

Fundación IDEA

Study on the Need for Human Capital in the Mexican Aerospace Industry

This report was prepared by Giulia Salieri and Lucrecia Santibañez with the assistance of Aurea Fuentes of Fundación IDEA.

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1. Executive Summary

This report explores the need for human capital in the Mexican aerospace industry in order to evidence possible bottlenecks that hinder the industry's development as well as providing intervention plan to streamline the industry. The analysis focuses on assessing the profiles and necessary skills to perform technical activities such as the designs, manufacturing and repairs. Administrative or corporate profiles were not taken into consideration.

The study was commissioned by the Ministry of the Economy with the financial and technical assistance from USAID.

In preparing the report, industry experts such as executives, university professors and officers were interviewed. Additionally, the relevant national and international publications were gathered and reviewed as well as press releases.

The study revealed the following problems in the supply of human resources for the sector:

1. **Despite having a good level of technical skills, Mexican engineers perceive themselves as lacking management skills.**

Respondents specifically criticized the lack of “soft” skills (i.e. interpersonal skills and teamwork), analysis and problem solving, understanding and taking into consideration the economic impact of their decisions and activities. Additionally, the graduates of engineering programs believe they do not have sufficient English language skills in general and for technical matters (except for ITESM and CETYS graduates).¹

2. **An urgent need to renew the universities' engineering lab equipment (aerospace and other specialties) in order to update these according to industry demands.**

Respondents specifically mentioned the need to endow universities with updated software first by substituting the use of the AutoCAD system with CATIA training. Some of the industry's executives were willing to help in purchasing the licenses.

3. **Concerns about the quality of the new aerospace engineering programs.**

Respondents emphasized the importance for engineers to have practical training and said they were concerned about whether the new programs had sufficient resources to create and maintain properly equipped labs and facilities. They also considered it opportune to execute agreements with the private sector to provide students with internships throughout their studies. Lastly, they mentioned the difficulty of finding properly trained professions, since the sector is relatively new in Mexico.

4. **Mexico has very few post-graduate programs, making it very difficult to train personnel in highly specialized fields.**

There are few post-graduate courses specific for the sector or that are relevant

¹ This comment basically refers to the schools where the respondents were recruited. Possibly, there are other schools in Mexico in addition to those mentioned herein whose graduates have a good command of the English language.

thereto. It would be appropriate to develop programs to address topics such as materials, power plant systems, structural analysis, design, mechanics and fluid calculation and MRO.

5. Technical training may be insufficient, specifically in northern Mexico.²

The only specialized programs that exist in northern Mexico (recently created) are CENALTEC and ITSON. Although the companies that were contacted in these regions currently did not seem to demand advanced levels of training before hiring, the lack of trained resources could hinder the transition to segments with more added value. Even so, respondents pointed out that there are few technicians trained in Computer Numerical Control.

In terms of the Querétaro region, companies stated that they were satisfied with the resources provided by UNAQ; although they expect growth and the continue adjustment to the industry's development.³

6. This industry does not have a system for occupation standards and skills, making it difficult to develop programs (especially vocational programs) that are relevant for the industry.

The only specialized programs that exist in northern Mexico (recently created) are CENALTEC and ITSON. Although the companies that were contacted in these regions currently did not seem to demand advanced level training before hiring, the lack of trained resources could hinder the transition to segments with more added value. Even so, respondents pointed out that there are few technicians trained in Computer Numerical Control.

Many programs that currently exist are based on the specific requirements for each company. The identification and classification of the principle occupations and relevant skills for the industry shall facilitate the better understanding by the schools in terms of the industry's needs and shall result in the development of relevant training programs.

Additionally, some respondents stated that the skill certification, particularly those that are most required (i.e. using CNC and CATIA) could be very attractive for the companies.

7. Some respondents expected additional impetus to the activities of the DGAC, specifically in view of the need for inspectors qualified to implement the BASA Agreement.

The implementation of the BASA Agreement entails immediately training inspectors qualified to verify compliance with the design and manufacturing standards for the components. The training of the first inspectors is underway and no problems were encountered; nevertheless, the DGAC seems to have little credibility in the industry. Some respondents expressed concern and sponsored

² It is important to mention that only businessmen from Baja California and Queretaro were interviewed. Therefore, this conclusion might not adequately reflect the requirements of other parts of Mexico.

³ It is important to state that an educational project was recently established between the Governments of Mexico and France for the purpose of developing the Aeronautical Campus in collaboration with UNAQ. This campus is expected to train from 600-700 university-level technicians (equivalent to approximately 200 graduates per year).

interventions to strengthen the institution.

These conclusions were presented to the authorities as well as to the coordinators of the educational programs as a starting point to brainstorm about how to design actions and educational programs that efficiently provide support for the industry's development.

It is also important to mention that in Mexico other important efforts are being made to research and develop strategies for the aerospace industry, some focusing on human capital and training.

ProMéxico is currently heading a survey to gather specific data about the number of active workers in each company of the industry, classified by their educational background, as well as the expected hiring for the next three years; similarly, FEMIA is requesting information about the future needs for human capital from its associates. It is suggested to the agencies working on this project (specifically: the Ministry of the Economy, ProMéxico, FEMIA and COMEA) to develop a proper degree of coordination and collaboration between them and with the institutions that may take actions in light of their conclusions and results in order to maximize the success and avoid duplicating costs.

2. Purpose of the Report⁴

The purpose of this report is to explore the principle needs for human capital in the Mexican aerospace industry and to evidence possible bottlenecks that hinder the industry's development in Mexico.

The aforementioned task shall be carried out by comparing the human resource profiles and the skills that the industry experts perceive as necessary to develop the aerospace industry and its supply in Mexico. The specialists who were interviewed for the study included executives, professors and officers who are industry experts. The information obtained is supplemented with the data collected from the relevant national and international publications, press releases and other public sources.

Due to time and resources, the analysis focuses on exploring the profiles and necessary skills to perform technical activities such as the designs, manufacturing and repairs. The profiles and necessary skills for other tasks required by the sector, such as administrative or corporate, were not taken into consideration in this study.

⁴ This study was made possible thanks to the contribution of many people. The authors would like to thank Jesús Serrano, Sergio Solís and Francisco Castillo of the Ministry of the Economy; and Alain de Remes and Ramiro Nava from USAID for their vision and support during all the stages of this Project. We are in debt with Manuel Sandoval and José Mariano Moreno of Promexico, as well as with Salvador Echeverría and Gabriel Lugo of CENAM for their support in providing information and contacts with industry executives and experts as well as feedback about the final draft. Salvador Ávila provided us with ideas and know-how at the beginning of this study. We would also like to thank all the industry specialists who we interviewed for contributing their expertise and experience to this study. Various members of Fundación IDEA provided support throughout this project. The authors are solely responsible for any error.

3. Acronyms and Abbreviations

BASA	Bilateral Aviation Safety Agreement Recognizes the validity of the certificates granted in Mexico for pieces and components designed and produced in Mexico and exported to the US.
CACEI	Certifying Board for Engineering Studies (Consejo de Acreditación de la Enseñanza en Ingeniería)
CAMC	Canadian Aviation Maintenance Council
CECATI	Training Center for Industrial Work (Centro de Capacitación para el Trabajo Industrial)
CECyTE	School for Science and Technology Studies (Colegio de Estudios Científicos y Tecnológicos)
CECyTE	School for Science and Technology Studies (Colegio de Estudios Científicos y Tecnológicos)
CENALTEC	High-tech Training Center
CETYS	Technical and Higher Education Center
CNC	Computer Numerical Control Refers to any device that can position handheld mechanical tools that is completely automated based on numerical information in real time (Wikipedia 2010). In the aerospace industry, these machines are typically used to perform turning and milling operations.
COMEIA	Mexican Council of Aerospace Education (Consejo Mexicano de Educación Aeroespacial)
CATIA	Computer-Aided Three-Dimensional Interactive Application Software that provides support in conceiving a design, production and analysis of products (Wikipedia 2010).
DG&T	Sizing and geometric tolerances
DGAC	Mexican Civil Aviation Department (Dirección General de Aeronáutica Civil)
EASA	European Aviation Safety Administration
FAA	Federal Aviation Administration
FEMIA	Mexican Federation of Aerospace Industry (Federación Mexicana de la Industria Aeroespacial)
R&D	Research & Development
IPN	National Polytechnic Institute (Instituto Politécnico Nacional)

