a full assessment of the Canadian market for forged products. Nevertheless, it is important to mention that such products are constantly gaining ground, as shown in Figure 35.

Figure 35: *Canadian Imports of Forged Products 1995-2005*

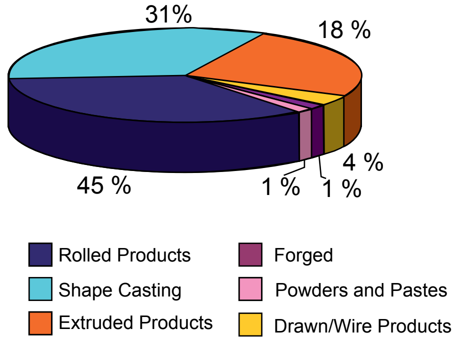


Source : Aluminum Statistical Review for 2005, Aluminum Association

5.2.6 SUMMARY

Despite the sharp increase in Asian production, the United States and Canada still rank as leading players in the semi-finished product industry. Results clearly demonstrate that North America remains a strong competitor in sectors achieving the highest production levels, i.e. rolled, extruded and shape cast products (see Figure 36). This is due to two main factors: complementarity in the mix of production and geographical proximity. Finally, North American production for 2005 was in the order of 11.6 million metric tonnes.

Figure 36: *Distribution of North American Production of Semi-Finished Products 2005*



Source : Aluminum Statistical Review for 2005, Aluminum Association

5.3 MANUFACTURERS AND SPECIALISED EQUIPMENT SUPPLIERS

The data gathered within the framework of the *Canadian Aluminium Transformation Technology Roadmap* was taken from a few specialised magazines such as Light Metal Age, Modern Casting, and from the survey conducted during the TRM project. While our sample is rather small, we believe it to be representative. It is difficult, even impossible, to form a clear view of the entire field of manufacturers and specialised equipment suppliers due to their great numbers in a wide range of fields. Nevertheless, our study has led to a **general picture of the industry** and the definition of **general trends**. Therefore, we limited our scope to those manufacturers and suppliers who described and identified themselves as being connected to aluminium and the aluminium industry.

These manufacturers and specialised equipment suppliers operate in **three key areas** of the aluminium industry. They are:

- **Primary production**
- **Secondary production and remelting (excluding casting foundries)**
- **Transformation (semi-finished product forming)**

Each of these sectors can be divided into several specific fields that, in turn, include a wide range of specialised products and/or equipment.

Primary production comprises **bauxite and alumina plants**, **carbon product centers**, **electrolysis potrooms and primary casting plants**.

The secondary production and remelting sector includes over 55 diverse and specialised market segments that fall within the following categories: Remelt casthouses attached to a rolling mill or an extrusion facility, independent casting facilities, UBC plants, and scrap recycling plants. Products in this sector are transformed into sheet ingots, extrusion billets, sheet coils, rod coils and, remelt ingots.

The **transformation** sector, or **semi-finished product forming**, can be divided in two areas: extrusion presses and rolling mills. The specialised magazines surveyed divide these two areas in more than 70 market segments.

This sector of the aluminium industry abounds with various types of technologies. Therefore, it is easy to see the complexity and diversity of business opportunities available to Canadian equipment and specialised suppliers.

5.3.1 THE POSITION OF CANADIAN MANUFACTURERS AND SPECIALISED EQUIPMENT SUPPLIERS

Over forty Canadian manufacturers and specialised equipment suppliers are well positioned on the global aluminium market. Due to the proximity of markets and long-term presence of aluminium in Canada, many businesses can hope to join the ranks of internationally recognised equipment suppliers in the near future.

Globally, the presence of Canadian manufacturers and specialised equipment suppliers is most notable in the primary sector. Indeed, according to specialty magazines, Canadian companies listed as manufacturers or suppliers accounted for 13% of the total number of companies in this field. Where secondary production and remelting are concerned, the Canadian market share is 10%, and drops to 5% for the transformation (forming) sector.

5.3.2 SURVEY RESULTS

While the Technology Roadmap is solely dedicated to aluminium transformation, certain survey results cannot be overlooked. More than **75% of respondents made interesting comments** regarding the fields of expertise of goods and services suppliers (equipment suppliers included).

When negotiating with a goods and services supplier, 72% of respondents declared that they look for the **best total solution**, meaning that they consider the price, quality, after-sales service, and extent to which a supplier can reliably meet their particular needs. The lowest-priced and best products available on the market only received, respectively, 17% and 11% of the votes from surveyed experts.

Many readers will say that, nevertheless, China exports at the lowest price and sells huge quantity of products in developed countries. This proves to be true. Large companies are currently caught in a paradox; on the one hand, there is pressure to lower production costs and, on the other, to improve product quality and maintain equipment and personnel productivity.

As for the **technical trends and issues** at play, when looking to buy equipment, goods and services suppliers need to **improve their technical knowledge of the processes** used by their customers, have a **better understanding of their customers' technical needs**, and make sure **equipment performance meets or exceeds specifications**. This trend was confirmed during TRM workshops when many specialists from large OEMs and MNEs stated that **suppliers must get involved early in design processes**, if they are to develop better value-added products and maintain their competitive edge.

Most respondents consider that the **main marketing and business advantages are awareness of customer needs**, **knowledge of metal processing**, and **technical after-sales service**. For survey respondents, the technical trends and issues are directly related to the marketing and business advantages that lead them to choose one supplier over another.

Globally, according to specialists the **missing links** are:

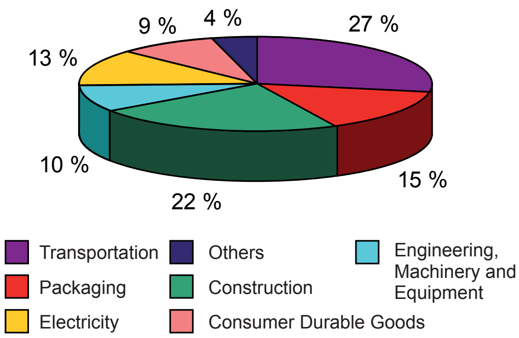
- Understanding the technology and the capacity to meet customer needs
- Problem-solving skills
- Level of knowledge, training, and service

It seems obvious that manufacturers and specialised equipment suppliers must continually strive to acquire and master knowledge related to processes and technologies, while maintaining close relations with customers and their needs. **Performance and reliability are the most influencing factors for equipment buyers, other than price.** In a globalisation context, buyers expect production and transformation equipment suppliers - looking to outdo competition - **to foster closer ties with customers** through better awareness of their needs and early involvement in the engineering stages of equipment. This strategy would certainly guarantee better-adapted equipment and quality after-sales service.

5.4 FINISHED PRODUCTS BY MARKET TYPE

Current markets are overflowing with aluminium-made finished products, and the soaring demand for the metal has had a significant impact on the global consumption of aluminium. **Today, three key market sectors particularly stand out: transportation, packaging, and construction** (Figure 37). The total value of finished products in these three areas is approximately **190 billion American dollars**. As shown in Figure 38, these products are found mainly in Asia, the Americas, and Europe. **World consumption of finished products required 44.1 million metric tonnes of aluminium in 2005**[xiii]**.**

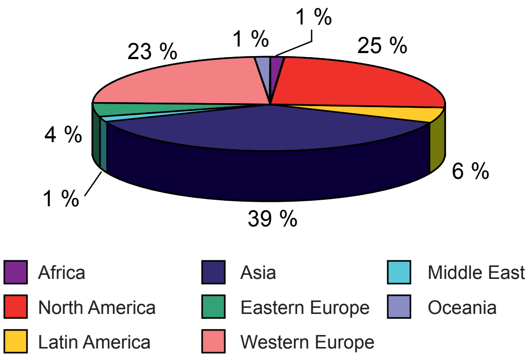
Figure 37: *Segmentation of Aluminium World Markets 2005*



Source : James F. King

[xiii] *James F. King*

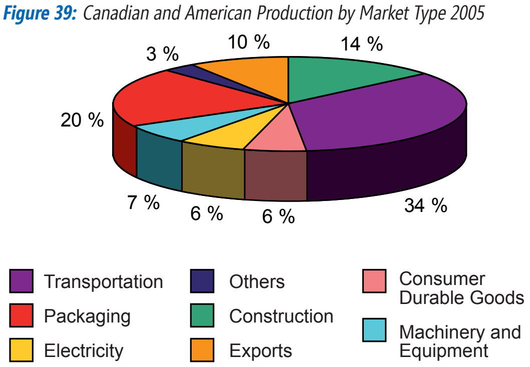
Figure 38: *Location of Aluminium Markets 2005*



Source : James F. King

In Canada and the United States, a remarkable 11.6 million metric tonnes of aluminium were delivered to customers in 2005[xiv]. The principal markets were, once again, transportation, packaging, and construction, making up over 68% of total distribution (Figure 39). Transportation experienced the highest Compound Annual Growth Rate since 2001, at 5.4%.

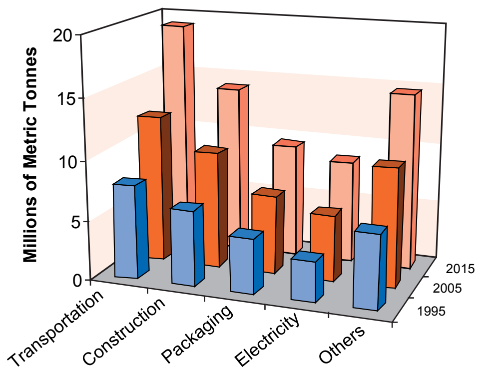
Figure 39: *Canadian and American Production by Market Type 2005*



Source : Aluminum Statistical Review for 2005, Aluminum Association

While transportation holds the largest share of the overall world market, major regional differences exist. For our 2005 reference year, packaging and construction held the 2nd and 3rd positions in the Canadian and American markets; those rankings were, however, reversed on the global scale[xv].

Figure 40: *Evolution of World Consumption by Market Type 1995-2015*



Source : James F. King

[xiv] Aluminum Statistical Review for 2005, Aluminum Association
[xv] Aluminum Statistical Review 2005 and James F. King

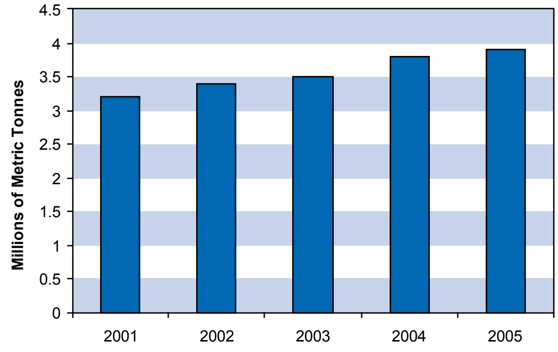
As shown in Figure 40, aluminium consumption should continue to increase steadily for all markets over the next several years. The electricity sector will have a CAGR of 4.6% over this period, representing the highest Compound Annual Growth Rate overall, followed by transportation at 4.3%. **In 2015, Asian consumption of aluminium products will likely be twice that of North America**, with a CAGR of 4.8% starting in 2005[xvi].

5.4.1 TRANSPORTATION MARKET

With **a world market share exceeding 27.9%, or 12.3 million metric tonnes**, the transportation industry ranks as the **largest consumer of aluminium**[xiv]. This sector includes the automotive, commercial vehicle, truck, bus, commercial airline, railway equipment, and marine (including recreational craft) industries. It is expected that 19.1 million metric tonnes of aluminium will be consumed by the transportation industry in 2015.

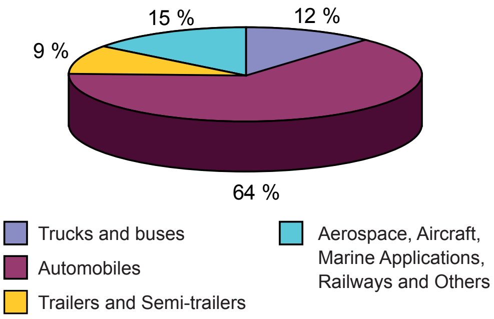
In Canada and the United States, the transportation market makes up 33.9% of total aluminium consumption. This industry's CAGR has been 5.4% since 2001, while the average CAGR for the entire aluminium market is 2.9%. Delivery of finished products made with aluminium reached more than 3.9 million metric tonnes in 2005, a 2% increase over 2004 (Figure 41)[xvii] distributed among four general sectors (Figure 42).

Figure 41: *Growth of the Transportation Market in Canada and the United States 2001-2005*



Source : Aluminum Statistical Review for 2005, Aluminum Association

Figure 42: *Segmentation of the Transportation Market in the United States and Canada 2005*



Source : Aluminum Statistical Review for 2005, Aluminum Association

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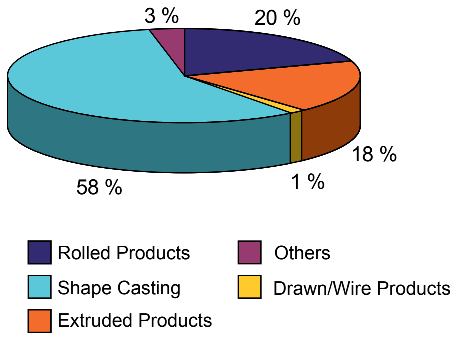
[xvi] *James F. King*
[xvii] *Aluminum Statistical Review 2005*

Figure 43: *World Consumption of Semi-finished Products for the Transportation Market 2005*



Source : James F. King

The transportation industry mainly uses aluminium shape castings; far more than sheet and extruded products (Figure 43).

Our survey for the transportation sector revealed that **aside from the price of materials**, there were **other relevant trends and challenges** that need to be addressed. Indeed, factors such as **weight of complete systems**, **mechanical properties of joined assemblies**, and **corrosion resistance** remain top priorities.[xviii] Fifty-seven respondents, mainly from Quebec, Ontario, and the United States, answered our survey and helped us derive the following information:

- The most important **marketing and business advantages** in this sector are directly tied to selection criteria for the material. They are **weight**, **corrosion resistance**, and **mechanical properties**.

- The **missing links** are also well defined. **Better design knowledge** and **improved joining technology** are looked for in all transportation sectors. **Moreover, the improvement of the mechanical properties of aluminium is still a major need for aeronautical applications.**

- Depending on the type of transportation-based market, certain factors like appearance or fashion can more or less influence the trends and issues that need to be addressed. For example, great importance is given to the appearance of recreational vehicles, while **resistance to fire is looked for in trains**.

- **Aluminium** is still generally considered a **replacement material** offering numerous possibilities for the industry. However, **it has become a material to be replaced in aeronautical applications due to the advent of composite materials**.

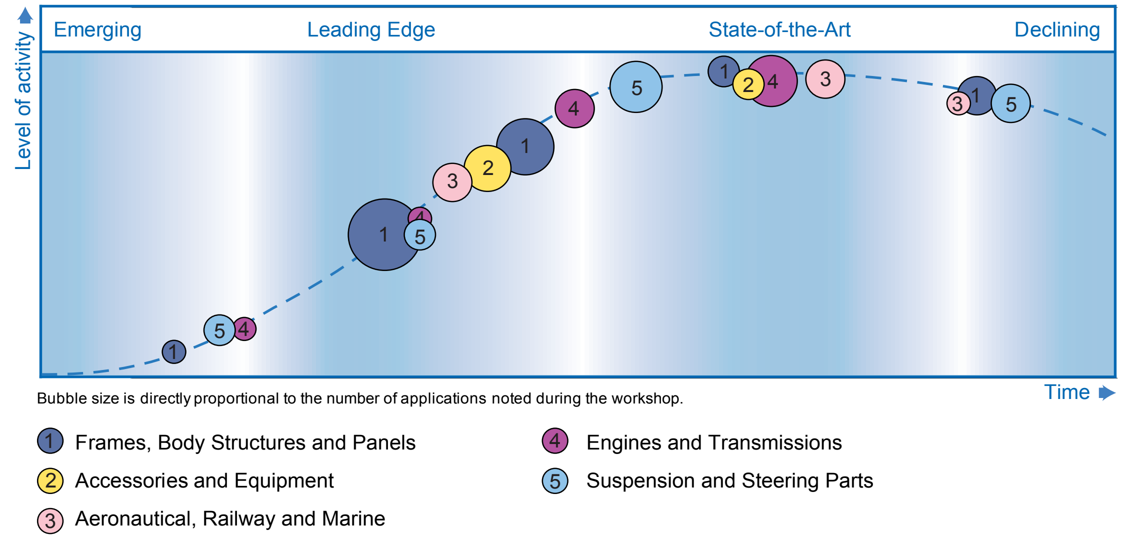
- Where **world regional differences** are concerned, it is important to note that **the use of aluminium in the European transportation industry is far more developed than in North America**. European consumers seem to be better aware of the advantages related to weight reduction, energy consumption, and recycling.

5.4.1.1 ALUMINIUM PRODUCT LIFE CYCLE

The Transportation Workshop held in Hamilton, Ontario, on May 9, 2006 shed light on the global situation of aluminium usage in the major product systems of the transportation sector. It was noted that emerging and growing applications showed positive signs, notably for frames, body structures and panels, as well as suspension and steering parts (Figure 44).

[xviii] *Compilation of survey results*

Figure 44: Life Cycle of Aluminium Applications in the Transportation Industry



Source : Canadian Aluminium Transformation Technology Roadmap Transportation Workshop

Products such as bumpers, truck and bus frames, air conditioner structures, diesel engine blocks, continuous variable transmissions, and seat suspensions are considered to be **emerging aluminium applications**.

Among **leading edge aluminium applications** are passenger vehicle frames, steering arms, cylinder heads, roof panels, cradles, floor panels, fire barriers, and side impact-beams.

Heat shields, tailgates, pier and marina structures, helicopter structures, pistons and alternator motors are considered **state-of-the-art** applications of aluminium.

Declining usage of aluminium is foreseen in hoods, doors, and small boats. Few applications are expected to disappear completely, but a way must be found to reclaim their competitive edge, or improve productivity and reduce costs.

5.4.1.2 STRATEGIC ISSUES

Workshop participants also identified the strategic issues facing the transportation industry in Canada, North America, and at the global level. These issues are technological, market-based or a combination of the two, and can also be influenced by socio-economic factors.

According to participants, **a systemic**, **multi-material approach needs to be developed** in which aluminium predominates, instead of looking to integrate larger amounts of the metal in the design phase. **Understanding how and when combining aluminium with other materials leads to better solutions is a huge challenge.**

Furthermore, an effort must be made to **teach aluminium** and aluminium transformation processes in engineering programs. We need to support continuous professional development for technical staff in aluminium: theory and practice.

As a result, it will be easier to **collaborate with the primary production and semi-finished product industries and integrate individual expertise into the design process**. Consequently, every role player in a project will have an opportunity to contribute actively to solutions and revive engineering-related professions.

Finally, it was said that **small organisations need to collaborate and develop synergy** in order to meet the globalisation challenge. It must be acknowledged that **we need to better master our technology if we are to control the situation and develop winning applications**.

5.4.1.3 NEEDS AND OPPORTUNITIES

Over forty needs and opportunities related to the transportation industry were listed within the framework of the Canadian Aluminium Transformation Technology Roadmap. Eight opportunities, however, stood out and were analysed by experts:

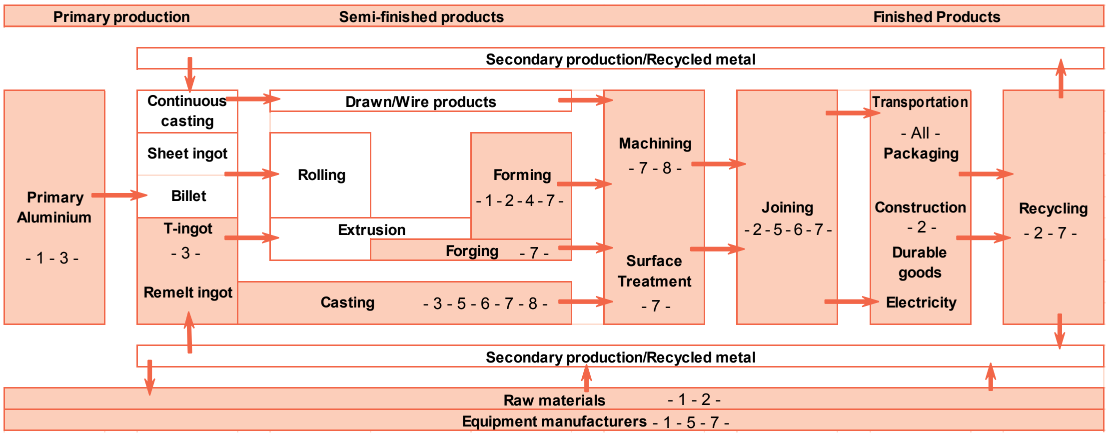
Transportation

1. Offer integrated aluminium solutions to OEM manufacturers
2. Develop multi-material solutions
3. Research & Develop alloys with higher strength and heat resistance for diesel engine
4. Research & Develop high formability, low cost, high strength aluminium alloys
5. Design lighter structures for trucks, buses, and recreational vehicles
6. Invent methods to produce larger castings with thinner walls
7. Achieve a significant cost reduction for the various aluminium transformation processes
8. Improve wear resistance, tribology and lubrication of aluminium surface

Chapter 6 - *Needs and Opportunities* – defines each of these opportunities and provides the reader with information pertaining to the markets and technologies targeted priority level, time frame, technical challenge, economic impact, key elements, and payoffs. This information will help in the decision-making process, leading to well-tuned R&D strategies that can answer to the needs identified by experts.

As shown in Figure 45, these projects have an impact on primary production, semi-finished products, finished products, and technology platforms. Each number inserted in the graph corresponds to the number of each opportunity listed.

Figure 45: *Opportunity Focal Areas for the Transportation Industry*



Source : David M. Moore

5.4.1.4 DISCUSSION

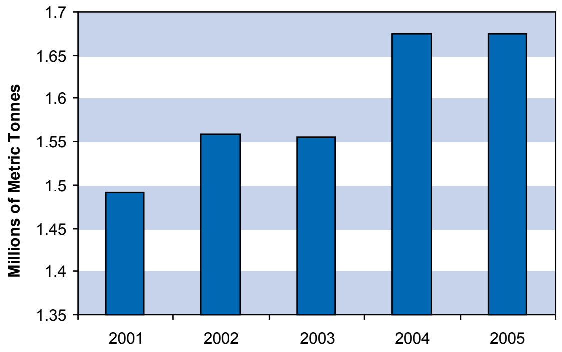
While Canadian imagination and innovative capacity are some of the strengths mentioned during the Transportation Workshop, all of the experts agreed to the fact that **synergy is crucial to the development and maintenance of the industry**. Industry role players need to start working together right away to find solutions and develop a systemic approach to their design processes. By creating closer ties within the supply chain, the competitive and added value aspects of Canadian products will make a difference on the global scale. While technological barriers for aluminium use are no longer an issue, in reality, engineers, designers, and drafters do not have enough expert guides dedicated entirely to aluminium. The calculations and potential applications for aluminium need to be taught if the use of the material is to grow. **Education and training are ever-present needs and must be part of future development strategies.**

5.4.2 THE CONSTRUCTION MARKET

Construction is a strong market for aluminium as the metal is used for infrastructures, architectural products, siding, and numerous other construction products. For instance, aluminium is increasingly being used in a wide range of large-structure construction and restoration projects, including buildings and bridges needing structural upgrades to meet load-bearing standards. The construction sector accounts for **22% of world consumption of semi-finished products**, or 9.7 million metric tonnes. Construction-related aluminium use is expected to reach 13.9 million metric tonnes by 2015[xix].

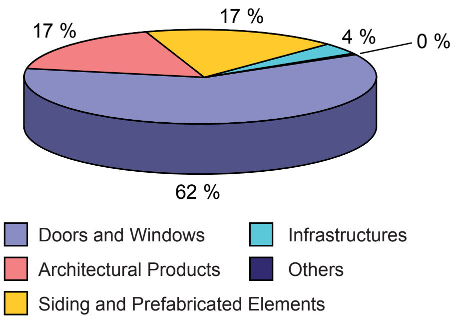
In Canada and the United States, the construction market accounts for 14.4% of total aluminium use. For 2001-05, the CAGR for the industry stood at 3%, compared to a 2.9% aluminium market average. Over 1.6 million metric tonnes of aluminium-based finished products were delivered in 2005, a slight increase of 0.5% over 2004 (Figure 46)[xx]. Figure 47 shows the segmentation of the construction market into general sectors, by order of importance. Doors and windows make up 62% of the market.

Figure 46: *Growth of the Construction Market in Canada and the United States 2001-2005*



Source : Aluminum Statistical Review for 2005, Aluminum Association

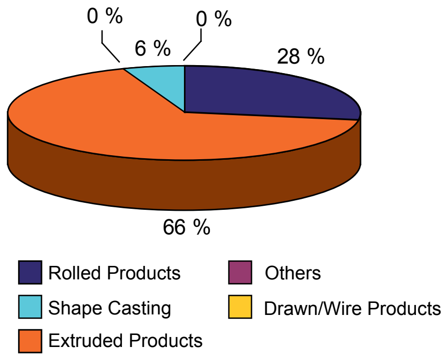
Figure 47: *Segmentation of the Construction Market in the United States 2005*



Source : Aluminum Statistical Review for 2005

[xix] *James F. King*
[xx] *Aluminum Statistical Review 2005*

Figure 48: World Consumption of Semi-finished Products for the Construction Market 2005



Source : James F. King

As shown in Figure 48, the construction market uses mostly extruded products, with a 66% market share. Only sheet products also have an interesting market share with 28%.

Future trends indicate that **Asian countries will continue to be the largest consumers of aluminium construction products as a 58% increase is expected by 2015**. North America should remain third with an increase of about 2% per year over the next 10 years.

