Photonics
For Advanced
Manufacturing Plus
by PIMAP+ partnership

D2.2 – Market trends analysis in North America

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1. Executive summary

Developed within the scope of the PIMAP+ project, the following document is the result of a desk research and embodies a market analysis of the current market trends and opportunities in USA and Canada, within the scope of photonics-enabled advanced manufacturing.

Departing from the introduction where the PIMAP+ project is presented, its objective and goals, the report is composed in 3 main sections:

(1) A first section devoted to explanation of the scope and methodology used in the study;
(2) A second section devoted to the main global trends pertaining to the PIMAP+ value chain (built upon the synergies between photonics, production technologies, steel and aerospace industries);
(3) A third section comprehending the two country reports, notably pertaining to the US and Canada, where specific market conditions in terms of user sectors will be identified, including major stakeholders for each sectors and events, and the framework regarding international trade.

The latter section comprehends a core part of the report, being based on the identification of the most pertinent manufacturing sectors in US and Canada and respective regions where the production is most concentrated, enabling the identification of targets, both in terms of sectors and regions, for future interventions.

As mentioned, it will be highlighted some of the main organizations and events in these countries that can be useful to further and consolidate the relationships within the PIMAP+ consortium towards the identified strategic markets, and create new opportunities for their SMEs.

Despite of the potential that these markets have, a note on the current trade framework will also expose the specifics for each country, and as such is developed in each country report.

The report conclusions will therefore enable a first basis for the identification of actions to be taken on the potential markets by the PIMAP+ clusters and their enterprises.

Under the PIMAP+ vision of deploying a joint internationalization plan, that exploits the synergies between the ecosystems of the 6 clusters, in the furthering of advanced KET[1]'s-based solutions for advanced manufacturing, the report enables an adequate assessment of opportunities and, more importantly, of potential targets for future actions, as it identifies the relevant user sectors (for the PIMAP+ value chain) and potential targets for implementing internationalization actions in terms of regions, relevant stakeholders (potential partners in the implementation of actions) and events.

This report complements other information tools, that are to be deployed by PIMAP+ partnership, that will support the development of the joint internationalization actions foreseen in the project and beyond.

[1] Key enabling technologies, of which photonics and advanced manufacturing technologies are an integrant part.

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2. Introduction

The PIMAP+ consortium has been set up to support 6 leading European clusters, their SMEs and regional ecosystem actors to strengthen cross-sectoral cooperation in the fields of photonics, advanced manufacturing, metalworking and aerospace industry. The associated scope and mission are defined in the motto “Photonics for Advanced Manufacturing (Plus)”.

Settled within the COSME (European Union Programme for Competitiveness of Enterprises and Small and Medium-sized Enterprises) call for European Strategic Cluster Partnership “Clusters Go International”, the initiative gathers 6 clusters, notably ALPHA-RLH (France) and Joensuu Science Park (Finland), both directly related to Photonics, Triple Steelix (Sweden) in the Steel Value Chain and related industrial applications, PRODUTECH (Portugal) and AFIL (Italy) both devoted to the Production Technologies Industry and Advanced Manufacturing and the Moravian Aerospace Cluster (Czech Republic). The project embodies an inter-cluster cooperation which aims to foster internationalization opportunities for SMEs in Canada, USA, China and Japan and the establishment of cross-European global value chains of SMEs offering photonics-enabled advanced manufacturing solutions.

The PIMAP+ project is a follow-up of the successful activities implemented in the PIMAP Partnership Strand 1 project funded under the COSME programme. After two years of action-oriented project implementation and a solid internationalization strategy, the partners now seek to accelerate the access of their ecosystems, notably SMEs, to international markets, to support the development of business agreements and to concretize B2B cooperation.

The specific objectives of PIMAP+ are:

- To support cross-sectoral cooperation among cluster organizations and SMEs
- To foster SME engagement and SME internationalisation
- To establish cooperation agreements with international business and research intermediaries in countries beyond Europe
- To create a European identity and explore the possibility to establish a metacluster
- To monitor the achievements of the PIMAP+ project and its SMEs via a set of indicators
- To develop a long-term exit strategy ensuring the sustainability of the PIMAP+ project

The current report has the objective to produce an analysis of the market trends and opportunities in the North American targeted geographical markets, notably USA and Canada, and therefore to support the coordination and cooperation within the partnership in the combined internationalization effort. It is a direct result of the work devoted to intelligence gathering under the PIMAP+ project.

At the basis of this report is the scope defined under PIMAP+ within the scope of its internationalization strategy, i.e., the establishment of a cross-sectoral value chain that supports the deployment of photonics-enabled production technologies and solutions that address the advanced manufacturing

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requirements of demanding industries, such as aerospace, as well as the several sectors of the manufacturing industry.

The current report embeds and systematizes relevant information for both the participating clusters and stakeholders. It builds on the work developed under PIMAP partnership project, notably by using the same methodological approach that was found pertinent to the established objectives. It updates the scope, in alignment with the clusters that currently are integrated in PIMAP+ partnership, and its statistical basis. And it provides for a first basis of intelligence, instrumental to (1) the launch of the targeted actions established under the joint internationalization implementation roadmap and (2) to the launch of initiatives directly by the companies, research organizations and other stakeholders, in the pertinent markets.

As the PIMAP+ partnership, the clusters and their respective ecosystems are deeply rooted within the smart specialization strategies of the comprised regions, the report is viewed as a key input in the formulation of new projects and initiatives, under the current and future regional, national and European policy instruments, including those pertaining to Europe's Resiliency and Recovery Plan, by leveraging the role that clusters can have in the therewith established objectives.

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3. Methodology

3.1. Methodological approach

Based on the desk research, this report on market trends and analysis of North America, focus on USA and Canada and is structured in 2 main sections:

a) A first section pertaining to the main global trends and opportunities within photonics, advanced manufacturing technologies, steel and aerospace industry, and which was construed based on secondary information sources, and notably from pertinent studies on trends, reports and other bibliography.

b) A second section pertaining to each one of the country reports (Canada and USA) and which, departing from the PIMAP+ value chain, was construed using the following approach:

   i. Country Overview (macroeconomic data) based on country reports;

   ii. Selection of pertinent client industrial sectors based on the country's statistics of the manufacturing industry, and notably having in mind the dimension, relevance and contribute of the specific sector to the manufacturing industry GDP in the specific country and its pertinence to the PIMAP+ foreseen value chain;

   iii. Description of each pertinent sector, and notably (1) main economic aggregates, (2) identification of the major locations of industry agglomerates, (3) main sector industrial associations, (4) main industry events and fairs;

   iv. Note on relevant information regarding international trade, which provide insights in terms of the framework for the exploitation of opportunities;

   v. Conclusions.

3.2. Notes on the industrial sectors' definition, collection of data and the use of the industry classification system

One challenge of this desk research is the choice of which classification of the economic activity is best suited for the analysis. In one hand, developing a study according to the Statistical Classification of the Economic Activities in the European Community (NACE) seems to be more appropriate since (a) the analysis addresses to a European perspective, (b) is oriented to PIMAP+ European participant clusters, and (c) aim to provide a common understanding on the sectors under analysis. In the other hand, this study is addressed to the North America region, that has defined its own classification system, North American Industry Classification System (NAICS), and which is more appropriate when it comes to the statistical analysis of the data collected and its results.

There is no direct concordance between the European and the North American classification systems. But, in 1948, it was developed the first version of the International Standard Industrial Classification of All Economic Activities (ISIC) with the goal to provide guidance to countries in developing national activity classifications and become an important tool for comparing statistical data on economic activities at the international level (United Nations, 2008).

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Not only ISIC, but also the other two classification systems have been revised throughout the years to achieve better convergence between each other. According to (European Commission, 2008) "*NACE is a derived classification of ISIC: categories at all levels of NACE are defined either to be identical to, or to form subsets of, single ISIC categories. The first level and the second level of ISIC Rev. 4 (sections and divisions) are identical to sections and divisions of NACE Rev. 2. The third and fourth levels (groups and classes) of ISIC Rev. 4 are subdivided in NACE Rev. 2 according to European requirements. However, groups and classes of NACE Rev. 2 can always be aggregated into the groups and classes of ISIC Rev. 4 from which they were derived. The aim of the further breakdowns in NACE Rev. 2, as compared with ISIC Rev. 4, is to obtain a classification more suited to the structures of the European economies.*"

The classifications among NACE and ISIC are clear and strongly related, the challenge comes when a relationship must be settled between NAICS and ISIC. European Commission (2008, p. 42) states that "*NAICS is developed on the basis of a production-oriented conceptual framework and classifies units, not activities. As a result, the structures of ISIC and NAICS are substantially different. However, statistical data collected according to NAICS can be aggregated into the two-digit divisions of ISIC Rev. 4/NACE Rev. 2, ensuring comparability of data. In many cases, more detailed links are possible.*"

Having in mind that the countries' analysis should be according to the NAICS, the US Census Bureau developed a table which provides a sound basis for the analysis by setting the concordance between NAICS 2017 and ISIC Rev. 4, thus providing detailed description of the direct relationships between classification systems and including the most specific levels of classification for both systems (attachment 1). Nevertheless, the NAICS does not relate directly to ISIC. While ISIC classifies economic units, *"NAICS is an industry classification system that groups establishments into industries based on the similarity of their production processes"* (US Census Bureau, 2017). This means that NAICS has a structure that does not follow pattern of ISIC, although we define concordance between them. So, according to the US Census Bureau (2017) *"NAICS uses a six digit coding system to identify particular industries and their placement in this hierarchical structure of the classification system. The first two digits of the code designate the sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry"*. Based on that the report will be built primarily using NAICs classification, but nevertheless punctual references may be used, for best convenience, to ISIC and NACE classification.

3.2.1. Photonics industry statistical definition

Photonics is defined as a multidisciplinary domain dealing with light, encompassing its generation, detection and management. It provides the technology basis for a variety of products and its application ranges from manufacturing systems and components to energy production, and from information and communication technologies to biomedicine, sensors and metrology.

Optech Consulting, (2017), under its market research to analyse the trends on photonics identifies ten different segments (which can be further divided into other sub-segments) : (1) Production Technologies; (2) Optical Measurements & Image Processing ; (3) Medical Technology & Life Sciences;

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(4) Communication; (5) Information Technologies; (6) Displays; (7) Lighting; (8) Defense & Security ; (9) Optical Components & Systems ; (10) Photovoltaics.

Anderson (2014), on his presentation about SPIE – The international society for Optics and Photonics, highlighted how ideal would be to have all photonics and optics companies using just one NAICS code, in order to account more accurately the value of the activities on this matter. Unfortunately, this does not happen in reality. In 2014, 2748 "Photonics" companies used 259 different NAICS codes (up to six-digit level).

Despite the above and having in mind that PIMAP+ is particularly focused on photonics for advanced manufacturing, this creates a basis for the selection of the pertinent NAICS codes, notably those pertaining to its application to production technologies, communication and information technologies and other manufacturing equipment. (European Commission, 2009a)

Table 1: Photonics-related sectors according to NAICS (pertinent to the PIMAP+)

NAICS Section – Manufacturing		
Sector	**Subsector**	**Name**
33	333	Machinery Manufacturing
	334	Computer and eletronic product manufacturing
	335	Electrical equipment, appliance, and component manufacturing
NAICS Section - Professional, Scientific, and Technical Services		
Sector	**Subsector**	**Name**
54	541	Professional, Scientific, and Technical Services

The table shows three manufacturing subsectors (333, 334, 335), and also the subsector 541 since it includes the research & development of photonics technologies.

3.2.2. Production Technologies statistical definition

Production technologies industry provides capital goods, notably industrial equipment, production lines, industrial software and other auxiliary/support technologies (e.g. robotics, machine vision applications, etc.) that enable the industrialization of all manufacturing industry's products.

When considering the production technologies industry, the statistical tools (notably classification systems) do not provide means for a comprehensive and detailed identification of its sectors and subsectors.

Neither the Statistical Classification of the Economic Activities in the European Community (NACE rev. 2), International Standard Industrial Classification of All Economic Activities (ISIC) nor North American Industry Classification System (NAICS) provide for a robust framework for the production technology industry identification, Notable, under ISIC, if the manufacturing of machines and equipment can be attributed to the division 28 (and despite other industrial equipment and components can be found in other divisions, e.g. 25), when considering software for industrial applications, the ISIC does not provide an adequate information, since it is not able to distinguish between industrial software and other purposes software. The same also applies to the other above mentioned classifications. In this sense,

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it can be defined under ISIC two groups of divisions, one, that we will refer to as Core group, that, in its scope all companies are in fact production technology companies, and second one that we will refer to as Extended group, that despite including production technologies companies it may include other companies that are not production technologies related (e.g. see example above on software).

Table 2: Production Technologies Sectors according to ISIC rev. 4

PRODUCTION TECHNOLOGIES DELIMITATION: CORE GROUP			
Section C – Manufacturing			
Division	**Group**	**Class**	**Name**
28	281		Manufacture of general-purpose machinery
	282		Manufacture of special-purpose machinery
PRODUCTION TECHNOLOGIES DELIMITATION: EXTENDED GROUP			
Section C – Manufacturing			
Division	**Group**	**Class**	**Name**
25	251		Manufacture of structural metal products, tanks, reservoirs and steam generators
	259	2593	Manufacture of cutlery, hand tools and general hardware
26	265	2651	Manufacture of measuring, testing, navigating and control equipment
27	271	2710	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus
33	331	3312	Repair of machinery
	332		Installation of industrial machinery and equipment
Section G – Wholesale and retail trade; repair of motor vehicles and motorcycles			
Division	**Group**	**Class**	**Name**
46	461		Wholesale on a fee or contract basis
	466		Other specialized wholesale
Section J – Information and communication			
Division	**Group**	**Class**	**Name**
58	582		Software publishing
62	620	6201	Computer programming activities
Section M – Professional, scientific and technical activities			
Division	**Group**	**Class**	**Name**
71			Architectural and engineering activities; technical testing and analysis
74	749		Other professional, scientific and technical activities n.e.c.