ITA	Technological Institute of Aeronautics (Instituto Tecnológico de Aeronáutica (Brazil))
ITESM	Technological Institute and Higher Education of Monterrey (Instituto Tecnológico y de Estudios Superiores de Monterrey)
ITESCA	Technological Institute of Cajeme (Sonora) (Instituto Tecnológico Superior de Cajeme (Sonora))
ITSON	Technological Institute of Sonora (Instituto Tecnológico de Sonora)
MIT	Massachusetts Institute of Technology
MRB	Material Review Board
MRO	Maintenance, Repair and Overhaul
UABC	Autonomous University of Baja California (Universidad Autónoma de Baja California)
UACH	Autonomous University of Chihuahua (Universidad Autónoma de Chihuahua)
UACJ	Autonomous University of the City of Juarez (Universidad Autónoma de Ciudad Juárez)
UNAQ	National Aeronautical University of Querétaro (Universidad Nacional Aeronáutica in Querétaro)
UPCH	Polytechnic University of Chihuahua (Universidad Politécnica de Chihuahua)
UPMH	Polytechnic Metropolitan University of Hidalgo (Universidad Politécnica Metropolitana de Hidalgo)
UTEQ	Technological University of Querétaro (Universidad Tecnológica de Querétaro)

4. Mexican Aerospace Industry: A New Industry that is Strongly Expanding

The aerospace industry centers on designing, manufacturing, marketing and maintaining aircrafts (airplanes, helicopters, unmanned aerial vehicle (drones), missiles, etc.), space crafts and rockets as well as the related equipment (propulsion, navigation systems, etc.)⁵. Companies with a presence in this sector in Mexico basically operate in the aerospace subsector, since it is still in the opening phase.⁶

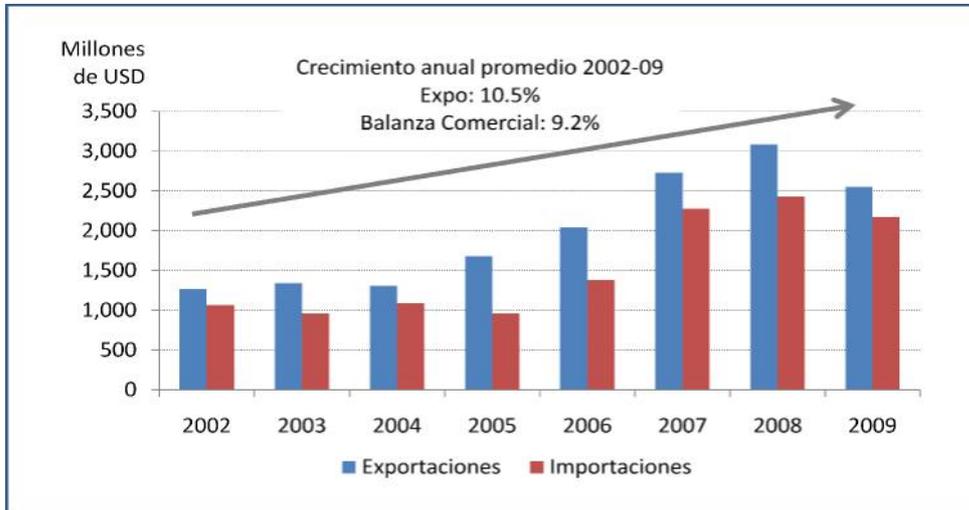
The sector currently experiences a dynamic growth. The size of the sector in terms of

⁵ Wikipedia 2010. "Aerospace Engineering" http://en.wikipedia.org/wiki/Aerospace_engineering

⁶ COMEA, 2008. "Presentation for the Ordinary Meeting of FEMIA", December 3, 2008.

exportations⁷ has doubled between 2003 and 2008, principally encouraged by foreign investment. According to data from Deloitte consulting firm, Mexico occupies the first place worldwide in securing investments for manufacturing in the aerospace industry with 33 billion dollars during 1990-2009.⁸

Image 1: Exportations and Importations of the Aerospace Industry



Source: Ministry of the Economy (Mexico)

The sum of foreign investment, together with recent events such as the execution of the Bilateral Aviation Safety Agreement (BASA) with the United States in 2007⁹ and the granting of 2.5 billion pesos in credits by National Bank of Foreign Commerce¹⁰ to this sector denote high expectations for growth of the sector in the medium term. Some locations have a low population or at least a few individuals who may be considered the Targeted Population.

In terms of employment, the industry is relatively small. Currently, it employs approximately 30,000 people, but has increased in recent years. Based on the expectations of certain industry executives who were interviewed for this study, this number may duplicate or even triplicate in the next five years.¹¹

⁷ Due to the limited supply relationships among local companies, it is estimated that the exportations are a good approximation of the sales.

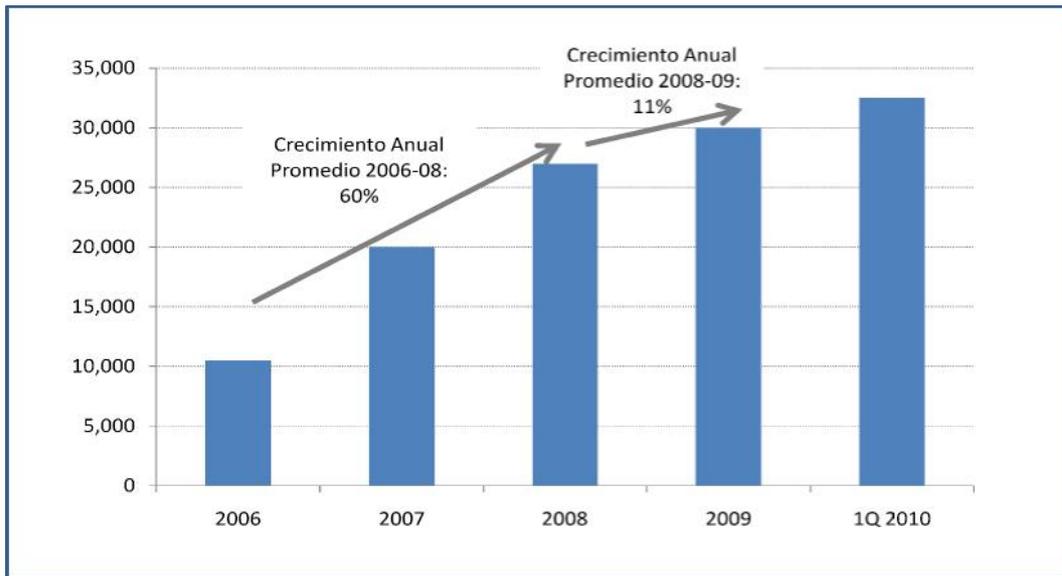
⁸ Rivero, A. 2010 "Country Secures More Aerospace Investment", Newspaper Reforma.com, July 26, 2010, <http://www.reforma.com/negocios/articulo/567/1132997/default.asp?Param=4&PlazaConsulta=reforma&esCobertura=false&DirCobertura=&TipoCob=0>

⁹ EFE2007. "Mexico and the US sign agreement for improved air safety." Newspaper "El Universidad" on September 18, 2007. <http://www.eluniversal.com.mx/notas/449933.html>

¹⁰ Rivero, A., Op. cit.

¹¹ It is important to state that currently Promexico is surveying all the industry's companies because it is endeavoring to discover the number of active workers in the industry as well as the amount of new jobs that are expected in the coming years. Once the study has concluded, the results shall permit a better estimate about the number of human resources that are necessary for the industry in the next years.

Image 2: Employment in the Mexican Aerospace Industry, Number of Individuals



Source: Ministry of the Economy (Mexico)

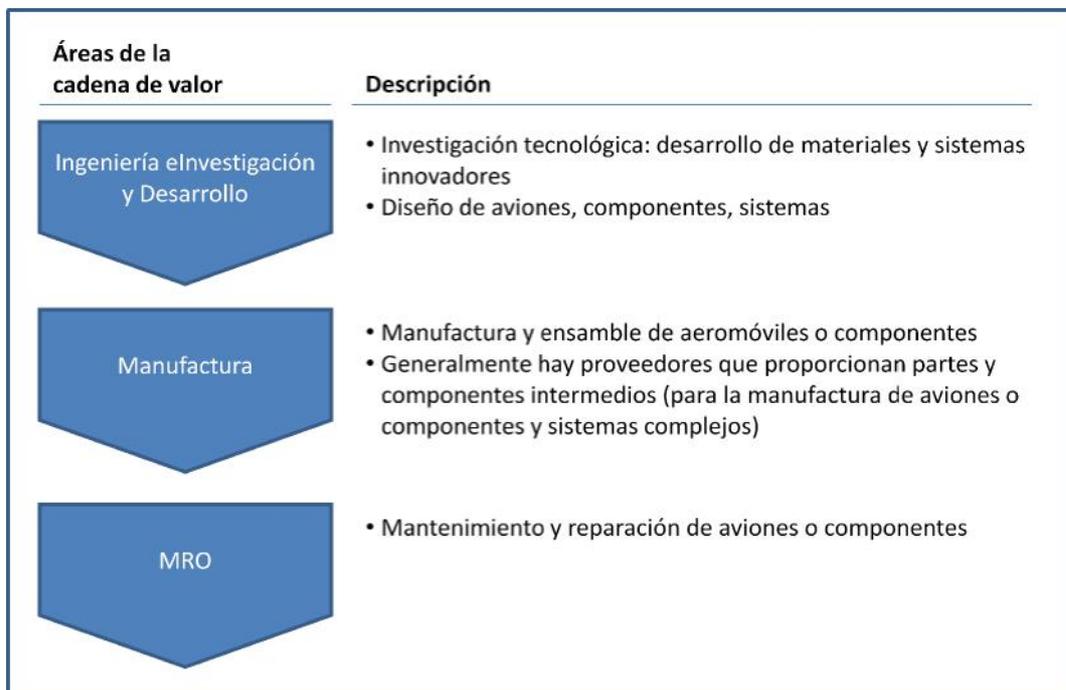
5. The Industry Has Potential to Move into Fields with More Added Value

Like many manufacturing industries, the Mexican aerospace industry strongly focuses on manufacturing and assembly of basic components for exportation.