TRM survey results showed that **the trends and issues, other than material costs are the energy-saving properties of building materials and awareness and acceptance of the mechanical properties of aluminium products by designers and contractors**. As far as **siding and architectural products** are concerned, the primary criteria for designers are **product quality and surface finish**, followed by **corrosion resistance**, as stated by 32 respondents mainly from Quebec, the United States and Ontario. The following information was also put forward:

- **Marketing and business advantages** differ by market sub-sector. For **infrastructures**, the three main advantages are **corrosion resistance**, **mechanical properties**, **and weight**. As for **siding and architectural products**, the three principal criteria are **appearance**, **corrosion resistance**, **and weight**.

- The **missing links** are **better design knowledge** and **improved joining techniques**, both of which are judged necessary improvements for the growth of the Canadian aluminium transformation industry in the construction market. The same needs were identified for the transportation market. Siding and architectural product contractors expressed their desire for a **wider range of sizes and shapes**.

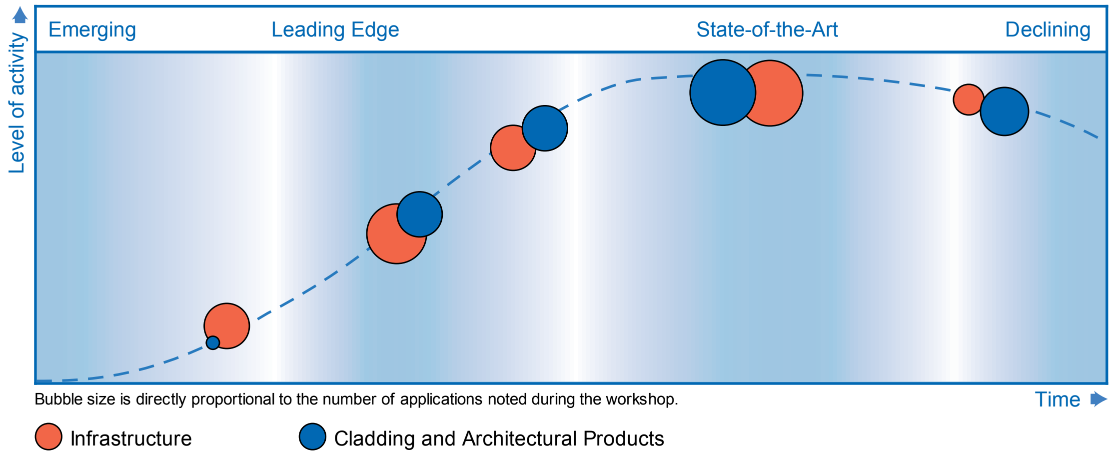
- Aluminium is considered a **replacement material** because, according to experts, the construction industry is not yet fully aware of the versatility of the material. This could lead to aluminium being replaced by less expensive materials if customers are not well-informed about the advantages of using aluminium.

- As far as **world regional differences** are concerned, respondents believe that the use of aluminium in the **European construction industry is far more developed than in North America** - exactly like the transportation industry. Respondents feel that European consumers are more conscious of the durability of aluminium products and choose it for its characteristics. It is, therefore, necessary to bring this awareness to North American consumers to generate market growth on the continent and acquire a level of expertise allowing Canadian siding and architectural product companies to compete on the demanding European market. As it is, the Asian market and that of other developing countries do not offer much potential because aluminium is seen as an expensive material. Here again, consumer awareness needs to be enhanced.

5.4.2.1 ALUMINIUM PRODUCT LIFE CYCLE

The Construction Workshop held in Montreal, Quebec, on May 31, 2006 led to an assessment of the global situation regarding applications vs. life cycle of construction-related products. **Growing applications seem to show good potential, as much for infrastructures as for siding and architectural products.** The number of applications listed is similar for these two market sub-sectors. However, it was noted that the infrastructure sub-sector shows a greater number of emerging applications (Figure 49).

Figure 49: *Life Cycle of Aluminium Applications in the Construction Industry*



Source : Canadian Aluminium Transformation Technology Roadmap Construction Workshop

The following applications were identified as **emerging:** building structures, towers, bridge restoration structures, roofing, tanks for liquid natural gas, top-of-the-line shutters (Canada), and roof tiles.

Leading edge applications are foot bridges, floating-roof reservoirs for the petrochemical industry, grilles, diffusing panels, and top-of-the-line shutters (international).

Stages, commercial curtain walls, amphitheatre seats, signs, railings, commercial windows, soffit, and gutters are considered **state-of-the-art** and are still widely used.

Declining uses are highway signs, residential windows, and certain siding products no longer fashionable.

5.4.2.2 STRATEGIC ISSUES

Workshop participants identified the strategic issues related to the construction market for Canada, North America, and around the world. These are technological or market issues, or a combination of both, tied to socio-economic considerations.

According to participants, the shortage of promotional material and information on the advantages of aluminium are the two major factors holding back the use of aluminium products in construction. General perception is that, unlike steel, the properties of aluminium products have not been improved over the past 20 years.

The extrusion process makes aluminium a unique metal and represents a major advantage for construction infrastructures as they are easy to assemble.

However, **it remains difficult to find adequate aluminium supplies within customer deadlines**. Moreover, in a last-ditch effort to compete with steel, some companies offer lower quality products at a price comparable to products made from other materials; a situation that could lead to the general impression that aluminium is an inexpensive material with no particular advantages. **Aluminium must be made more competitive** than certain other products. Furthermore, its properties within its own niches need to be substantiated in order to develop winning strategies. Doing so would bring construction material manufacturers to **better express their needs to large producers**.

According to workshop participants, **the industry needs to establish a network** similar to that of the steel industry. **By developing a common vision, a deployment strategy could be implemented for lobbying and promotional purposes.** The usefulness and advantages of aluminium need to be advocated by a single, strong voice. Better representation on national committees would increase the influence of the industry and lead to important projects that illustrate the advantages of aluminium. Experts would then have an opportunity to collaborate on meaningful projects and work towards the harmonisation of standards and codes.

This cannot be achieved without making available to professionals purpose-built training on a continuous basis. This would favour professional development on the theoretical and practical levels, leading to better use of the material.

A considerable organisational effort is needed in various fields for the development of this market. Fundamentally, this requires the involvement of every industry role player.

5.4.2.3 NEEDS AND OPPORTUNITIES

About fifty construction-based needs and opportunities were tabled within the framework of the Canadian Aluminium Transformation Technology Roadmap. Five of them were chosen and analysed by experts:

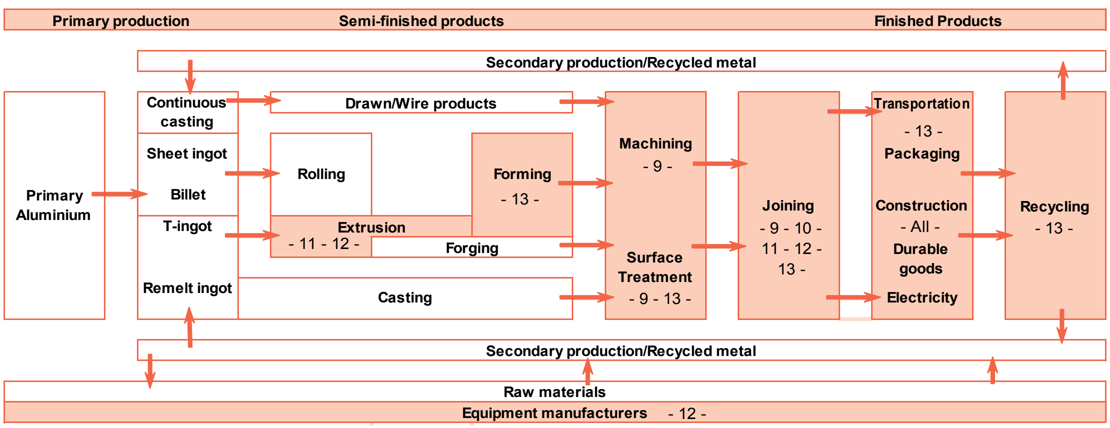
Construction

9. Upgrade aging civilian infrastructures
10. Offer modular structures for easy on-site assembling
11. Offer large extruded shapes
12. Develop integrated design software for aluminium
13. Offer an Aluminium Design Solutions Centre

Chapter 6 - *Needs and Opportunities* – defines each of these opportunities and gives the reader information relative to markets and technologies, priority level, time frame, technical challenge, economic impact, key elements, and payoffs. This information will help in the decision-making process, leading to well-tuned R&D strategies that can answer to the needs identified by experts.

As shown in Figure 50, these projects have an impact on primary production, semi-finished products, finished products, and technology platforms. Each number inserted in the chart below corresponds to the number of each opportunity listed.

Figure 50: *Opportunity Focal Areas for the Construction Market*



Source : David M. Moore

5.4.2.4 DISCUSSION

In Canada, it appears obvious that the road to success for aluminium in the construction sector goes through better promotional methods and training for decision-makers. However, designers are also limited by standards and available design tools. The aluminium transformation industry must work hand-in-hand in order to face this difficult challenge.

The presence of the industry on national standards committees is needed if its opinion is to be heard. This is only possible if there is unity. Synergy remains a key element for promoting the advantages of aluminium.

Interaction between various groups formed by specialty or geographical location can create this synergy.

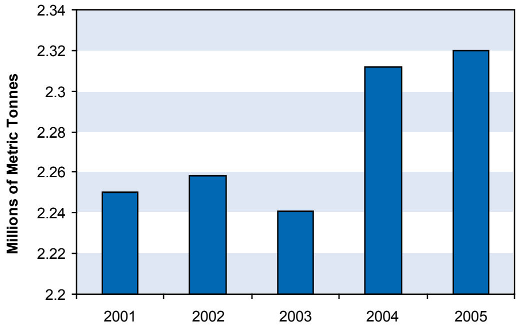
Finally, long-term promotion requires training for the industry and supporting tools for design. This cannot be undertaken by a single group, but rather requires a concerted effort from all the role players in Canada.

5.4.3 THE CONTAINERS AND PACKAGING MARKET

Aluminium foil is largely used for wrapping food as it acts as both a container and protective shield. It is versatile, resists both heat and cold, and is easily sterilised. It makes an excellent barrier against liquids, vapours, and light. Over and above wrapping food, aluminium foil is used in the packaging of various pharmaceutical and cosmetic products. Containers and packaging materials make up **15% of total world aluminium consumption** of semi-finished products, or 6.6 million metric tonnes. It is expected that, by 2015, 9.5 million metric tonnes of aluminium will be used for packaging products. Sheet and foil products make up 91% of that tonnage[xxi].

In Canada and the United States, the containers and packaging market makes up 20% of total aluminium usage. For 2001-05, the CAGR for the industry stood at 0.9%, compared to a 2.9% aluminium market average. Over 2.3 million metric tonnes of finished products were delivered to customers in 2005, a slight increase of 0.3% over 2004 (Figure 51)[xxii]. **Beverage cans are the most widespread product with a market share exceeding 80% in the United States and Canada** (Figure 52).

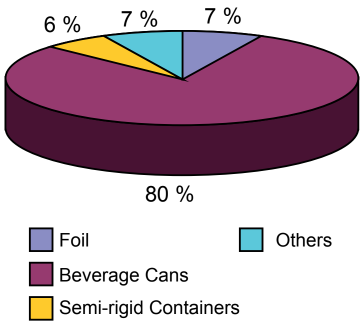
Figure 51: *Growth of the Packaging Market in Canada and the United States 2001-2005*



Source : Aluminum Statistical Review for 2005, Aluminum Association

[xxi] *James F. King*
[xxii] *Aluminum Statistical Review 2005*

***Figure 52:** Segmentation of the Packaging Market in the United States 2005*



Source : Aluminium Statistical Review for 2005, Aluminum Association

Technology Roadmap survey results for the packaging market platform showed that **the most important tendencies and issues, other than material costs, are recyclability and availability**. As far as **semi-rigid products** are concerned, the primary criteria influencing designers is **product quality**, **recyclability** for **beverage cans** and **material properties** for **foil**. Twenty-four respondents from Quebec, the United States and Ontario provided these comments. The following items were also put forward:

- **Marketing and business advantages** vary slightly between sub-contractors, but it was still possible to determine the three most important, i.e. **mechanical and physical properties**, **recyclability**, and **weight**. However, recycling is the leading advantage for beverage cans, while material properties are the most relevant factors in the foil sub-sector.
- The **missing links** are **better mechanical properties**, **a wider range of sizes and shapes**, and **better design knowledge**, all of which are necessary improvements for the growth of the industry.
- Depending on applications and world location, aluminium is considered more a **replacement material than a material to be replaced**. In North America, for example, plastics are gaining ground while the aluminium market is huge in China and India. The arrival of the aluminium bottle makes it a replacement material and simplifies the recycling of this type of container as well.
- As far as **world regional differences** are concerned, it has been noted that **the North American container and packaging market is dominated by the beverage can while Europe relies on a wider variety of products**. However, these markets seem to become intermixed as certain products cross borders more easily than others.

5.4.3.1 DISCUSSION

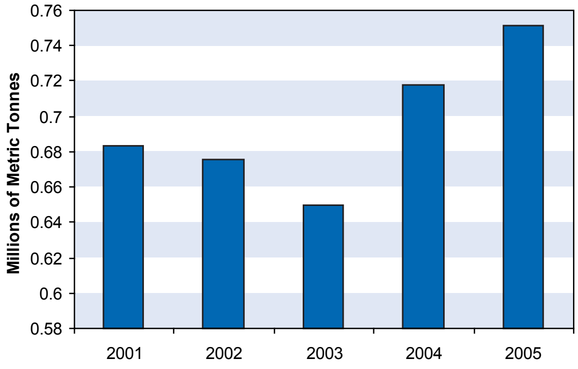
While North America was the largest consumer of packaging-related products from 1995 to 2005, it had the lowest annual growth rate. Growth in the order of 23.6% is expected by 2015, which should be enough to maintain first place. However, with predicted CAGRs of 5.2% and 5.12%, respectively, Asian and Eastern European countries should grab substantial shares of the market with the advent of product diversification.

5.4.4 THE ELECTRICITY MARKET

Since WWII, aluminium has replaced copper as the leading material for high-voltage electrical transmission lines, and its usefulness remains undeniable. Aluminium is still the most economical way to transmit electrical power; weight for weight, it carries twice as much power as copper. It is used in the setting up of transmission lines, and the construction of pylons and various types of equipment. The electricity sector makes up **13% of world aluminium consumption**, or 5.5 million metric tonnes. It is expected that 8.6 million metric tonnes will be used by 2015.

In Canada and the United States, the electricity sector accounts for 6.5% of total aluminium usage. For 2001-05, the CAGR for the industry stood at 2.6%, compared to a 2.9% aluminium market average. In all, over 0.7 million metric tonnes of finished products were delivered to customers in 2005; an increase of 4.7% over 2004[xxiii] (Figure 53).

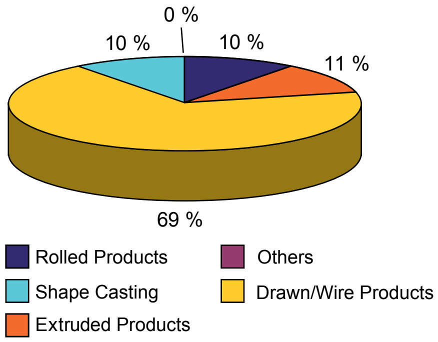
Figure 53: *Growth of the Electricity Market in Canada and the United States 2001-2005*



Source : Aluminum Statistical Review for 2005, Aluminum Association

Obviously, the electricity market makes massive use of drawn/wire products (Figure 54).

Figure 54: *World Consumption of Semi-finished Products by the Electricity Market 2005*



Source : James F. King

The TRM survey showed that, for the electricity sector, **the most relevant trends and issues, other than material costs, are weight reduction and energy efficiency**. Eighteen respondents from the electrical sector, mainly in Quebec and the United States, filled out the survey. The following ideas were also put forward:

- The three main **marketing and business advantages** are, in order of importance, **mechanical and physical properties**, **weight**, and **corrosion resistance**.
- The **missing links** are as follows: **improved physical properties (current-carrying capacity), better design knowledge**, and **improved joining technology**.
- According to experts, aluminium is considered as a **replacement material** because copper replacement opportunities are still high.
- As far as **world regional differences** are concerned, there seems to be little difference between continents. The use of aluminium in the electricity market is essentially regulated by the physical properties of the material. Standards are very strict, meaning that the alloys and products are similar around the world.

[xxiii] *Aluminum Statistical Review 2005*

5.4.4.1 DISCUSSION

The electricity sector should continue to develop over the next several years, with **Asia as a major consumer, followed by Western Europe**. While the properties of aluminium make it a preferred material in this market, innovation remains a primary concern for designers in order to supersede copper, which is still widely used.

5.4.5 THE MARKET FOR OTHER FINISHED PRODUCTS

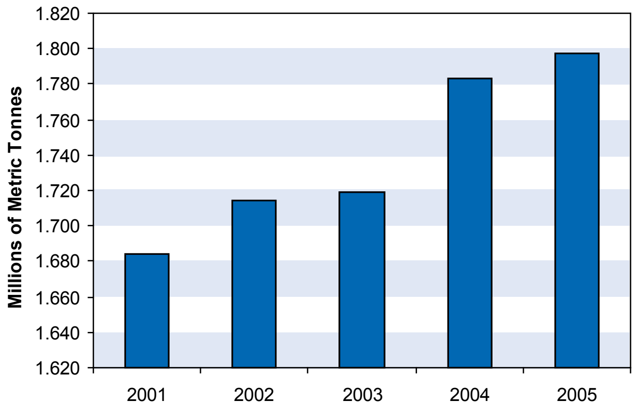
Aluminium is used in a wide array of other sectors such as **consumer goods** (for the most part air conditioners, freezers and refrigerators) (9%), **engineering, machinery and heavy equipment** (10%), and **other products** (4%). Overall, **these markets make up 23% of world aluminium consumption**, or 9.9 million metric tonnes. The use of aluminium in these areas is expected to reach 12.8 million metric tonnes by 2015, distributed as follows (in metric tonnes): 6.4 for engineering, machinery and heavy equipment, 5.7 for durable consumer goods, and 2.6 for other products.

In Canada and the United States, the total market for other finished products accounts for 15.5% of total aluminium usage (6.1% for durable consumer goods, 6.5% for engineering, machinery and heavy equipment, and 2.9% for other products). Figure 58 shows, in percentages, the distribution of these markets.

The CAGR for the other Canadian and American industry markets was 3% for 2001-05, compared to a 2.9% aluminium market average. The sub-sectors with the highest CAGRs are engineering, machinery and heavy equipment with 3.7%, followed by consumer goods with 2.4%, and other products with 2.2%.

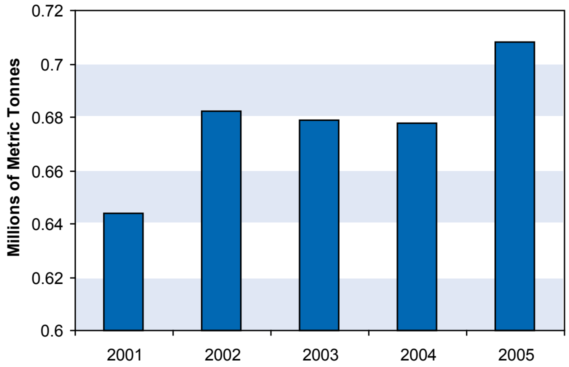
Total delivery of finished products made from aluminium in Canada and the United States reached over 1.8 million metric tonnes in 2005, a 0.8% increase over 2004 (Figure 55). Machinery and equipment accounted for 0.75 million metric tonnes (Figure 56), consumer goods, 0.7 (Figure 56), and other products, 0.3 (Figure 58). This represents a 3.4% increase in delivery of machinery and equipment, 1.5% for consumer goods, and 10.5% for other products.

Figure 55: *Growth of the Other Markets in Canada and the United States 2001-2005*



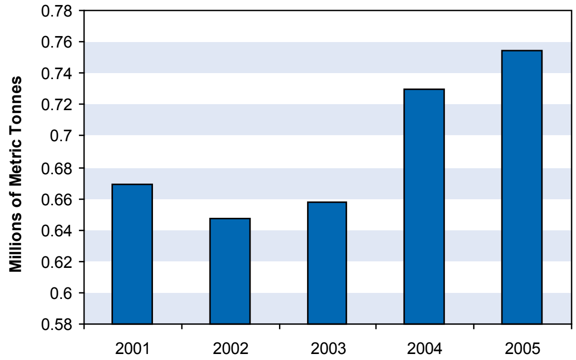
Source : Aluminum Statistical Review for 2005, Aluminum Association

Figure 56: Growth of the Durable Consumer Goods Market in Canada and the United States 2001-2005



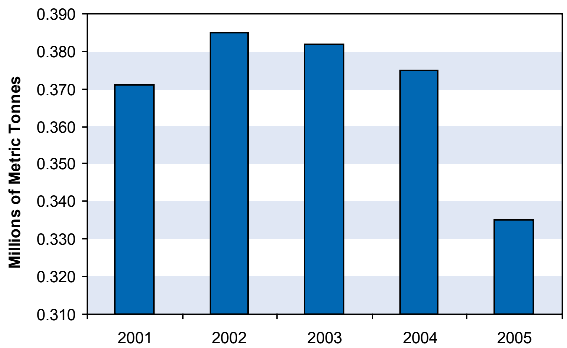
Source : Aluminum Statistical Review for 2005, Aluminum Association

Figure 57: Growth of the Machinery and Equipment Market in Canada and the United States 2001-2005



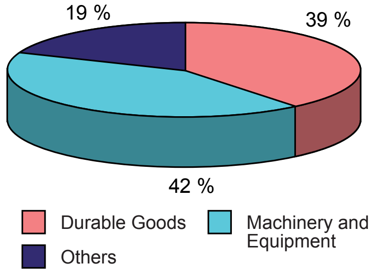
Source : Aluminum Statistical Review for 2005, Aluminum Association

Figure 58: Growth of Other Markets in Canada and the United States 2001-2005



Source : Aluminum Statistical Review for 2005, Aluminum Association

Figure 59: Segmentation of the Market for the Other Products in the United States and Canada 2005



Source : Aluminum Statistical Review for 2005, Aluminum Association

The TRM survey showed that the **trends and issues** differed somewhat from the other market sectors. In the **machinery and equipment** sector, **material properties**, **weight reduction**, and **corrosion resistance** are prioritised. For **consumer goods**, the concerns are material properties and surface finish. Twenty-one respondents mainly from Quebec, Ontario, and the United States completed the survey. The following results were also put forward:

- **Marketing and business advantages** are **weight**, **corrosion resistance**, and **mechanical properties**. Finish is also important for consumer goods.
- **Three missing links** were also defined: **better design knowledge**, **enhanced mechanical properties**, and **improved joining techniques**.
- Aluminium is considered a **replacement material** when costs are low enough and improved properties are at stake. Corrosion resistance is of primary importance in the machinery and equipment sector.
- **World regional differences** are minimal and part of product differentiation.

5.4.5.1 DISCUSSION

Once again, Asia dominates the consumption of engineering, machinery and equipment products, durable consumer goods and a large number of other products. Western Europe, with one half of Asian consumption, comes in second place. Moreover, **for the period between 2005 and 2015, North America is expected to register the lowest growth in this type of consumption, with an increase of 27%**. By using aluminium as a replacement material, opportunities are many for the creation of new products, when prices remain competitive with other materials.

5.5 ALUMINIUM INDUSTRY TECHNOLOGY PLATFORMS

The technology and market survey and technology platform workshops generated **aluminium-specific data** and highlighted certain issues the users of aluminium are confronted with.

This section explores the following technology platforms:

- **shape casting**
- **forming**
- **joining**
- **surface treatment**
- **machining**

A detailed study of each platform revealed valuable information pertaining to how aluminium is used in each sector, the **state of the technology** in numerous types of processes, **major strategic issues** and **needs and opportunities** that need to be addressed by the industry.

Furthermore, it is important to state that only the needs and opportunities that are directly related to a given platform were included in this section. The experts that took part in the TRM process focused on the general considerations that are most likely to help the Canadian aluminium transformation industry strengthen its development tool. Chapter 8, *Recommendations*, provides the results of their reflection.

5.5.1 SHAPE CASTING

During a shape casting process, molten aluminium alloy is poured and solidified in moulds to produce final or near-final shape products. There are various types of shape casting processes, each having its own specifics, advantages and disadvantages, which may vary depending on the type of part being fabricated.