The difficulties come from how industries are defined under the several statistical classifications, not being able to capture adequately the Production Technologies value chain, as the pertinent industry companies are scattered in several divisions and groups, and as some groups have a wider scope encompassing other value chains (e.g., division 58, division 62, among others). Under NAICS, the Production Technologies Core group can be attributed to the sub-sector 333 Machinery Manufacturing.

3.2.4. Aerospace industry statistical representation/definition

Aerospace industry is involved in all aspects pertaining to the design, building, testing, selling and maintaining aircrafts and other flight vehicles. Includes a wide range of companies operating in airframe design, avionics, composite materials, and many others. It is a high technology industry with high requirements in terms of applied science, R&D, engineering and advanced manufacturing. In terms of statistical information, and despite elements of its value chain can be found in several sectors, its core can be circumscribed to a specific subsector, under NAICS, notably 3364 – Aerospace Product and Parts Manufacturing, which include aircraft manufacturing, aircraft engine and engine parts

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manufacturing, other aircraft parts and auxiliary equipment manufacturing, as well as guided missile and space vehicle related manufacturing.

Table 3: Aerospace related Sectors according NAICS (pertinent to the PIMAP+)

31-33 Manufacturing	
Subsector	**Name**
3364	Aerospace Product and Parts Manufacturing

3.2.3. Steel industry statistical representation/definition

The steel industry encompasses a wide and comprehensive value chain, from mining till the incorporation of steel parts in the products of several products (from the automotive to household products). Nevertheless PIMAP+ defines a wider approach "The PIMAP+ consortium has been set up to support 6 leading European clusters, their SMEs and regional ecosystem actors to strengthen cross-sectoral cooperation in the fields of photonics, advanced manufacturing, metalworking and aerospace industry" (PIMAP+ Consortium, 2019). As such, for the purposes of the herewith report the pertinent statistical representation is broader comprising not only steel, but a broad metals value chain. This also implies an overlap in pertinent sectors, e.g., the sectors of the production of industrial equipment or aerospace are therefore also relevant sectors in the metals value chain. The pertinent codes are therefore summarized in table 3.

Table 4: Steel and User Sectors according to NAICS (pertinent to the PIMAP+)

21 – Mining, Quarrying and Oil and Gas Extraction	
Subsector	**Name**
212	Mining (except Oil and Gas)
213	Support Activities for Mining
31-33 Manufacturing	
Subsector	**Name**
331	Primary Metal Manufacturing
332	Fabricated Metal Product Manufacturing
333	Machinery Manufacturing
334	Computer and Electronic Product Manufacturing
335	Electrical Equipment, Appliance and Component Manufacturing

3.2.4. Statistical representation/ definition of pertinent client sectors for PIMAP+ Value chain

Since the PIMAP+ is focused in the application of photonics for advanced manufacturing, all the manufacturing subsectors (according to NAICS) should be considered when assessing the opportunities in these two countries for the PIMAP+ value chain (table 3).

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Table 5: Manufacturing Subsectors NAICS 2017

Code	Subsector
311	Food manufacturing
312	Beverage and tobacco product manufacturing
313	Textile mills
314	Textile product mills
315	Apparel manufacturing
316	Leather and allied product manufacturing
321	Wood product manufacturing
322	Paper manufacturing
323	Printing and related support activities
324	Petroleum and coal products manufacturing
325	Chemical manufacturing
326	Plastics and rubber products manufacturing
327	Non-metallic mineral product manufacturing
331	Primary metal manufacturing
332	Fabricated metal product manufacturing
333	Machinery manufacturing
334	Computer and electronic product manufacturing
335	Electrical equipment, appliance, and component manufacturing
336	Transportation equipment manufacturing
337	Furniture and related product manufacturing
339	Miscellaneous manufacturing

Source: US Census Bureau

Within these, and as we will be able to see in the specific countries report (and according to the economic structure of both Canada and US), the following ones can be highlighted:

- Production Technologies & Heavy Machinery
  - 333 - Machinery manufacturing
- Metal Manufacturing
  - 331 – Primary metal manufacturing
  - 332 – Fabricated metal manufacturing
- Plastics
  - 326 – Plastics and Rubber products manufacturing
- Automotive
  - All industry groups from 336 – Transport equipment manufacturing except 3364 – Aerospace products and parts manufacturing.
- Aerospace
  - 3364 – Aerospace products and parts manufacturing
- Chemical Manufacturing
  - 325 – Chemical manufacturing

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- Food Processing and Manufacturing
    - 311 – Food manufacturing
- Information Technologies
    - 334 – Computer and electronic product manufacturing
- Electrical Equipment
    - 335 – Electrical equipment, appliance, and component manufacturing

Similar to the previous sections, final remarks shall be made to the fact that some sectors are directly correspondent with one subsector, i.e.: machinery manufacturing, while others, e.g. metal manufacturing, are represented by two subsectors or more. In the latter case, this is due to its presence both at an upstream and downstream level of the value chain. Due to the diversity of products and applications, the analysis will be made by looking at industry groups, where applicable (four-digit NAICS).

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4. SCOPE

According to European Commission (2009a), Key Enabling Technologies are knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly-skilled employment. They enable process, product and service innovation throughout the economy and are of systemic relevance.

The following could be regarded as the most strategically relevant KETs, given their economic potential, contribution to solving societal challenges and knowledge intensity:

- Nanotechnology
- Micro and nanoelectronics, including semiconductors
- Photonics
- Advanced Materials
- Biotechnology
- Advanced manufacturing technologies

The PIMAP+ partnership is mostly focused on the mobilization of KETs, specifically photonics and advanced manufacturing technologies, in supporting smart manufacturing and related industrial applications. It aims to strengthen cross-sectoral cooperation in the fields of photonics, advanced manufacturing, metalworking and aerospace industry. This requires the definition of the relevant domains of photonics and production technologies, on a first level, since they are enablers of advanced manufacturing; steel as a comprehensive value chain that pervades all industries; aerospace industry as a high interest/high demanding client sector; and other pertinent user sectors, understood as the relevant sectors of the manufacturing industry, and as such clients for photonics enabled advanced manufacturing.

4.1. Photonics

As previously mentioned, photonics is defined as a multidisciplinary domain dealing with light, encompassing its generation, detection and management. Among other things it provides the technological basis for the economic conversion of sunlight to electricity which is important for the production of renewable energy, and a variety of electronic components and equipment such as photodiodes, LEDs and lasers (European Commission, 2009a). Its application domains ranges from manufacturing systems and components, to laser machining, from automotive and aerospace, to energy and environment monitoring, from information and communications technologies to home automation, from biomedicine and biotechnology to sensors and metrology, among several others.

This represents a challenge to define precisely what are the using sectors of these technologies and on how photonics can be classified as an industrial sector.

According to Optech Consulting, (2017) it is possible to divide Photonics in a broad range of segments:

- Production Technology
- Open Measurement & Machine Vision
- Information Technology & Life Science

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- Information Technology – Consumer Electronics, Office Automation & Printing
- Optical Communications
- Flat Panel Displays
- Lighting
- Defence Photonics
- Optical System & Components
- Photovoltaic

Photonics is not a market or an industry but a collection of technologies based on light that creates or enables many end-use applications and markets. However, it is often convenient to talk about the collection of entities that develop, manufacture, and distribute optics and photonics components, systems, and enabled products as the “photonics industry.”

The range and diversity of photonics applications make it difficult to characterize this industry and to assess its economic impact. The industry is global with many companies, though most are relatively small. Photonics is a powerful fuel for the global economic growth engine, and it is gaining significance in the world’s economy.

The photonics value chain starts with raw materials like glass and semiconductor substrates and progresses through optical components and subsystems to photonics-enabled products such as lighting systems, data centers, and smart phones. The global photonics-enabled marketplace is based on these “end-use” products.

Photonics technologies also underpin a large range of enabled services based on the Internet, which relies on optical fiber to transport its data. These services include cloud computing, streaming video, and e-commerce.

Each level of the value chain has higher value than the previous one, so the total revenues associated with the enabled services, for instance, are much larger than those derived from the core components.

4.2. Production Technologies

The production technologies sectors have a key positioning in the several industrial value chains that compose our economy. It provides capital goods, notably industrial equipment, production lines, software and other auxiliary/support technologies that enable the industrialization of all manufacturing industry products.

A wider perspective of the value chain is considered, having at its core the producers of industrial equipment and machines, software houses that develop industrial solutions —such as Manufacturing Execution Systems—, and engineering consultancy companies and system integrators that provide a turn-key solution for their customers. Upstream, we have the suppliers that provide inputs, materials and base technologies, which include photonics solutions (such as industrial lasers and sensors), and downstream the several sectors of the manufacturing industry, in its broader sense, including agro-food, extractive industries and even service-related sectors such as utilities and construction.

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In the supply chain of KETs, advanced manufacturing systems denote the range of high-technologies involved in manufacturing, leading to improvements in terms of new product properties, production speed, cost, energy and materials consumption, operating precision, waste and pollution management (European Commission, 2009b). Therefore, in order to simplify the understanding of KETs, advanced manufacturing technologies are also defined as one of them (European Commission, 2016). As a KET advanced manufacturing technologies and also advanced materials are used in, and encompass, the several PIMAP+ pertinent value chains, both the comprised by the participant clusters, as well as those of the pertinent market applications.

4.4. Aerospace

Aerospace is the effort in engineering, science and business to fly in the atmosphere of Planet Earth and surrounding space. Aerospace organizations are responsible for design, manufacture, operate and maintain aircrafts. This activity has a lot of variety, with many commercial, industrial and military applications.

The aerospace industry is a world leader in advancing science and technology due to the high value and complex by the number of components in finished products. This industry is engaged in the research, development and manufacture of flight vehicles as well subsystems such propulsion and avionics, and all the necessary key support systems for testing, operation and maintenance of the vehicles.

4.3. Steel

Steel has a high tensile strength and low cost making it a privileged material for diverse uses such as buildings, infrastructures, cars, machines, scientific equipment, medical devices, trains and electrical appliances and related value chains.

Because of the important role played by steel, it is often used as a proxy of economic evolution. In integrated steel plants steel is manufactured from the basic raw materials like iron ore, coking coal and fluxes like limestone and dolomite. The main means of production include raw material handling plants, coke ovens, sinter plants, refractory material plants, blast furnaces, steel melt shops, light and medium merchant mills, wire rod mills, medium merchant and structural mills, special bar & structural mills. In addition to these main production units, there are several auxiliary units like power plants, engineering shops, oxygen plants, among several others.

For the purposes of PIMAP+, the steel industry denotes a horizontal intersection with all pertinent sectors, notably (1) it provides the base materials that will be used in the photonics related instruments and solutions, (2) it integrates the industrial equipment that embody advanced manufacturing technologies (3) it is present directly or indirectly (via equipment and tools that were used to produce the products of the several industrial sectors) in all manufacturing activities, including aerospace and (4) it encompasses metalworking, which is a key user sector that is at the core of the majority of the world economies.

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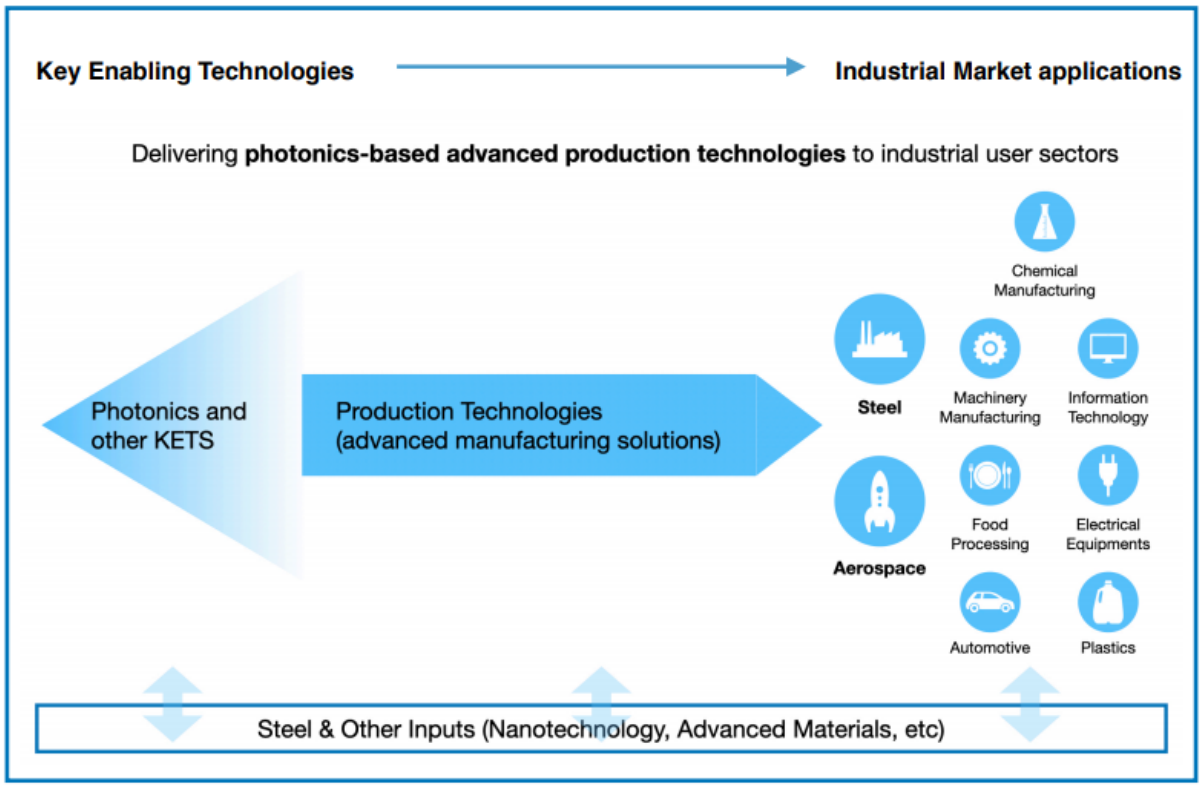
4.5. PIMAP+ Value Chain: photonics-enabled production technologies

The PIMAP+ scope (defined as "photonics for advanced manufacturing") corresponds to the intersection between photonics and production technologies, while addressing to the pertinent user sectors from the manufacturing industry. Consistent with the concept, the PIMAP+ (cross-sectoral) value chain encompasses upstream the development and provisioning of photonics and other KETs, that will be integrated in production technologies (industrial equipment, systems and solutions), addressing to the manufacturing needs of the several industrial sectors, and notably aerospace and metalworking.