Presently, 80% of the industry's companies are dedicated exclusively or principally to manufacturing – mostly to basic components. Only 10% of the companies are dedicated to research & development (R&D) activities; while the remaining 10% are dedicated to maintenance and repair activities for airplanes or components (MRO).¹²

¹² Solis, S., "Aerospace Industry in Mexico", Ministry of the Economy.

Image 3: Aerospace Industry Value Chain



Source: Interviews with the industry's experts and exponents.

An increase in the R&D area could facilitate the development of specific skills and redirection the industry towards segments with more added value in all the areas.

Although the active companies within the industry are mostly foreign, they usually carry out these activities in their country of origin; however, some companies are tending to develop more skills that together with the cheaper cost of Mexican engineers are gradually attracting more complex research and development projects.

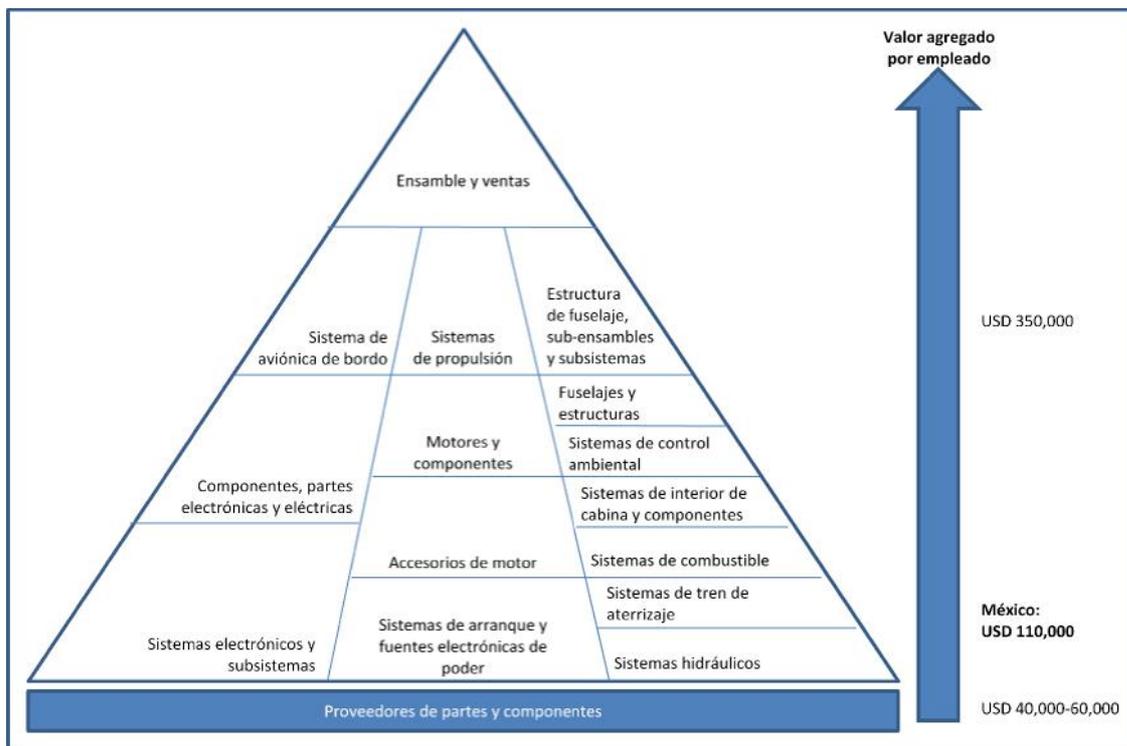
However, in order for this tendency to continue and become increasingly stronger, it is important for the country to have personnel who are highly educated and who have the skills to learn how to tackle projects of this kind. In this sense, it is important to mention that the literature evidences a strong correlation between the educational background of the workers in a country and its capacity to attract the transfer of technology from abroad and exploit it for economic growth.¹³

The MRO area also has extreme potential for development due to the low cost of workmanship in Mexico with respect to the rest of North America and the importance of the Mexican and US air fleets. The Mexican air fleet is the fifth largest in the world for the number of airplanes and the fleets of executive jets both Mexican and US are respectively the first and second in the world.¹⁴ Mexico has clear advantages if it wished to position itself as the principal maintenance and repair center for the region, and it would also need to have trained personnel to perform these tasks.

¹³ Education does not necessarily have to be related to the industry's advanced know-how. Other countries' experiences (i.e. Costa Rica, Finland) the intervention that increased the transfer of technology was primarily related to improvements in teaching basic and transversals skills (i.e. learning skills and problem solving), as well as the use of technology and command of the English language. Source: "Lifelong Learning in the Global Knowledge Economy, The World Bank, 2010".

¹⁴ Work Group of the Mexican Aerospace Industry, 2010 "National Flight Plan: Map of the Technological Route of the Mexican Aerospace Industry 2009"; preliminary draft.

Image 4: Aerospace Industry Supply Chain



Source: Document “National Flight Plan 2009”

6. The Industry’s Development Requires the Availability of Highly Trained Human Resources

The industry is characterized by low production volume, high requirements and little margin for error in each stage of the design, manufacturing and repair process. Therefore, in addition to the high rate of technological innovation, the companies of this industry are characterized by advanced training requirements at the beginning¹⁵ and subsequently for the workers (technicians and professionals). This implies a significant investment in training by the companies and placing importance on the capacity to identify and withhold good candidates.

6.1.1 Skills Required by Workers in All Areas of the Value Chain

Little margin for error permitted by the industry translates into the need for highly trained human resources and proper attention to detail, discipline and responsibility as well as teamwork skills. Specifically, management positions require engineers with leadership abilities and interpersonal skills (communication, people management and troubleshooting).

The need for on-the-job training, whether initially or subsequently, due to the constant improvements to technologies, materials and processes make the capacity for quick

¹⁵ The majority of the positions in the industry sectors require learning routine activities, which are specific to each company and role and tend to remain constant throughout time. The majority of the learning at work, therefore, tends to happen when workers begin to serve at a new position (Lifelong Learning in the Global Knowledge Economy, The World Bank, 2003). Initial learning is especially critical for the aerospace industry due to little margin for error and high cost of these, it is necessary for workers to quickly learn to perform their tasks with high quality.

learning skills also an essential characteristic that is sought from workers in this industry.

The aerospace industry requires professionals to have a strong command of English, including the capacity to read and write technical documents in this language. Additionally engineers and supervisors use English to communicate on a daily basis with foreign clients and/or colleagues –making it a prerequisite for hiring engineers. The respondents mentioned that for technical level, a basic level of English was needed that is sufficient to understand written instruction and that may be obtained by on-the-job training.

The Six Sigma Methodology is also a requirement (although it may be learned relatively fast by on-the-job training). The characteristics of the production, maintenance and repair work for airplanes could worsen existing medical conditions; therefore, personnel are required to be in healthy conditions. Furthermore, workers must have good sensory capabilities (sight, hearing, tact) because the work requires extreme accuracy and ability to detect the minimal errors and defects in structures, systems and components.¹⁶

6.1.2 Skills Required by the Engineering, Research and Development Areas

In addition to the aforementioned transversal skills, specific capacities exist that are required by the engineering, research and development areas. Most employees are engineers in this area.

The following table details the type of activity that engineers generally focus on for each specialty.

Image 5. Principle Activities for Engineers in the R&D Area, by specialization

Specialty	Principle Activity
Aeronautical and Aerospace Engineering	Development, design and testing aerospace vehicles and complex components
Mechanical Engineering	Design of mechanical components and development of instruments and machinery necessary to produce parts
Electrical and Electromechanical Engineering	Development of electrical components
Industrial Engineering	Development of production methods and systems; resolution of logistical problems concerning manufacturing and transportation.