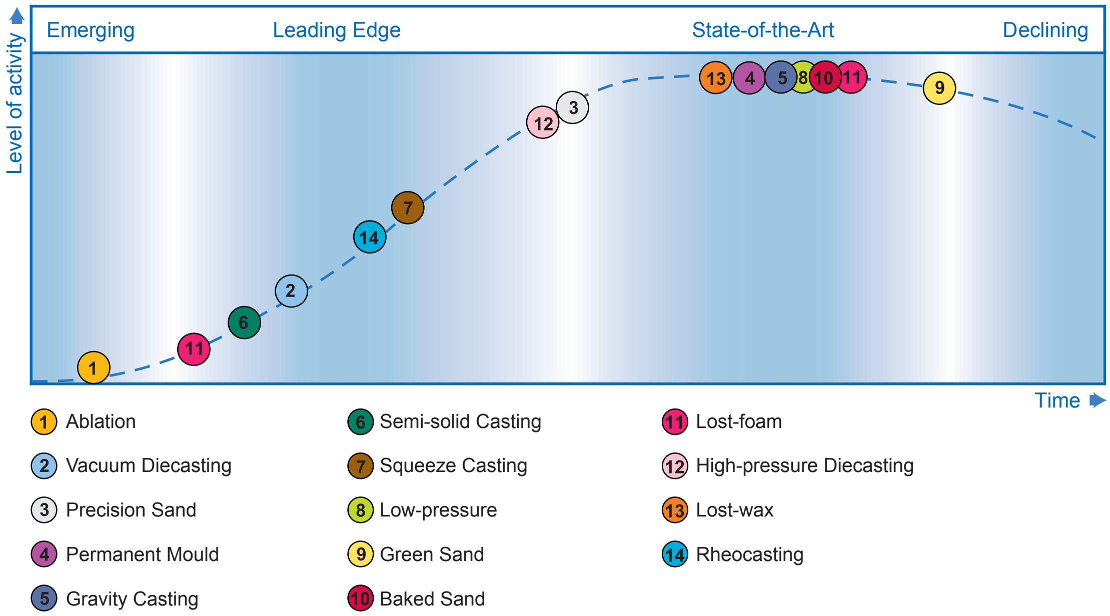
Survey results for the shape casting technology platform revealed that, aside from the price of raw materials, there were other relevant **trends and challenges** that still need to be considered. Indeed, factors such as **structural performance, productivity and modelling capacities**[ii] were among the top priorities. Moreover, the need to enhance structural erformance in every shape casting process stands out as the most important challenge. These results were taken from a survey that was completed by 37 respondents working in the shape casting industry. The information provided by these specialists, who were mainly from Quebec, the United States, and Ontario, allowed them to reach the following conclusions:

- The best **marketing** and **business advantages** are **consistency of product properties**, **cost** and **performance**.
- **Missing links** were also clearly defined. **Enhanced performance, improved scientific understanding of processes and availability of engineering systems** are the objectives that need to be achieved.

5.5.1.1 LIFE CYCLE OF TECHNOLOGY

The Shape Casting Workshop, held on June 13, 2006 in Montreal, Quebec, provided a global view of shape casting process life cycles by sector. The information obtained demonstrated that a large part of the industry relies on state-of-the-art technologies (see Figure 60).

Figure 60: *Life Cycle of Technology in the Shape Casting Industry*



Source : Canadian Aluminium Transformation Technology Roadmap Shape Casting Workshop

Emerging technologies include processes such as ablation, semi-solid casting (thixomoulding), lost-foam and vacuum diecasting.

Leading edge technologies include rheocasting, squeeze casting, high-pressure diecasting and precision sand.

Lost-wax, permanent mould, gravity casting, low-pressure, baked sand, lost-foam and green sand are all in the **state-of-the-art** processes category.

At the present moment, there are no **declining** technologies in this sector. **Very few processes will completely disappear** any time soon because the industry always manages to find new ways of giving them a competitive edge or efficiently adapting aging methods to new realities. Some experts consider that thixomoulding is seriously losing ground to other processes. However, this process was never really adequately deployed, so we decided to keep it in the emerging technologies category.

This workshop lead to the following observation: **Eastern Europe, Asia, the Middle East, and Mexico have developed low-cost manufacturing processes that give them a competitive advantage over Canadian production and reduced its share of world markets**. Moreover, despite the fact that numerous shape casting technologies were initially implemented in North America, these countries can rely on the efficiency and performance of fairly young industrial parks; an asset that puts them ahead of Canada.

5.5.1.2 STRATEGIC ISSUES

Workshop participants also identified the strategic issues facing the shape casting processes used in Canada, North America and around the world. These issues are part technological, market-based or a combination of both, and can also be influenced by socio-economic factors.

According to participants, **issues relative to shape casting are not wholly based on technological factors**. Other concerns, such as human resources, knowledge, regulations, recycling and research and development must be taken into consideration. Nevertheless, **metal quality control and availability of product predictability models were pinpointed as technological challenges for the shape casting platform**.

As far as **human resources** are concerned, the main issue is to **efficiently train and maintain highly qualified technical personnel in organisations**. It was equally shown that **shape casting engineers know considerably more about other materials and molds than they do about aluminium**.

Experts also believe that **despite the development of quality technical know-how, it is not necessarily put to good use during the development of new applications**.

Furthermore, it is of the utmost importance to reach a **worldwide consensus** on occupational health and safety and environmental **regulations**, since Canadian businesses have standards that differ from those set by emerging countries. Doing so would offer **better working conditions** to certain workers, ensure a **worldwide commitment to the environmental cause** and **increase Canada's competitiveness** in terms of production costs.

Aluminium offers a virtually endless life cycle; an advantage that should be taken more into consideration by product designers. Indeed, aluminium is infinitely recyclable and has a low long-term environmental impact. These assets should be considered at the outset of any product design process.

Ensuring the **coordination of Canadian research and development** activities would allow to better sharpen the focus and thrust of development efforts in key areas. Furthermore, such an initiative would establish the complementarity of Canadian and American research and development activities.

5.5.1.3 NEEDS AND OPPORTUNITIES

Over sixty shape casting needs and opportunities were tabled during the activities of the Canadian Aluminium Transformation Technology Roadmap. A few casting experts work with the TRM team to review the eight opportunities that showed the most potential for growth. They are stated as follows:

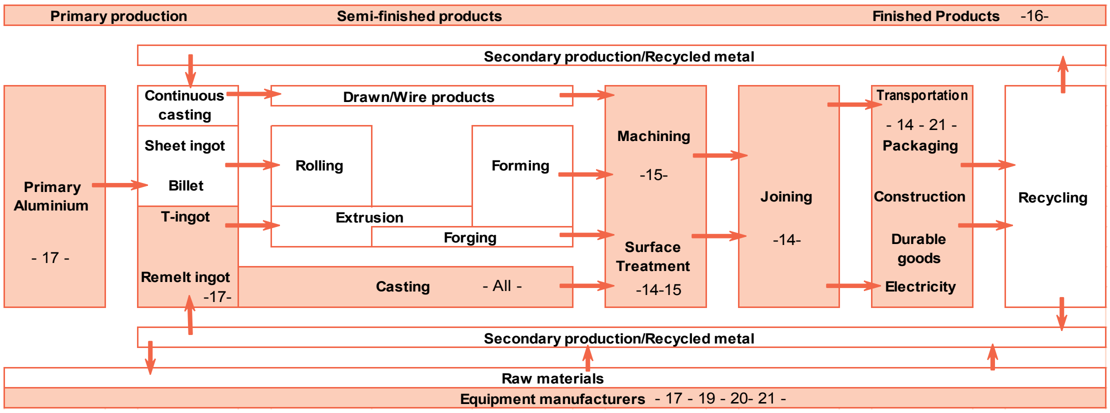
Shape Casting

14. Perform alloy development for semi-solid rheocasting of structural components
15. Develop a "Best Practice Guide for Shape Casting"
16. Offer aluminium Casting Competitiveness Tools
17. Make products from readily available liquid alloys from Canadian primary plants
18. Offer non-competitive process optimisation
19. Improve real-time monitoring of products and processes with advanced sensors and systems
20. Improve and diffuse energy efficiency solutions for foundries
21. Offer larger castings with thinner walls

Chapter 6 – *Needs and Opportunities* – defines each of these opportunities and provides the reader with information regarding the markets and technologies targeted, priority level, time frame, technical challenge, economic impact, key elements, and payoffs. This information will guide industry players in their decisions and help determine the research and development strategies required to meet the needs stated by experts.

As shown in Figure 61, these projects will have an impact on semi-finished and finished products and technology platforms. Each number on the chart (14-21) refers to a specific opportunity. See the list above for quick reference.

Figure 61: *Opportunity Focal Areas for Shape Casting Technologies*



Source : David M. Moore

5.5.1.4 DISCUSSION

The Shape Casting Workshop has clearly demonstrated that there is a **lack of communication among Canadian organisations**. **As a result, industry players miss excellent opportunities to use readily available equipment, and take part in projects and knowledge sharing initiatives.** Furthermore, it would be beneficial for Canada to create links with American organisations, such as USCAR (United States Council for Automotive Research), DOE (Department of Energy), DOT (Department of Transport), which conduct various types of shape casting development projects.

Those who took part in the Shape Casting Workshop noted that parts casting businesses could build on Canadian molten metal and transportation infrastructures.

It was also mentioned that most present-day Canadian shape casters are still reactive and not proactive to industry trends. They answer to requests for bids and are at the mercy of their contract givers. They do not have enough resources to turn this situation around and are under increasing pressure to lower their prices. Therefore, they are obviously in need of high performance processes to remain competitive and have neither the time nor the resources to make their niche stand out.

Entrepreneurs find if difficult to keep up with the rapid changes imposed by the new global economy. However, numerous shape casting alliances already exist, and a wide variety of information is made available by American and European organisations. The best known alliances are very active and provide access to quality information. Here are a few examples: AFS, NADCA in United States, France-based CTIF, CQRDA in Québec, NRC, college and university networks. In short, there is a lot of information available and many alliance groups are ready to support entrepreneurs. However, the lack of efficient structures needed to encourage small players to go beyond the present situation remains a pressing issue.

To achieve better results and ensure the survival of this sector, businesses need solutions that will structure their needs. Of course, to think that such solutions can come from only one support organisation would be somewhat utopian. It is obvious that only the concerted efforts of many players will generate the desired outcomes. The opportunities mentioned on the previous page cannot be carried forward without the collaboration of support organisations.

According to specialists, the issues are not technology-based. They insist on the fact that despite the development of quality technical know-how, it is not necessarily put to good use during the development of new applications. Equally important, an inefficient communication system can be held responsible for insufficient knowledge sharing, lack of participation in various types of projects and limited accessibility to specialised equipment.

5.5.2 FORMING

Forming operations include a series of processes based on the plastic deformation of aluminium alloy. Such operations can be carried out with warm forming processes, i.e. above recrystallisation temperature (for example: forging, extrusion), or with cold forming processes (for example: drawing, bending).

TRM survey results for the forming sector showed that, aside from the price of raw materials, **productivity, formability and structural performance of materials** are the main **trends and challenges** that need to be addressed. These issues were provided by thirty forming specialists, almost all of which were from Quebec, the United States and Ontario. The process also permitted to note other important facts, including:

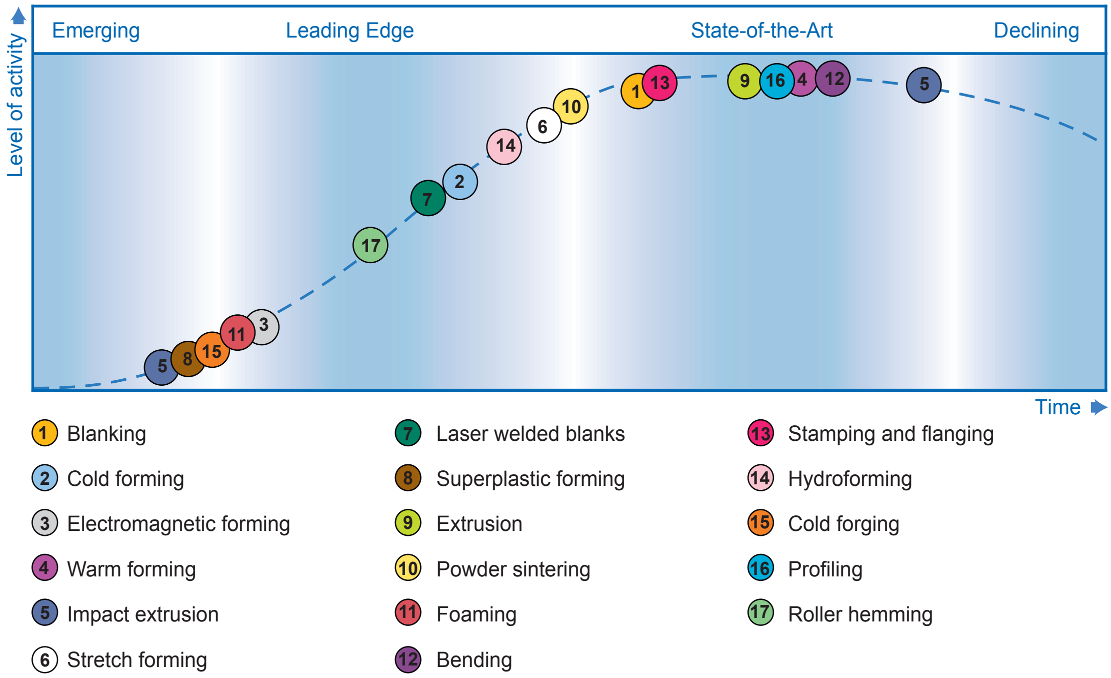
- The best **marketing** and **business advantages** are, successively, **productivity**, **product performance** and **consistency of product properties**.

- **Four missing links** have also been clearly defined and are of equal importance. They are stated as follows: **availability of engineering systems, market demand, enhanced performance**, and **scientific understanding**. The forming platform includes a comprehensive cluster of processes. The wide span of differences between each process explains why each one has its own distinct needs.

5.5.2.1 LIFE CYCLE OF TECHNOLOGY

The Forming Workshop, held on September 12, 2006 in Toronto, Ontario, enabled us to provide a global view of the life cycle of the technological processes involved in forming operations (see Figure 62).

Figure 62: *Life Cycle of Technology in the Forming Industry*



Source : Aluminium Transformation Technology Roadmap Forming Workshop

Emerging technologies include: impact extrusion, cold forging, superplastic forming, foaming and electromagnetic forming. Moreover, the following technologies were also placed in this catergory, as they are only beginning to be used in forming applications: incremental forming, vacuum forming, stretch forming, asymmetrical forming and equiangular extrusion.

Leading edge processes include: roller hemming, laser welded blanks, warm forming, hydroforming, stretch forming and powder sintering.

Even though processes such as blanking, stamping, flanging, extrusion, profiling, hot forging, bending and impact extrusion are all listed in the **state-of-the-art** category, they remain very popular in Asian regions where they are still widely used.

There are no **declining** technologies in this sector.

5.5.2.2 STRATEGIC ISSUES

Workshop participants also identified the strategic issues facing the forming processes used in Canada, North America and around the world. These concerns are part technological, market-based or a combination of both and can also be influenced by socio-economic factors.

According to participants, **one important strategic issue is the supply chain. Indeed, many semi-finished elements are not readily available in the appropriate dimensions, thus causing long delivery lead times**. Moreover, designers do not take into account the fact that **even if aluminium is more expensive, its extended life cycle reduces its purchase cost in the long run**. For example, Europeans seem more likely to choose aluminium as a residential construction material because, contrary to North America, their homes are built to last longer and financed for longer periods of time.

From an academic point of view, **aluminium is a subject that is generally covered in very limited sections of course syllabi**. Very rarely do we come across a school that dedicates a whole 45-hour course to aluminium. Changing this approach would allow us to retain aluminium-based expertise and disseminate it to future professionals. More specifically, **coordinated efforts could provide easy access to aluminium-related knowledge and ensure a more efficient dissemination to students and professionals**.

Also, better strategies should be used to **inform the general public about the advantages of using aluminium**. Doing so would help consumers make more informed choices. It is a well-known fact that buyers are often conservative when it comes to choosing building materials, and would rather use those they know than to try new ones. Changing such a buying habit is a long and tedious process which can be achieved by making information readily available and easily accessible.

Lobbying activities should be organised by networks of key decision makers. This strategy would be more efficient than the solo lobbying initiatives that are presently taking place throughout the sectors of the industry.

Specialists believe that replacing any given material by aluminium is going to be a difficult feat to accomplish. The main issues the industry will need to overcome are: implementation costs, information dissemination and learning, employee training and ensuring well-established relationships with a wide array of suppliers. It is, therefore, of the **utmost importance for the industry to support the implementation and promotion of aluminium as a replacement material** for certain products.

5.5.2.3 NEEDS AND OPPORTUNITIES

Close to fifty forming needs and opportunities were tabled during the activities of the Canadian Aluminium Transformation Technology Roadmap. A few forming experts worked with the TRM team to review the five opportunities that showed the most potential for growth and analysed them. Here are their results:

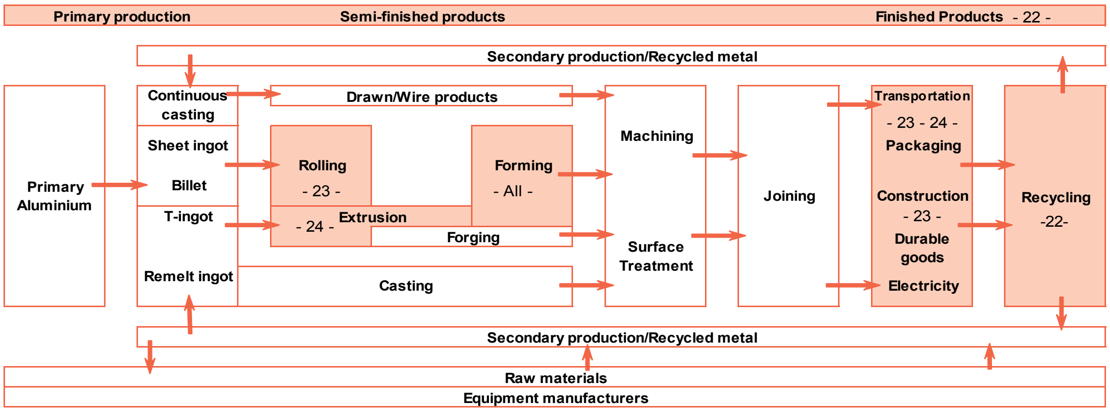
Forming

22. Create an aluminium life cycle cost/benefit body of knowledge
23. Design Aluminium multi-material flat panels
24. Research & Develop aluminium hydroforming
25. Improve process simulation of forming technologies
26. Invent new forming processes suitable to industry needs

Chapter 6 – *Needs and Opportunities* – defines each of these opportunities and provides the reader with information regarding the markets and technologies targeted, priority level, time frame, technical challenge, economic impact, key elements, and payoffs. These elements will guide stakeholders in their decisions and help set the research and development strategies necessary to meet the needs stated by industry specialists.

As shown in Figure 63, these projects will have an impact on semi-finished and finished products and technology platforms. Each number on the chart (22-26) refers to a specific opportunity. See the list above for quick reference.

Figure 63: *Opportunity Focal Areas for Forming Technologies*



Source : David M. Moore

5.5.2.4 DISCUSSION

According to aluminium forming specialists, the following elements are the **cornerstones of this sector: awareness to the capabilities of aluminium, knowledge sharing and training**. Furthermore, specialists also consider that a larger number of key stakeholders, including governments, legislative authorities, consumers, general public, transport companies, students and manufacturers should have **a better understanding of industry needs.** Indeed, **enhanced public and industry awareness will simplify knowledge sharing, promote collaboration initiatives and foster enabling synergy**. As a result, everyone would speak the same language and focus on the same issues. Moreover, **training remains a prime concern** in this sector. Satisfying the need for efficient training would promote awareness among the academia and the development of refresher training courses for professionals already working in the field.

There are **many emerging and leading edge technologies** in the forming sector. Canada should focus on these technologies and go out of its way to corner them. Doing so would put it ahead of other countries that rely on state-of-the-art technologies. Current data shows that **most of the contracts carried out with mature technologies have shifted to Asia**. Moreover, it must be taken into account that implementing new technologies always involves risks. While this may be true, coordinated research and development initiatives would reduce them and nurture the development of a homogeneous knowledge base from coast-to-coast. In the same way, **various types of specialised**

forming equipment could be made readily available for research and development. This would assure an optimum usage of equipment and favour the acquisition and development of other processes.

Despite the fact that high risk projects are seldom publicised, several interesting avenues remain to be explored. As purchasing and investment decisions are often based on immediate costs and not on product life cycle, Canadians should review their decision-making process. Achieving this would open up new arenas for exploration.

5.5.3 JOINING

Joining is a process in which discrete components are attached together, during the final steps of production, to produce a finished device or product. Mechanical (bolting and riveting), metallurgical (welding and brazing) or chemical (adhesives) operations can be used to join components.

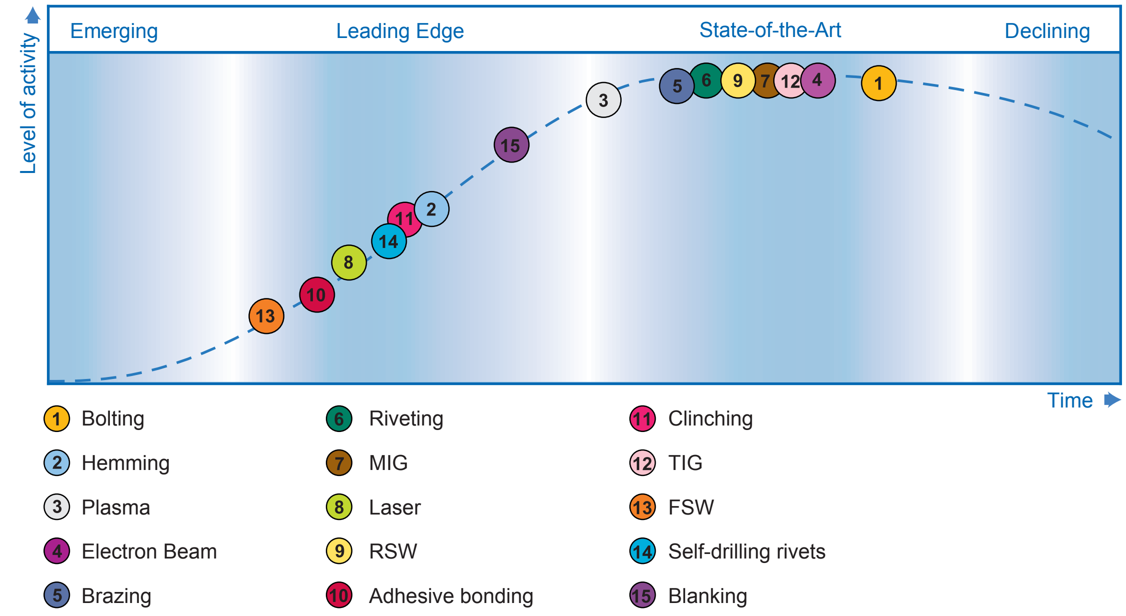
Technology Roadmap survey results for joining demonstrated that, aside from the price of raw materials, there were other relevant **trends and challenges** that need to be taken in account. Above all, factors such as **structural performance**, **productivity and access to joining properties databases** were among the leading priorities. These results were taken from a survey that was filled out by 31 joining experts mostly from Quebec, the United States and Ontario. The information they provided allowed them to reach the following conclusions:

- The most efficient **marketing** and **business advantages** are, successively, **product performance**, **design attributes** and **consistency of product properties**.
- **Missing links** are stated as follows: **availability of engineering systems**, **enhanced performance**, and **scientific understanding**. Filling these gaps would be the best way to help the industry to thrive.

5.5.3.1 LIFE CYCLE OF TECHNOLOGY

The Joining Technology Platform Workshop, held on September 27, 2006 in Montreal, Quebec enabled us to present an overall view of the life cycle of the technological processes used in this sector. On one hand, survey results showed that there are no **emerging or declining technologies** in this sector. On the other hand, the industry has numerous growing and mature technologies (see Figure 64).

Figure 64: *Life Cycle of Technology in the Joining Industry*



Source : Aluminium Transformation Technology Roadmap Joining, Surface Treatment and Machining Workshop

There are no **emerging** technologies in this platform.

Leading edge (growing) technologies include friction stir welding, adhesive bonding, laser, riveting, self-drilling rivets, clinching, hemming, blanking and plasma processes.

Even though brazing, riveting, resistance spot welding (RSW), metal arc welding (MIG), tungsten arc welding (TIG), electron steam and bolting rank as **state-of-the-art (mature)** processes, they remain very popular and are still widely used in the joining sector.

Presently, there are no **declining** technologies in this field.

Workshop participants equally mentioned that **most of the competition in this sector comes from Asia**.

5.5.3.2 STRATEGIC ISSUES

Workshop participants also identified the strategic issues facing the forming processes currently used in Canada, North America and around the world. These concerns are part technological, market-based or a mix of both and are influenced by socio-economic factors.

According to participants, the **main issue resides in the management and dissemination of knowledge**. Some recommended the development of a large-scale North American network capable of disseminating information relative to technologies and markets. Its reach would stretch from early design stages (standards, databases) right through to training (aluminium-based knowledge, specialisation activities) and foster research and development collaboration among industry players.

On the other hand, it was found that a certain number of **technological challenges await solutions**. To illustrate, specialists believe that more efficient surface treatment processes would simplify adhesive bonding, long-term testing could enhance adhesive bonding performance, further research would prevent distortion during welding operations, etc.

From a North American perspective, the aluminium transformation industry should concentrate its efforts on **productivity and automation** to better respond to market needs. More than ever, clients are seeking components that are virtually ready to install on finished products. Hence, aluminium transformers are bombarded with new requirements from around the world and must immediately adapt to remain competitive and meet market demands.

5.5.3.3 NEEDS AND OPPORTUNITIES

About twenty joining needs and opportunities were presented during the Canadian Aluminium Transformation Technology Roadmap activities. Industry specialists chose the three most likely to generate concrete results and analysed them. They include:

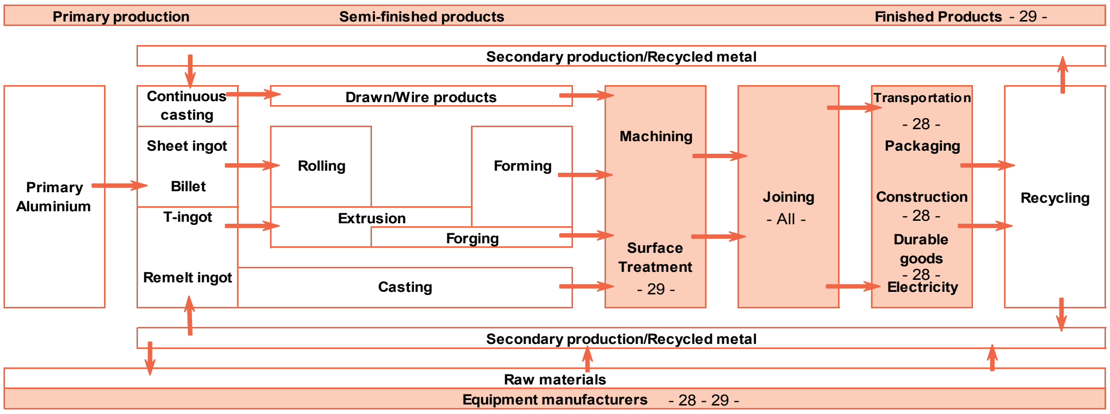
Joining

27. Develop a body of knowledge on adhesives
28. Form an interest group on friction stir welding of aluminium
29. Develop or adapt sensing technologies for aluminium surface characterization

Chapter 6 – *Needs and Opportunities* – defines each opportunity and gives the reader information regarding the markets and technologies targeted, priority level, time frame, technical challenge, economic impact, key elements, and payoffs. Once again, these elements will guide industry players in their decisions and help determine the research and development strategies required to meet the needs stated by specialists.