Figure 1: PIMAP+ Value Chain



A comprehensive cross-sectoral and market perspective of the value chain is considered, having at its core the production technologies industry (producers of industrial equipment and machines, software houses that develop industrial ICT solutions, and engineering consultancy companies and system integrators that provide a turn-key solution for their customers), having a key positioning in the several industrial value chains, by providing and delivering advanced manufacturing capacities and solutions to the several industrial sectors.

Upstream, we have the suppliers of materials, systems and key enabling technologies particularly photonics solutions (such as industrial lasers and sensors) and others. Downstream, we have the several sectors of the manufacturing industry in its broader sense, which are users of production technologies and the costumers and recipients of advanced manufacturing solutions, notably aerospace, steel and metalworking but also including many others agro-food, to utilities sector.

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5. Global trends in Photonics, Production Technologies, Steel and Aerospace Industry

5.1. Photonics Global Market Trends

When it comes to the photonics market or industry there is no clear or widely accepted definition about it, even though many of entities use photonics technology every day. Over the past fifty years, photonics has evolved into an innovative technology, driven by the development of the laser as a light source and new production techniques.

It is difficult to keep count the number of products and end products that are being launched onto the global markets. The complexity of the categories increases with higher value. For the enabled products, lighting systems serve a different set of end-users with unique market dynamics and regulatory environment. As a result, each "photonics-enabled" market sector moves independently, which means that measuring the size and impact of each one is difficult. Each market segment is significant and comprises many smaller sectors, they move independently of the others, but all are dependent on photonics.

The same component can serve more than one end-use or "enabled" market. Based on that, an SPIE analysis has focused its efforts on the core photonics components business. The analysis found that there were, in 2018, about 4,300 companies, in 53 countries, making and selling core photonics components, which means an increase of 58% since 2012.

Photonics is one of the fastest growing high-tech industries in the world today. The value of finished goods and services produced in 2018 (global GDP) amounted to about 84 trillion U.S. dollars. The value of light-enabled products and services is estimated to be between 7 trillion and 10 trillion annually, which means that photonics represents roughly 11% of the world's economy. (SPIE 2020)

Among the applications, the production technology segment of the photonics market is projected to grow at the highest CAGR[2], in terms of value. This is attributed to the increasing use of photonics products to improve the process and energy efficiency of production technologies. Also, a driving factor for the market is the increasing adoption of digital model in production workflows resulting in smart manufacturing.

The photonics market was projected to grow from USD 686,9 billion in 2019 to USD 780.4 billion by 2023, at a CAGR of 7%. The demand for the photonics in multiple applications is expected to drive the growth of the photonics markets across the globe. Improved properties, such as better energy efficiency and longer lifespan contribute to the increased demand for photonics. Growing digitalization and increasing preference for smart infrastructures and smart manufacturing are driving the consumption of the photonics products in the global market. (SPIE 2020)

[2] Compound Annual Growth Rate.

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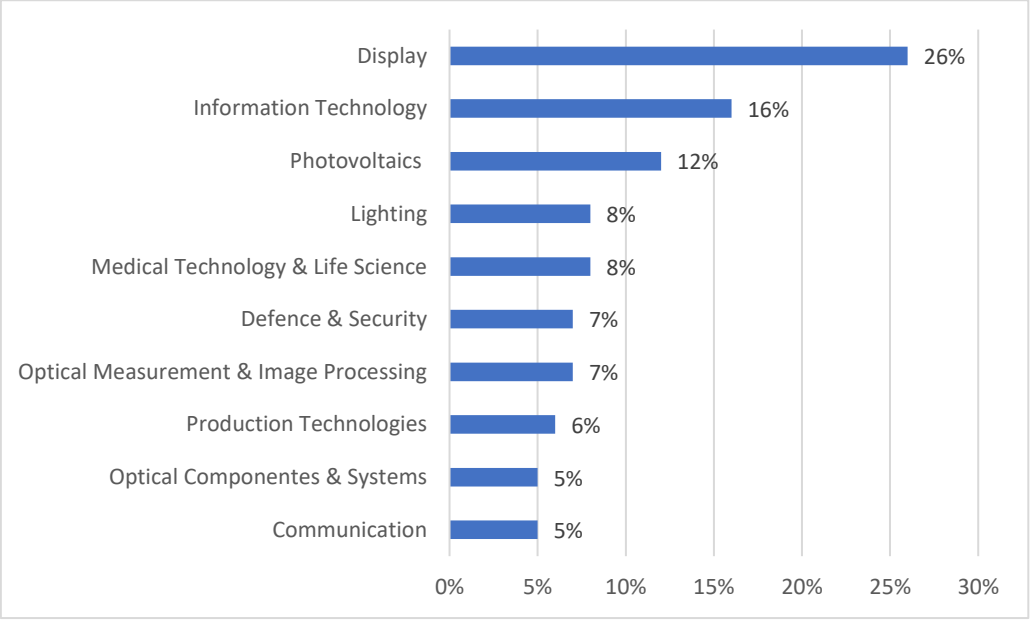
Optech Consulting, (2017)[3] developed a market research to analyse the trends, up to 2015, for ten different segments (which can be further divided into other sub-segments), summarized by the organization:

- Production Technologies
- Optical Measurements & Image Processing
- Medical Technology & Life Sciences
- Communication
- Information Technologies
- Displays
- Lighting
- Defense & Security
- Optical Components & Systems
- Photovoltaics

Having in mind the focus of PIMAP+ (Photonics for Advanced Manufacturing) the Production Technologies and Optical Measurements & Image Processing are the ones to highlight.

The statistical results for each segment, presented by Optech Consulting, provide a generic idea on the global trends of the Photonics markets, in a global approach.

Graphic 1: Global Photonics Market by Segment (%) 2015



Source: Optech Consulting

[3] Recent studies have been developed, but nevertheless the methodology used is less robust or informative having in mind the scope of PIMAP+ project, and hence justifying this selection.

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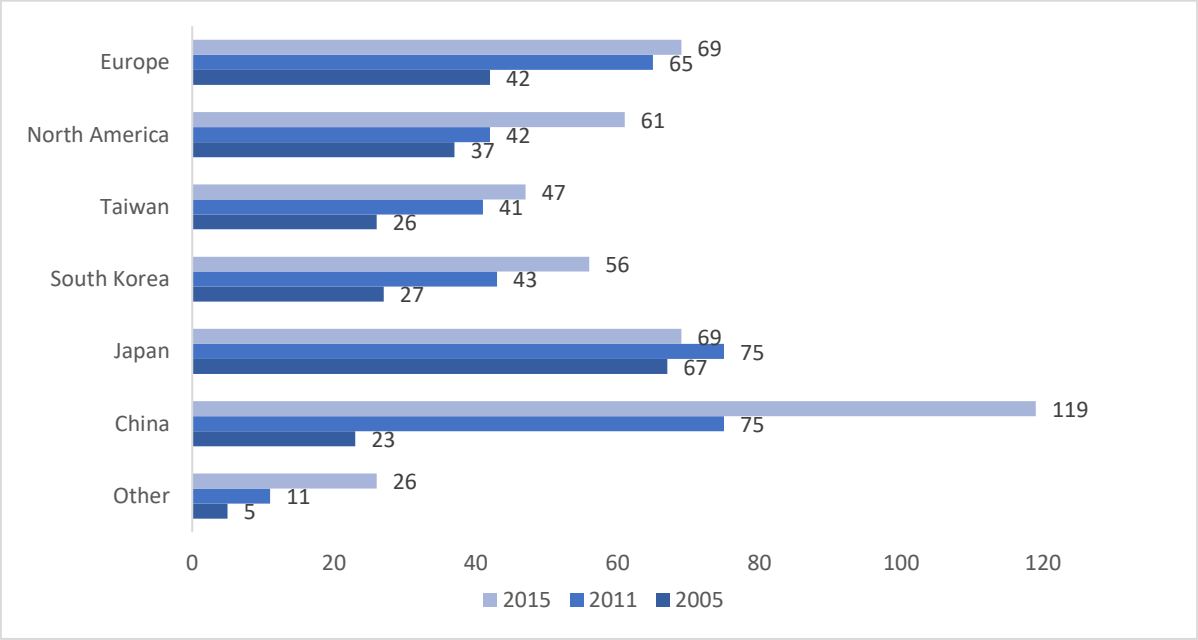
These industry segments contributed to the largest revenue of the market and is expected to maintain its lead. This is on account of a large deployment of the photonics products like lasers in the manufacturing industries such as oil & gas, automotive, and others. Within all the manufacturing industries, lasers are used for application purposes such as cutting, drilling, welding and others.

Other relevant segments for Photonics, are the products used to transmit, store, acquire and display information, which account for 47% of the total of Photonics Market (also used in production technologies, notably in Human machine interfaces, among others). They include segments such as Panels Displays (117,9 billion EUR), Information Technology products (71 billion EUR) and Communication (22 billion EUR).

For Optical Measurements & Image Processing, the total market volume of Photonics based measurement & image processing in 2015 was 33.2 billion EUR, up from 26.5 billion EUR in 2011, corresponding to a CAGR of 5,8% (Optech Consulting, 2017). The market growth during this period was supported by many sub-segments, such as binary sensors, spectrometers, fiber-optic measurement systems, while market growth for measurement systems for the semiconductor industry lagged behind. Nevertheless, the growing pace of this segment has also slowed down, as observed in graph 2, the CAGR from 2005 to 2011 was slightly higher, around 7,1%.

One last segment to be analysed is Photovoltaics, which was booming during the period between 2005 and 2011, with a CAGR of 33,3%, way higher than any other segment, and between 2011 and 2015 the segment crashed, but still with a positive growing result, to a shy 2,8% CAGR. This was due to drastic price cuts for solar cells and modules driven by manufacturers in China. The harsh price decrease drove most of the manufacturers in Europe out of business. In the meantime, also major Chinese manufacturers, including some with multibillion US dollars of annual revenues, had to file for bankruptcy (Optech Consulting, 2017).

Graphic 2: Photonics Production Volume by Country (billion euros) 2015



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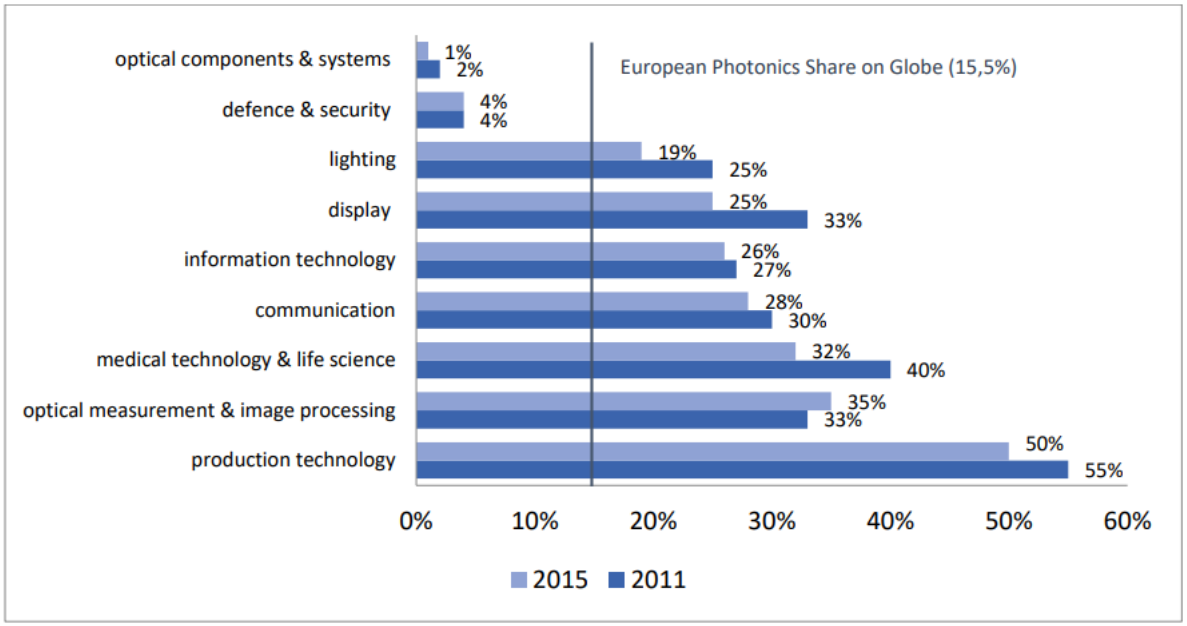
Source: Optech Consulting

The global share of the photonics components market is shifting as dominance of Asia, specifically China, increases. China represents more than a quarter of the Global Photonics market share and a production volume of 119 billion Euros, while Europe, North America, Taiwan, South Korea and Japan share quite similarly the other three quarters, being other regions only represented by 6% of the total market share. Despite of the growing trend of all the regions, by 2011, China became the region with highest volume of production along with Japan. For the next period, China kept growing at a very high pace and became world leader in Photonics, far from all the other regions.