Source: US Labor Department, Career Guide to Industries, Edition 2010-11

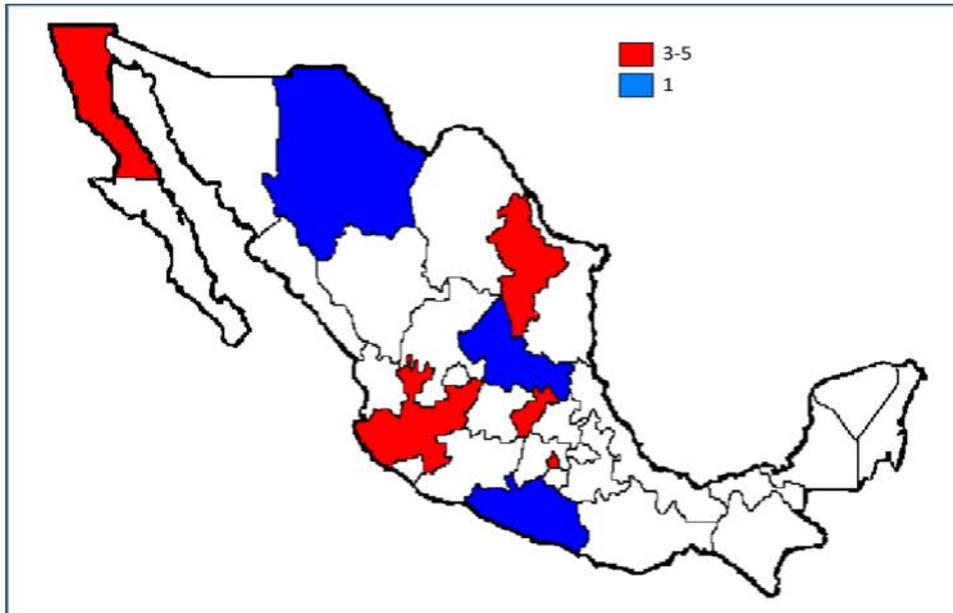
Presently, the demand for aerospace engineers is low since the design work is not carried out in Mexico. In the medium or long term, the industry might evolve in that direction, requiring specialists for more complex activities. But for now, the respondents mentioned that their recruits focus on mechanical and industrial engineers as well as engineering technicians and computer experts (analysts, scientists, engineers, programmers, support staff, network and database administrators).

Proficiency and use of software programs for design purposes and, specifically the CATIA program, are also important. Respondents stated that it would be preferable for engineers to be familiar with these before they are hired, since in their opinion it takes 6 to 12 months to become fully knowledgeable with the program.

¹⁶ Six Sigma is a methodology developed in the nineties by Motorola, Inc., consisting in the stages DMAIC –Define, Measure, Analyze, Improve, Control – to resolve problems and to reduce the errors or defects in delivering the product or service to the client. The method uses statistical tools that reduce variations in the procedures to maximum possible. (Morales, 2007).

Engineering, research and development activities are primarily carried out in Baja California, Mexico City, Jalisco, Nuevo León and Querétaro, where the majority of the industry's trained human resources are found.

Image 6. Geographical Distribution of the Companies and Institutes Active in Research and Development.



Source: FEMIA, Directory of the Aerospace Industry

6.1.3. Skills Required in the Manufacturing Area

Personnel working in the manufacturing area is comprised of 20-30% of engineers and 70-80% of technicians and operators.¹⁷

In general, engineers hold positions related to coordination and process control, machinery maintenance and quality control. Some are in charge of supervising the components for defects and determining how to fix these without compromising the structural integrity of the piece or how to discard these properly.¹⁸

Engineers working in this area require an advanced level of technical skills; specifically:

- The ability to “translate” designs and specifications during manufacturing processes;
- Knowledge about the industry's standards and requirements (including materials and compounds, mandatory tracking documentation);
- Deep knowledge of the characteristics of the materials (to make decisions on how to handle them);
- Knowledge about IT and design programs (specifically, CATIA) and about technical systems used in manufacturing (specifically, CNC) and the capacity to visualize and manipulate tridimensional pieces in virtual systems.

Supervising positions require leadership and people management skills. Depending on the

¹⁷ Estimates gathered from interviews with the industry's executives.

¹⁸ This process is generally called MRB (Material Review Board).

companies and the position level, the Jobs may be entrusted to engineers (today largely dominated by mechanical or industrial engineers) or technicians with many years of experience.

Engineers in charge of reviewing components with a defect must have knowledge of structural analysis. Many of these positions are dominated by aeronautical or aerospace engineers since this training is part of their syllabus.

The manufacturing area needs technical operators, machinists, assemblers and installers of aircraft parts.

While operators do not need advanced studies they require good measurement skills, reading comprehension and knowing how to develop tridimensional objects starting from dimensional designs. Although respondents reported a preference for recruiting personnel with high school diplomas, some of them stated that they also took into account graduates of junior high school since many times the number of candidates is reduced and prevents a proper selection based on skills. In addition to the skills, respondents reported as a prerequisite having some prior work experience in the manufacturing industry.

Immediately prior or after entering into the industry, the personnel hired receive basic training regarding the industry and the tasks they will perform. It is important to note that in the case of technical resources, specific training in the industry is limited and, in the majority of the cases, it is only the training provided by the companies since no open technical level courses exist for the public that cover the specific requirements for the industry.

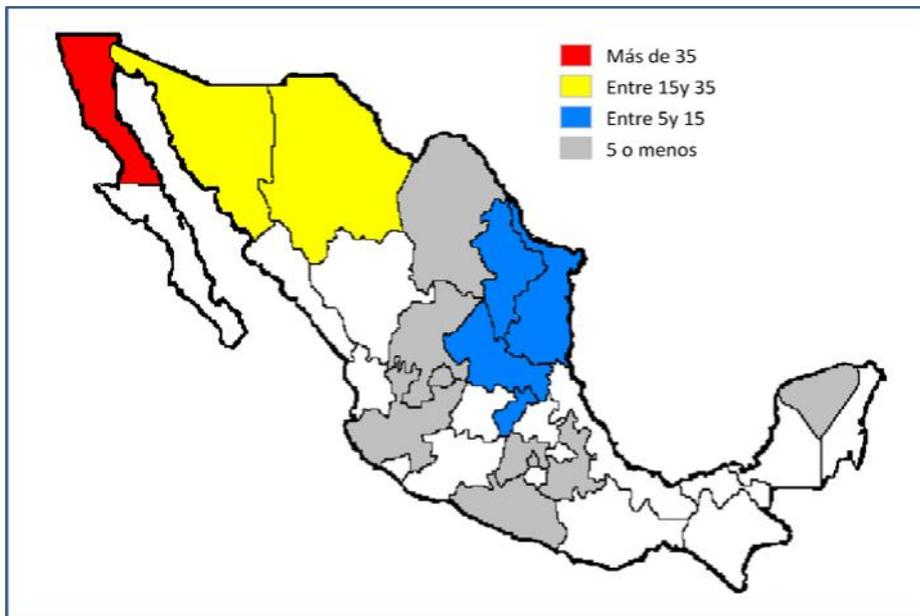
In some cases, companies have signed agreements with schools so these provide tailor-made training programs to their employees. To date, this experience seems to indicate that these ad hoc courses are more successful than standard courses, at least in terms of relatively short training sessions for basic technicians: for example, a course designed to instruct about the joint needs of the companies in the sector that is offered by UNAQ was cancelled after the first year because it was unsuccessful with the companies despite the fact that this school has experience in offering courses that are customized to each company and are highly appraised by it.¹⁹ Machinists require skills to program and operate CNC machines. According to a respondent, training a machinist in CNC so he can hold a position as a machinist takes over one year, including theoretical and practical training.

In one of the companies we visited, the installers of aircraft components were selected from among the operators who stood out for being highly skilled, very interested in these activities and trained in the work. Activities involving aircraft installations (and, therefore, the number of persons required) is still limited in Mexico because airplanes are not completely manufactured (the components are general sent abroad).

The following map shows the states in Mexico where manufacturing activities are carried out for the aerospace industry and, therefore, where human resources are needed. It is important to state that the largest companies are mostly located along the border and in the state of Querétaro.

¹⁹ More details are established in section 7.2 with respect to the technical programs of UNAQ as well as subsequent considerations about how programs might be developed, based on international experience, which are interesting for all the companies within the industry.

Image 7. Geographical Distribution of the Companies and Institutes Active in Manufacturing, number (2009).



Source: FEMIA, Directory of the Aerospace Industry

6.1.4. Skills Required in the MRO Area

Personnel in the MRO area are entrusted with preventive maintenance and repairs of the airplanes and components.