As shown in Figure 65, these projects will have an impact on semi-finished and finished products and technology platforms. Every number on the chart (27-29) refers to a specific opportunity. See the list above for quick reference.

Figure 65: *Opportunity Focal Areas for Joining Technologies*



Source : David M. Moore

5.5.3.4 DISCUSSION

Joining is a critical sector that could very well ensure the success of the Canadian aluminium industry. Joining-based processes are part of every simple or complex system and present markets, such as the transportation and construction sectors, even go so far as requiring multi-material solutions. As a result, joining has become a major concern for industry stakeholders.

It is an absolute necessity for the Canadian aluminium industry to enhance its joining capacities and develop a body of knowledge for this platform. Developing and deploying improved joining methods could give Canada a substantial edge over global competition.

As stated in previous sections, better collaboration and cooperation among key Canadian industry players would reduce risks and provide opportunities for optimising resource use.

5.5.4 SURFACE TREATMENT

A surface treatment process on aluminium is when a thin organic or metallurgical coating is applied to the surface of an aluminium component to protect it against the weather or facilitate the bonding of a finishing primer (for example: paint or adhesive).

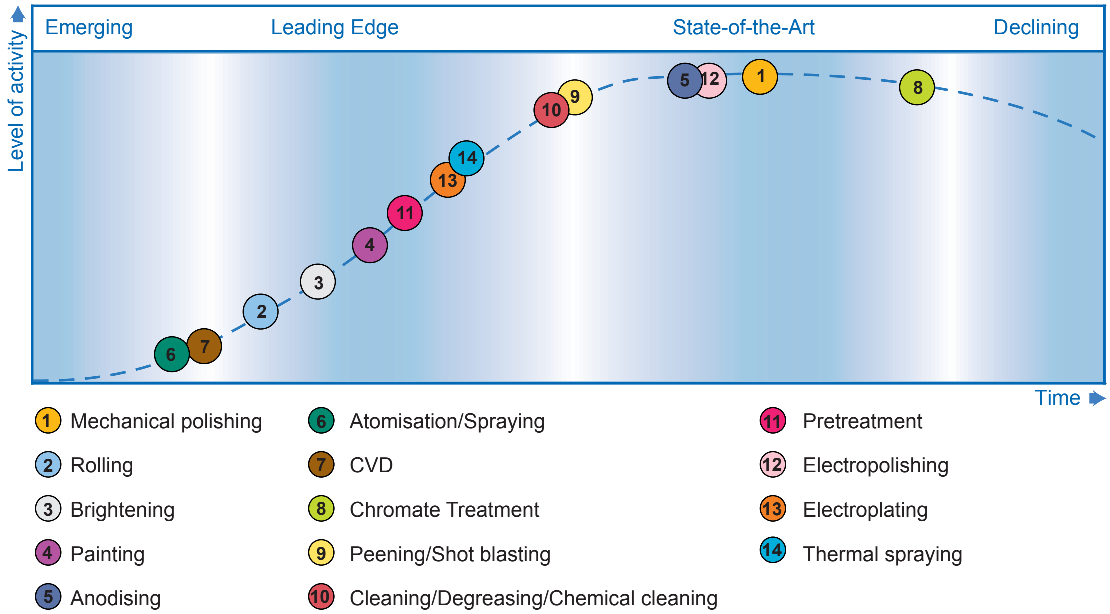
TRM survey results for this platform showed that **current trends are to focus on the protection of the environment and safety of workers**. Similarly, the survey also **revealed that chromate treatment should be abandoned - a major concern that still needs to be resolved**. Twenty-five surface treatment specialists studied this platform, most of which were from Quebec, Ontario and the United States. Here are their conclusions:

- The most efficient **marketing** and **business advantages** are, successively, **product performance**, **consistency of product properties and design attributes**.
- **Missing links** are: **the need for enhanced performance and scientific understanding and availability of engineering systems**.

5.5.4.1 LIFE CYCLE OF TECHNOLOGY

The Surface Treatment Workshop, held on September 27, 2006 in Montreal, Quebec, enabled our specialists to provide a global view of the life cycle of the technological processes involved in these operations. It was noted that **most surface treatment processes are based on leading edge (growing) technologies and few of them have reached maturity (State-of-the-art)** (see Figure 66).

***Figure 66:** Life Cycle of Technology in the Surface Treatment Industry*



Source : Aluminium Transformation Technology Roadmap Joining, Surface Treatment and Machining Workshop

The following processes are considered as **emerging** technologies: thermal spraying based on cathode sputtering and chemical vapour deposition.

Leading edge (growing) technologies include: rolling, brightening, painting, pretreatment, electroplating and thermal spraying.

Peening, shot blasting, cleaning/degreasing, chemical cleaning, anodising, electropolishing and mechanical polishing are all considered as **mature (State-of-the-art)** processes. However, they are still very popular in this sector.

To end, chromate treatment is the only **declining** process.

5.5.4.2 STRATEGIC ISSUES

Workshop participants determined the strategic issues facing the surface treatment processes currently in use in Canada, North America and around the world. They are part technological, market-based or a combination of both and influenced by socio-economic factors.

Based on the information provided by participants, one of the most pressing issues is to **make aluminium products more appealing to a wide array of markets**. Indeed, niche markets show the highest growth potential for the aluminium industry.

A few transformers should have **factory layouts capable of fabricating very large parts/components** (architectural and structural products) and analyse different types of **cost reduction options**.

Moreover, markets are presently on the lookout for **new and improved surface properties**, i.e. low aerodynamic influence, heat transfer, wettability and noise absorption. The marketing of aluminium alloys offering these properties will pave the way to new uses in a myriad of niche markets.

5.5.4.3 NEEDS AND OPPORTUNITIES

About twenty surface treatment needs and opportunities were tabled during the activities of the Canadian Aluminium Transformation Technology Roadmap. A few surface treatment experts work with the TRM team to review the five opportunities that showed the most potential for growth and analysed them. They are stated as follows:

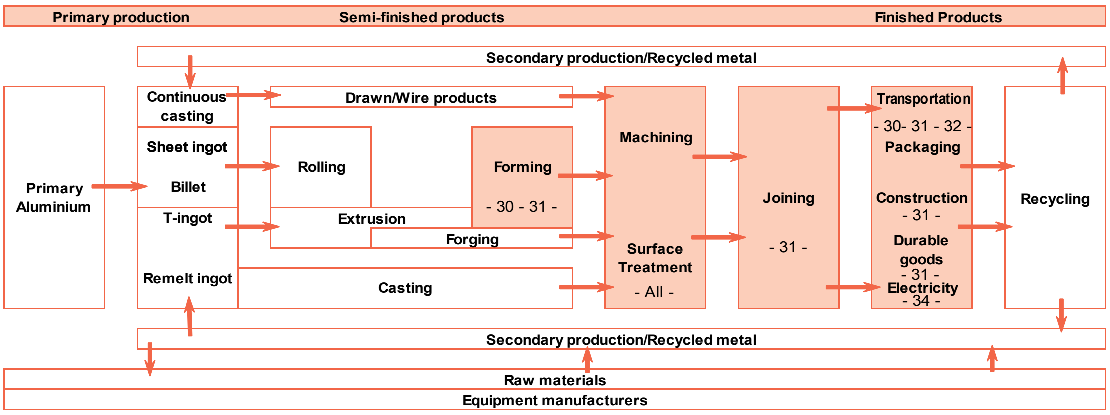
Surface Treatment

30. Offer prepainted sheet products capable of surviving forming operations
31. Develop chrome-free conversion treatment
32. Offer low-cost, decorative metal texturing
33. Develop a paint that can be applied to aluminium substrate without using conversion films
34. Research & develop a treatment to prevent the adhesion of ice to aluminium surfaces

Chapter 6 – *Needs and Opportunities* – defines each of these opportunities and provides the reader with detailed information pertaining to targeted markets and technologies, priority level, time frame, technical challenge, economic impact, key elements, and payoffs. Once again, these elements are provided to guide industry players in their decisions and help define the research and development strategies needed to meet the needs stated by experts.

As shown in Figure 67, these projects will have an impact on semi-finished and finished products and technology platforms. Each number on the chart below (30-34) refers to a specific opportunity. See the list above for quick reference.

Figure 67: *Opportunity Focal Areas for Surface Treatment Technologies*



Source : David M. Moore

5.5.4.4 DISCUSSION

With technologies such as thermal spraying, the industry would be capable of offering new materials, thus generating valuable opportunities in a wide variety of markets. Equally important, the general **availability of prepainted sheet products capable of surviving forming operations** would shorten production and delivery lead times.

Furthermore, the **development of new characteristics** would optimise the use of certain surface treatment processes and definitely give them a competitive edge. For instance, bringing to market enhanced pre-treatment processes based on the use of aluminium-compatible finishing primers could lead to interesting market opportunities.

5.5.5 MACHINING

Machining involves all the cutting operations used on a piece of work to give it a final shape. Depending on alloy characteristics and types of tools used, the rough piece is shaped and cut to desired specifications.

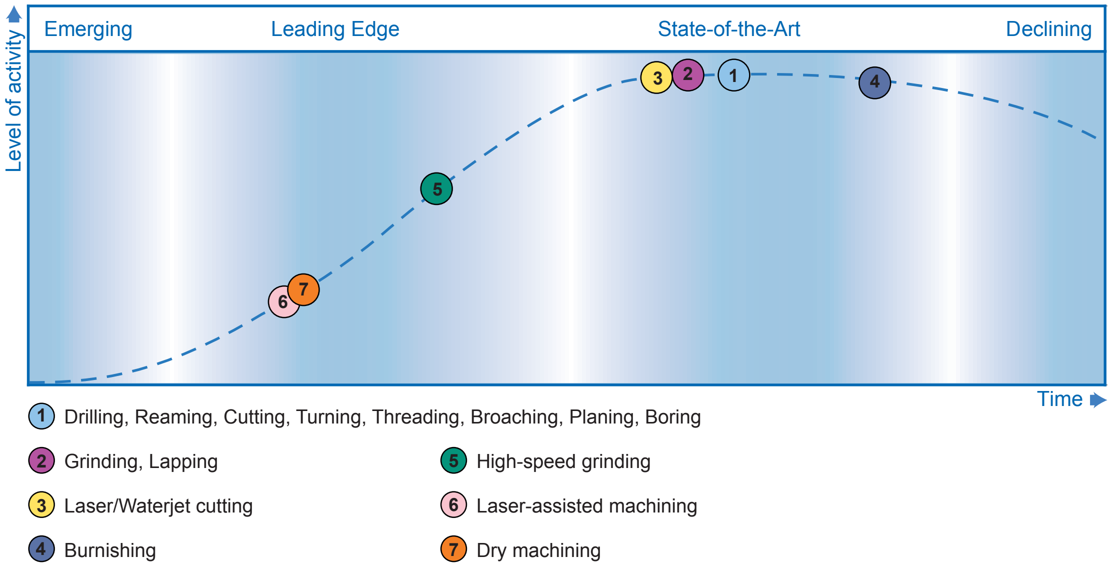
TRM survey results for machining demonstrated the **trends and challenges** that need to be taken into consideration.

Above all, factors such as **productivity**, **structural performance**, **and surface quality** were the top priorities. These results were taken from a survey that was filled out by 17 joining experts who were mostly from Quebec, the United States and British Columbia. The principal **marketing** and **business advantages** are increasing **productivity** and the ability to perform **dry machining operations**.

5.5.5.1 LIFE CYCLE OF TECHNOLOGY

The workshop, held on September 27, 2006 in Montreal, Quebec, provided a global view of machining process life cycles. The information obtained demonstrated that **the majority of machining technologies rank in the mature category and very few new technologies were developed lately** (see Figure 68).

Figure 68: *Life Cycle of Technology in the Machining Industry*



Source : Aluminium Transformation Technology Roadmap Joining, Surface Treatment and Machining Workshop

Results show that there are no **emerging** technologies in this sector.

Leading edge (growing) technologies include the following processes: laser-assisted, dry and high-speed machining.

Laser and waterjet cutting, lapping, drilling, reaming, cutting, turning, threading, broaching, planing, boring and burnishing are all considered as **mature (state-of-the-art)** technologies.

5.5.5.2 STRATEGIC ISSUES

Workshop participants also pinpointed the strategic issues facing the machining processes currently being used in Canada, North America and around the world. These major concerns are part technological, market-based or a mix of both and are influenced by socio-economic factors.

According to experts, the industry has **misconceptions** and a general **lack of knowledge** about the machining sector. Surprisingly, many believe that machining involves expensive operations. It would be interesting to **promote the advantages of aluminium machining**, and an efficient way to achieve this would be to compare machined products to other materials and processes.

At the same time, government laboratories and universities could organise **advanced machining technology demonstration and transfer activities** to address the shortcomings of this sector, i.e. designer and operator training, simulation tool optimisation, research and development, quick access to technical data.

The synergy that would arise from such coordination activities would put the industry in an excellent position to build upon this base and help seize numerous opportunities before others master them.

5.5.5.3 NEEDS AND OPPORTUNITIES

Some twenty machining needs and opportunities were highlighted during the Canadian Aluminium Transformation Technology Roadmap activities. A few machining experts work with the TRM team to review the four opportunities that showed the most potential for growth and analysed them. They are stated as follows:

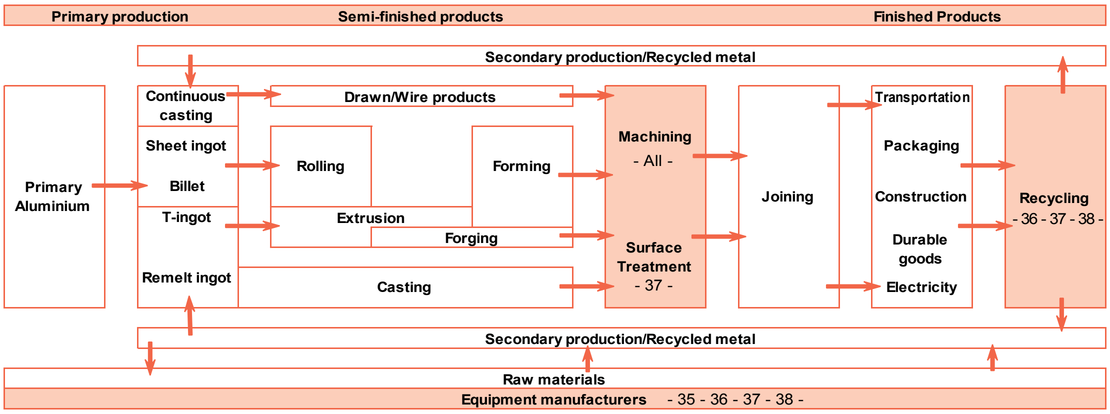
Machining

35. Form an interest group on aluminium machining
36. Automate measurement systems to optimise part positioning and enhance equipment performance
37. Promote adoption of aluminium dry machining or MQL (Minimum Quantity Lubrication)
38. Develop analytical tools, numerical simulations, and software capabilities for aluminium machining

Chapter 6 – *Needs and Opportunities* – defines each of these opportunities and provides the reader with information regarding the markets and technologies targeted, priority level, time frame, technical challenge, economic impact, key elements, and payoffs. These elements will, once again, guide industry players in their decisions and help determine the research and development strategies needed to meet the needs stated by workshop experts.

As shown in Figure 69, these projects will have an impact on semi-finished and finished products and technology platforms. Each number on the chart (35-38) refers to a specific opportunity. See the list above for quick reference.

Figure 69: *Opportunity Focal Areas for Machining Technologies*



Source : David M. Moore

5.5.5.4 DISCUSSION

Most machining processes are considered as mature technologies. Therefore, it is of the greatest importance to **begin optimising these processes** immediately in order to remain competitive. Similarly, there are still pressing needs at various levels and **training remains a major issue**. Also, the **growth of dry machining** should equally lead to interesting opportunities for transformers willing to implement this technology in their factories.

Organising technology demonstrations and transfer activities to promote the use of machining processes should breathe new life into this platform and help fill many knowledge gaps.

To face this challenge, it is mandatory for the industry to disseminate information to entrepreneurs, guide researchers, coordinate training efforts and quickly deploy new production competencies. Furthermore, the industry must be able to assess progress, communicate its strategies, and foster concerted actions among industry support groups.

6. NEEDS AND OPPORTUNITIES

The following pages present the opportunities most likely to stimulate aluminium transformation in Canada. These **opportunities are divided into 2 markets and 5 technologies**:

- Markets:
  - Transportation
  - Construction

- Technologies:
  - Shape casting
  - Forming
  - Joining
  - Surface treatment
  - Machining

These needs and opportunities are rooted in the answers to the written questionnaires (surveys) and/or suggestions made by participants at the 5 workshops. In all, **over 270 opportunities were tabled**.[xiv]

At this stage, it is essential to make a clear difference between a suggested opportunity and a recommendation. A large number of general recommendations put forth during the workshops were noted and are discussed in the Recommendations chapter of this TRM.

An opportunity is a situation which can be seized or modified by a person, company, institution or government to turn it into a better situation and create or transfer wealth. For instance, an opportunity could be to market a new aluminium alloy with superior mechanical properties because it would create wealth for both the seller and user. On the other hand, providing training to architects pertaining to the advantages of aluminium would be considered a recommendation - not an opportunity - simply because such an action would not generate wealth per se.

Workshop participants based their assessment and prioritisation of each recommendation on three criteria (in order of importance): **most probable time frame**, **technical challenge** and **payoffs**. Thus, an opportunity received the highest priority if it met the following criteria: short implementation time frame, low technical challenge and high payoffs.

This version of the Canadian Aluminium Transformation Technology Roadmap (2006 Edition) is based solely on the opportunities that were deemed as "Top priority" or "High priority" level. In all, this represents no less than 38 opportunities for both categories.

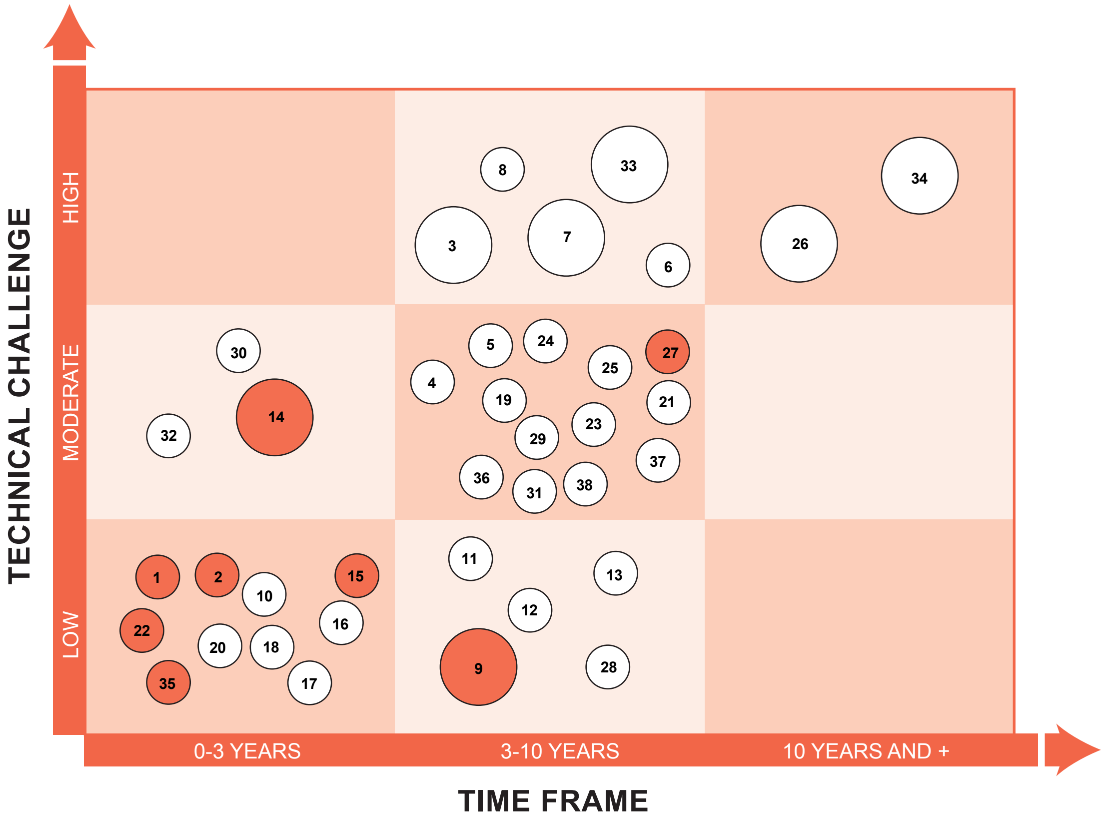
Moreover, an in-depth review to sharply focus and explain the 38 opportunities listed below was done by a few experts along with the TRM team. Each is provided with a short summary and the most probable payoffs they could generate.

[xiv] *The opportunities suggested in the present document were kept on file by Réseau Trans-Al Inc., and can be consulted upon request*

The following opportunities were found to be particularly relevant:

Sector	Opportunities
Transportation	1. Offer integrated aluminium solutions to OEM manufacturers 2. Develop multi-material solutions 3. Research & Develop alloys with higher strength and heat resistance for diesel engine 4. Research & Develop high formability, low cost, high strength aluminium alloys 5. Design lighter structures for trucks, buses, and recreational vehicles 6. Invent methods to produce larger castings with thinner walls 7. Achieve a significant cost reduction for the various aluminium transformation processes 8. Improve wear resistance, tribology and lubrication of aluminium surface
Construction	9. Upgrade aging civilian infrastructures 10. Offer modular structures for easy on-site assembling 11. Offer large extruded shapes 12. Develop integrated design software for aluminium 13. Offer an Aluminium Design Solutions Centre
Shape Casting	14. Perform alloy development for semi-solid rheocasting of structural components 15. Develop a ''Best Practice Guide for Shape Casting'' 16. Offer aluminium Casting Competitiveness Tools 17. Make products from readily available liquid alloys from Canadian primary plants 18. Offer non-competitive process optimisation 19. Improve real-time monitoring of products and processes with advanced sensors and systems 20. Improve and diffuse energy efficiency solutions for foundries 21. Offer larger castings with thinner walls
Forming	22. Create an aluminium life cycle cost/benefit body of knowledge 23. Design Aluminium multi-material flat panels 24. Research & Develop aluminium hydroforming 25. Improve process simulation of forming technologies 26. Invent new forming processes suitable to industry needs
Joining	27. Develop a body of knowledge on adhesives 28. Form an interest group on friction stir welding of aluminium 29. Develop or adapt sensing technologies for aluminium surface characterization
Surface Treatment	30. Offer prepainted sheet products capable of surviving forming operations 31. Develop chrome-free conversion treatment 32. Offer low-cost, decorative metal texturing 33. Develop a paint that can be applied to aluminium substrate without using conversion films 34. Research & develop a treatment to prevent the adhesion of ice to aluminium surfaces
Machining	35. Form an interest group on aluminium machining 36. Automate measurement systems to optimise part positioning and enhance equipment performance 37. Promote adoption of aluminium dry machining or MQL (Minimum Quantity Lubrication) 38. Develop analytical tools, numerical simulations, and software capabilities for aluminium machining

Figure 70: *Technical Challenge vs. Time Frame for Each Opportunity*



Note 1: Bubble size indicates wealth creation potential

Note 2: Dark orange bubbles indicate top priority level and light orange bubbles a high priority level

Transportation

#	Offer integrated aluminium solutions to OEM manufacturers	Technologies or markets
1		Transportation

Priority level: Top

Time Frame: 0 - 3 years | 3 - 10 years | 10 years and +

Key elements

Need a systemic solution not a part by part problem solving. Identify optimal processing routes for various classes of parts in a system. Synergy between several areas of expertise is key. Strategic partnership needed between OEM, Tier1, Al producers, SMEs, Government Identify places in transportation systems where cost can be reduced or functionality improved.

Technical challenge: Low | Moderate | High

Economical impact: $ | $$ | $$$

Payoffs

Weight reduction, cost reduction
Better mechanical properties of the assembly,
better insulation, corrosion resistance, dent resistance, etc.

Transportation / Construction

#	Develop multi-material solutions	Technologies or markets
2		Transportation Construction

Priority level: Top

Time Frame: 0 - 3 years | 3 - 10 years | 10 years and +

Key elements

Need process simplicity and validation to achieve cost competitive assembly with desired properties. Particular issues are joining and forming of these assemblies. Recycling can also become an issue.

Technical challenge: Low | Moderate | High

Economical impact: $ | $$ | $$$

Payoffs

Weight reduction, cost reduction
Better mechanical properties of the assembly,
Better insulation, corrosion resistance, dent resistance, etc.