By taking a deeper look into the application of the Photonics production in Europe share over the global market in 2015, with exception to Photovoltaics, some of the segments have a bigger weight globally than the total volume of production Europe has. This means that, for example, while the volume of Photonics production in Europe represents 15,5% of the total, when looking specifically for the Production Technologies segment in Europe, this represents, in 2015, half of the global production.

Nevertheless, when assessing the European photonics production share in global market segments, we see the predominance of 2 key segments that are at the core of advanced manufacturing, representing the competitive advantages of European Photonics Industry, notably the segments “Production Technology” and “Optical Measurement & Image Processing” (and notably providing leads in regard to a European specialization).

Graphic 3: European photonics production share in global markets per segment (excluding photovoltaics)



Source: Optech Consulting

The production technology segment accounts for a European production volume of 13,1 billion EUR. The measurement & image processing segment comprises a European production volume of 11,7 billion EUR. The two segments together account for a 2015 production volume in Europe of about EUR 25 billion corresponding to 36% of the European Photonics production (Optech Consulting, 2017).

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The technological progress of light-based technologies has driven the new wave of innovation by offering sustainable solutions to global obstacles recognized as a key driver for the global photonics market. Still to be assessed are the consequences of COVID-19 in the photonics industry value-chain.

5.2. Advanced Manufacturing Technologies Global Market Trend

Manufacturing supply chains are becoming increasingly global, with customization and the integration of service offerings becoming the new norm. These product transformations are being driven by significant advances in digital connectivity and analytics, which are also playing a role in creating more efficient supply chains and factory floors.

In short period, manufacturing technology is expected to advance to new frontiers, resulting in an increasingly automated and data-intensive manufacturing sector that will likely replace traditional manufacturing.

In today's highly dynamic environment, advanced technologies have become even more essential in improving economic competitiveness and national prosperity. As a result, many nations, including the United States (US), have invested heavily in establishing national innovation ecosystems which connect people, resources, policies and organizations to collectively translate new ideas via advanced technologies into commercialized products and services.

21st century advanced manufacturing competitiveness has fully converged the digital & physical worlds where advanced hardware combined with advanced software, sensors, and massive amounts of data and analytics results in smarter products, processes, and more intricately connected customers, suppliers, and manufacturers. Here is a deeper dive look at some of the most promising technologies:

- Predictive Analytics
- Smart, Connected Products (IoT)
- Advanced Materials
- Smart Factories (IoT)
- Digital Design, Simulation and Integration
- High Performance Computing
- Advanced Robotics
- Additive Manufacturing (3D Printing/Scanning)
- Open-Source Design/Direct Customer Input
- Augmented Reality

The trends in advanced manufacturing technologies for future globally are summarized as below:

- Nano-engineering of Materials and Manufacturing
- Additive and Precision Manufacturing
- Robotics and Adaptive Automation
- Next Generation Electronics Manufacturing

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- Continuous Manufacturing Pharmaceuticals and Bio Manufacturing
- Design and Management of Distributed Supply
- Green Sustainable Manufacturing

Clearly, a strong focus on innovation is essential to the health of not only individual companies, but also the overall economy. For advanced manufacturers to grow and succeed in the highly competitive global market, there are a number of key insights to guide solid business strategy development.

5.4. Aerospace Industry Global Market Trend

The aerospace market consists of sales of aerospace equipment (including aircraft) and related services by entities (organizations, sole traders and partnerships) that produce commercial aircraft, undertake aircraft maintenance, repair and overhauling services, and produce support and auxiliary equipment, such as radar, air traffic control towers and satellites for civilian purpose.

The global aerospace market reached a value of nearly USD 342, 4 billion in 2019, with 3,1% CAGR since 2015. The market is expected to decrease to USD 296,1 billion in 2020 at a rate of -14%, due to lockdown norms imposed by various countries and economic slowdown owing to the covid-19 outbreak and the measures to contain it. The market is then expected to recover and grow at a CAGR of 6,5% in 2021 and reach USD 358,8 billion in 2023 (Deloitte, 2020).

In the historic period, before the pandemic, the growth resulted from increased demand for air travel technological advances, emerging economies, social behaviour and low interest rates. In the negative side, there were the exchange rate fluctuations, political uncertainties, volatile raw material prices and grounding of planes.

Since the beginning of 2020, the airline and aerospace industries have been in unprecedented turmoil. The Covid-19 crisis has kept passengers at home in lockdown in their millions, grounded airlines around the world, pushed some to go out of business, and resulted in orders for the delivery of new aircraft to be postponed or outright cancelled, causing massive shockwaves all along the supply chain. The constant growth we witnessed over the last 10 years has been brought to a very abrupt halt. The full impact of these disruptions cannot yet be fully assessed and nor do we have any way of knowing exactly how the aerospace industry will fare over the next few years. However, it is safe to say that there will be overcapacities in the market and increasing cost pressures.

Airlines, airframe manufacturers, and suppliers will have to adapt to the reduced demands and navigate the challenges to their existence that this presents. Airbus has already asked the governments of the UK, France, Germany and Spain to support companies that are in the business of supplying airframe manufacturers — bankruptcies would massively complicate the restart of the airframe manufacturers' supply chain.

The market has witnessed an inclination toward the incorporation of lightweight materials for aerospace parts manufacturing, on account of improvement in terms of performance and cost-efficiency of the end-use structure.

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The players operating in the aerospace parts manufacturing market face competition in terms of product quality and design. They are targeting customers with customized requests to sustain in the market. The major players are looking to emerging technologies such as additive manufacturing to replace the traditional manufacturing process of smaller aircraft components with complex structures.

Increasing usage of composites for manufacturing fuselage to reduce fatigue maintenance, in high tension loaded environment, is expected to drive the overall cost of aerostructure thereby impacting the market on a positive note. The segment led the market in 2019.

Cabin interior manufacturing is estimated to reach USD 117.4 billion by 2027, owing to extensive use of high-strength and lightweight materials. Cabin interiors exhibit less complex structure as compared to airframe parts, however, it demonstrates mechanical requirements set by regulatory authorities, such as stringent fire, smoke, and toxicity limits (Deloitte, 2020). (Deloitte, 2020)

Avionics manufacturing is expected to grow in line with aircraft manufacturing, as they are designed to increase the safety and utility of an aircraft. Actuators account for a major share of avionics manufacturing, as they are used in all the systems of an aircraft including oxygen, air, hydraulic, fuel, and water systems. In addition, actuators are used in flaps, landing gear, and weapon systems.

Increasing demand for advanced composite materials for the manufacturing of innovative fighter planes is expected to aid market growth. Also, increasing demand for aerospace parts from NATO countries for surveillance aircraft as well as fighter aircraft, owing to rising security threats is anticipated to positively impact the growth over the forecast period.

Increasing government initiatives for space exploration is predicted to benefit the growth of the market for aerospace parts manufacturing.

5.3. Steel and other Metals Global Market Trend

The steel industry as well as related metal industries are in a technology shift, i.e., the 4th industrial revolution – based on the next level of digitalization. The vision is to implement the latest possibilities to control and automate production, improve quality control and planning systems and finally optimize the entire business concept e.g., by the use of Artificial Intelligence (AI).

This requires a big step further to get control over thousands of process parameters, sometimes in a harsh and demanding environment. In many cases also the precision and reliability of sensors need to be improved and advanced models must be utilized to develop e.g., process control algorithms in complex process equipment.

Investments in new and improved systems is often a challenge in the steel industry due to the capital-intensive assets needed but relatively low profitability in this part of the metals value chain. During the last decades, specifically the Chinese and Asian markets have been dominant in steel related capex projects, while Europe and the Americas have been lagging. There are several reasons for this, such as a dramatically growing Asian market, large global overcapacity, global markets and competition, the

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existence of old outdated steel mills with low costs but high environmental impact in certain countries, “unfair” government support, etc.

China has supported their steel industry and invested heavily in the most modern equipment for steel production, much of it from European origin. This has increased overcapacity issues as many old steel mills remain in operation, and China is without competition the world’s biggest steel exporter.

Motivated by matters of national security and other reasons, the Trump administration imposed high tariffs on most imported steel qualities to the US some time ago. As the US market is undersupplied from domestic production, this has triggered massive investments in new steel production capability that is currently under construction in the US. The most modern technology is naturally included. This will further increase the global overcapacity though.

These trends have also forced Europe to reply with similar actions, in order not to be flooded by cheap Asian imports. However, we have not yet seen the same need for construction of totally new capacity since Europe is still a net exporter of steel. Consolidation of the industry has gone far, and it is difficult for the leading companies to integrate further without conflicting with antitrust/monopoly legislation.

This leaves Europe in a situation where adaptation and revamping of “old” equipment is needed, which is an extra complexity since many companies are stuck with a mishmash of different old digital and analogue systems, special solutions, modern digital systems and homemade improvements.

5.4. Preliminary notes on COVID-19 and its impacts in manufacturing

The COVID-19 pandemic has had an unprecedented and disruptive impact on the global economy and societies since the first cases were reported in December 2019. As a result, manufacturing and overall industrial production have seen the sharpest declines, reflecting worries about supply chain disruptions, and reviving financial market fears of a recession. This comes at a time when many manufacturers were already facing other economic challenges, including volatile exchange rates, high interest rates and negative bank loan quality.

Even if supply chain disruption frequency had increased in recent years, the COVID-19 pandemic brought many businesses to a standstill. It opened questions on the critical need for companies to re-evaluate their existing supply chain, to adopt risk mitigation strategies as well as it put the political focus worldwide in the recovery of the economies, by pushing forward industrial resiliency plans.

On the other side the pandemic also brought the attention of the world manufacturing industry, on the importance that advanced manufacturing technologies have in industrial competitiveness (via the adoption of more agile and flexible production systems and supply advanced robotics, artificial intelligence and big data), but also as means for resiliency.

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6. Country Report: Canada

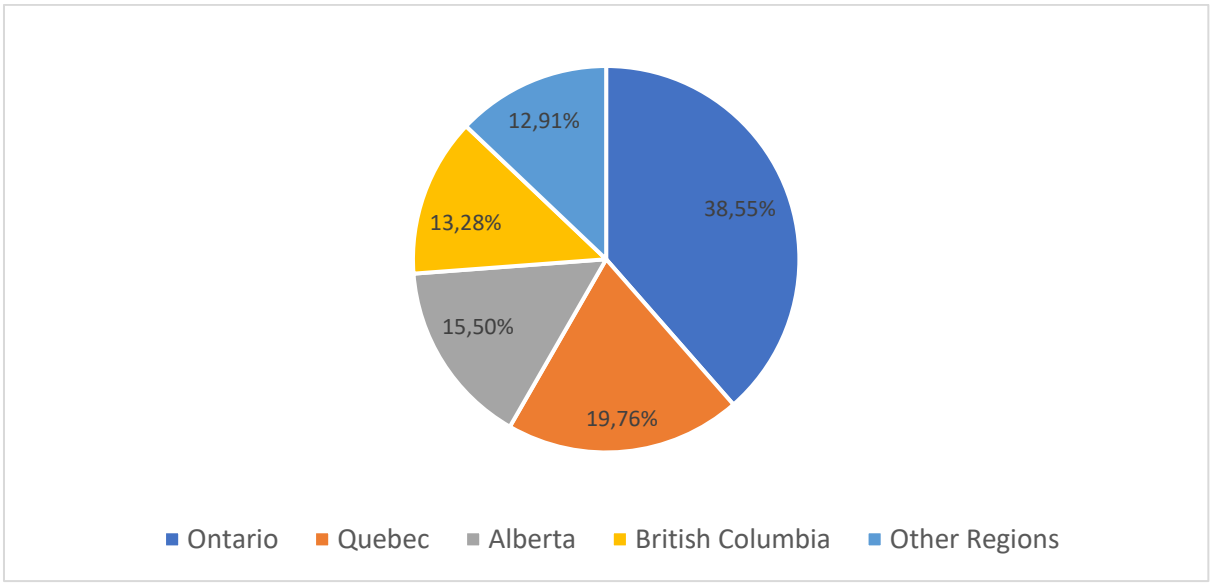
6.1 General Overview

Canada is one of the biggest countries in the world, not only in area, but also from the economic point of view. It is also one of the most open economies when it comes to international trade, establishing its closest relationships, mostly due to their geographic proximity, with the other North American countries, notably USA and Mexico.

According to the Canada Statistics, with a population of 37,6 million, in the end of 2019, the country presented a Gross Domestic Product (GDP) of 1,736 trillion USD, showing a 1,6% Real Growth Rate. For the same period, the country had a decrease of 0,43% in Gross Fixed Capital Formation (Canada Government 2020).

The country is divided in 13 main industrial regions, with four of them standing out from the rest, as shown in graph 3, Ontario (38,5%), Quebec (19,8%), Alberta (15,5%) and British Columbia (13,3%) (Canada Government 2020).

Graphic 4: Distribution of GDP per Industrial Region (2019)



Source : Statistics Canada

In terms of International trade, in 2019, Canada imported a volume of 453,1 billion USD and exported 446,5 billion USD, having a slight deficit in trade balance of 6,6 billion USD. The main suppliers of Canada are the USA, covering 75,4% of the volume of imports, followed by China (3,9%) and United Kingdom (3,3%) (Canada Government 2020).