Engineers are needed for this area (in a different proportion depending on the specific focus of the companies: an aircraft maintenance workshop stated that this means less than 5% of the production personnel, while the workshops of specific components are estimated at 20-30%) who are mostly occupied with the design and review of maintenance procedures for airplanes as well as logistical procedures and the organization of the activities. In light of the necessary skills, the aeronautical specialization is in high demand and also requires electronic engineers for certain positions.

By law, the majority of the aircraft maintenance and repair tasks and components must be performed by or under the supervision of the technicians whose skills are certified by the Civil Aviation Department (DGAC). Therefore, this department is in great need of technicians with this type of certification.²⁰

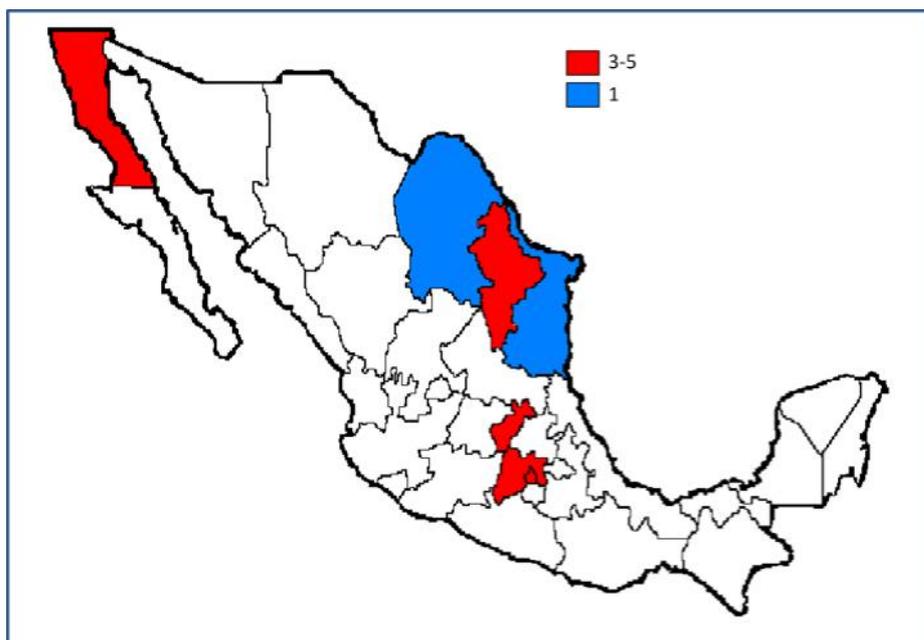
The requirements for certification by the DGAC include having completed high school or vocational school, preferably in the area of physics-mathematics, have the proper physical conditions (certified according to the terms established by the Regulation of the Preventive Medicine Service for Transportation), finish and pass the instruction course recognized by the Aeronautical Authority and the theoretical-practical exams established by it. The instruction courses recognized by the Aeronautical Authority include those offered by CONALEP (for more information see Annex 10.3).

²⁰ A respondent of an aircraft maintenance company quantified these at approximately 60% of the production personnel of the company, while a respondent of a component maintenance company quantified these as 30%.

In addition to technicians certified by the DGAC, the department needs workers tasked with painting and repairing the seats. Depending on the focus of the workshop, other specialized technicians may be needed, such as chemist technicians and specialists in machining.

The map below shows the location of the companies that are active in the MRO area in Mexico and also shows the geographical distribution of the demand for human resources trained to work in this area.

Image 8. Geographical Distribution of the Companies and Institutes Active in MRO, number (2009).



Source: FEMIA, Directory of the Aerospace Industry

6.1.5. Other Needs of the Industry: the Inspectors of the Civil Aviation Department

The DGAC is the authority entrusted with verifying and certifying compliance with the quality standards and security in various areas of the manufacturing and air transportation. Among these, the DGAC authorizes the MRO workshops tasked to perform maintenance and repairs to Mexican airplanes, and grants the certifications required to implement the BASA agreement. Therefore, the existence of this organization in a sufficient number of inspectors who are properly trained is critical for the future development of the industry.

7. Despite the industry's growth and the training programs, gaps exist in the resources offered.

7.1 Engineering Programs (graduate and postgraduate)

Several representatives of the industry stated having difficulty employing graduates of engineering programs with no work experience, regardless of the specialization. Despite

recognizing the good technical level of the engineering graduates, a lack of interpersonal and problem solving skills is perceived in the industry. In terms of interpersonal skills, the criticisms focus on the difficulties faced by graduates in presenting ideas and to relate to other team members –particularly if they differ in age or education.

In terms of the difficulties with problem-solving, a foreign respondent commented about the low demands of national schools compared to other countries. In his opinion, the level needed to graduate is low; and, therefore, students are not adequately motivated to learn how to face challenges of this kind.

These skills (communication, teamwork, applying analytical techniques and problem-solving) are not only valued by companies within the industry, but apparently by all employers of engineers.

Consequently, perhaps it would be interesting to rethink the requirements of the engineering syllabus and evaluate the possibility of including courses that could make acquiring these skills easier.

It is important to point out that certain universities are taking measures in this regard. For example, the National Polytechnic Institute (IPN) has supplemented its syllabus with humanities studies with the goal of stimulating students to develop their self-esteem and confidence as well as their abilities to communicate effectively. Assessing these programs would be advisable to correct or replicate them in other schools, depending on the results.

Respondents also commented about the need for a good level of English. Only a few universities in Mexico have graduates who are proficient in this language (CETYS and ITESM).²¹ Respondents also stated that they would like to find more candidates with proper skills to understand and draft technical documents in this language, but few candidates have these abilities.

Another criticism made by respondents was the lack of awareness or interest regarding the economic impact caused by the activities performed at work. Various respondents commented about the difficulty of instilling the importance of cost considerations in decision-making.

Among the technical skills, most respondents criticized the universities for offering training in obsolete software (i.e. AutoCAD) and suggested substituting it with the latest programs – specifically, CATIA (also used by the automobile industry).

In some cases, companies within the aerospace industry have provided financial support to local universities so they may acquire lab infrastructure and, specifically, licenses for the latest software (i.e. Gulfstream financed the purchase of licenses for CATIA in UABC).²² During the investigation, some executives who were interviewed stated their willingness to help universities purchase the licenses for software.

Lastly, the respondents commented on the difficulty in identifying the best candidates in the workplace due to the variation in the quality of the graduates.

²¹ It is important to note that the comments made by respondents basically refer to the institutions where they recruit. Perhaps graduates from other schools in Mexico have a good command of English.

²² In an interview, it was mentioned that companies of other industries (i.e. automobile) could participate in these type of initiatives; for example, INP was granted licenses for software packages (including CATIA) at a very reduced price through an agreement with General Motors.

7.1.1 Aeronautical and Aerospace Engineering Programs in Mexico

Until the 2006-07 school year, IPN was the only institution in Mexico to offer programs in Aeronautical Engineering.²³ In 2009, 250 students had graduated from the Aeronautical Engineering Program and 12 from the master's degree program in Aeronautical Engineering in Maintenance and Production.

However, the fact that there are few aeronautical engineers in the market does not seem to be currently perceived as a relevant hindrance to the industry's development. Aeronautical specialty seems to be viewed as extremely relevant for the design of complete airplanes or complex parts, activities that are yet to be carried out in Mexico; and for the MRB²⁴ positions (review components with manufacturing defects to determine whether and how these can be repaired or if they can be discarded), which are very limited in number.

Table 1 – The Mexican Aerospace Education Council (COMEA)

Created in October 2007, COMEA is an association that groups together several high schools, vocational schools, universities and postgraduate programs.

Its goal is to strengthen its human capital according to the needs of the aerospace industry by developing academic, scientific and technological programs. It acts as a speaker to ensure stronger ties in terms of training with the industry's present and future requirements.

It is also expected to serve as a channel to provide feedback for schools insofar as the preparation of the graduates with respect to the industry's needs and as a board that promotes adjustments to the curricula.

Source: interviews

Presently, most companies normally hire mechanical and industrial engineers and in fewer numbers electrical and mechanical engineers. Perhaps the demand for aeronautical engineers will increase in the future as a result of the development of R&D activities and more complex manufacturing; however, it is unlikely that they become the majority. In fact, some of the respondents stated that even in their headquarters (abroad), aeronautical engineers are the minority of all the engineers who are employed.

In spite of this, some respondents regretted that Mexico lacks programs that provide advance training with materials (specifically, compound materials) and the latest electrical systems.

Many also lamented the fact that IPN's aerospace programs focus excessively on design and maintenance, while currently manufacturing is the most developed area in Mexico.

This, along with the hope and aspiration of further developing R&D activities, suggests the needs to adjust the offer of the engineers trained in aerospace matters, not only increasing their numbers, but also diversifying the focus of the programs towards subject matters and areas of the value chain that present the highest level of demand for these resources.

Possibly in response to these demands, as of the 2007-08 school year, other graduate and

²³ ANUIES.