Transportation

#	Research & Develop alloys with higher strenght and heat resistance for diesel engine	Technologies or markets
3		Transportation

Priority level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Need alloys supporting higher heat stress. Car manufacturers have a goal of producing more diesel engines in the near future and many parts of these engines could be in aluminium. Needs collaborative effort.

Technical challenge: Low | Moderate | **High**

Economical impact: $ | $$ | **$$$**

Payoffs

Weight reduction, cost reduction
Increased market share, new applications for the particular process applied to aluminium
Huge market for aluminium

Transportation

#	Research & Develop high formability, low cost, high strength aluminium alloys	Technologies or markets
4		Transportation

Priority level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Need formability (crack free flat bend), low cost, high strength, high volume sheet product.

Technical challenge: Low | **Moderate** | High

Economical impact: $ | **$$** | $$$

Payoffs

Weight reduction, cost reduction
Better mechanical properties, number of aluminium components in transport systems
Surface finish, recyclability

Transportation

5

Design lighter Structures for trucks, bus, and recreational vehicles

Technologies or markets
Transportation

Priority level
High

Time Frame
0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Public Transit is key to reducing GHG emissions. Lighter truck structures meen heavier payload. Needs local government buy-in or needs a major OEM contribution. Requires thorough design knowledge for heavy load under fatigue conditions and validated joining methodes (welding, bonding, riveting, etc). Needs effecient technology transfer methods and qualified people at the receiving end. Needs recognition of long-term cost-effectiveness of aluminium solutions vs. higher initial costs.

Technical challenge
Low | **Moderate** | High

Economical impact
$ **$$** $$$

Payoffs

Operation costs, GHG emmissions, Energy consumption
Quality, Durability

Transportation

6

Invent methods to produce larger castings with thinner walls

Technologies or markets
Transportation

Priority level
High

Time Frame
0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Need high integrity casting. Near net shape. Low porosity level. Consistant micro-structure. Low inclusion level. Low distortion after heat treatment. Lower cost than alternative solutions. Weldability.

Technical challenge
Low | Moderate | **High**

Economical impact
$ **$$** $$$

Payoffs

Weight reduction, cost reduction
Increased market share, new application for castings

Transportation

#		Technologies or markets
7	**Acheive a significant cost reduction for the various aluminium transformation processes**	Transportation

Priority level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Many aluminium processes are complex, require know-how, skilled workers and, therefore are more expensive in comparison with competing materials. The key of this opportunity is to find ways to simplify processing of aluminium through better understanding of best practices, by better predictive models, using new alloys or processes.

Technical challenge: Low | Moderate | **High**

Economical impact: $ | $$ | **$$$**

Payoffs

Weight reduction, cost reduction
Increased market share
New applications for the particular process applied to aluminium

Transportation

#		Technologies or markets
8	**Improve wear resistance, tribology and lubrication of aluminium surfaces**	Transportation

Priority level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Opportunity to reduce friction needed to improve machining precision, speed and surface quality mainly in engines applications. Almost all surfaces in an engine have a functional purpose.

Technical challenge: Low | Moderate | **High**

Economical impact: $ | **$$** | $$$

Payoffs

Cost reduction
Increased market share
New applications for the particular process applied to aluminium

Construction

#		Technologies or Markets
9	**Upgrade aging civilian infrastructures**	Construction

Priority Level

Top

Time Frame

0 - 3 years | **3 - 10 years** | 10 years and +

Key Elements

One of the key element is the aluminium industry's ability to promote solutions involving life cycle costs that are lower than those of traditional materials such as steel or cement. It would be important to able to demonstrate lower installation and maintenance costs. It is also key to bring governments to listen to the needs of the industry and take part in its development. To acheive this opportunity, it wil be important to increase the industry's influence on national and North American standards.

Technical Challenge

Low | Moderate | High

Economic Impact

$ | $$ | **$$$**

Payoffs

New applications for aluminium, exportable local expertise

Construction

#		Technologies or Markets
10	**Offer modular Structures for easy on-site assembling**	Construction

Priority Level

High

Time Frame

0 - 3 years | 3 - 10 years | 10 years and +

Key Elements

The need is for structures that use the benefits of clipping extruded aluminium shapes. This type of product is already very popular in Europe, and it has a good chance of breaking into the North American market if it is launched with an efficient marketing strategy. Consumer perception is of prime importance and promoters must highlight the key features of the product, i.e. the fact that it is a high-end product and its durability. Contractors will be interested by the decrease in labour costs.

Technical Challenge

Low | Moderate | High

Economic Impact

$ | **$$** | $$$

Payoffs

On-site skilled labour costs, structure assembly time

Construction

# 11	Offer large extruded shapes	Technologies or Markets: Construction

Priority Level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key Elements

The design of structural and architectural elements is often limited by the availability of large extruded shapes. Assembling many extruded shapes to achieve a specific design is not looked upon as an interesting architectural solution or recommended as an efficient structural strategy. Assembly based on friction stir welding (FSW) seems to offer an interesting approach to this challenge. This opportunity would allow aluminium-based structural and architectural products to compete better with rival products made with alternative materials.

Technical Challenge: **Low** | Moderate | High

Economic Impact: $ | **$$** | $$$

Payoffs

On-site skilled labour costs, structure assembly time

More applications for aluminium

Construction

# 12	Develop integrated design software for aluminium	Technologies or Markets: Construction

Priority Level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key Elements

Software program designed specifically for aluminium applications that would integrate matrix analysis, dimensioning in compliance with Canadian, American and European standards, an *on-line* reference tool, and links to suppliers of aluminium products (extrudes, wholesalers, and main producers).

Technical Challenge: **Low** | Moderate | High

Economic Impact: $ | **$$** | $$$

Payoffs

More aluminium applications by structure designers

Construction

#	Offer an Aluminium Design Solutions Centre	Technologies or Markets
13		Construction

Priority Level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key Elements

Virtual or real resource centre for architects and engineers interested in task training. The AISC.ORG (American Institute of Steel Construction) and NSBA.ORG (National Steel Bridge Association) should serve as bases for the development of our own site. For example: log-on to WWW.AISC.ORG

Technical Challenge: **Low** | Moderate | High

Economic Impact: $ | **$$** | $$$

Payoffs

More aluminium applications

Shape Casting

#	Perform alloy development for semi-solid rheocasting of structural components	Technologies or markets
14		Casting

Priority level: Top

Time Frame: **0 - 3 years** | 3 - 10 years | 10 years and +

Key elements

Need alloys with high as-cast properties. Heat treatable or not. Alloys that can be welded. Good mechanical properties. Low cost in large volume. Heat treating, in particular, is very energy intensive and alloys which can be artificially aged right out of the die to give properties which otherwise would require a T6 would be very valuable.

Technical challenge: Low | **Moderate** | High

Economical impact: $ | $$ | **$$$**

Payoffs

Weight reduction, cost reduction
Better mechanical properties, number of aluminium components in transport systems
Surface finish, recyclability

Shape Casting

#		Technologies or markets
15	**Develop a "Best Practice Guide for Shape Casting"**	Casting

Priority level: Top

Time Frame: 0 - 3 years | 3 - 10 years | 10 years and +

Key elements

Need best practices that are not process specific even though would lead any casting foundry to lower costs and higher quality. A guide could be a compendium of several best practices currently in use in the fields of metal treatment, dross recovery, furnace cleaning, metal handling, safety, mold maintenance, heat treatment, efficient machining on foundry alloys, etc.

Technical challenge: Low | Moderate | High

Economical impact: $ $$ $$$

Payoffs

Cost reduction
Quality, Up-time, Knowledge Diffusion

Shape Casting

#		Technologies or markets
16	**Offer aluminium Casting Competitiveness Tools**	Casting

Priority level: High

Time Frame: 0 - 3 years | 3 - 10 years | 10 years and +

Key elements

Need to develop a body of knowledge for aluminium casting competitiveness. Provide to Canadian casters a real market development tool to promote their capabilities. Maintain a list of Canadian Al Casters with their capabilities and experience. Show where aluminium casting is competitive and calculate the true cost of Al versus other materials and identify niches where foundries can be competitive. Explain to the many market sectors what are the advantages of using this material. Need data on effectivity of aluminium to provide a solution. Need figures, data, research, analysis to support the industry. There is a need to increase awarness of key players and decision makers. Could include tips for specification and buyer's guide for ordering casting parts.

Technical challenge: Low | Moderate | High

Economical impact: $ $$ $$$

Payoffs

More aluminium usage
Job creation
Wealth creation locally
Less market share going offshore because for lack of a Canadian solution

Shape Casting

#	Make products from readily available liquid alloys from Canadian primary plants	Technologies or markets
17		Casting

Priority level: High

Time Frame: 0 - 3 years | 3 - 10 years | 10 years and +

Key elements

Transport and volume are two important issues that need answers. Could liquid alloys be transported for long distance (>400 km) or maintained economically liquid for long periods of time (>24 hours)? Could large primary plants deliver small volumes to small production facilities? Could need help from brokerage firms.

Technical challenge: Low | Moderate | High

Economical impact: $ | $$ | $$$

Payoffs

Energy consumption
Cost saving, quality of supply

Shape Casting

#	Offer non-competitive process optimisation	Technologies or markets
18		Casting

Priority level: High

Time Frame: 0 - 3 years | 3 - 10 years | 10 years and +

Key elements

A number of casting best practices already exist but need better deployment. Optimisation and control of many non-competitive elements such as metal treatment and furnace optimization are often limited by availability of resources in SME's. Trade networks and local support organizations could be key to better deployment. This opportunity can be linked with opportunity # 2. This alone cannot compensate for market focus or specialisation that remains key to sustainability.

Technical challenge: Low | Moderate | High

Economical impact: $ | $$ | $$$

Payoffs

Cost reduction, Downtime
Reliability, Productivity, Quality, Environment friendly
More time left for customer prospection

Shape Casting

#		Technologies or markets
19	**Improve real-time monitoring of products and processes with advanced sensors and systems**	Casting

Priority level

High

Time Frame

0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Need cost effective and reliable solutions aiming at improving quality or characterization of quality. Low cost in-situ measurements and NDT technologies are still needed. Reliability is a key element to acheive low cost in high volume domain.

Technical challenge

Low | **Moderate** | High

Economical impact

$ **$$** $$$

Payoffs

Cost reduction,
Productivity, Quality

Shape Casting

#		Technologies or markets
20	**Improve and diffuse energy efficiency solutions for foundries**	Casting

Priority level

High

Time Frame

0 - 3 years | 3 - 10 years | 10 years and +

Key elements

This is an on-going challenge. Incremental and revolutionary process technologies are both needed. This is true for melting furnace, holding furnace and solution heat treatment oven design.

Technical challenge

Low | Moderate | High

Economical impact

$ **$$** $$$

Payoffs

Cost reduction, Energy consumption
Environment friendly

Shape Casting

#	Offer larger castings with thinner walls	Technologies or markets
21		Casting

Priority level	Time Frame
High	0 - 3 years / **3 - 10 years** / 10 years and +

Key elements

Need maintaining productivity while acheiving high integrity casting. Need new machines and technics, and advance modeling development. Could it be done through alloy development?

Technical challenge	Economical impact
Low / **Moderate** / High	$ / **$$** / $$$

Payoffs

Weight reduction, cost reduction
Increased market share, new application for castings

Forming

#	Create an aluminium life cycle cost/benefit body of knowledge	Technologies or markets
22		Forming

Priority level	Time Frame
Top	**0 - 3 years** / 3 - 10 years / 10 years and +

Key elements

Need a source of reliable information and examples of applications to demonstrate how life cycle cost can benefit usage of aluminium over other material. Canadian SME's should become familiar with life cycle cost/benefit analysis to demonstrate the advantages of aluminium.

Technical challenge	Economical impact
Low / Moderate / High	$ / **$$** / $$$

Payoffs

Promotion of Al products
Better profit margin for SMEs

Forming

# 23	Design Aluminium multi-material flat panels	Technologies or markets: Forming
Priority level	High	
Time Frame	0 - 3 years / **3 - 10 years** / 10 years and +	
Key elements	Need to be low cost in building and transportation applications.Training and Support, Skill labour, Quality control, Design Knowledge. This is a market pull opportunity for several markets and especially transportation.	
Technical challenge	Low / **Moderate** / High	
Economical impact	$ / **$$** / $$$	
Payoffs	Weight reduction, cost reduction Better mechanical properties, new products Process contrôle, Shorter time-to-market	

Forming

# 24	Research & Develop aluminium hydroforming	Technologies or markets: Forming
Priority level	High	
Time Frame	0 - 3 years / **3 - 10 years** / 10 years and +	
Key elements	Need reliability of predictive models for design software. Availability of low cost extruded or sheet-based tubes in the case tube-hydroforming is still an issue in large volume for automotive applications.	
Technical challenge	Low / **Moderate** / High	
Economical impact	$ / **$$** / $$$	
Payoffs	Weight reduction, cost reduction Better mechanical properties Number of aluminium components in transport systems	

Forming

# 25	Improved process simulation of forming technologies	Technologies or markets: Forming
Priority level: High	**Time Frame:** 0 - 3 years / **3 - 10 years** / 10 years and +	
Key elements		
Need to increase the level of knowledge and understanding of each forming technology to increase competitiveness, improve design, shorten prototyping time and speed up implementation by OEM and SEM. Validation is key.		
Technical challenge: Low / **Moderate** / High	**Economical impact:** $ / **$$** / $$$	
Payoffs		
Weight reduction, cost reduction Better mechanical properties, new products Process contrôle Shorter time-to-market		

Forming

# 26	Invent new forming processes suitable to industry needs	Technologies or markets: Forming
Priority level: High	**Time Frame:** 0 - 3 years / 3 - 10 years / **10 years and +**	
Key elements		
Need new processes for low-cost and complex parts. For example: warm forming (database), induction and laser forming, blanks forming with variable properties, sheet hydroforming		
Technical challenge: Low / Moderate / **High**	**Economical impact:** $ / $$ / **$$$**	
Payoffs		
Cost reduction, weight reduction in systems More Al products available		

Joining

#	Develop a body of knowledge on adhesives	Technologies or markets
27		Joining

Priority level: Top

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

The implementation of adhesive bonding technology in an industrial environment is difficult and limits its application as a widely used joining technique. The wettability of the substrate by the adhesive, temperature, humidity, the curing time and the joint geometry are factors rendering that technique very different from the other joining technologies. The cold joining with adhesives can't be simply reduced to the selection of the best adhesive. The optimum performance of adhesive bonding requires taking into account factors such as surface preparation, method of application of the adhesive, quality control, joint design and geometry.

Technical challenge: Low | **Moderate** | High

Economical impact: $ | **$$** | $$$

Payoffs

Knowledge, Knowledge transfer, Innovation
Lower assembly time and costs

Joining

#	Form an interest group on friction stir welding of aluminium	Technologies or markets
28		Joining

Priority level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Technology groups (or special interest groups) establish strategic collaboration with all stakeholders in a technology sector. They also promote the development and adoption of new technologies in industry. Work groups bring together representatives from industry, universities and government, who together decide upon the technological direction of precompetitive R&D activities. Subjects to be study in FSW: Parameters, tools and materials properties. Should include at least one large product manufacturer (OEM).

Technical challenge: **Low** | Moderate | High

Economical impact: $ | **$$** | $$$

Payoffs

Knowledge sharing
Innovation

Joining

#		Technologies or markets
29	**Develop or adapt sensing technologies for aluminium surface characterization**	Joining

Priority level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Rapid characterisation of surface would be very useful for both welding and adhesive bonding of aluminium. For welding, it is essential to obtain stable welding quality by dealing with shortcomings such as the dimensional inaccuracy and weld strain of work pieces. Sensing equipment suitable for the reflective properties of aluminum is required. For adhesive bonding, (as well as other non-fusion joining processes including friction stir welding and ultrasonic bonding) roughness and cleanliness, as examples, are key parameters of a surface that would affect the bond quality. Today, several solutions could be developed with optic systems, lasers, cameras and computers. Some commercially available solutions exist already but are optimized for steel or other materials and rarely take into account the specific properties of aluminium.

Technical challenge: Low | **Moderate** | High

Economical impact: $ | **$$** | $$$

Payoffs

Better quality of joining, more competitive solutions
Cost reduction

Surface Treatment

#		Technologies or markets
30	**Offer prepainted sheet products capable of surviving forming operations**	Surface Treatment

Priority level: High

Time Frame: **0 - 3 years** | 3 - 10 years | 10 years and +

Key elements

This is an on-going opportunity that requires constant and incremental improvements. It is a large opportunity for Automotive flat panels and appliances. The key elements are: color matching when several parts are assembled together, hemming and forming for creating complex shapes, and the compatibility with the entire manufacturing process.

Technical challenge: Low | **Moderate** | High

Economical impact: $ | **$$** | $$$

Payoffs

Time saving, more aluminium applications
Less steps than in batch mode

Surface Treatment

#	Develop chrome-Free Conversion Treatment	Technologies or markets
31		Surface Treatment

Priority level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Chromate conversion coating provides a very effective surface treatment to promote both: adhesion to organic coating onto aluminium and protection against corrosion. Concerns over the environmental hazards that chromates present, demand replacememt by more environmentally friendly materials. OSHA in USA is expected soon to issue new regulations that will curtail the permitted levels of hexavalent chrome to which shop workers can be exposed. Canadian authorities are likely to follow suite. At present time, new solutions do exist for aerospace systems but these solutions are expensive and not easily adaptable for manufacturing industry and especially SMEs. The need is to develop a surface pre-treatment to maximize initial adhesion and corrosion resistance when covered by a common polymer paint

Technical challenge: Low | **Moderate** | High

Economical impact: $ | **$$** | $$$

Payoffs

Environment,
Cost saving in case of new regulations

Surface Treatment

#	Offer low-cost, decorative metal texturing	Technologies or markets
32		Surface Treatment

Priority level: High

Time Frame: **0 - 3 years** | 3 - 10 years | 10 years and +

Key elements

Texture and color availability are key elements. Color matching when several parts are assembled together and forming for creating complex shapes are also important. This opportunity requires continous improvements. It is a large opportunity for appliances and architectural products.

Technical challenge: Low | **Moderate** | High

Economical impact: $ | **$$** | $$$

Payoffs

More aluminium application, higher profit margin products

Surface Treatment

#	Develop a paint that can be applied to aluminium substrate without using conversion films	Technologies or markets
33		Surface Treatment

Priority level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Several factors which contribute to the adhesion of a paint coating are nature of substrate, surface preparation/pretreatment, composition of the resin used as binder, nature of the solvent used, viscosity and applications of the paint and thickness of the coating. The influence of these parameters on adhesion of paint coatings to metal substrate has not been fully established. In an attempt to generate practical information about them, the following aspects have to be studied : i) The influence of acid value and hydroxyl value of the resin used as binder. ii) Effect of surface preparation and pretreatment. iii) The variation in adhesion strength with thickness of the paint coating. iv) The level of pigmentation and part replacement of prime pigments by extenders/fillers. v) The bond strength of paint coatings to metal substrates.

Technical challenge: Low | Moderate | **High**

Economical impact: $ | $$ | **$$$**

Payoffs

Process speed
Cost saving

Surface Treatment

#	Research & develop a treatment to prevent the adhesion of ice to aluminium surfaces	Technologies or markets
34		Surface Treatment

Priority level: High

Time Frame: 0 - 3 years | 3 - 10 years | **10 years and +**

Key elements

Ice adhesion to Aluminium electric conductors causes many problems for humans. There have been attempts to reduce the ice adhesion through the use of special coatings, but the fundamental physics of ice adhesion need further understanding.

To do this, a better understanding is needed toward the physical mechanisms of ice adhesion and how ice adheres to solid surfaces. In particular, we need to know the nature and strength of molecular bonding between ice and aluminium. The basic mechanisms of ice adhesion can be divided into three main categories: electrostatic interaction, covalent or chemical bonding, and dispersion or fluctuating forces.

Technical challenge: Low | Moderate | **High**

Economical impact: $ | $$ | **$$$**

Payoffs

Security of electrical supply
Cost savings in case of freezing rain

Machining

#		Technologies or markets
35	**Form an interest group on aluminium machining**	Machining

Priority level: Top

Time Frame: 0 - 3 years | 3 - 10 years | 10 years and +

Key elements

Technology groups (or special interest groups) establish strategic collaboration with all stakeholders in a technology sector. They also promote the development and adoption of new technologies in industry. Work groups strengthen linkages between private sector and R&TD (Research and Technology Development) institutions by bringing together representatives from industry, universities, and government, and research organisations. Together, they coordinate R&TD activities for manufacturer needs and decide upon the technological direction of precompetitive R&TD activities. A technology group should include at least one large OEM.

Technical challenge: Low | Moderate | High

Economical impact: $ $$ $$$

Payoffs

Knowledge sharing, Innovation,
Innovation leading to new local and global markets
Higher coordination of R&TD activities for manufacturer needs
Higher competitiveness of the Canadian industry in the global market

Machining

#		Technologies or markets
36	**Automate measurement systems to optimise part positioning and enhance equipment performance**	Machining

Priority level: High

Time Frame: 0 - 3 years | 3 - 10 years | 10 years and +

Key elements

The development, implementation and use of automated measurement systems are crucial to set-up accurately and rapidely the parts and the cutting tools. These systems could be used also for automatic maintenance of giving machining accuracy through state evaluation of the cutting tools (tool wear detection and dimensional inspection) and parts (on-line dimensional inspection). Consequently, these systems enhance the part accuracy and reduces scraps, while increasing the productivity by reducing the set-up time. In addition, intelligent sensor based monitoring is very important in all steps of production, mainly in flexible production systems. The development and implementation of rationale monitoring organization is required to reduce the errors of "false rejection" or the "overlooking defect". Moreover, the development and implementation of adaptive control techniques will push the usage of the equipment to their full capacity, and concequently enhance the performance of these equipment.

Technical challenge: Low | Moderate | High

Economical impact: $ $$ $$$

Payoffs

Higher productivity
Higher inspection throughput
Higher machining accuracy and product quality
Shorter set-up time, Less scrap, Lower energy consumption, Lower costs
Environmently greener

Machining

#	Promote adoption of aluminium dry machining or MQL (Minimum Quantity Lubrication)	Technologies or markets
37		Machining

Priority level

High

Time Frame

0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

MQL is a new technique that delivers a continuous supply of the required minimum quantity of lubricant mixed with air onto the tool tip. The use of MQL is beneficial for the part being produced, for the tool and the machine being used, for the environment and for the overall economy. It improves the surface quality of the part, increases the tool life, improves chip recycling, decreases machine maintenance due to contamination by coolant, saves costs represented in lubricant, its disposal and in cleaning cycle times, reduces occupational hazards associated with airborne cutting fluids, and is environmentally friendly. Closing the economic gap between wet and dry drilling remains a technical challenge. To successfully substitute conventional wet machining with near dry machining, two main issues should be resolved. One is the development/ adaptation of MQL equipment for these specific cutting operations while maintaining conventional machining performance. The other is the establishment of methods for chip removal, mainly in drilling.

Technical challenge

Low | **Moderate** | High

Economical impact

$ | **$$** | $$$

Payoffs

Cost savings on high volume machining
Better part surface quality
Less occupational hazards associated with airborne cutting fluids
Less negative effects on the environment (Environment friendly)

Machining

#	Develop analytical tools, numerical simulations, and software capabilities for aluminium machining	Technologies or markets
38		Machining

Priority level: High

Time Frame: 0 - 3 years | **3 - 10 years** | 10 years and +

Key elements

Machining process requires considerable investment of time and resources. For a timely startup in applying high performance machning, high speed machining or high precision machining, models describing the principles of machining processes for aluminum are required. Based on these models, optimal machining parameters could be derived. An integration of these models enables the selection of the most cost effective manufacturing method or processing route.The resulting analytical and software tools should be able to predict chatter, machining stability, dynamics of thin-walled structures, burr formation, residual stresses, distortion and warpage, and tool life in machining aluminium. Computer simulation of the cutting process can potentially reduce the number of design iterations and result in a substantial cost savings. It will also help the development of new machining technologies.

Technical challenge: Low | **Moderate** | High

Economical impact: $ | **$$** | $$$

Payoffs

Higher productivity,
Higher machining accuracy,
Higher part quality, Less scrap,
Lower cost
Development of a solid knowledge-based economy leading to innovation

7. CONCLUSION

The publication of the Canadian Aluminium Industry Technology Roadmap in 2000 brought **positive**, **tangible results**, one of them being the creation of the National Research Council's Aluminium Technology Centre.

Almost seven years later, it is clear that **the relative importance of Canada as a primary producer is decreasing** in spite of increased production output. The situation is the same for semi-finished products. In the next few years, we will lose our position as the world's 10th largest producer of rolled products. Indeed, we are importing more extruded products from overseas and maintaining the status quo with respect to the production of shape castings, without necessarily being a major player. This can be explained by massive production growth in countries such as China.

The North American aluminium industry is largely vertically integrated, with the manufacturing chain distributed between Canada, the United States and even subsidiary operations in Europe. Thus Canada imports much of its semi-finished aluminium products despite its large primary metal production.

In tandem with the rise of worldwide production, **aluminium consumption will grow significantly all over the world in the next ten years**. Asia is expected to consume twice as much aluminium as North America. These facts could mean an interesting windfall for the Canadian aluminium transformation industry. A prodigious array of possibilities will be distributed among markets.

In order to resist the progressive leakage of finished product manufacturing to emerging economies, Canadian manufacturers are encouraged to **invest in leading-edge design and manufacturing technologies** rather than attempting to defend mature methods.

Depending on social choices, the growth of aluminium consumption in the transport industry will be between 20% and 70% in North America. In any case, synergy is necessary to better control the technologies that allow us to develop winning applications, and greater potential for the creation of wealth. Several emerging and growing technologies now need **a multi-material and system approach** to achieve increased usage. It is, therefore, necessary to develop an understanding of the mechanisms of material combinations and favour designer training. This would allow the Canadian industry to seize a multitude of opportunities that would be applicable in diverse markets.