Manufacturing is a major contributor to the Canadian economy, accounting for $201 billion in 2019, which represents 11,4% of Canadian GDP.

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The most relevant manufacturing subsectors, in terms of GDP and Compound Annual Growth Rate (CAGR), in 2020, are listed below:

- 311 – Food Manufacturing
- 325 – Chemical Manufacturing
- 326 – Plastics and Rubber Products Manufacturing
- 331 – Primary Metal Manufacturing
- 332 – Fabricated Metal Products Manufacturing
- 333 – Machinery Manufacturing
- 336 – Transportation Equipment Manufacturing

6.2. Relevant Markets

The analysis of both Canada and USA will go according to a market selection which comprises some the market subsectors above mentioned. The following topics, with respect to Canadian markets, will provide a more detailed analysis in terms of volume of production of their subsectors and industry groups (in terms of GDP), location quotient and employment, main organizations and clusters for each market and potential events for PIMAP+ partners to participate throughout the year of 2021.

6.2.1 Food Processing & Manufacturing

The first market to be analysed is the Food Processing & Manufacturing. It is represented by the largest manufacturing subsector, in 2019. The subsector 311 – Food Manufacturing, has a GDP of 26,696 billion CAD (Canada Government 2020).This subsector is divided into several industry groups with well distributed weight among each other. Enlisted below are some of the industry groups that contribute the most for subsector:

- 3114 – Fruit and vegetable preserving and specialty food manufacturing – 3,317 billion CAD
- 3115 – Dairy Product Manufacturing – 3,009 billion CAD
- 3116 – Meat Product Manufacturing – 5,640 billion CAD
- 3118 – Bakeries and Tortilla Manufacturing – 4,385 billion CAD
- 3119 – Other Food Manufacturing – 4,095 billion CAD

For this market, in 2019, Quebec has 2.373 establishments and Ontario has 3.489 establishments.

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Figure 2: Food Processing & Manufacturing geographic distribution in Canada | 2019

Source: Canada Government

In a matter of Organizations and Clusters, 4 were identified:

- Food, Health & Costumer Products of Canada, dedicated to food and product safety;
- Ontario Food Cluster, for the agrofood industry;
- Ontario's Golden Horseshoe Food and Farming Alliance, a food cluster;
- GTA Food & Beverage Cluster.

The biggest event in the sector is the SIAL Canada and it will occur from September 21 to 23, 2021 Toronto, ON.

The most relevant companies for this market are Kraft Heinz Canada, JBS and Saputo.

6.2.2 Automotive

This market comprehends the subsector 336 – Transport Equipment Manufacturing subsector, excluding the 3364 – Aerospace Products and Parts Manufacturing industry group. The Government of Canada (2018b) refers to the number of industry groups that, together, represent the automotive market as 336[x] – All Transport Equipment Manufacturing except Aerospace, and it produced, in 2019, a total GDP of 15,37 Billion CAD.

Canada's automotive industry is centered in the heart of North America's largest vehicle producing region: The Great Lakes automotive manufacturing cluster. Ontario is the main region for the development of the Automotive market, with 1.255 establishment.

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Figure 3: Automotive geographic distribution in Canada | 2019

Source : Canada Government

In terms of Organizations and Clusters, 3 has to be highlighted :

- Automotive Parts Manufacturers' Association, which fused in many areas such as parts, equipment, tools, supplies, advanced technology, and services for the automotive industry;
- Automotive Industries Association of Canada;
- Canadian Vehicle Manufacturers' Association.

In Canada, the most important companies in Automotive market are Magna International and Bombardier.

6.2.3. Aerospace

The Aerospace market is represented in one industry group, notably 3364 – Aerospace Products and Parts Manufacturing. The industry group had a GDP volume, in 2018, of 13,1 billion CAD representing more than 1/4 of the total GDP of Transports Equipment Manufacturing subsector.

Geographically speaking, Quebec is the most relevant region for this market, having 258 establishments in Canada's aerospace sector.

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Figure 4: Aerospace geographic distribution in Canada | 2019

Source: Canada Government

There are two organizations and clusters to be identified in this area:

- Aerospace Industries Association of Canada;
- Aero Montreal

The biggest event in Canada for Aerospace industry is the Canadian Aerospace Summit, which was cancelled in 2020 due to covid-19 and does not have yet a date defined.
The main companies in Canada are Rheinmetall and Bombardier.

6.2.4. Chemical Manufacturing

The Chemical Manufacturing market, represented by 325 – Chemical Manufacturing subsector, accounted in 2018, a production of 21,325 billion CAD. The subsector is composed by two main industry groups:

- 3251 – Basic Chemical Manufacturing – 5,671 billion CAD
- 3254 – Pharmaceutical and Medicine Manufacturing – 5,599 billion CAD

The Institute for Competitiveness & Prosperity (2018) identifies 51 different clusters that are represented by several NAICS industries (five-digit level). Those clusters might not represent all industry groups from one subsector. This is the case of the Chemical manufacturing sector, which is distributed between the cluster for upstream chemical manufacturing and the cluster for downstream chemical manufacturing.

Ontario has 1299 establishments in this market.

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Figure 5: Chemical Manufacturing geographic distribution in Canada | 2019

Source : Canada Government

A referred organization should be the Chemistry Industry Association of Canada, dedicated to the manufacture of basic chemicals and resins for a wide range of Canadian industries.

Two companies were considered the most relevants for this sector, Imperial Oil and 3M Canada.

6.2.5. Production Technologies & Heavy Machinery

Represented by the subsector 333 – Machinery Manufacturing, accounts a GDP of 17,625 billion CAD, in 2018.

In terms of location, both Ontario and Quebec are important for this market. Ontario has 3.563 establishments and Quebec has 1.498 establishments.

Figure 6: Production Technologies & Heavy Machinery geographic distribution in Canada | 2019

Canada Government

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Two main organizations are identified, first, the Canadian Tooling and Machining Association, focused in tool & die, machine tool and precision machining, and second, the Canadian Association of Mold Makers, which is the leading association representing mold makers in Canada.

For the events, a few can be listed:

- Instrumentation, System & Automation (ISA) Calgary Show
  28-29 Sep 2021 | Calgary, AB
- National Heavy Equipment Show
  15-16 Apr 2021 | Mississauga, ON
- International Conference on Production Automation and Mechanical Engineering
  30-31 Jul 2021 | Montreal QC
- International Conference & Exhibition on Advanced & Nano Materials
  09-11 Aug 2021 | Ottawa, ON

A key company for this segment, in Canada, is Celestica.

6.2.6. Metal Manufacturing

This market specifically aggregates two subsectors, since they are highly correlated, the 331 – Primary Metal Manufacturing and 332 – Fabricated Metal Products Manufacturing. Both subsectors were identified previously as important subsectors in terms of GDP, the first one, with a GDP of 11,664 billion CAD, in 2018, the only one with negative growth, and the second one with a GDP of 15,835 billion CAD, in 2018.

The subsector 331 does not have any industrial group with a production volume that stands out from the others, but the in the subsector 332, the industry group of Architectural and Structural Metals Manufacturing presents a volume of 6 billion CAD in GDP and Machine Shops, Turned Product, and Screw, Nut and Bolt Manufacturing has a GDP of 3,081 billion CAD.

Regarding the geography the division at the upstream and downstream clusters is also made, with Ontario and Quebec being once again the main locations. The first one has 5.639 establishments and the second one has 3.271 establishments, in 2019.

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Figure 7: Metal Manufacturing geographic distribution in Canada | 2019

Source : Canada Government

There are three organizations to be highlighted in this market:

- Canadian Steel Producers Association, for steel producers
- AluQuebec
- Aluminum Association of Canada

Two important events will occur during 2021:

- Metalworking Manufacturing and Production Expo

18 Apr | Abbotsford, BC
18 May | Winnipeg, MB
16 Jun | Ottawa, ON

- The 60th Conference of Metallurgists

16 - 19 Aug | Digital Event

- 12th International Conference on Magnesium Alloys and their Applications

15 - 18 Jun | Montreal, QC

Two companies are the most relevant for this market in Canada, Price Industries Limited and American Iron and Metal Company

6.2.7. Plastics

The Plastics market is represented by the industry group 326 – Plastics and Rubber Products Manufacturing. having a GDP contribution of 10,865 billion CAD, in 2018.

Geographically speaking the plastics market is mostly located in Ontario, with 1326 establishment and a GDP with 5.536,8 billion CAD.

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Figure 8: Plastics geographic distribution in Canada | 2019

Source : Canada Government

One major association is the Canadian Plastics Industry Association, which represents companies in the business of plastic products manufacturing, machinery, moulds, and resins. This association become a division of the Chemistry Industry Association of Canada.

The main event for plastics manufacturing, the Advanced Design & Manufacturing Expo Toronto, will occur between 11 and 13 of May, 2021, in Toronto, Ontario, and was designed with special attention to packaging materials, plastics and molding.

For the plastics sector, CCL Industries and NOVA Chemicals can be highlighted.

6.2.8. Information Technologies and Electrical Equipment

Other two relevant markets for Photonics technology applications, which are not represented by subsectors that top the table of manufacturing subsectors, are Information Technologies (IT) and Electrical Equipment.

The IT market, which for simplification purposes will only have the manufacturing industries accounted, represented by the 334 – Computer and Electronics Products Manufacturing, had a production of 6,555 billion CAD in 2019 and the Electrical Equipment market, represented by the 335 – Electrical Equipment, Appliance and Component Manufacturing, had a production of 4,409 billion CAD, in 2019.

For this market, Ontario is the main region, with a GDP of 3.427,9 billion CAD and 2.400 establishments.

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Figure 9: IT & Electrical Equipment geographic distribution in Canada | 2019

Source : Canada Government

Two organizations were identified, TECHNATION for IT and Electro Federation Canada for Electrical Equipment.

The most representative companies in Canada, for this segments, are Wescam and Nedco.

6.3. Other Relevant Organizations and Events

There are a few other Organization and Events that are not only directed to specific markets but to the manufacturing sector as a whole. The Canadian Government, for instance, developed a project that intended to challenge the Small and Medium Enterprises to cooperate between them by generating 5 different super clusters, one of which, dedicated to Advanced Manufacturing. It aims to enhance the growth and competitiveness of participating firms and maximize economic benefits.

In specific, the Advanced Manufacturing Supercluster will build up next-generation manufacturing capabilities, incorporating technologies like advanced robotics and 3D printing (Government of Canada, 2018).

Listed below are some organizations dedicated to manufacturing sector, including the Advanced Manufacturing Supercluster:

- Canadian Manufacturers & Exporters
- Canadian Manufacturing Coalition
- Next Generation Manufacturing Canada (supercluster)

Also, some Events can be identified as generic for the manufacturing sector:

- Salon Industriel de L'Abitibi – Témiscamingue
  1 – 2 Jun 2021 | Rouyn-Noranda, QC
- Salon Industriel de Laval
  18 – 19 Aug 2021 | Laval, QC
- Western Manufacturing Technology Show

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1-3 Jun 2021 | Edmonton, AB

- Canadian Manufacturing Technology Show

  4-7 Oct 2021 | Toronto, ON

Canada has Photonics specific organizations too, such as:

- Photons Canada
- Optonique (Quebec Cluster)
- Ecotech Quebec

And also a Photonics specific event:

- Photonics North Conference

31 May – 2 Jun 2021 | Online Event

6.4. Free Trade and Barriers

Canada is an open economy that plays an important role in the international commerce, benefiting from many free trade deals and agreements with different countries and regions. Among them, with relevance for this desk research, it is taken into account the North American Free Trade Agreement (NAFTA), settled in 1994, and active since then, with USA and Mexico. And the Comprehensive Economic and Trade Agreement (CETA), 2017, with the EU.

As seen before, Canada's biggest trading partner is the USA. Through NAFTA, countries have a very strict relationship which, according to the signed agreement, aims, mainly, to eliminate barriers to trade in, and facilitate the cross-border movement of goods and services between the territories of the parties, promote conditions of fair competition in the free trade area and increase substantially investment opportunities in the territories of the parties. The agreement not only increased the internal competition and the volume of trading goods and services within the region, but also made more difficult to non-American countries to export to Canada.

More recently, the US government proposed a renegotiation of NAFTA which, according to the Office of the United States Trade Representative, highlights topics such as: the creation of a more level playing field for American workers, including improved rules of origin for automobiles, trucks, other products, and disciplines on currency manipulation and supporting a 21st Century economy through new protections for U.S. intellectual property, and ensuring opportunities for trade in U.S. services.

The replacing agreement is called United States-Canada-Mexico Agreement (USMCA). which entered in to force on July 1, 2020, replacing the North American Free Trade Agreement (NAFTA). Qualifying goods and services which had zero tariffs under NAFTA will remain at zero under USMCA. USMCA is a 21st century, high-standard trade agreement, supporting mutually beneficial trade resulting in freer markets, fairer trade, and robust economic growth in North America. The Agreement modernizes and rebalances U.S. trade relations with Mexico and Canada, and it reduces incentives to outsource by providing strong labour and environmental protections, innovative rules of origin, and revised investment provisions.

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In 2017, Canada and EU, signed the CETA agreement, that removed 98,2% of all customs duties on the immediate, and it is predicted to be 100% in seven years from now (aicep Portugal Global, 2018). Most of the products imported that still get customs duties are from food and textile sectors. According to an European Commission (2018) press release, *"(…) CETA has given a boost to the business climate between the EU and Canada, offering valuable legal certainty for EU companies looking to export. Although it is too early to draw any firm conclusions, the initial trade results are pointing in the right direction. Across the EU, the latest statistics available, covering the October 2017 to June 2018 period, suggest that exports are up by over 7% year on year. Of these, certain sectors are doing especially well. Machinery and mechanical appliances, which make up one fifth of EU exports to Canada, are up by over 8%."*

6.6. Conclusions

Regarding the previous analysis, it is possible to highlight some subsectors and industry groups from the North American Industry classification system, with interest in the fields of photonics, advanced manufacturing, metalworking and aerospace industry.