²⁴ Material Review Board.

postgraduate programs will be opened in the field of the Aeronautic and Aerospace Engineering, some of which focus on manufacturing. Programs are offered by the Autonomous University of Nuevo León (UANL), the Autonomous University of Chihuahua (UACH), Technical and Superior Educational Center (CETYS) of Chihuahua, the National Aeronautical University of Querétaro (UNAQ), the Polytechnic Metropolitan University of Hidalgo (UPMH), Polytechnic University of Chihuahua (UPCH), the Autonomous University of Baja California (UABC), and the Autonomous University of the City of Juarez (UACJ), also in Chihuahua. The estimated number of graduates of aerospace engineering programs will gradually increase in the next years until reaching approximately 400 graduates and 40 postgraduates in 2014.²⁵ Additionally, the Superior Technological Institute of Cajeme (ITESCA) of Sonora started offering aeronautics within its mechanical engineering program. An estimated 20 graduates are expected for this program as of 2011.

Image 9. Aerospace Engineering Programs in Mexico and Number of Graduates (present and future)

Institution	State	Program	Graduates 2009	Future Graduates (estimates, per year)
IPN, Esime Ticoman	DF	Aeronautical Engineering Options: 1) Air Transportation Operation 2) Design and Construction	250	200
UACH	Chihuahua	Aerospace Engineering		20 as of 2011
CETYS	Baja California	Aerospace Engineering		15 as of 2011
ITESCA		Mechanical Engineering, Aeronautical option		20 as of 2011
UANL	Nuevo León	Aeronautical Engineering Graduate Program geared towards Design and Manufacturing Options: 1) Structure and materials 2) Aerodynamics and propulsion systems 3) Avionics		40 as of 2012
UACJ	Chihuahua	Aerospace Engineering		20 as of 2012
UNAQ	Querétaro	Aeronautical Engineering specializing in Manufacturing		20 as of 2012
UPMH		Aeronautical Engineering, option: Air Transportation		20 as of 2013
UPCH		Aerospace Engineering		20 as of 2013
UABC	Chihuahua	Aerospace Engineering		50 as of 2013
	Baja California			

Source: COMEA

The number of graduate programs in aeronautical engineering that were recently raises poses questions about whether the efforts to expand the education offer are not excessive with respect to the amount (it is important to note that most companies did not state that they needed a significant number of aeronautical engineers) in detriment to the quality: investments in labs and necessary equipment to ensure a good level of training are essential and the perception is that the financial commitment is unclear in terms of constructing and maintaining proper facilities that have updated equipment for all programs, including the most consolidated of the IPN. It is also worth mentioning that the lack of practical experience in the syllabus of the Mexican universities is evident in comparison with top

²⁵ Formation, Update and Training Program COMEA-FEMIA.

rated foreign universities.²⁶

A respondent mentioned that some institutions intend to remedy the insufficient infrastructure through student exchange agreements with national and foreign universities (specifically with the National Polytechnic Institute and the University of New Mexico in the US), where students may receive proper practical training. However, presently there are not enough scholarships to ensure that many students may take advantage of these opportunities. Also, it is worth noting that signing exchange agreements with the US, along with the current scarcity of aeronautical engineers in Mexico, could favor a migration of the best graduates to other countries.²⁷

Another difficulty faced in establishing the aforementioned programs is the lack of properly prepared faculty members. To remedy this situation, some universities are attempting to attract foreign professors. On the other hand, programs are being created to train the faculty, which are basically oriented towards the graduates of the IPN aeronautical engineering programs, which includes a master's degree program (national) as well as a practice period within the industry; nevertheless, doubts linger about the preparation of these professors as well as the probabilities that graduates of these programs will choose to enter into the industry instead of teaching.

Also worth noting is that the only aeronautical engineering program that is presently accredited with CACEI (Engineering Education Accreditation Council) is IPN's program. This accreditation allows the quality of the program and certificate of the graduates to be recognized in all of North America – and, therefore, may boost confidence in the abilities of Mexican aeronautical engineers among foreign companies who are considering investing in Mexico. With the information at our disposal, we cannot reach conclusions about whether the lack of accreditation of new programs is due to their recent creation and to the processing time (or, perhaps, due to the existence of bottlenecks therein) or to the breach of the minimum necessary requirements.

Despite the introduction of the programs described above and in addition to pointing out doubts about them, several executives stated that the postgraduate programs that focus on the industry existing in Mexico (specified in the table below) are still insufficient with respect to the needs – in particular, the lack of master's degree programs that could provide engineers with several years of experience and specialized skills in subjects such as power plant systems, structural analysis, design, mechanics and calculation of fluid, MRO.

²⁶ Also see Annex 10.2.

²⁷ Additionally, this could also boost confidence in the abilities of Mexican aeronautical engineers and, therefore, the transfer of activities with more added value towards Mexico.

Image 10. Aerospace Engineering Postgraduate Programs in Mexico and Number of Graduates (present and future)

Institution	State	Program	Graduates 2009	Future Graduates (estimates, per year)
IPN, Esime Ticoman	DF	Postgraduate Program in Maintenance and Production	12	10
UANL	Nuevo León	Postgraduate Program in Engineering of Aerospace Materials	15	15
UANL	Nuevo León	Postgraduate Program in Aeronautics Engineering Control-Systems	20	15
CETYS	Baja California	Postgraduate Program in Aerospace Engineering	0	10 as of 2012
ITESM, Querétaro campus	Querétaro	Program consisting of 80 hours of professional concentration in Aeronautics		20 as of 2012

Source: COMEA

7.2 Technical Level Human Resources

Technicians needed in the manufacturing area

So far, it seems that a large portion of the training required by technicians has been provided by the same companies according to their specific needs, regardless of agreements with schools – that have led to the development of courses or programs directed only at employees of the development companies. Particularly, thanks to an agreement with the State of Querétaro, the National Aeronautics University in Querétaro (UNAQ) offers courses in technical training that address all the company’s requirements and are open for candidates selected by them –where the company undertakes to hire a significant number of graduates after graduation. Respondents of the companies based in the state of Querétaro have stated to be largely satisfied with the results of such programs.

Although the development of customized programs might in part be the result of the extensive range of requirements within the companies as well as the limited programs offered (in the case of the northern region) as well as availability (in the case of UNAQ, the training programs described above are financed by the state), the success of programs covering common interests may be possible if the industry’s primary needs are identified and training standards for these are drafted. For this purpose, Table 2 briefly describes the results obtained by the Canadian aerospace industry in response to a significant effort in this sense.

Respondents mainly lamented that the active manufacturing companies lacked technicians trained in CNC. Some companies have developed training programs in collaboration with schools (in Baja California: CECATI, CECITE and the Technological School of Mexicali) in order to train its own employees even when training takes more than one year.

Table 2 – Creation of standards and curricula for training programs for the Canadian Aerospace Industry

Prior to 1991, the Canadian aerospace industry was characterized by the few training courses for this industry; the existing programs were mostly tailor-made for each company and were characterized by vast range of contents. This hampered the mobility of employees as well as the identification of qualified candidates for the companies.

To solve this problem, the Canadian Aviation Maintenance Council (CAMC), in collaboration with the industry's advocates, have taken steps to develop and maintain updated a list of the principle occupations within the industry: for each one has defined the qualifications required as well as the training standards in order to obtain them.

For some of the occupations defined in such a way, the CAMC has also developed syllabus available for purchase by Canadian training centers.

This resulted in the creation of an extensive number of training programs for the aerospace industry in vocational centers, based on the syllabus developed by the CAMC. In light of the many schools that have adopted the syllabus of the CAMC, it has become, to all intents and purposes, a nationwide standard.

Also, the availability of the standards of competition at a nationwide level have permitted an IT system to be developed for the job notice board where candidates may construct structured profiles based on qualifications recognized by the industry. Employers may insert a description about the profiles that are needed by their company according to the same standards, thereby making the search for jobs and employees much easier.

The list of occupations defined by the CAMC is included as Annex 10.5.

Source: "A Human Resources Study of the Canadian Aviation Manufacturing and Maintenance Industry", 2002

Additionally, CENALTEC and UNAQ recently began to offer courses for technicians specializing in CNC.

A respondent also mentioned the absence of technical machinists in Mexico who are capable to making prototypes without numerical control; nevertheless, demand for the latter seems to be low and limited to the most advanced design centers.

Regarding skills, some respondents lamented the difficulty in finding responsible employees who have a high sense of precision –who are willing to indicate any mistake or error committed by them or others in the workplace. Others noted that despite the low educational requirements established by the industry, many candidates with the basic skills that are sought must be interviewed –specifically, reading comprehension and writing, understanding tridimensional realization of two-dimensional plans and quick learning; a respondent added that 30 candidates are normally interviewed for each position.