The construction industry is continuing to expand. Over the next 10 years, a growth of 58% on the Asiatic continent should take place, with a comparative rate of 20% for Europe and North America. **The lack of promotion and information to the public limits the introduction of a number of emerging and leading edge applications.** The competitiveness of aluminium must be enhanced so that winning strategies in our own and world-wide niches could be put in place. This can be accomplished at several levels, whether taking advantage of the system approach, life-cycle analysis or through the combination of certain materials.

At the level of diverse technology platforms, the needs for the aluminium transformation industry are striking. With the aid of state-of-the-art technologies, **developing countries are gaining ground** in the shape casting and forming sectors. Soon, these countries will do the same for products requiring emerging and leading edge technologies and the technological gap will be reduced ushering in fierce competition. The joining industry in Canada must distribute its competency bases and continue to develop its capacities. Methods respecting the environment and health of workers have also been called for in the surface treatment industry. Furthermore, **offering treated alloys with improved properties could open the door to new niche markets**. Promotion for machining and training support for new machining equipments and processes would revitalise this technology platform.

Canadian manufacturers and specialised equipment suppliers can count on favourable prospects worldwide. However, having a better idea of the production technologies used by their clients and targeted markets, would make it possible for Canadian suppliers to offer the **best total solution** to their customers.

7 CONCLUSION

Canada currently possesses knowledge at the most recent and advanced technological level and must continue to count on this technology. Nonetheless, it is necessary to consider human-based issues such as **knowledge acquisition and training** to be able to stay at the forefront of the industry.

Canadian industry should immediately **get together to rise up to the challenge**. It is a bold commitment but a doable one. For example, technology deployment activities or collaborative R&D could well reduce risks and allow for optimal usage of equipment and resources.

According to specialists in workshops, several opportunities for successful aluminium promotion might be missed if support organisations and other institutions do not collaborate and cooperate amongst themselves. **Systematic coordination** of these collaborations, which is seen to be lacking at the moment, along with an actual commitment to work together is of the utmost importance to ensure the greater good.

From these observations come **four recommendations** that will allow the Canadian industry to consolidate its position. **Thirty-eight needs and opportunities** were also selected for their potential to create wealth, reasonable time frames and achievable technical challenges. Appropriation of these recommendations and opportunities by the stakeholders of the aluminium transformation field will allow Canada to step into a leading position.

8. TECHNOLOGY ROADMAP RECOMMENDATIONS

RECOMMENDATION 1

Ensure the systematic coordination and cooperation of all aluminium transformation industry players in Canada

The participants of all five workshops unanimously suggested putting in place a coordination structure. Many also confirmed that there should be more cooperation between the different interest groups.

We highly recommend that business associations having aluminium at the center of their operations be invited to a table, along with consulting engineer and architect groups, university groups, research centres, government organisations, aluminium producers and some OEMs.

HOW AND BY WHOM?

Obviously, the initial goal remains coordination and cooperation. This does not mean creating a new overseeing structure or another acronym, but rather joining together all parties involved in today's aluminium transformation industry.

It is important to maintain structured relationship between industry players. Over the past five years, a great deal of work and constructive initiatives were undertaken without overall coordination, which may have led to lost opportunities for creating synergy at the national level.

The Aluminium Transformation Technology Roadmap (2006) steering committee groups and organisations would already constitute a good start-up group to which other players in aluminium transformation could be added.

POSSIBLE MANDATE

This formalised action group would have the mandate of structuring and promoting aluminium transformation in Canada. More precisely, it would act as both an axis and a beacon by assuring a better-coordinated presence for aluminium industry players and thereby maximising impact. Moreover, such an alliance would play an important role in communications with public decision-makers, technical people, business people and the public at large. It must be able to ensure maximum public exposure on both Canadian and North American fronts. The mandate could include the coordination of R&D, transfer and promotion activities, along with efforts to make sure Canadian and North American standards include aluminium as a material in areas where it has traditionally been absent.

COMMITMENT

The establishment of an aluminium industry coordination and collaboration structure, with representation from various sectors of the industry, would require formal and true commitment from large aluminium producers and participating organisations. This commitment would not be limited to a simple financial contribution, although this would be considered an important gesture. Rather, it is essential to define the expectations for all parties and clarify them where necessary. Without the participation and commitment of its representatives and members, such a committee will not be able to receive the support it needs, or have the ability to mobilise members around the same topic. Nothing speaks louder than consensus when it has been applied to a given activity through commitment.

COMMON VISION

Defining an ultimate goal or vision will allow everyone to find their own way to a common result and establish cooperation strategies. An efficient approach to rallying industry players might be through the achievement of the 38 opportunities listed in the TRM-2006. Another approach could involve the development of a long-term vision for the Canadian aluminium transformation industry. This would require full contribution from each and every party represented since this vision would be carried over several years. It would also constitute a determining factor of the general development axes for aluminium transformation in Canada. A number of countries have already begun this process and are working at attaining a common, rallying vision to create wealth.

FOLLOW-UP

For efficient monitoring purposes, committee members should be able to follow progress vs. objectives on a chart, to determine if intervention is required in the pursuit and success of one or several opportunities. This would allow for comparison with other countries, leading to faster, more interactive assessment of our performance as a transforming country.

RECOMMENDATION 2

Promote the Canadian capacity of "designing for aluminium" instead of simply "manufacturing out of aluminium"

Many designers make the basic mistake of taking a steel structure, part or joined assembly and wanting to reproduce it as is, but using aluminium. This usually leads to less than desirable results and most people tend to blame the grey metal or joining difficulties.

Going forward with this recommendation requires that we **further stimulate** Canadian capacity to design for aluminium. To this end, the PRAL (Presses de l'aluminium) have made substantial headway over the past few years by publishing a few books and promoting numerous works on aluminium transformation methods, in both English and French. Other countries have also released publications on transformation methods. It would be advantageous to become **better acquainted** with the published material available.

Organising contests in Canadian universities and colleges is also a good solution. For example, many groups, companies, and universities support student teams in their use of aluminium during the "SAE Formula" competition and ''Genie-Al'' in Quebec.

The designers who need to receive assistance in **developing the ability and the desire** are not university researchers and professors. Rather, they are engineers, architects, industrial designers, and intuitive people who have design experience and good knowledge of aluminium, and are aware of current and developing fabrication methods.

RECOMMENDATION 3

Promote continuous training in the aluminium industry (architects, engineers and designers)

Workshops and courses are needed to ensure that **architects, engineers, and designers, who have strategic influence on the choice of materials**, are always at the cutting edge of aluminium knowledge. The courses currently available in colleges and universities tend to neglect aluminium; they however could be designed by professors or recognised specialists. Awareness and familiarisation workshops could also be organised.

RECOMMENDATION 4

Update the Aluminium Transformation Technology Roadmap

Because the TRM is intended to be an iterative tool, it must keep up-to-date with the latest scientific and technological advances, and needs to reflect changes in the market. By ensuring the follow-up of the TRM, industry players will be able to assess any progress made and inquire about the latest technological breakthroughs.

Ideally, the industry will take specific steps to ensure that businesses make informed and systematic use of the information provided in the technology roadmap.

Réseau Trans-Al inc. and NRC's Aluminium Technology Centre can initially look after TRM updating. To this end, the written survey could be repeated and a literature search carried out once a year or every two years. One or two workshops could also be held every two years, with guest experts on various subjects.

ANNEXE A – GLOSSARY

Alloy	One of a large number of substances having metallic properties and consisting of two or more elements.
Anodizing	An electrolytic oxidation process in which the surface layer of a metal is converted to a coating consisting largely of oxide and having protective, decoration or functional properties.
Architectural products	Aluminium products used in the construction of generally large buildings and that have an impact on the look of the building and design of the architecture.
Bending	The straining of material, usually flat sheet or strip metal, by moving it around a straight axis lying in the neutral plane.
Billet	A solid cylindrical casting used for hot extrusion into rod, bar, tube or shape or for hot piercing into tube.
Blanking	The preparation of a shaped sheet part for stamping by die cutting or laser cutting.
Bolting	The assembly of two or more parts using bolts and accessories.
Boring	The operation of enlarging and truing a drilled or bored hole with a single-point cutting tool.
Brazing	A group of welding processes in which aluminium component are joined by heating them to a suitable temperature and by using a filler metal that melts and flows below the melting temperature of the components.
Brightening	The production of bright surfaces by chemical or electrochemical smoothing of a metal surface.
Broaching	The machine-shaping of metal or plastic by pushing or pulling a broach across a surface or through an existing hole in a workpiece.
Burnishing	The mechanical smoothing of surfaces by rubbing under pressure essentially without removal of the surface layer.
Cable and wire drawing	Making wire by drawing it through successively smaller round holes in steel dies.
Casthouse (Casting Centre)	In a casthouse, molten aluminium is poured from crucibles into mixing furnaces, where various alloying additions are made to bring the chemical composition up to customer specifications.
Chemical etching	The dissolution of the material of a surface by subjecting it to the corrosive action of an acid or an alkali.
Chemical vapour deposition (CVD)	Process for depositing thin films from a chemical reaction of a vapour or gas.
Cladding	The exposed surface of a building or the preparation of a multi-layer aluminium product.
Cleaning	Removal of scales, rust, grease or oil, etc., to produce a clean surface.

Clinching	Stitchfolding and clinching are simple and cost-effective methods for sheet material assembly. They do not require any rivets or screws or other separate fasteners. They do not require any complex systems for high power and cooling, which are typical for spot welding installations.
Cold forging	Forging of metal at temperature below its recrystallization temperature.
Consumer durables (Durable goods)	Consumer goods with a relatively long life span (e.g.: appliances).
Continuous casting	A process in which metal is continuously solidified while being poured through a water cooled mould which determines a cross-sectional shape.
Corrosion resistance	Ability of a metal to withstand corrosion attack.
Cutting	Separation of material by the operation of one or more cutting blades or tools.
Drilling	The operation of producing a hole in solid material by means of a cutting centre drill.
Electromagnetic forming	**Electromagnetic forming (EM forming or Magneforming)** is a type of *high energy rate* metal forming process that uses pulsed power techniques to create ultrastrong pulsed magnetic fields to rapidly reshape metal parts. The technique is sometimes called *high velocity forming.*
Electron beam welding	A welding process which produces coalescence of metals with the heat obtained from a concentrated beam composed primarily of high velocity electrons impinging upon the surfaces to be joined.
Electroplating	The processes for depositing a layer of metal onto the surfaces of metallic or non-metallic conductors by immersing the articles in an electrolyte containing a salt of the metal to be deposited, and making them the cathodes of the electrolytic cell.
Electropolishing	Electrochemical process used for surface smoothing.
Enamelling	Action or process of covering with melted, powdered glass.
Equipment supplier	Business specializing in the design, fabrication and distribution of made-to-order aluminium production or transformation equipment.
Extrusion	The operation of producing rods, tubes, and various solid and hollow sections, by forcing heated metal through a suitable die by means of a ram; applied to numerous nonferrous metals, alloys, and other substances.
Forging	A method of forming parts by forging a heated solid slug or blank cut from wrought material into a die cavity.
Forming	Any manufacturing process by which parts of components are fabricated by shaping or moulding a piece of metal stock.
Friction stir welding	A solid-state metal joining process producing high-strength, defect-free joints in metallic materials. The process employs a pin tool with a low rotational speed and applied pressure that "mechanically stirs" two parent materials together to produce a uniform weld.

Green sand casting	Moulding process involving a clay bonded moulding sand which is hardened solely through the ramming pressure applied prior to stripping.
Grinding	Process of removing metal by the cutting action of a solid, rotating, grinding wheel.
Hemming	Forming of an edge by bending the metal back on itself.
High pressure die casting	The most common casting process for aluminium. Cycle times are very fast. Metal utilisation is high with little process scrap. Highly detailed and complex castings are possible. The process is highly automated and used for large or small volume parts.
Hydroforming	A metal-shaping process that uses high-pressure fluid to form tubes into complex structural shapes.
Impact extrusion	The formation of a tubular closure by the rapid application of force through a punch on a metal blank, the metal flowing up around the punch to form a tubular section.
Infrastructure	Installations which serve as a basis for the functioning of all sectors of the economy, such as transport, communications, school buildings, hospitals, public buildings, etc.
Investment casting	A method in which a wax pattern between a two-layered mould is removed by melting and replaced with molten metal.
Lapping	Mechanical surface treatment process used to bring a product up to dimensional tolerance levels and improve surface quality.
Laser welding	A welding process which produces coalescence of materials with the heat obtained from the application of a concentrated coherent high energy light beam impinging upon the members to be joined.
Lost-foam casting	A variety of sand casting processes in which a consumable polystyrene pattern is left in the sand mould - the sand in this case being loose i.e. without a binder. Upon metal entry, the pattern evaporates. Lost-foam casting can produce parts with complex internal cavities that are difficult to achieve by other casting methods. EX – Aluminium engine blocks and cylinder heads, along with nodular iron crankshafts and differential carriers, are all produced using the lost-foam process.
Low pressure die casting	Similar to high pressure DC except that lower pressures are used to force the metal into the die. Low-pressure die casting is especially suited to the production of components that are symmetric about an axis of rotation.
Machining	Performing various cutting or grinding operations on a piece of work.
Mechanical properties	Properties of a material that reveal its elastic and inelastic behaviour when force is applied, thereby indicating its suitability for mechanical applications.
MIG	(Metal Inert Gas) A term used to describe gas metal arc welding.
Milling	Machining process using a rotating multi-tooth tool (cutter), in which the cutting and feed motions are produced either solely by the cutter, or the cutting motion is produced by the cutter and the feed motion is performed by the workpiece.

Modelling	The computer simulation of a system that exists in the real world, such as an aircraft fuselage or the cash flow of a business.
OEM (Original Equipment Manufacturer)	Any person, firm or corporation involved in the manufacturing of original motor vehicle equipment used for building or assembling commercial vehicles.
Packaging	Receptacles and any other components or materials necessary for the receptacle to perform its containment function.
Paste	A blend of powder or flakes with a thinner or plasticizer.
Peening	A process of cold-working the surface layer of a metallic part by hammering or shot blasting.
Permanent mould casting	A casting formed in a metal mould, the molten metal being introduced by gravity or low pressure feed.
Planing	A metal cutting process using a single point tool (planing tool) in which the workpiece is reciprocated in linear motion during which the cut is made in one direction by the tool being lowered before each cutting stroke.
Plasma arc welding	An arc welding process which produces coalescence of metals by heating them with a constricted arc between an electrode and the workpiece (transferred arc) or the electrode and the constricting nozzle (nontransferred arc).
Polishing	The removal of metal by the action of abrasive grains, which are embedded in a soft matrix or attached to the surface of a wheel or an endless belt.
Pore free low pressure die casting	Casting technique used to fabricate porosity-free parts with mechanical properties that can be improved by thermal treatment.
Potroom	A potroom is a building where aluminium electrolysis takes place in a long line of pots. A ''pot'' is an electrolytic bath of molten cryolite (sodium aluminium fluoride) within a large carbon or graphite lined steel container. A typical aluminium smelter consists of around 300 pots. These will produce some 125,000 tonnes of aluminium annually. However, some of the latest generations of smelters are in the 350-400,000 tonne range.
Powder	An aggregate of discrete particles of aluminium, substantially all of which are finer than 1,000 microns.
Powder sintering	Coalescence of solid particles into a single piece by the application of heat and pressure.
Precision sand casting	Newer varities of the basic sand casting technology to give improved casting quality and consistency. Mould inversion is used to allow the gates to become risers. These processes have allowed much higher productivity as well as lighter castings.
Pretreatement	The mechanical and/or chemical preparation stages in a process made before the anodising, coating or plating operation, for example polishing, degreasing, cleaning, etching.
Primary aluminium	Primary aluminium is produced by electrolysis. It is the product of smelting alumina in an electric furnace that reduces the oxide to aluminum metal, which is cast into ingots for further processing.

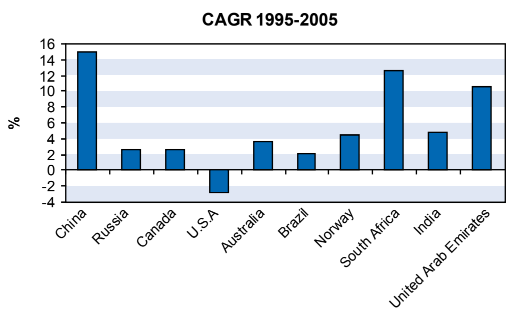
Primary production	See Primary aluminium.
Reaming	A method of machining holes to size with a fluted, hardened and ground, accurately-sized cutting tool called a reamer.
Recycled metal (see secondary aluminium)	See secondary aluminium.
Recycling	The concept of taking an item that has performed its functions and instead of throwing it away, recirculating it back into the business stream, either in its original form or in some other form.
Remelt ingot	Small (30-40 kg) pure aluminium ingot made from primary or recycled aluminium that will be remelted in a parts casting centre or used in a casting centre to balance an alloy mixture.
Rheocasting	Metallurgical process consisting in forming alloys at a temperature within its solidification range and then putting them under pressure to lower their viscosity during shearing resistance operations.
Riveting	A joining operation using metal rivets.
Roll forming	A process for forming metal sheet or strip stock into desired shapes of uniform cross-section by feeding the stock longitudinally through a series of roll stations equipped with contoured rolls - two or more rolls per station.
Rolling	Rolling out an ingot in a rolling mill by successive passes to reduce its thickness to the proper gauge by extending it lengthwise.
Rolling mill	A machine for shaping material by passing and repassing it between rolls.
RSW (Resistance spot welding)	A resistance welding process produces coalescence of the faying surfaces in one spot, by the heat obtained from the resistance to electric current through the work parts held together under pressure by electrodes.
Secondary aluminium	Aluminium from a recycled source, i.e. aluminum-bearing scrap or aluminum-bearing materials.
Secondary production	See Secondary aluminium.
Semi-finished products	Product obtained either by rolling, extrusion, wire-drawing or forging of ingots or by continuous casting, and generally intended for conversion into finished products.
Semi-solid die casting	Similar to high pressure die-casting but with semi-solid feed stock. Based on the properties of semi-solid metal i.e. metal that is between the liquidus and solidus in temperature and is typically 50% solid and 50% liquid.
Shape casting	Metal object cast to the required shape by pouring liquid metal into a mould.
Sheet ingot (rolling ingot)	A cast form of ingot suitable for rolling into flat products such as coil of foil, thin sheets or laminated into plates. Sheet ingots can be produced in a wide range of alloys and purity levels and in different shapes (although always rectangular) and sizes.

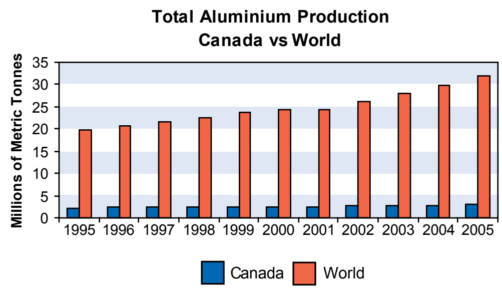
Soldering	An operation in which metallic parts are joined by means of a metal having a melting temperature much lower than that of the parts to be joined (generally lower than 450°C), and wetting the parent metal(s). The parent metal(s) does(do) not participate by fusion in making the joint. **Soldering differs from brazing** in that temperatures below 800°F (427°C) are used.
Squeeze casting	The application of pressure during the solidification process which can produce significant improvement in mechanical properties.
Stamping	Forming metal, usually under impact, by compression within dies designed to produce the required shape.
Stretch forming	Shaping by applying tension to stretch the sheet or part, wrapping it around a die.
Superplastic forming	High temperature forming process requiring a very fine-grained structure. Very complex shapes can be produced.
Surface treatment	General term denoting a treatment involving a modification of the surface.
Tailor welded blanks	A TWB is fabricated by welding together two or more sheets of metal of different thicknesses and/or material grades to produce a single blank, which is subsequently formed.
Tapping	The operation of forming internal threads by means of a tap.
Thermal spraying	The high temperature application of a metallic layer to the surface of materials.
Thixocasting	In thixocasting (or thixoforming) a pre-stirred and cast billet having the characteristic "globular" microstructure is induction reheated and injected into the die cavity. The metal flows under thixotropic conditions.
Threading	Thread cutting on a lathe is often called thread chasing ... A single-point cutting tool is used to cut screw threads on engine lathes ... Other methods of cutting screw threads are: chasing threads with a threading die, thread milling, thread rolling, and thread grinding.
TIG	(Tungsten Inert Gas) Term used to describe gas tungsten arc welding.
T-ingot	Pure aluminium ingot alloyed into the shape of a T to facilitate handling by a forklift. T-ingots are cast in casting centres using a DC process and then cut into lengths of about 1 metre.
Tribology	The science and technology of interacting surfaces in relative motion and of the practices related thereto.
Turning	Cutting motion is affected by the rotation of the workpiece and by the lateral movement (feed movement) of the tool.
Vacuum casting	Casting in an evacuated enclosure in which the mould was previously placed. This process is usually associated with melting in vacuum the metal involved.
Warm forming	An elevated temperature forming operation in which the work material temperature and process conditions are such that no work-hardening is detectable in the product immediately after deformation.

ANNEXE B – SUPPLEMENTAL CHARTS

ALUMINIUM PRODUCTION... FROM PAST TO FUTURE

1995-2005





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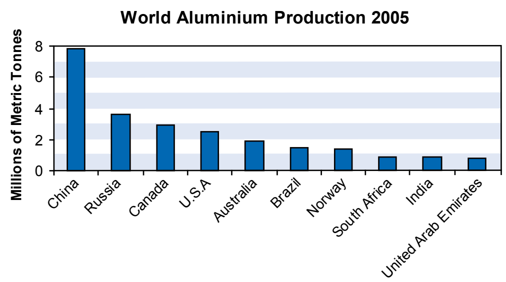

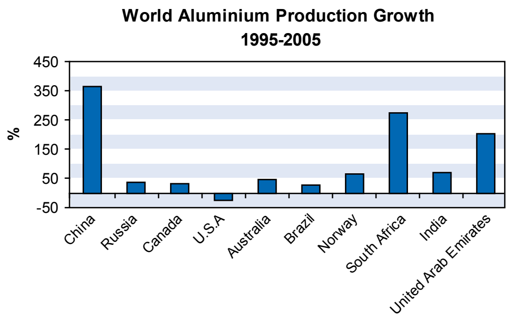

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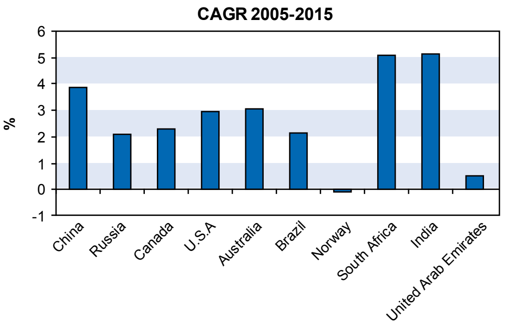

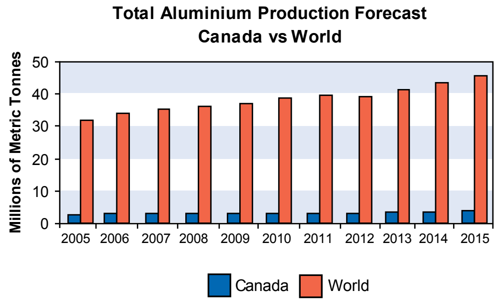

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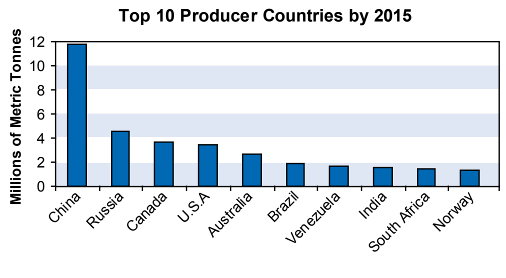
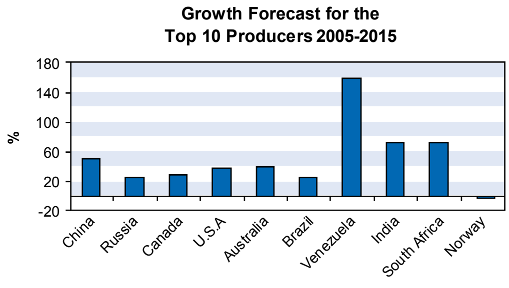
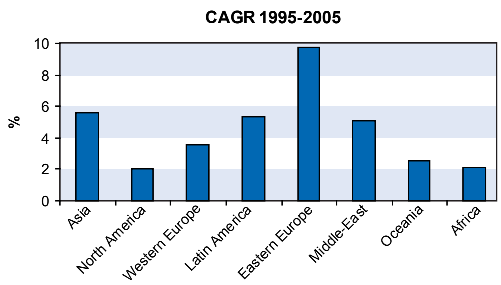


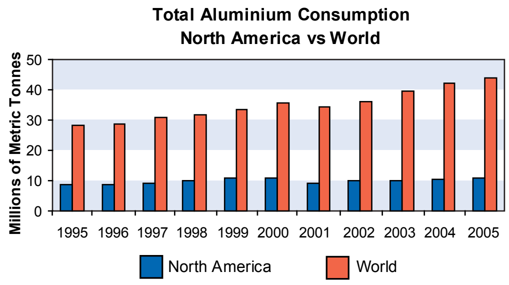


Sources : Aluminum Statistical Review 2005 and James F. King

ALUMINIUM PRODUCTS CONSUMPTION... FROM PAST TO FUTURE

1995-2005





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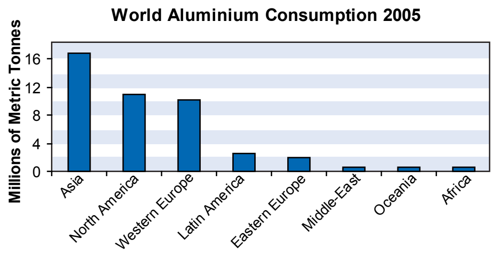