Firstly, one major economical region, in terms of GDP, for the country's economy is the region of Ontario, by being a region that always has a relevant share of the total employment and usually a location quotient higher than 1. Quebec is also a region with a pertinent share of the GDP.

From the markets studied, the first one to highlight is the Food Processing, with the highest GDP values and it is settled mostly in Ontario and Quebec. Other Markets, that are not as big as the Food Processing, but with good growing trends are the Chemical Manufacturing and Plastics, also mostly located in Ontario and Quebec.

These industrial sectors represent opportunities for solutions in the fields of photonics, advanced manufacturing, metalworking and aerospace industry. that PIMAP+ partnership aims to deliver, under the motto « Photonics for Advanced Manufacturing ». The identification of regions, sectoral events and stakeholders represent a first instrumental basis for the deployment of prospective missions, international promotion actions and future deployment of partnerships and internationalization support services for the clusters' stakeholders benefit.

Due to a generic growing trend of these top Manufacturing Markets, and to the broad application of Photonics, it is advised to take more into account some of the wider manufacturing events to participate. Also the existence of the Next Generation Manufacturing Canada, the super cluster specially dedicated to advance manufacturing, of Photons Canada, a key organization representing Optics and Photonics applications, and OPTONIC cluster serve as a very good starting point for contacting the Canadian Market.

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7. Country Report: United States of America

7.1. General Overview

The USA is the biggest economy in the world. It is also one of the top traders in the international markets, establishing a close relationship with the other North American countries, USA and Mexico, due to their geographic proximity and trade deals, and with China, especially in the imports perspective.

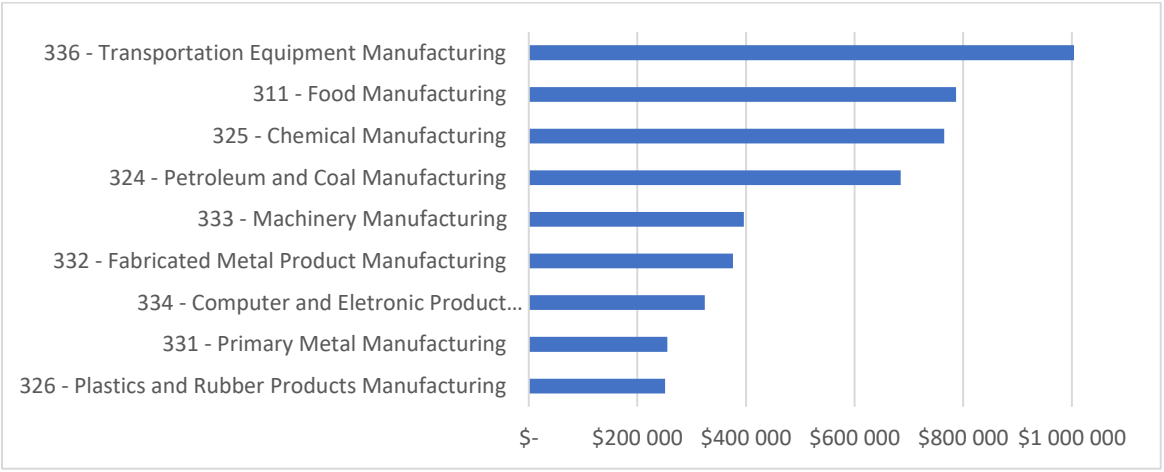
With a population of 328,2 million, in 2019, the country presented a Gross Domestic Product (GDP) of 20,54 trillion USD, and shows a 2,9% real growth rate. Also, for the same period of time, the country had a 2,26% growth in Gross Fixed Capital Formation (U.S. Census Bureau).

In terms of International trade, in 2019, the USA imported a volume of 3,1 trillion USD and exported 2,5 trillion USD, having a big deficit in trade balance of 617 billion USD. The main suppliers of USA are: Canada (21,4%) followed by Mexico (14,8%) and China (8,2%), due to the reasons mentioned above.

The most relevant manufacturing subsectors (enlisted below) were identified, not through GDP, as in Canada, but through the total value of shipments and receipts for service, in 2018.

- 311 – Food Manufacturing (787 billion USD)
- 324 – Petroleum and Coal Products Manufacturing (684,9 billion USD)
- 325 – Chemical Manufacturing (765,1 billion USD)
- 326 – Plastics and Rubber Product Manufacturing (251,1 billion USD)
- 331 – Primary Metal Manufacturing (255,1 billion USD)
- 332 – Fabricated Metal Product Manufacturing (375,9 billion USD)
- 333 – Machinery Manufacturing (395,9 billion USD)
- 334 – Computer and Electronic Product Manufacturing (324,3 billion USD)
- 336 – Transportation Equipment Manufacturing (1 trillion USD)

Figure 10: Main Manufacturing Subsectors in USA by Shipments and receipts for services (x1000000 USD) | 2018



Source: U.S. Census Bureau

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The figure above shows the volume of shipments and receipts for services per subsector, in 2018. The graph allows us to understand the relevance of the subsectors for the American economy, being the subsector of transport equipment the most relevant, with a volume of sales higher than 1 trillion USD, followed by two other subsectors, with a very high volume of sales too, the food manufacturing and the chemical manufacturing subsectors.

7.2 Relevant Markets

The further analysis will be made by the same approach as the one for Canada, regarding the location, which according to President and Fellows of Harvard College (2018), USA also divides activities into clusters, the same 51 as Canada. The analysis of each American market or clusters with relevance to Photonics applications will go through number of employees.

7.2.1. Automotive

Since the main manufacturing subsector in the USA is the 336 – Transport Equipment Manufacturing and by the same logic as the one presented for Canada, it is convenient to start by the Automotive Market, by excluding the one industry group that represents the Aerospace market, 3364 – Aerospace Products and Parts Manufacturing. The Automotive market had sales (value of shipment and receipts received) in the amount of 744,741 billion USD, in 2018.

Concerning the industrial location, the most relevant states are: Michigan, Ohio and Indiana. Michigan has 180.091 employees, Indiana has 149.373 and Ohio has 119.036 employees.

Figure 11: Automotive geographic distribution in the USA | 2018

Source: USA Census Boreau

In terms of Organizations and Clusters, one to be highlighted is the Motor & Equipment Manufacturers Association, which represents motor vehicle and mobility suppliers and parts manufacturers.

Some events were identified for this market in 2021:

- American Automotive Summit

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Date and location to be announced

- Automation Technology Expo West
  11- 12 Aug 2021 | Anaheim, CA
- Automotive Parts Suppliers Conference
  28-29 Apr 2021 | Detroit, MI

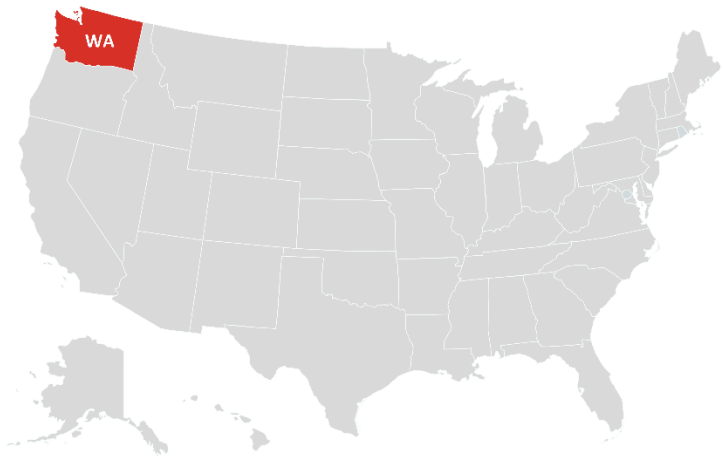
For this sector, USA has 13.546 establishments, and the most representative companies are General Motors and Ford Motors.

7.2.2. Aerospace

The industry group 3664 – Aerospace Products and Parts Manufacturing had a sales volume, in 2018, of 262,942 billion USD, representing around a quarter of the total sales of Transports Equipment Manufacturing subsector.

Geographically speaking, Washington is the most relevant state for this market, having 68.606 employees.

Figure 12: Aerospace geographic distribution in the USA | 2018



Source: USA Census Boreau

The main organization is the Aerospace Industries Association, which, as referred by the organization, embodies every high-technology manufacturing segment of the U.S. aerospace and defense industry including commercial aviation and avionics, manned and unmanned defense systems, and space technologies and satellite communications.

There are two main events in the USA for 2021:

- Aerospace Raw Materials & Manufacturers Supply Chain Conference
  07 Jun 2021 | Beverly Hills, CA
- AeroDef Manufacturing
  20 - 23 Sep 2021 | Long Beach, CA

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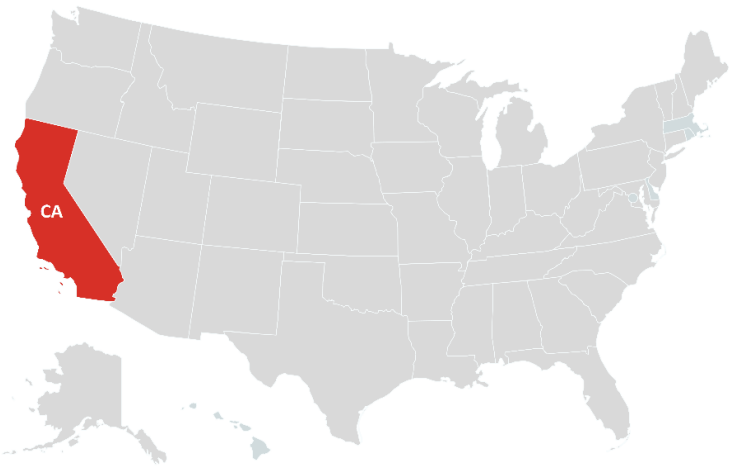
In the aerospace sector, USA has 1.764 establishments and the most important company is Boeing.

7.2.3. Food Processing & Manufacturing

The Food Processing & Manufacturing market is represented by the second largest manufacturing subsectors in 2018 (graph 4). The subsector 311 – Food Manufacturing, has a volume of sales 786,991 billion USD. The subsector is divided into several industry groups with well distributed weight among each other, except one that outstands, 3116 – Animal Slaughtering and Processing, in 2016, which had more than a quarter of the total volume of sales of the subsector, about 216,792 billion (USD)

For this market, California is the most important state, with 169.326 employees.

Figure 13: Food Processing & Manufacturing geographic distribution in the USA | 2018



Source: USA Census Boreau

In a matter of Organizations and Clusters, a main organization was identified, Food Processing Suppliers Association (FPSA), which is a trade association for suppliers to the food processing and packaging industry. And three Events were identified too:

- FPSA 2021 Annual Conference
  27-29 Apr 2021 | Indian Wells, California
- Food Automation & Manufacturing Conference & Expo
  12-15 Sep 2021 | Miami, FL
- Process Expo
  12-15 Oct 2021 | Chicago, IL

For this market, the country has 34.988 establishments, and the most relevant company is PepsiCo.

7.2.4. Chemical Manufacturing

The Chemical Manufacturing market, represented by 325 – Chemical Manufacturing subsector, accounted in 2018, sales of 765,145 billion USD. And similarly to Canada, the two main industry groups that compose the subsector are:

- 3251 – Basic Chemical Manufacturing – 228,449 billion USD

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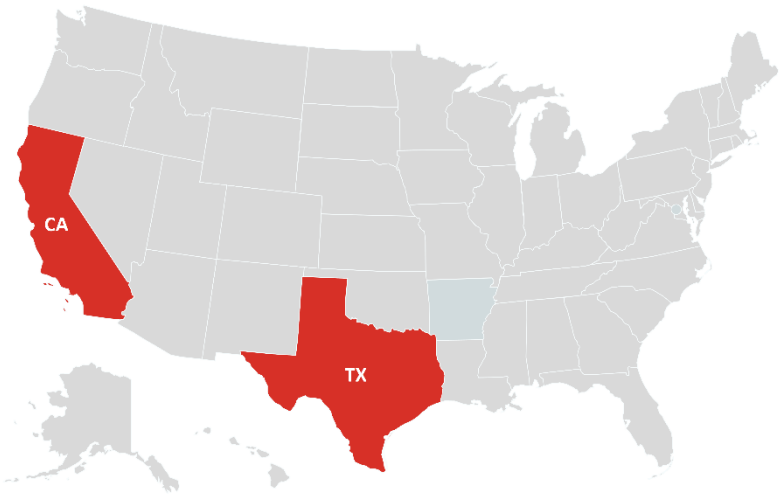
- 3254 – Pharmaceutical and Medicine Manufacturing – 215,109 billion USD.

California and Texas are the main state in this market with 79.459 and 74.157 employees, respectivelly.

Figure 14: Chemical Manufacturing geographic distribution in the USA | 2018



Source: USA Census Boreau

Two main organizations to highlight are the Society of Chemical Manufacturers and Affiliates and the American Chemistry Council, the first solely dedicated to the specialty and fine chemical industry and the second represents a diverse set of companies engaged in the business of chemistry.

One event can be interesting for the 2021, the Specialty & Custom Chemicals America, from 14 to 16 April, in Fort Worth, TX.

For this segment 19.725 establishments were counted, with special relevance for Dow and Lyondellbasell.