Recent efforts have been observed throughout Mexico aimed at creating technical educational programs focusing on the industry: these were introduced recently in ITSON (Sonora); UNAQ (Querétaro); and CENALTEC (Chihuahua).

Additionally, a recent agreement was signed by the Governments of Mexico and France to develop the aeronautical campus attached to UNAQ that will offer university-level technical programs in manufacturing aeronautics and aircraft maintenance and whose certificates will be recognized in the US and Europe.

The lack of technical programs focusing on this industry is noteworthy in the state of Baja California, where the majority of the industry's companies are located.

In terms of the relevant vocational training programs, although not specific for the industry, two respondents in Mexico commented about the lack of demands on students, and, as a result the stimulation for growth as well as the lack of faculty (the general perception is that faculty members are the people who did not have job alternatives and who have little experience in the industry). Nevertheless, a person gave positive feedback about the technical-university level programs; specifically in terms of UTEQ.

Table 3 – The Alamo Aerospace Academy: an innovative experiment in technical training for the aerospace industry

The Alamo Area Aerospace Academy is a group of 8 companies, 17 independent school districts, a junior college and a group of local government agencies. It was founded in 2001 to address the needs in terms of human resources of the companies in the aerospace industry established in San Antonio, Texas caused by the presence and expansion of companies such as Lockheed Martin and Boeing and the need to replace a large number of retirees of the baby boomer generation.

The Academy supplements the education received by the students during the last two years of high school with additional courses that enable them to develop skills such as mechanics specializing in fuselage or engines. If students decide to continue their university studies, the training received is recognized by various institutions as equivalent to 30 college credits.

Students are normally employed as interns by local companies during the summer between the first and the second year at the Academy and may expect a salary of approximately US\$2,500. After graduation, students are hired by companies and generally earn a salary in excess of US\$10 per hour (may reach US\$15 depending on the experience and education); this type of work provides financial support to students wishing to continue their studies, but who need a part-time job to do so.

The school has a capacity of 160 students (80 new entries for each year).

The information available seems to indicate that almost all of the students who graduate from the Academy continue their studies in vocational schools or universities; and that the Academy has faced some difficulties in finding new students. Based on the information available, we cannot reach clear conclusions about the school's success rate.

SOURCE: Cutcher-Gershenfeld, J., T. Kochan, B. Barrett, E. Rebentisch, y R. Scott. Developing a 21st Century Aerospace Workforce. MIT Labor Aerospace Research Agenda and Lean Aerospace Initiative. Version 2 - White Paper, 2001; <http://www.alamo.edu/academies/aaaa.htm>

Several respondents noted that the lack of actual proof and skills prior to starting technical programs (whether these focused on aeronautics or not) becomes a disadvantage for graduates who later seek jobs in the industry that require staff in a good state of health and with physical capacity and skills. Specifically, work requirements for the aerospace industry include being detail-oriented in addition to having good physical condition. Candidates with visual or hearing impairments are not recruited, nor with bone structure defects because this could limit their ability to efficiently complete tasks.²⁸ According to a respondent of the UNAQ, the lack of an adequate selection in this regard (which public institutions cannot make for legal purposes) resulted in the launching of a basic technical standardized program, 30% of graduates were not taken into consideration as viable candidates by the industry for medical reasons.

²⁸ Generally, these candidates also do not satisfy the minimum medical requirements to obtain a license as a maintenance technician (MRO) from the DGAC.

The table below specifies the technical programs focusing on the aerospace industry existing in Mexico as well as the number of graduates (present and expected in the next years) for each of them.

Image 11. Technical Programs focusing on the aerospace industry (manufacturing area) in Mexico and Number of Graduates (present and expected)

Institution	State	Program	Graduates 2009	Future Graduates (estimates, per year)
UNAQ	Querétaro	University Technician in Avionics	-	15 as of 2010
ITSON	Sonora	University Technician, option Aerospace Manufacturing	-	25 as of 2011
CENALTEC	Chihuahua	Technician Specializing in DG&T	35	50
CENALTEC	Chihuahua	Technician Specializing in Manufacturing	35	50
CENALTEC	Chihuahua	Technician Specializing in CNC	35	50

Source: COMEA, interviews in the industry

Technicians needed in the MRO area

Compared to the rates of business growth expected by executives of this area, the number of registrations in courses for maintenance technicians (the termination and approval of the course is a prerequisite to obtaining the license from the DGAC) offered by public institutions (presently, CONALEP and CECYT) is insufficient. Therefore, certain workshops –such as the Mexican MRO- have their own schools to train more students according to their needs and the resource availability in the market.²⁹

Existing maintenance technicians are perceived as having sufficient quality standard; however, two respondents anticipated investments in updating and integrating equipment at the schools.

The table below specifies existing technical MRO training programs in Mexico as well as the number of graduates for each of them.

Image 12. Technical Programs focusing on the aerospace industry (manufacturing area) in Mexico and Number of Graduates (present and expected)

Institution	State	Program	Graduates 2009	Future Graduates (estimates, per year)
CONALEP	DF, Jalisco, Nuevo León, Querétaro and Quintana Roo	Professional Technicians Options: 1) Aircraft maintenance 2) Lamination 3) Avionics maintenance	70	50 for each option
CECYT (2,3,4,7)	DF and Mexico State	Technician specializing in aircraft maintenance	0	90 as of 2012

Source: COMEA

²⁹ A respondent mentioned that his company's internal training center currently trains approximately 100 technicians per year; this number is higher than the current annual graduates of the CONALEP programs.

7.3 Other Human Resources Needed for the Industry

Many of the respondents expressed that they perceived a shortage in both the number and level of training of the DGAC inspectors as well as certain distrust in the institution's ability to identify and respond quickly and efficiently to the industry's demands.³⁰

For now, this does not represent a bottleneck for the aircraft manufacturing industry: the quality of the MRO workshops is generally guaranteed by the certifications granted by international authorities³¹ and component design activities in Mexico are still very limited.

However, a possible shortage in the future of inspectors in the future who are trained to grant BASA-related certifications could become a bottleneck to develop design activities in Mexico in the medium and long term. Currently, the first 15 BASA inspectors are being trained in Mexico.

Although specific problems are not mentioned, some respondents expressed a certain preoccupation in terms of the DGAC's ability to comply with the expectations of the industry and anticipated it being strengthened in the future.

7.4 Certifications and Quality Standards

Mexico does not have nationally recognized quality standards for human resources or accreditation systems for the industry's skills training programs. The only exception is the regulation imposed by the Civil Aviation Department for training and the certifications granted to engineers and MRO technicians that are necessary to authorize the use of airplanes or parts after being repaired. Until now, this regulation is considered to be functional.³²

By introducing certificates that are recognized by all the companies within the industry, the following will be successfully achieved:

- 1) Schools will understand what companies require skills and, therefore, develop programs that are relevant and interesting for the industry;
- 2) Individuals who are interested in working in the industry will understand better the skills that are required by companies in the industry;
- 3) Companies will have a clearer understanding about the actual skills of job candidates, making it easier to select personnel;
- 4) The possibility of mobility within the workplace will be easier.

As an example of the type of certifications that may be useful for the industry, Annex 10.5 includes a list of the certifications granted by the Canadian Aviation Maintenance Council.

Respondents also mentioned that two certificates that would be useful immediately is the proper handling of CATIA and CNC systems.

³⁰ This distrust has been recently updated by the FAA decision to downgrade the security rating for Mexican aviation, which the DGAC is in charge of guaranteeing. Source: <http://www.eluniversal.com.mx/notas/698817.html>

³¹ To carry out maintenance on an aircraft, MRO workshops need to be authorized by the authority of the country where the plane is registered, regardless of the country where the workshop is located. Therefore, it is not strange that the workshops are certified by the authorities of various countries.

³² This system is similar to the one used in the European Union, which is described in Annex 10.3

8. Suggestions to Improve Skills Training for the Aerospace Industry

In the last five years, the Mexican aerospace industry has strongly expanded due to significant investments from abroad, among other reasons. In the future, the industry has the potential to not only continue with this trend (some respondents believed that employment could double or triple in the next five years), but also evolve to segments with more added value.

In order for this to become a reality, it is critical for the industry's expansion to include an effort dedicated to ensuring the availability of a sufficient number of human resources who have the training required by the industry. Recently, the industry and the academic community began to take actions to promote the creation of training programs that focus on the industry; the first significant results included the creation of the Mexican Council of Aerospace Education (COMEA), which acts as a speaker and representative for all high schools, vocational schools and universities with sector-related programs. COMEA has already contributed to the design and opening of various university and technical programs focusing on the industry.