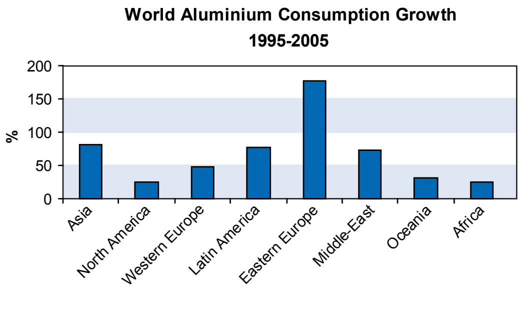

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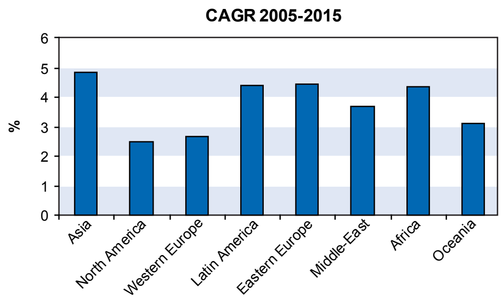

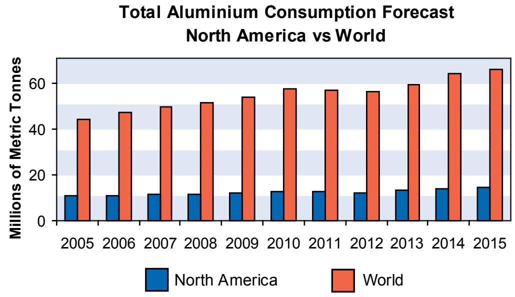

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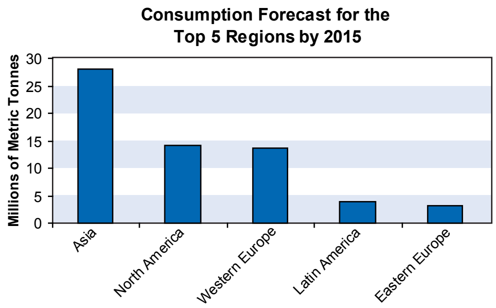
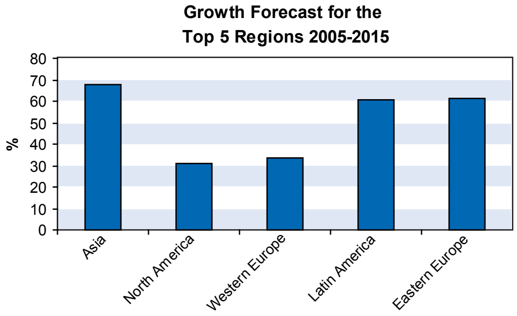
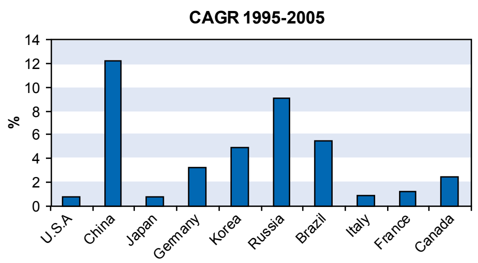


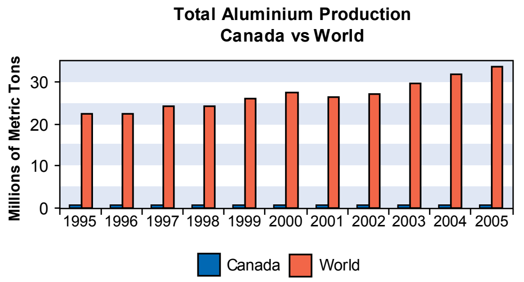


Sources : Aluminum Statistical Review 2005 and James F. King

SEMI-FINISHED PRODUCTS PRODUCTION… FROM PAST TO FUTURE

1995-2005





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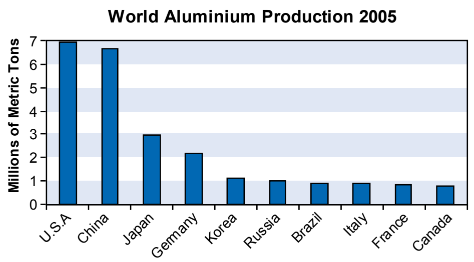

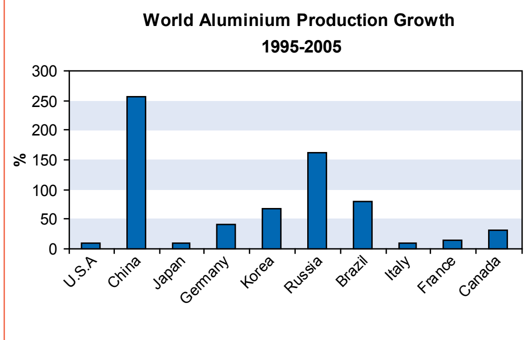

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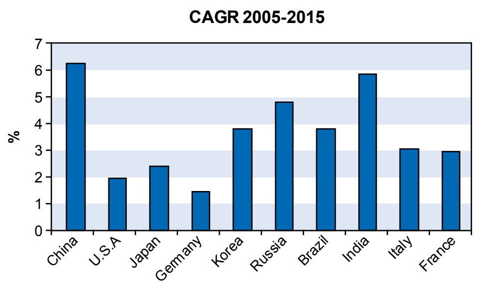
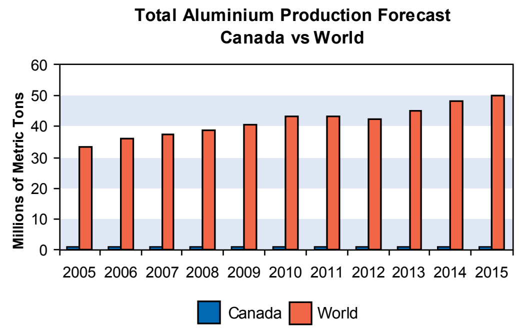
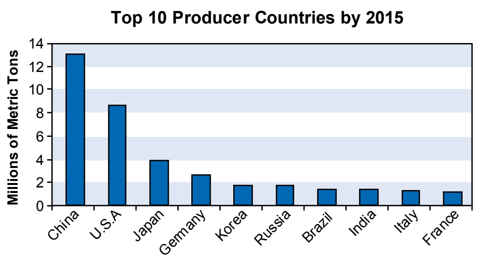
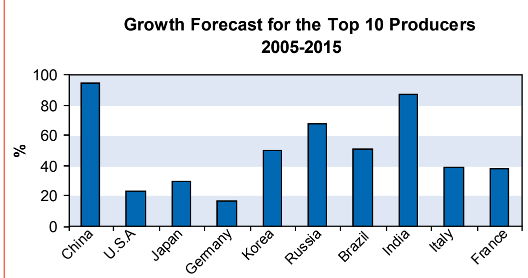




2015



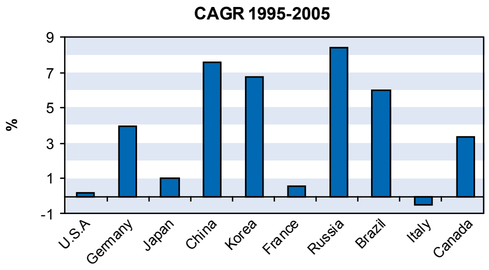


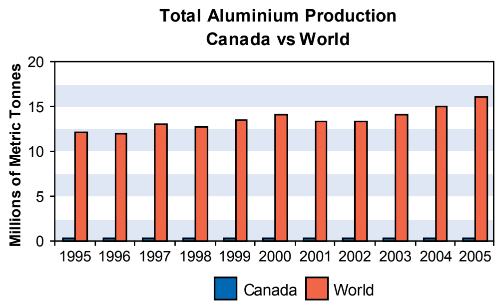
Sources : James F. King

**Does not include shape casting*

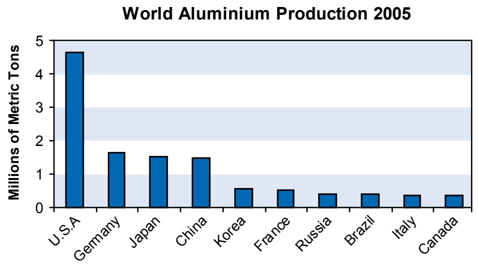
ROLLED PRODUCTS PRODUCTION... FROM PAST TO FUTURE

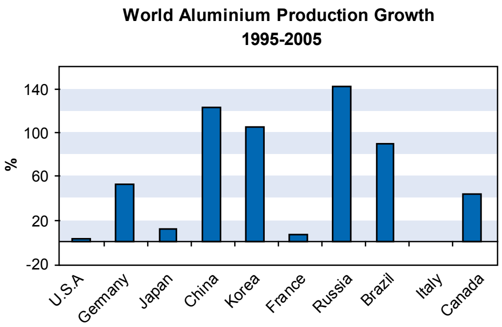
1995-2005



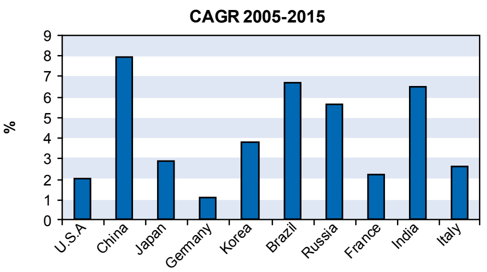


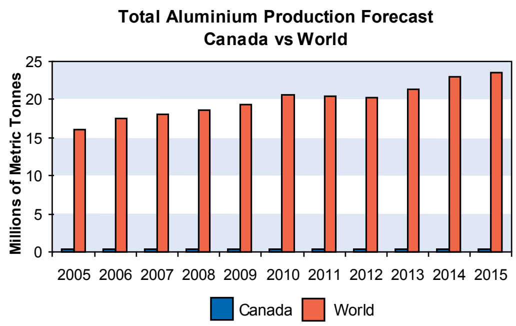
2005



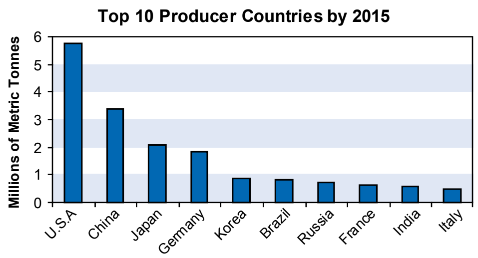


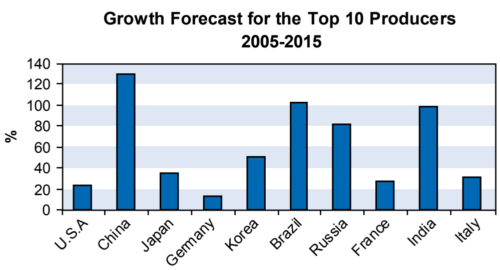
2005-2015





2015

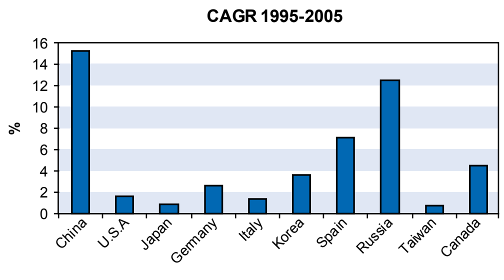


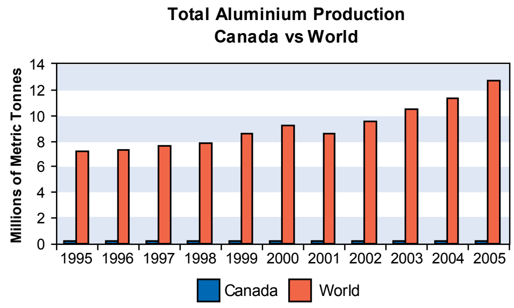


Sources : Aluminum Statistical Review 2005 and James F. King

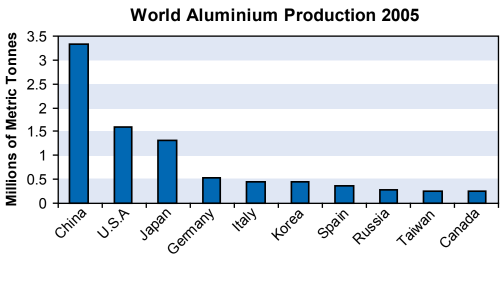
EXTRUDED PRODUCTS PRODUCTION… FROM PAST TO FUTURE

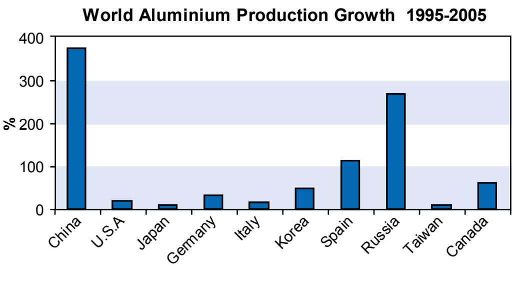
1995-2005



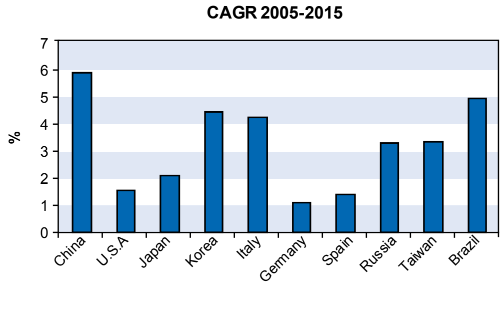


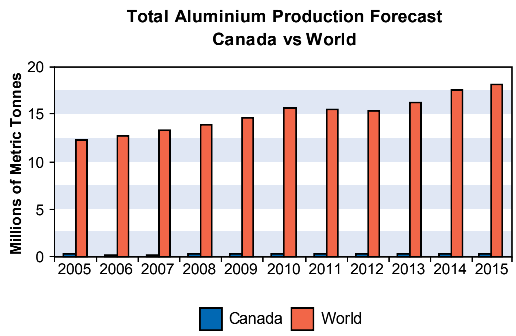
2005





2005-2015





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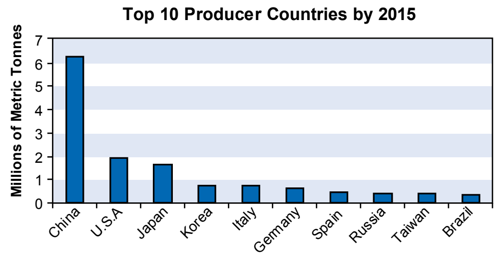
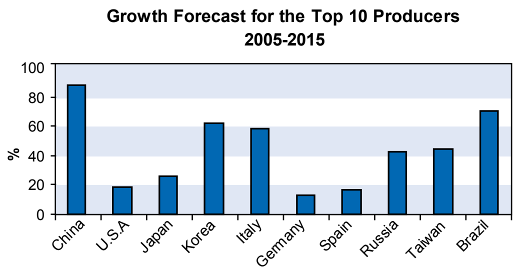
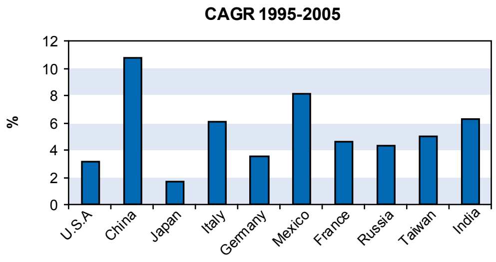


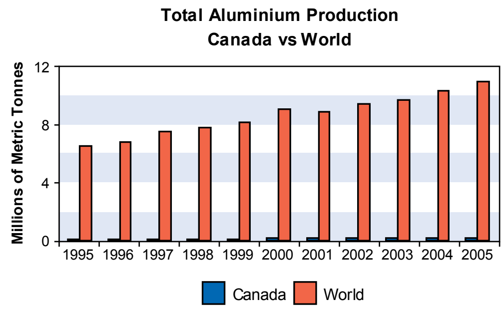


Sources : James F. King

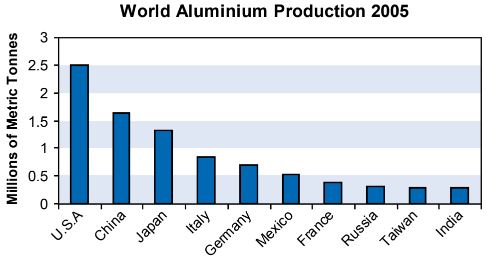
SHAPE CASTING PRODUCTS PRODUCTION... FROM PAST TO FUTURE

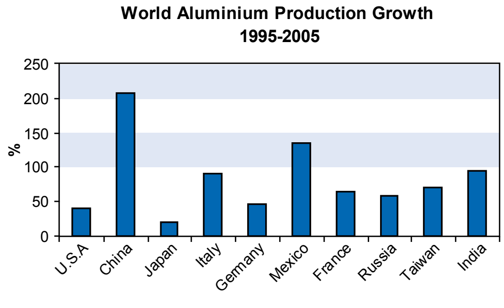
1995-2005



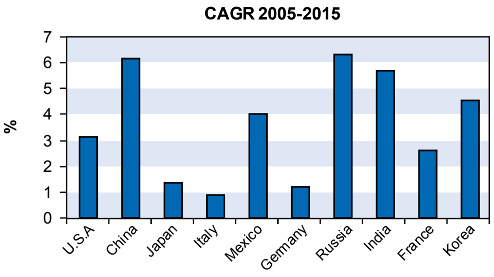


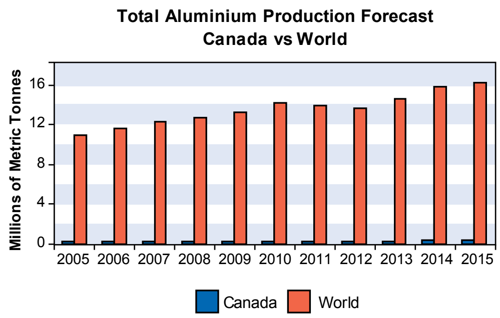
2005





2005-2015





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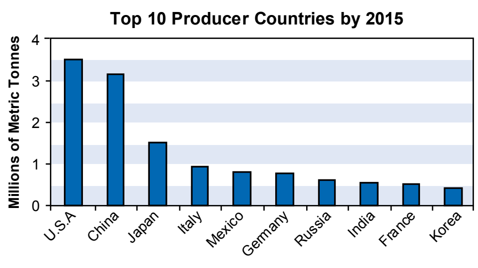
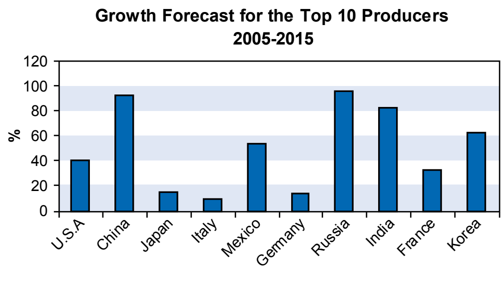
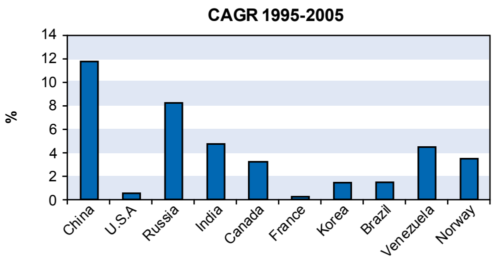