7.2.5. Production Technologies & Heavy Machinery

Represented by the subsector 333, Machinery Manufacturing, had sales, in 2018, 395,951 billion USD. One main industry group to highlight from this subsector is the 3331 – Agricultural, Construction and Mining Machinery Manufacturing – 91,505 billion USD in sales, in 2018.

The market gets divided between Metalworking Technology and Production Technology. For metalworking, the two main states are Michigan and Ohio, with 74.681 employees. Regarding production technologies cluster, the distribution goes very wide, with Ohio, Wisconsin and Michigan. For both California, Texas and Illinois are very importants states.

Texas, Ohio and Michigan are the most important states in this sector. In 2018, Texas had 78.328 employees, Ohio had 75.407 and Michigan had 74.681 employees.

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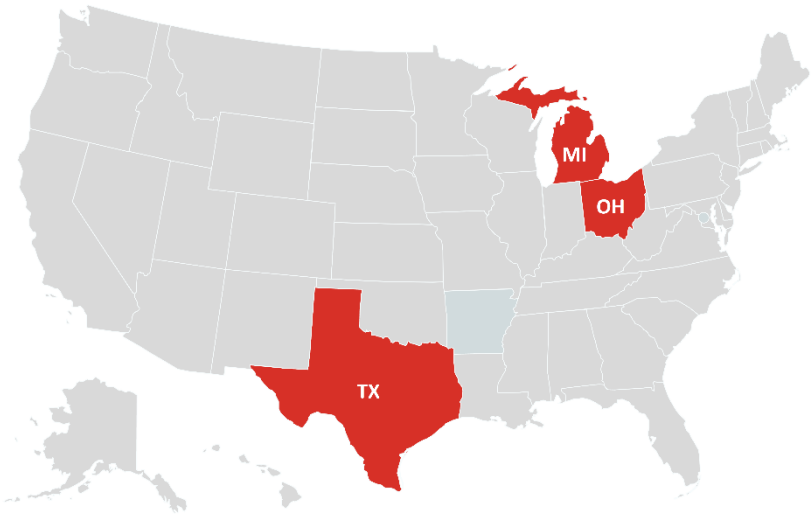
Figure 15: Production Technologies & Heavy Machinery geographic distribution in the USA | 2018



Source: USA Census Boreau

A few organizations acting on this market are listed:

- Fabricators & Manufacturers Association, International
- Precision Metalforming Association
- The Association for Manufacturing Technology

And a few events too:

- Houstex

  New dates soon | Houston, TX
- Precision Machining Technology Show

  10-12 Aug 2021 | Cleveland, OH
- Robotics Summit and Expo

  4-5 Oct 2021 | Boston, MA
- Advanced Manufacturing Expo & Conference

  10-11 Aug 2021 | Anaheim, CA
- FABTECH

  13-16 Sep 2121 | Chicago, IL

The USA has 31.137 establishments in this market and a exemplary company is Caterpillar.

7.2.6. Metal Manufacturing

This market will aggregate two subsectors 331 – Primary Metal Manufacturing and 332 – Fabricated Metal Products Manufacturing. For the first one, the volume of sales in 2018 was 255,087 billion USD, and the second one was 375,880 billion USD. Its most relevant industry group is the 3323 – Architectural and Structural Metals Manufacturing with sales of 98,151 billion USD, in 2018.

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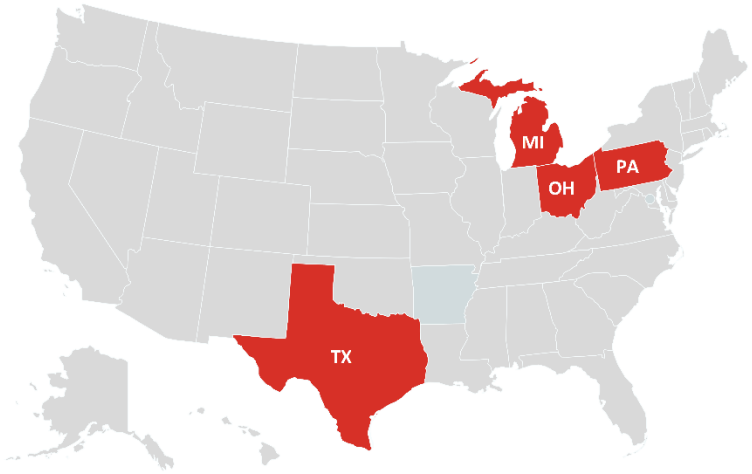
Regarding the geography, the division at the upstream and downstream clusters is also made for the metal manufacturing market. California is the most important state with 169.326 employees and Texas is the second one with 98.500 employees.

Figure 16: Metal Manufacturing geographic distribution in the USA | 2018



Source: USA Census Boreau

One organization to follow is American Iron and Steel Institute, that represents other metal manufacturing Associations (list). And few events can also be found:

- Aluminum USA
  1-2 Sep 2021 | Louisville, KY
- AISTech Conference & Exposition
  29 Jun – 1 Jul 2021 | Nashville, TN

In this market, the USA has 64.147 establishments and one of the key companies operating is Nucor.

7.2.7. Information Technologies and Electrical Equipment

In the USA, the Computer and Electronic Product Manufacturing subsector, representing the IT market, settles in one of the top positions of the manufacturing sector. It has a total volume of sales of 324,264 billion USD, in 2018. In terms of most relevant industry groups, two of them represent almost the totality of the subsector in 2018. First the 3344 – Semiconductor and Other Electronic Component Manufacturing with 99,952 billion USD in sales and 3345 – Navigational, Measuring, Electromedical, and Control Instruments Manufacturing with 163.014 billion USD in sales.

Since in the Canadian analysis, electrical equipment market, through the subsector of Electrical Equipment, Appliance and Component Manufacturing, was grouped with IT market due to their high correlation among each other and with Photonics and Microwaves, for the USA the same aggregation must be done. Therefore, the subsector 335 – Electrical Equipment, Appliance and Component Manufacturing had, in 2018, 132,678 billion USD of sales.

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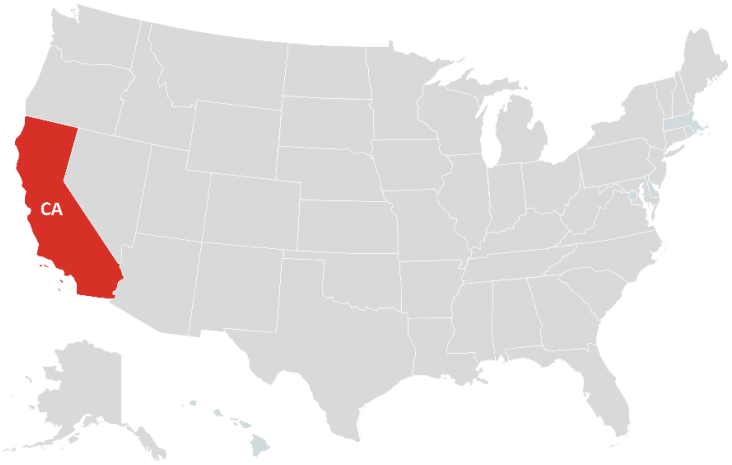
For both markets, California is the most important state. In the IT market, a very big amount of people are employed there (compared to total), about 292.579 workers.

Figure 17: IT & Electrical Equipment geographic distribution in the USA | 2018



Source: USA Census Boreau

In terms of Organizations, some can be highlighted:

- IPC
- Electronic Components Industry Association
- Consumer Technology Association

And a few events are also happening in 2021:

- IPC APEX EXPO
  08-12 Mar 2021 | Digital Event
- Advanced Semiconductor Manufacturing Conference
  10-12 May 2021 | Digital Event
- EDS Summit
  30 Aug – 2 Sep 2021 | Las Vegas, NV
- Technology and Standards Spring Forum
  03-06 May 2021 | Digital Event

29.434 establishments were counted in this USA market, with emphasis in Apple and Microsoft.

7.2.8. Plastics

Lastly, the Plastics market, represented by the last subsector from the ones mentioned as the most relevant, 326 – Plastics and Rubber Products Manufacturing. The subsector, despite of being the one with lowest sales in the group, 251,099 Billion USD, in 2018.

From the states that employ most workers, is important to highlight Ohio and Michigan. The first one had 69.301 employees and Michigan had 53.843 employees, in 2018.

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Figure 18: Plastics geographic distribution in the USA | 2018

Source : USA Census Boreau

Two major associations are the Plastics Industry Association and the Manufacturers Association for Plastic Processors, both focused on packaging materials, plastic and molding.

And one important event that has one edition in the west of USA and other in the East of USA:

- Plastec West
  10-12 Aug 2021 | Anaheim, CA
- Plastec East
  15-17 Jun 2021 | New York, NY
- NPE 2021 – The Plastic Show
  17-21 May 2021 | Orlando, FL

For this sector, the USA has 13.309, and Exxonmobil and Chevron are the most important companies in this segment.

7.3. Other relevant Organizations and Events

There are a few other Organization and Events that are not only directed to specific markets but to the manufacturing sector as a whole as the ones enlisted below:

- National Association of Manufacturers
- Association for Manufacturing Excellence

Also, some Events can be identified as generic for the manufacturing sector:

- Industry of Things World USA
  12-13 Jul 2021 | San Diego, CA
- American Manufacturing Summit
  2021 dates to be announced
- The Manufacturing & Technology Show
  09-11 Nov 2021 | Cleveland, OH

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- SAMA Trade Show
  12 May 2021 | San Antonio, TX
- Pack Expo
  27-29 Set 2021 | Las Vegas, NV

And also two Photonics specifics event :

- SPIE Photonics West, the biggest in North America
  06-11 Mar, 2021| San Francisco, California
- SPIE Optics+ Photonics
  01-05 Aug 2021 | San Diego, California

USA has Photonics specific organizations and clusters too, such as:

- The National Center for Optics and Photonics Education
- Arizona Technology Council
- New York Photonics
- Florida Photonics Cluster
- Arkansas Photonics Industry Alliance
- Colorado Photonics Industry Association
- Michigan Photonics Cluster
- Montana Photonics Industry Alliance
- New Mexico Optics Industry Association

7.4. Free Trade and Barriers

The United States has innumerous trade deals established across the world. One of the most important deals is NAFTA, which is established with its biggest trading partners, with exception to China, although some changes, proposed by USA are being submitted at the moment, as explained previously.

But despite of USA being a very open market and having trading deals with many different countries, under the Trump administration the US Government is defining some protectionist policies that aim to improve the domestic production and consequently increase the number of jobs. This type of policies becomes a challenge for companies which try to enter in the American Market as suppliers. For the United States, the main goal of trade agreements is to reduce barriers to U.S. exports, protect U.S. interests competing abroad, and enhance the rule of law in the FTA partner country or countries. The reduction of trade barriers and the creation of a more stable and transparent trading and investment environment make it easier and cheaper for U.S. companies to export their products and services to trading partner markets. Hopefully, Biden administration will follow a different approach, and reinforce links with commercial partners, and notably Europe.

Europe is no exception to these policies, and the companies can get affected by a raise in the price of their products when reaching the US market. Starting on 1st of June, 2018, the USA impose additional duties of 25% and 10% respectively on imports of steel and aluminum from the EU and other countries (European Commission, 2018a). These duties can have a particular impact in some of the markets analysed before.

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The White House (2018) stated that current quantities and circumstances of steel and aluminum imports into the United States threaten to impair national security. These excessive imports are driven in large part by the worldwide glut from overproduction by other countries.

In 2018, at the direction of the President, U.S. Trade Representative Robert Lighthizer notified Congress that the Administration intended to initiate negotiations on a trade agreement with the European Union (EU). The U.S. trade and investment relationship with the EU is the largest and most complex economic relationship in the world. Transatlantic trade flows (goods and services trade plus earnings and payments on investment) averaged an estimated $6.1 billion each day of 2019, in trade based on the first three quarters of 2019. The total stock of transatlantic investment was $5.9 trillion in 2018 (latest data available). Still in 2018, President Trump and European Commission President Juncker announced the formation of an Executive Working Group to work on a new and wide-ranging approach to eliminate tariff and nontariff barriers and increase trade.

Biden administration heralds an opportunity for Europe, and particularly for the European Union to revive its relationship with the US. After very strained EU-US relations over the past four years, the election of Biden and his early statements have produced a positive effect and expectations at Europe's side. This can foster opportunities also for PIMAP+ partnership.

7.5. Conclusions

The previous analysis comprehends which subsectors and industry groups, from NAICS, with interest to photonics, advanced manufacturing, metalworking and aerospace industry., present some attractive results in terms of sales and their growing trend. The trends in the USA are not as positive as in Canada, the Automotive and Aerospace Market show a great behaviour between 2012 and 2016, also Plastics, at slower, but positive pace. However, the other markets are following decreasing sales trends. Nevertheless, the US market has a much bigger volume than the Canadian, and this could mean more business opportunities.

In terms of location, three main regions can be considered. First, the northeast of the country (Illinois, Michigan, Indiana, Ohio, Pennsylvania and a few other states) is already an area known historically for being manufacturing intensive. Then in the South and Southwest two other states, that in many cases are becoming more manufacturing intensive, the state of California and the state of Texas.

These industrial sectors represent opportunities for the solutions that PIMAP+ partnership aims to deliver. The identification of regions, sectoral events and stakeholders represent a first instrumental basis for the deployment of prospective missions, international promotion actions and future deployment of partnerships and internationalization support services for the clusters' stakeholders benefit.

The USA also presents a bigger amount and more diverse number of organizations and clusters than Canada, and is the home of some of the biggest manufacturing and, more specifically, Photonics events and fairs, e.g. Photonics West.

Finally, in terms of policies for trade, it is becoming more difficult for companies to enter in the American market. However, USA is a country with a tradition of liberal markets and is a member of the WTO. And

it is very prone to be competitive through technological progress, allowing the companies from other countries, especially Europe, to come with new advanced manufacturing solutions.

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8. Bibliographic References

AIAC. (2019). *State of Canada's Aerospace Industry.*

aicep Portugal Global. (2018). *Canadá - Ficha de Mercado.*

Anderson, S. (2014). *SPIE - The international society for optics and photonics.*

Anderson, S. G. (2020). *SPIE Industry Update: Trends and Outlook.*

Deloitte. (2020). 2020 global aerospace and defense industry outlook. Acquired on the 12th of October, 2020, from https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx-global-outlook-ad-2020.pdf

European Commission. (2008). *NACE Rev.2 Statistical classification of economic activities in the European Community.* Luxembourg: Office for Official Publications of the European Communities.

European Commission. (2009a). *Preparing for our future: Developing a comm on strategy for key enabling technologies in the EU ({SEC(2009) 1257}).*

European Commission. (2009b). *Preparing for our future: Developing a comm on strategy for key enabling technologies in the EU - Current situation of key enabling technologies in Europe ({COM (2009) 512}).*

European Commission. (2016). *Key Enabling Technologies.* Acquired on the 28th of October, 2020, from https://ec.europa.eu/growth/policy/key-enabling-technologies_en

European Commission. (2019a). *Preparing for our future: Developing a comm on strategy for key enabling technologies in the EU ({SEC(2009) 1257}).*

Government of Canada. (no data). Acquired on the 5th of December, 2020, from Canada's new superclusters: https://www.ic.gc.ca/eic/site/093.nsf/eng/00008.html

Government of Canada. (no data). Acquired on the 10th of December, 2020, from https://www.statcan.gc.ca/eng/start

Optech Consulting . (2017). *Market Research Study Photonics 2017 (Market Research).* Düsseldorf, Tägerwillen: European Technoogy Platform.

President and Fellows of Harvard College. (2018). Clusters | U-S Cluster Mapping. Acquired on the 20th of October, 2020, from http://www.clustermapping.us/cluster

SPIE - The International Society for optics and photonics. (2020). *2020 Optics and Photonics Industry Report.*

U.S Census Bureau. (s.d.). U.S. Census Bureau Economic Indicatores. Acquired on the 9th of December, 2020, from https://www.census.gov/

U.S. Census Bureau. (2018). Annual Survey of Manufactures: Summary Statistics for Industry Groups and Industries in the U.S.: 2018. Acquired on the 27th of November, 2020, from https://data.census.gov/cedsci/table?q=am1831&n=N0000.00&tid=ASMAREA2017.AM1831BASIC01&hidePreview=false

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United Nations. (2008). International Standard industrial classification of all economic activities (ISIC) (Rev.4). New York.

US Census Bureau. (2017). *North American Industry Classification System.* United States: Claitor's Publishing Division.

White House. (2018). What You Need to Know About Implementing Steel and Aluminum Tariffs on Canada, Mexico, and the European Union. Acquired on the 15th November, 2020, from https://www.whitehouse.gov/articles/need-know-implementing-steel-aluminum-tariffs-canada-mexico-european-union/

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9. Attachments

Attachment 1: NAICS 2017 correspondence to ISIC rev. 4

2017 NAICS US	2017 NAICS US TITLE	ISIC 4.0	ISIC Revision 4.0 Title
331511	Iron Foundries	2823	Manufacture of machinery for metallurgy
332216	Saw Blade and Handtool Manufacturing	2816	Manufacture of lifting and handling equipment
332216	Saw Blade and Handtool Manufacturing	2819	Manufacture of other general-purpose machinery
332216	Saw Blade and Handtool Manufacturing	2821	Manufacture of agricultural and forestry machinery
332313	Plate Work Manufacturing	2816	Manufacture of lifting and handling equipment
332313	Plate Work Manufacturing	2823	Manufacture of machinery for metallurgy
332410	Power Boiler and Heat Exchanger Manufacturing	2819	Manufacture of other general-purpose machinery
332420	Metal Tank (Heavy Gauge) Manufacturing	2819	Manufacture of other general-purpose machinery
332420	Metal Tank (Heavy Gauge) Manufacturing	2823	Manufacture of machinery for metallurgy
332911	Industrial Valve Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
332912	Fluid Power Valve and Hose Fitting Manufacturing	2812	Manufacture of fluid power equipment
332913	Plumbing Fixture Fitting and Trim Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
332919	Other Metal Valve and Pipe Fitting Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
332919	Other Metal Valve and Pipe Fitting Manufacturing	2819	Manufacture of other general-purpose machinery
332991	Ball and Roller Bearing Manufacturing	2814	Manufacture of bearings, gears, gearing and driving elements
333111	Farm Machinery and Equipment Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
333111	Farm Machinery and Equipment Manufacturing	2818	Manufacture of power-driven hand tools
333111	Farm Machinery and Equipment Manufacturing	2821	Manufacture of agricultural and forestry machinery
333111	Farm Machinery and Equipment Manufacturing	2825	Manufacture of machinery for food, beverage and tobacco processing
333111	Farm Machinery and Equipment Manufacturing	2826	Manufacture of machinery for textile, apparel and leather production
333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing	2818	Manufacture of power-driven hand tools
333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing	2821	Manufacture of agricultural and forestry machinery
333120	Construction Machinery Manufacturing	2816	Manufacture of lifting and handling equipment
333120	Construction Machinery Manufacturing	2818	Manufacture of power-driven hand tools
333120	Construction Machinery Manufacturing	2819	Manufacture of other general-purpose machinery
333120	Construction Machinery Manufacturing	2821	Manufacture of agricultural and forestry machinery
333120	Construction Machinery Manufacturing	2824	Manufacture of machinery for mining, quarrying and construction
333131	Mining Machinery and Equipment Manufacturing	2816	Manufacture of lifting and handling equipment
333131	Mining Machinery and Equipment Manufacturing	2818	Manufacture of power-driven hand tools
333131	Mining Machinery and Equipment Manufacturing	2824	Manufacture of machinery for mining, quarrying and construction
333132	Oil and Gas Field Machinery and Equipment Manufacturing	2824	Manufacture of machinery for mining, quarrying and construction
333241	Food Product Machinery Manufacturing	2819	Manufacture of other general-purpose machinery
333241	Food Product Machinery Manufacturing	2825	Manufacture of machinery for food, beverage and tobacco processing
333242	Semiconductor Machinery Manufacturing	2829	Manufacture of other special-purpose machinery
333243	Sawmill, Woodworking, and Paper Machinery Manufacturing	2821	Manufacture of agricultural and forestry machinery
333243	Sawmill, Woodworking, and Paper Machinery Manufacturing	2822	Manufacture of metal-forming machinery and machine tools
333243	Sawmill, Woodworking, and Paper Machinery Manufacturing	2829	Manufacture of other special-purpose machinery
333244	Printing Machinery and Equipment Manufacturing	2829	Manufacture of other special-purpose machinery
333249	Other Industrial Machinery Manufacturing	2815	Manufacture of ovens, furnaces and furnace burners
333249	Other Industrial Machinery Manufacturing	2819	Manufacture of other general-purpose machinery
333249	Other Industrial Machinery Manufacturing	2822	Manufacture of metal-forming machinery and machine tools
333249	Other Industrial Machinery Manufacturing	2823	Manufacture of machinery for metallurgy
333249	Other Industrial Machinery Manufacturing	2825	Manufacture of machinery for food, beverage and tobacco processing

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333249	Other Industrial Machinery Manufacturing	2826	Manufacture of machinery for textile, apparel and leather production
333249	Other Industrial Machinery Manufacturing	2829	Manufacture of other special-purpose machinery
333316	Photographic and Photocopying Equipment Manufacturing	2817	Manufacture of office machinery and equipment (except computers and peripheral equipment)
333318	Other Commercial and Service Industry Machinery Manufacturing	2817	Manufacture of office machinery and equipment (except computers and peripheral equipment)
333318	Other Commercial and Service Industry Machinery Manufacturing	2819	Manufacture of other general-purpose machinery
333318	Other Commercial and Service Industry Machinery Manufacturing	2822	Manufacture of metal-forming machinery and machine tools
333318	Other Commercial and Service Industry Machinery Manufacturing	2825	Manufacture of machinery for food, beverage and tobacco processing
333318	Other Commercial and Service Industry Machinery Manufacturing	2826	Manufacture of machinery for textile, apparel and leather production
333318	Other Commercial and Service Industry Machinery Manufacturing	2829	Manufacture of other special-purpose machinery
333413	Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing	2819	Manufacture of other general-purpose machinery
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	2815	Manufacture of ovens, furnaces and furnace burners
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	2815	Manufacture of ovens, furnaces and furnace burners
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	2819	Manufacture of other general-purpose machinery
333514	Special Die and Tool, Die Set, Jig, and Fixture Manufacturing	2822	Manufacture of metal-forming machinery and machine tools
333515	Cutting Tool and Machine Tool Accessory Manufacturing	2822	Manufacture of metal-forming machinery and machine tools
333517	Machine Tool Manufacturing	2822	Manufacture of metal-forming machinery and machine tools
333517	Machine Tool Manufacturing	2823	Manufacture of machinery for metallurgy
333519	Rolling Mill and Other Metalworking Machinery Manufacturing	2822	Manufacture of metal-forming machinery and machine tools
333519	Rolling Mill and Other Metalworking Machinery Manufacturing	2823	Manufacture of machinery for metallurgy
333611	Turbine and Turbine Generator Set Units Manufacturing	2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
333612	Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing	2814	Manufacture of bearings, gears, gearing and driving elements
333613	Mechanical Power Transmission Equipment Manufacturing	2814	Manufacture of bearings, gears, gearing and driving elements
333618	Other Engine Equipment Manufacturing	2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
333912	Air and Gas Compressor Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
333912	Air and Gas Compressor Manufacturing	2819	Manufacture of other general-purpose machinery
333914	Measuring, Dispensing, and Other Pumping Equipment Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
333921	Elevator and Moving Stairway Manufacturing	2816	Manufacture of lifting and handling equipment
333922	Conveyor and Conveying Equipment Manufacturing	2816	Manufacture of lifting and handling equipment
333922	Conveyor and Conveying Equipment Manufacturing	2824	Manufacture of machinery for mining, quarrying and construction
333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	2816	Manufacture of lifting and handling equipment
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	2816	Manufacture of lifting and handling equipment
333991	Power-Driven Handtool Manufacturing	2818	Manufacture of power-driven hand tools
333991	Power-Driven Handtool Manufacturing	2819	Manufacture of other general-purpose machinery
333992	Welding and Soldering Equipment Manufacturing	2819	Manufacture of other general-purpose machinery
333993	Packaging Machinery Manufacturing	2819	Manufacture of other general-purpose machinery
333994	Industrial Process Furnace and Oven Manufacturing	2815	Manufacture of ovens, furnaces and furnace burners
333995	Fluid Power Cylinder and Actuator Manufacturing	2812	Manufacture of fluid power equipment
333996	Fluid Power Pump and Motor Manufacturing	2812	Manufacture of fluid power equipment
333997	Scale and Balance Manufacturing	2819	Manufacture of other general-purpose machinery
333999	All Other Miscellaneous General Purpose Machinery Manufacturing	2815	Manufacture of ovens, furnaces and furnace burners

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333999	All Other Miscellaneous General Purpose Machinery Manufacturing	2816	Manufacture of lifting and handling equipment
333999	All Other Miscellaneous General Purpose Machinery Manufacturing	2819	Manufacture of other general-purpose machinery
333999	All Other Miscellaneous General Purpose Machinery Manufacturing	2829	Manufacture of other special-purpose machinery
336211	Motor Vehicle Body Manufacturing	2816	Manufacture of lifting and handling equipment
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
336330	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
336340	Motor Vehicle Brake System Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
336390	Other Motor Vehicle Parts Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
336390	Other Motor Vehicle Parts Manufacturing	2819	Manufacture of other general-purpose machinery
336412	Aircraft Engine and Engine Parts Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
339113	Surgical Appliance and Supplies Manufacturing	2813	Manufacture of other pumps, compressors, taps and valves
339920	Sporting and Athletic Goods Manufacturing	2829	Manufacture of other special-purpose machinery
339940	Office Supplies (except Paper) Manufacturing	2817	Manufacture of office machinery and equipment (except computers and peripheral equipment)
339940	Office Supplies (except Paper) Manufacturing	2819	Manufacture of other general-purpose machinery
339991	Gasket, Packing, and Sealing Device Manufacturing	2819	Manufacture of other general-purpose machinery
339993	Fastener, Button, Needle, and Pin Manufacturing	2826	Manufacture of machinery for textile, apparel and leather production
339999	All Other Miscellaneous Manufacturing	2819	Manufacture of other general-purpose machinery

Attachment 2: Photonics Industries (NAICS)

Relevant Photonics Codes (NAICS)	Name
327212	Other Pressed and Blown Glass and Glassware Manufacturing
333249	Other Industrial Machinery Manufacturing
333314	Optical Instruments and Lens Manufactures
333316	Photographic and Photocopying Equipment Manufacturing
333517	Machine Tool Manufacturing
33421	Telephone Apparatus Manufacturing
334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables
334516	Analytical laboratory instrument manufacturing
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing
42349	Other Professional Equipment and Supplies Merchant Wholesalers
42361	Electrical Apparatus and Equipment, Wiring Supplies, and Related Equipment Merchant Wholesalers
42369	Other Electronic Parts and Equipment Merchant Wholesalers
42383	Industrial Machinery and Equipment Merchant Wholesalers
54133	Engineering Services
541511	Custom Computer Programming Services
54171	Research and Development in the Physical, Engineering, and Life Sciences
551112	Offices of Other Holding Companies

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