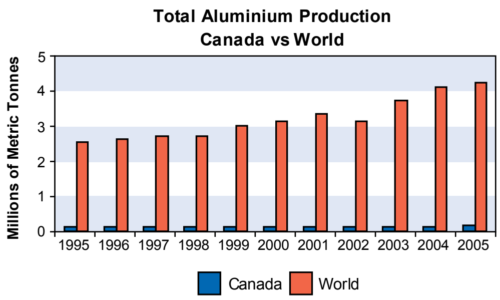


Sources : James F. King

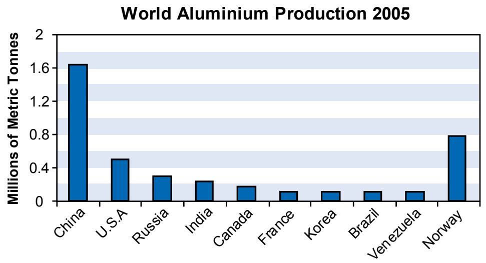
DRAWN/WIRE PRODUCTS PRODUCTION… FROM PAST TO FUTURE

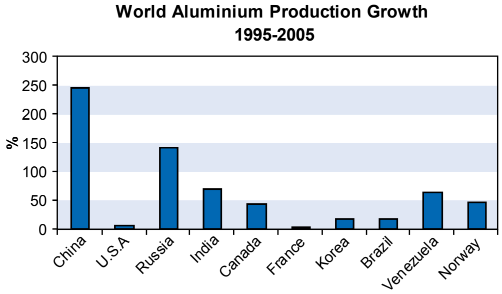
1995-2005



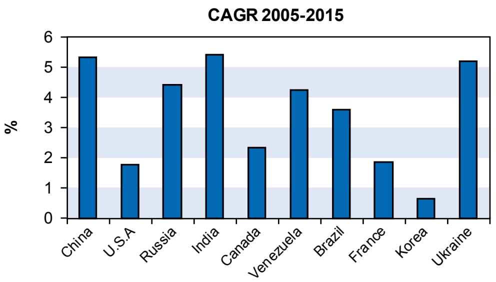


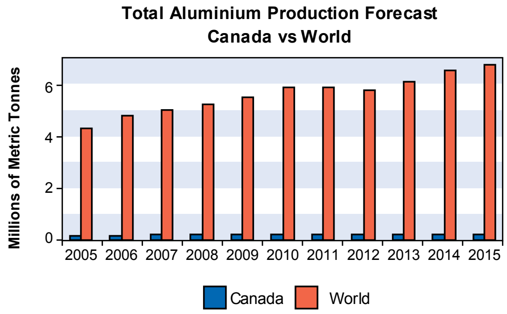
2005



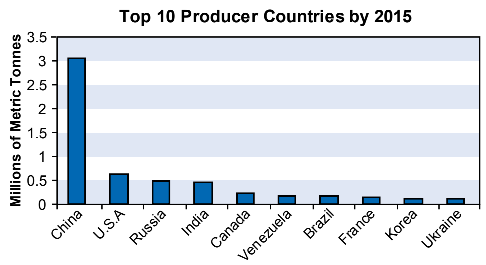


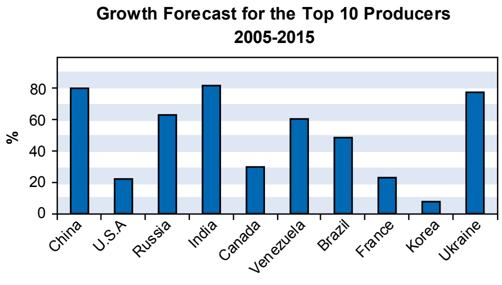
2005-2015





2015

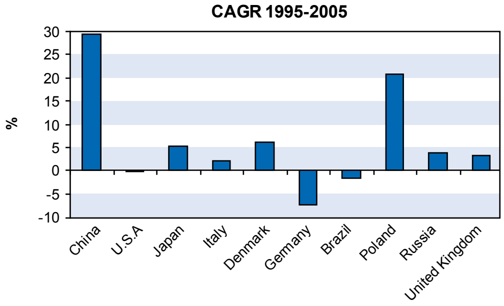


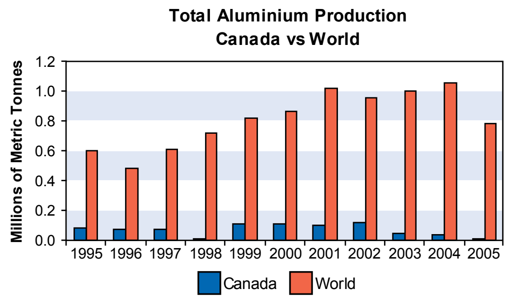


Sources : James F. King

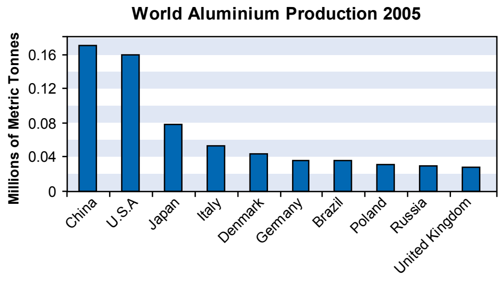
OTHER PRODUCTS PRODUCTION... FROM PAST TO FUTURE

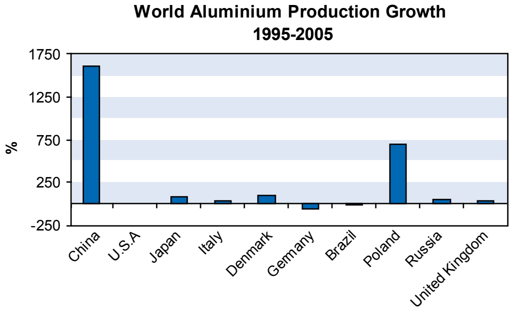
1995-2005



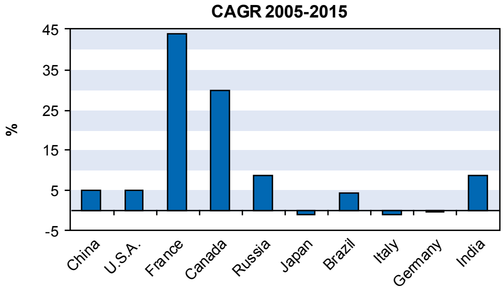


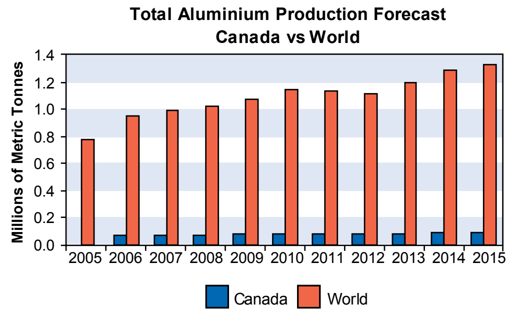
2005



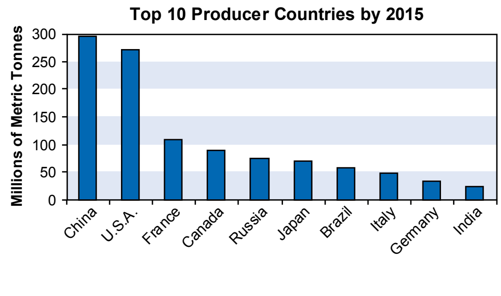


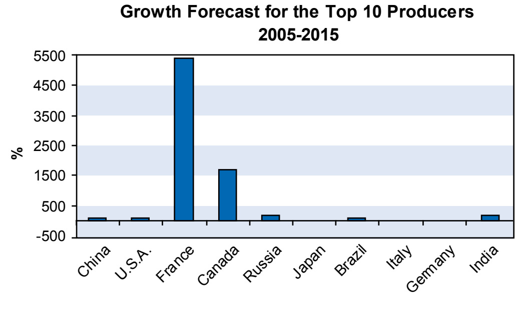
2005-2015





2015



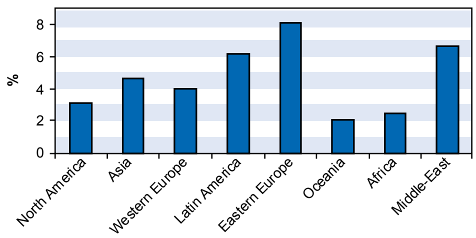


Sources : James F. King

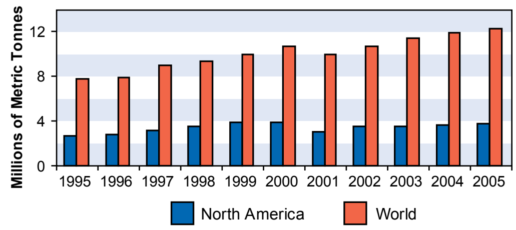
TRANSPORTATION PRODUCTS CONSUMPTION... FROM PAST TO FUTURE

1995-2005

CAGR 1995-2005

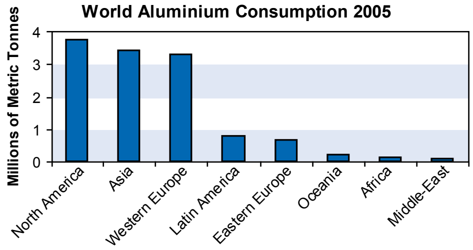


Total Aluminium Consumption North America vs World

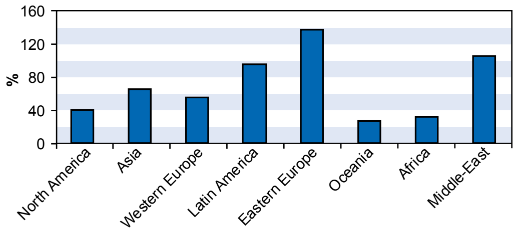


2005

World Aluminium Consumption 2005

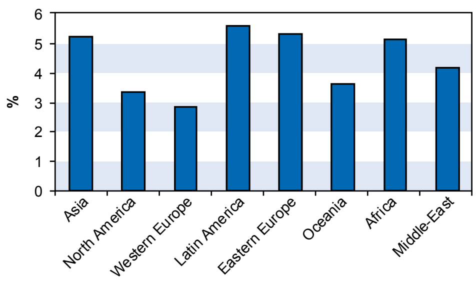


World Aluminium Consumption Growth 1995-2005

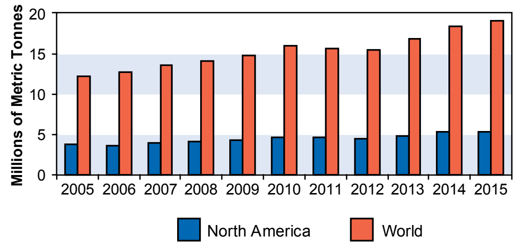


2005-2015

CAGR 2005-2015

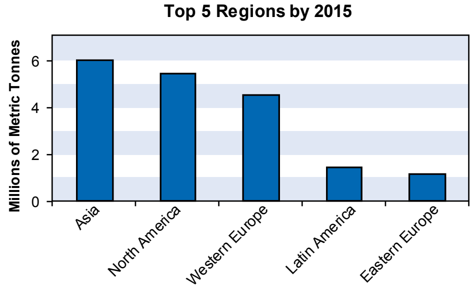


Total Aluminium Consumption Forecast North America vs World

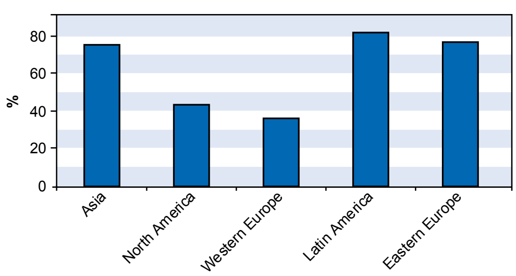


2015

Consumption Forecast for the Top 5 Regions by 2015



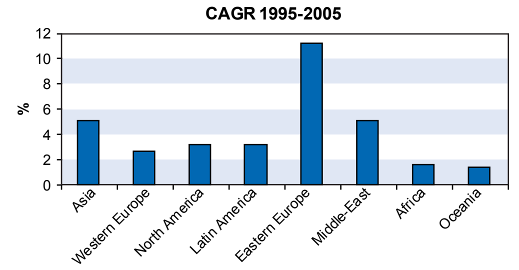
Growth Forecast for the Top 5 Regions 2005-2015

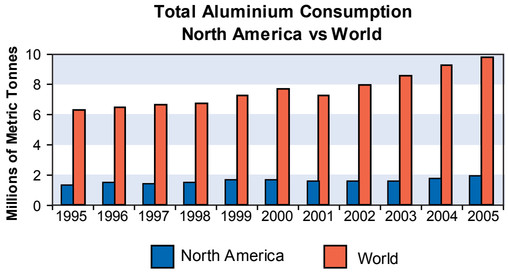


Sources : Aluminum Statistical Review 2005 and James F. King

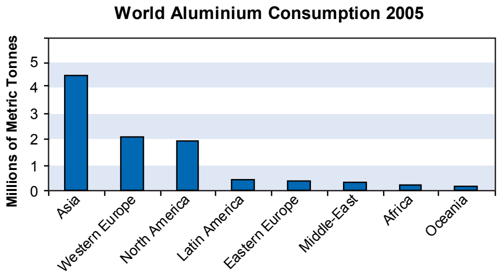
CONSTRUCTION PRODUCTS CONSUMPTION... FROM PAST TO FUTURE

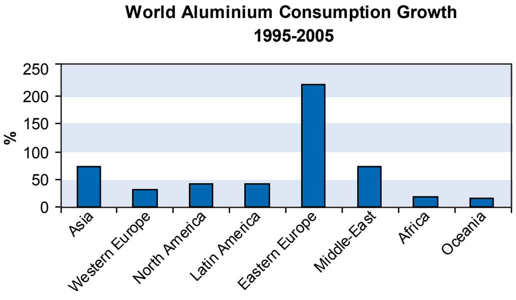
1995-2005



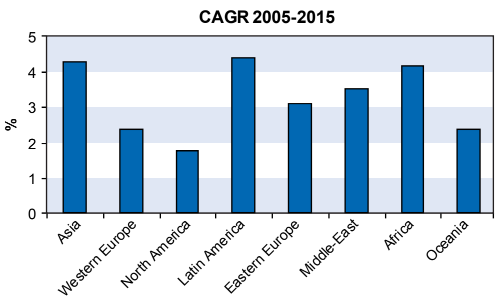


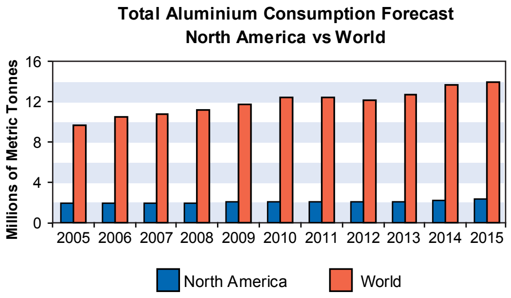
2005



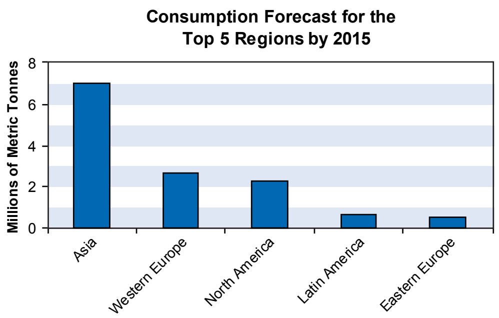


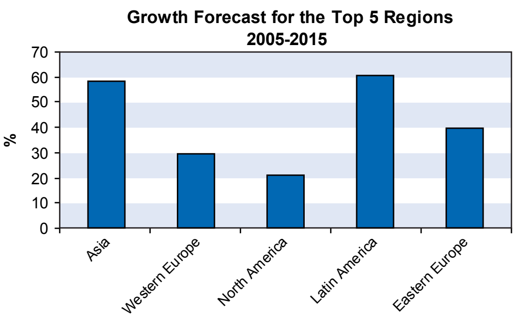
2005-2015





2015

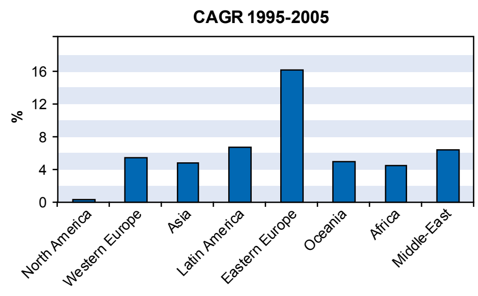


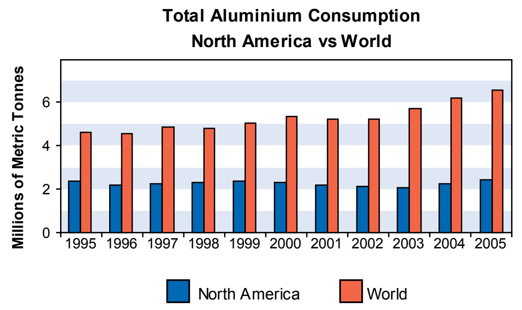


Sources : Aluminum Statistical Review 2005 and James F. King

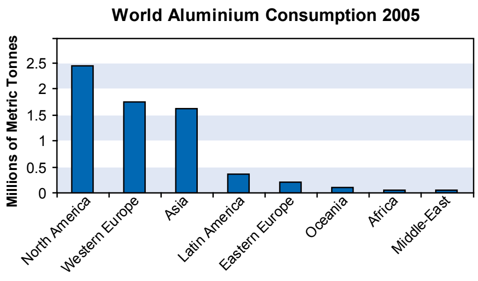
PACKAGING PRODUCTS CONSUMPTION... FROM PAST TO FUTURE

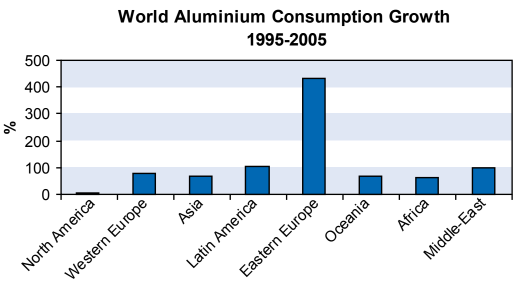
1995-2005



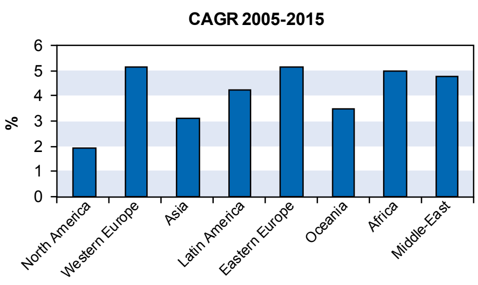


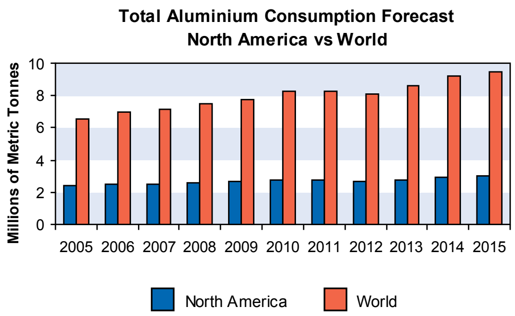
2005





2005-2015





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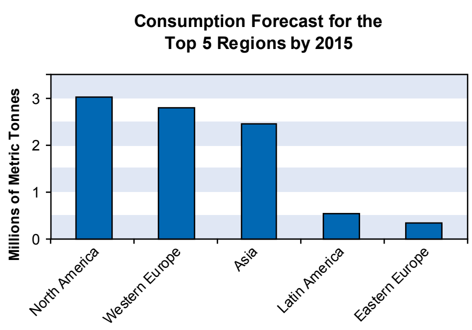
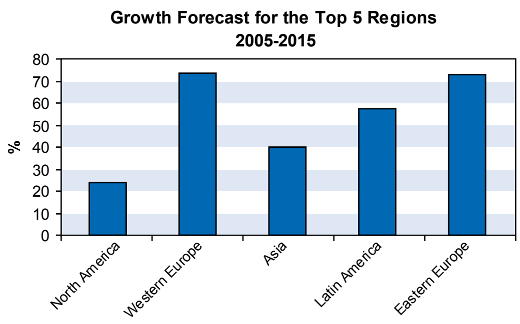
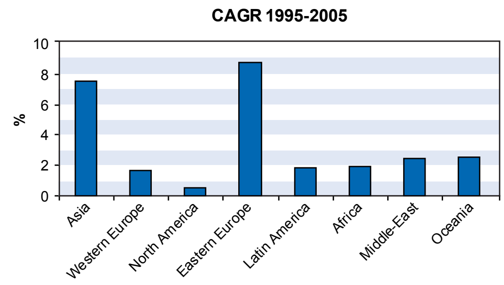


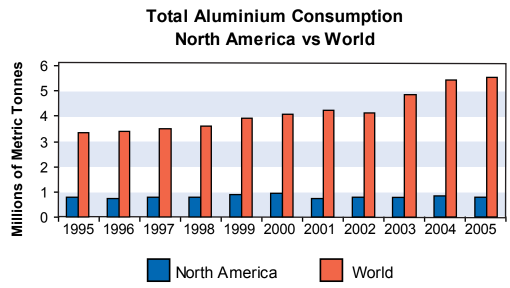


Sources : Aluminum Statistical Review 2005 and James F. King

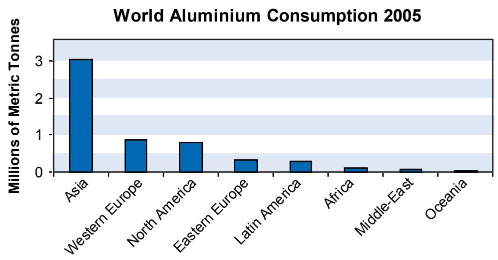
ELECTRICITY PRODUCTS CONSUMPTION... FROM PAST TO FUTURE

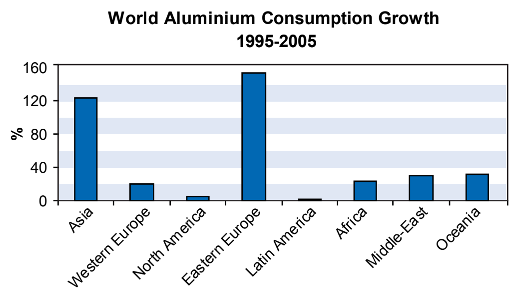
1995-2005



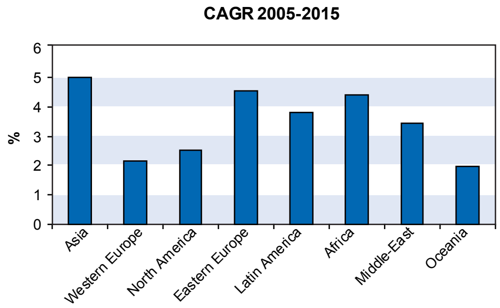


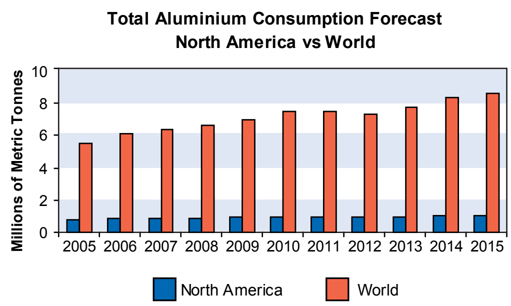
2005



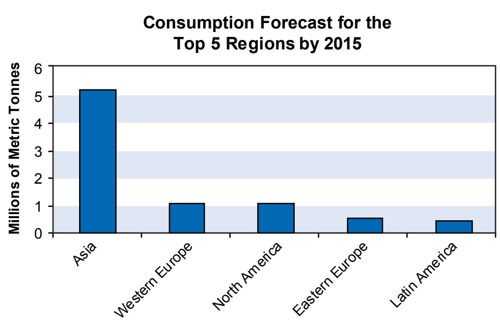


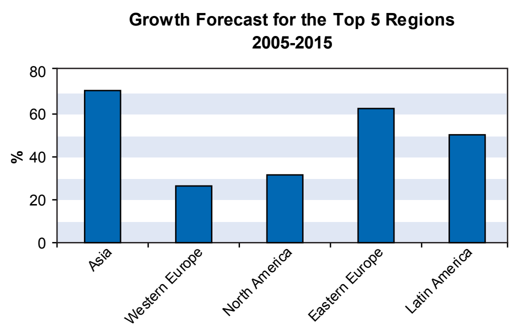
2005-2015





2015

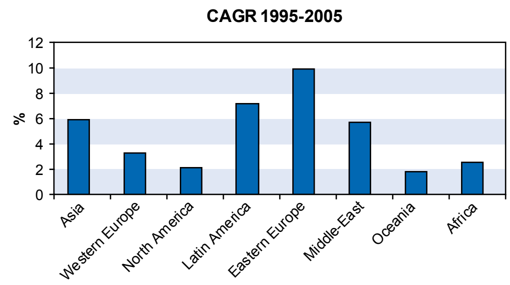


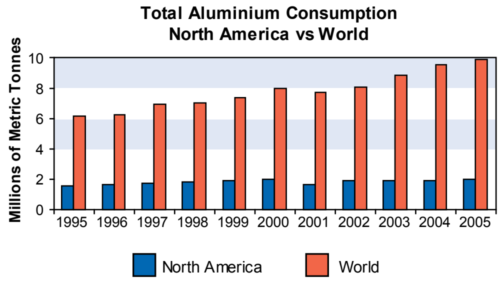


Sources : Aluminum Statistical Review 2005 and James F. King

OTHER PRODUCTS CONSUMPTION... FROM PAST TO FUTURE

1995-2005





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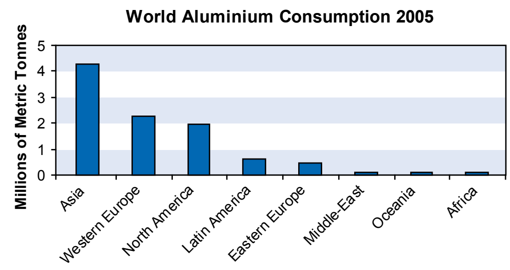
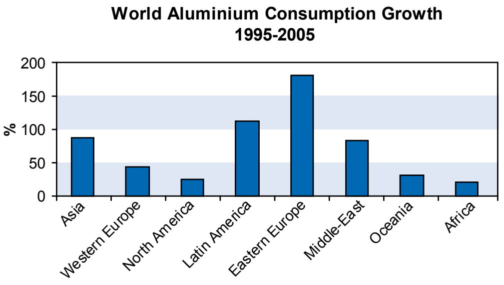
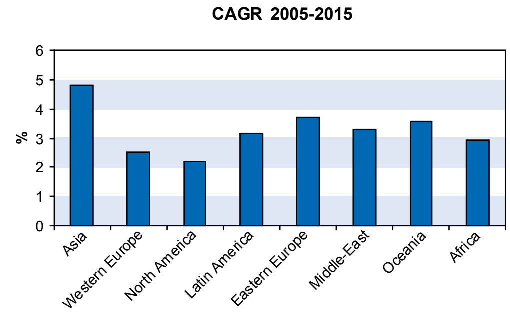
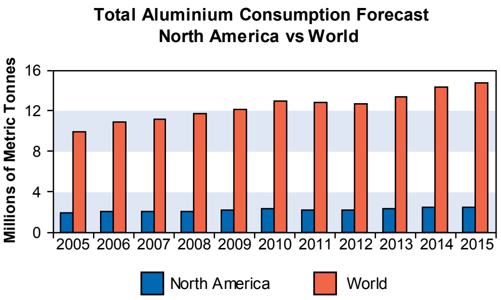




2005-2015





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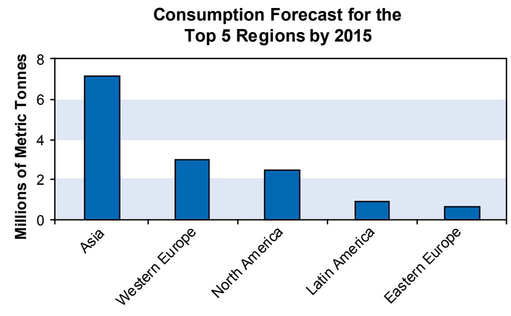

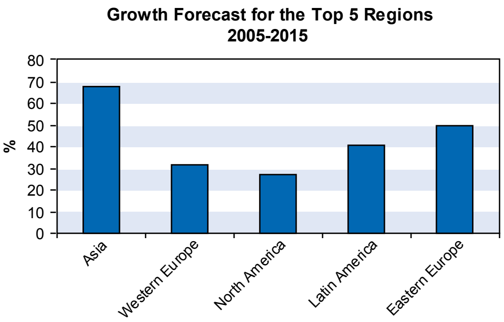

Sources : Aluminum Statistical Review 2005 and James F. King

ANNEXE C – LIST OF FIGURES

ANNEXE D - RECOMMENDED BIBLIOGRAPHY[xxv]

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RECOMMENDED WEBSITES

AA	www.aluminum.org
AA- Automotive Aluminum	www.autoaluminum.org/main
AAC	www.aac.aluminium.qc.ca
Alcan Inc.	www.alcan.com
Alcoa Inc.	www.alcoa.com
Aleris International Inc.	www.aleris.com
Aluminium-Verlag	www.alu-verlag.de/alu_verlag
CQRDA	www.cqrda.ca
CTIF	www.ctif.com/anglais/en/index.asp
EAA	www.eaa.net/eaa/index.jsp
IAI	www.world-aluminium.org/default.asp
NADCA	www.diecasting.org/default.htm
Norsk-Hydro	www.hydro.com/en/index.html
Novelis Inc.	www.novelis.com
NRC-CNRC	www.nrc-cnrc.gc.ca
Réseau Trans-Al Inc.	www.trans-al.com
TALAT	www.eaa.net/eaa/education/TALAT/index.htm
USCAR	www.uscar.org/guest/index.php

ANNEXE E – ACRONYMS

AA	Aluminum Association
AAC	Aluminium Association of Canada
AFS	American Foundry Society
Alcan-ARDC	Arvida Research and Development Center
Alcan-KRDC	Kingston Research and Development Center
CAGR	Compound Annual Growth Rate
CED	Canada Economic Development
CIFM	Centre intégré de fonderie et de métallurgie
CMI	Cast Metals Institute
CQRDA	Centre québecois de recherche et de développement de l'aluminium
CRIQ	Centre de recherche industrielle du Québec
CTIF	Centre technique industriel de la fonderie
CURAL	Centre universitaire de recherche sur l'aluminium
CVD	Chemical Vacuum Deposition
EAA	European Aluminium Association
FSW	Friction Stir Welding
IAI	International Aluminium Institute
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquefied Natural Gas
LTE	Laboratoire des technologies de l'énergie
MIG	Metal Inert Gas
MNE	Multi-National Entreprise
MQL	Minimal Quantity Lubricant
NADCA	The North American Die Casting Association
NRC	National Research Council
NRC-ATC	Aluminium Technolgy Centre
NRC-CISTI	Canada Institute for Scientific and Technical Information
NRC-IAR	Institute for Aerospace Research
NRC-IMI	Industrial Materials Institute
NRC-IRC	Institute for Research in Construction
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
PRAL	Les Presses de l'aluminium
REGAL	Regroupement aluminium-Centre de recherche sur l'aluminium
RSW	Resistance Spot Welding
R.V.	Recreational Vehicles
SME	Small and Medium Entreprise
TALAT	Training in Aluminium Application Technologies
TIG	Tungsten Inert Gas
TMS	The Minerals, Metals & Materials Society
TRM	Technology Roadmap
UBC	Used Beverage Cans
UQAC	University of Quebec at Chicoutimi
USCAR	United States Council for Automotive Research

Printed in Canada

With the financial support of the following collaborators:

ALUMINUM ASSOCIATION OF CANADA
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Canada Economic Development for Quebec Regions
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