Despite these efforts, gaps still exist between the industry's needs and human resources available. The list below details some of the risks and opportunities pondered by the industry's executives and experts:

1. Engineering programs graduates are believed to be professionals who lack management skills –specifically, in terms of communication, teamwork, analysis and problem solving, being aware of the financial impact of their activities. Therefore, the recommendation was to seek integration of the course work for the engineering programs, courses and experience to focus on developing these skills; along those lines, the effectiveness of actions already taken with some schools, such as the National Polytechnic Institute, should be evaluated.
2. Barring few exceptions (specifically, the ITESM and CETYS were mentioned), the average level of English among graduates of engineering programs in Mexico is considered to be insufficient. Promoting better command of the language is suggested, possibly analyzing and replicating the teaching methods used by the ITESM and CETYS. Additionally, respondents were encouraged to focus more on writing skills and reading comprehension of technical texts.
3. Despite the fact that in the last three years several aeronautical and aerospace engineering programs have been created, doubts linger about whether the level of the faculty and the investment in labs will be sufficient to guarantee a high quality level in the education that is offered. It could make sense to concentrate investments in developing less programs, located in the states with more development in the industry (i.e. Baja California and Querétaro) – especially considering still limited demand, although currently being expanded, of resources with this specialty. With respect to the high cost of the facilities, it is also suggested to consider the possibility of using these to offer programs at different levels (university and vocational schools) as in the case of UNAQ.
4. The reduced number of postgraduate programs in Mexico creates difficulties in training personnel in highly specialized subjects. The suggestion is to develop

specialized programs for subjects, power plant systems, structural analysis, design, mechanics, fluid calculations and MRO.

5. Design software used by most engineering programs offered by universities are perceived to be obsolete (i.e. AutoCAD) while there is a lack of training in packages currently used by the industry –specifically CATIA. It is suggested to evaluate the possibility of investing in the purchase of licenses and training of the most recent software packages for schools, especially if these are also used in other industries in addition to the aerospace.³³ Certain companies of the industry have stated their willingness to contribute financially to the investments that are needed.
6. Although the companies in northern Mexico do not seem to demand, for the time being, advanced level of training for candidates for technical positions (except for machinists), the lack of training programs in this region may cause a significant barrier to transition towards segments with more added value. The recommendation is to prepare a strategy to promote the recently created programs (i.e. CENALTEC and ITSON) as well as the incorporation of new programs that are intimately related to the industry. Specifically, the respondents mentioned the need for CNC training programs.
7. In order to facilitate the development of technical programs and relevant training courses that the entire industry finds interesting, it is recommended to promote the development, in collaboration with the industry, a system to define the main occupations and training necessary for the industry, as well as the minimum training standards necessary to reach these. Therefore, it may be useful to analyze the experience of other countries where the industry is more developed – in the case of this document, information was included about Canada.
8. Respondents of the productive sector have expressed distrust with respect to the capacity of the DGAC in acting swiftly and efficiently in response to industry needs and recommended that this agency be strengthened; furthermore, they expressed concerns about whether the number and educational background of the inspectors who are training to certify compliance with the quality standards in aerospace manufacturing established according to BASA is sufficient. The lack of resources in this sense could constitute a significant barrier for the development of the sector, specifically the R&D area.

Lastly, during the course of this study, it was noted that other significant efforts for investigation and development of strategies was being carried out for the industry, where some of these focused on training. It is recommended to encourage more collaboration between the companies leading these efforts (specifically, the Ministry of the Economy, ProMéxico, FEMIA, COMEA) to ensure better coordination and avoid duplicating costs.

9. Sources

9.1. Respondents, people who were interviewed

Sergio Alberto Solís Cabello – Head of Opinions about Foreign Trade Methods, Ministry of the Economy, Mexico

³³ CATIA is also used in the automobile industry.

Manuel Sandoval Ríos – Executive Director of Prospective Analysis and Innovation, ProMéxico

José Mariano Moreno Blat – Analysis Manager of the Aerospace Industry, ProMéxico
Carlos J. Bello Roch – CEO, FEMIA

Alfredo Juárez Gómez – CEO, COMEA

Agustín Cano Galván – Department of Engineering, Standards and Certification, Civil Aviation Department

Norma del Carmen Muñoz Madrigal – Assistant Director of Basic Training Level, National Aeronautical University of Querétaro (UNAQ)

Sorayda Herrera – Head of the Human Resources Department, National Aeronautical University of Querétaro (UNAQ)

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Sachiko García – Human Resources, Bombardier (Manufacturing Center Mexico)

Alfredo Cárdenas – Director, Centre for Research and Technology of Honeywell Aerospace in Mexicali

Francisco J. Lafuente González – Director of Engineering and Development, ITR

Berenice López Félix – Director of Human Resources, Gulfstream Aerospace Mexicali

Alejandro González Montesinos M. – Design Engineer, Gulfstream Aerospace Mexicali

Stephane Vitrac – Director, SNECMA México

Pia Hernandez – Human Resources, Messier Services Americas

Héctor Cobo – Maintenance Director, Mexicana MRO Services

Joseph Alonso – Expert in Mexico of the M.E.N.-M.E.S.R., French Embassy

9.2. Bibliography and References

A Human Resource Study of the Canadian Aviation Manufacturing and Maintenance Industry. November 2002.

Mexican Council of Aerospace Education (COMEA). 2008. Presentation. Ordinary Meeting of FEMIA, December 3, 2008.

Cutcher-Gershenfeld, J., T. Kochan, B. Barrett, E. Rebutisch and R. Scott. Developing a 21st Century Aerospace Workforce. 2001. MIT Labor Aerospace Research Agenda and Lean Aerospace Initiative. Version 2 - White Paper.

EFE. 2007. "Mexico and EU Sign Agreement to Improve Air Safety" Newspaper: *El Universal*, September 18, 2007 <http://www.eluniversal.com.mx/notas/449933.html>

Mexican Aerospace Industry Work Group. 2010. National Flight Plan: Map of Route for Technology for the Mexican Aerospace Industry 2009. Preliminary Version.

Hafeez, Arshad. 2008. «The Future of Aerospace.» Quality (Aerospace Special Section): 14-16.

Hernández, Y., A.L. Rivera, S. Santillán and V.M. Castaño. 2010. «Aviation in Mexico: Current Status and Perspectives. Part I.» Science Today.

INEGI. 2010. « National Occupation and Employment Survey.»

The World Bank. 2003. «Lifelong Learning in the Global Knowledge Economy»

MORALES, Jorge Antonio. 2007. "Application of the Six Sigma Methodology, in the improvement of fuel use for vehicles according to its conditions for use." Thesis for a Master's Degree. Universidad Iberoamericana.

«Regulations EASA. 2003. » Official Journal of the European Union. nº L 315/74. Annex III.

Ministry of Communications and Transportation. Regulations for the issuance of permits, licenses and training certificates for aeronautical personnel.

2010 http://www.sct.gob.mx/fileadmin/normatividad/transporte_aereo_2010/12%20Reglamento%20para%20la%20Expedici%F3n%20de%20Permisos,%20Licencias%20y%20Certificados%20de%20Capacidad%20del%20Personal%20T%20E9cnico%20Aeron%20E1utico.pdf

Rivero, A. 2010 "Country Captures Largest Aerospace Investment" Newspaper: *Reforma.com*, July 26, 2010 <http://www.reforma.com/negocios/articulo/567/1132997/default.asp?Param=4&PlazaConsulta=reforma&EsCobertura=false&DirCobertura=&TipoCob=0>

Solís, Sergio Alberto. 2010. Mexican Aerospace Industry (presentation). Ministry of the Economy

2010. "FAA Lowers Rating for Civil Aviation in Mexico " Newspaper: *El Universal.mx*, July 30, 2010 <http://www.eluniversal.com.mx/notas/698817.html>

Websites

Alamo Area Aerospace Academy. 2010 <http://www.alamo.edu/academies/aaaa.htm>

Bureau of Labor Statistics. 2010. <http://www.bls.gov>

Concordia Instituto for Aerospace Design and Innovation. 2010. <http://ciadi.concordia.ca>

Delft University of Technology. 2009. Degree Program Aerospace Engineering.

<http://www.tudelft.nl/live/pagina.jsp?id=6a4e19d5-abdb-431c-af1d-a128835f8d25&lang=en>

National Polytechnic Institute. 2010. Aeronautical Engineering.

http://www.ipn.mx/WPS/WCM/CONNECT/IPN_HOME/IPN/ESTRUCTURA_PRINCIPAL/OFERTA_EDUCATIVA/SUPERIOR/INGENIERIA_Y_CIENCIAS_FM/TITULOACADEMICO_ESIME_TIC_ING_A.HTM

Technological Institute of Aeronautics - ITA. 2010. Catalogue de [professions. www.ita.br](http://www.ita.br)

Massachusetts Institute of Technology. 2010. Course 16: Aeronautics and Astronautics.

<http://web.mit.edu/aeroastro/academics/undergrad/degrees.html>

ProMéxico. Aeroespacial. 2010.

<http://www.promexico.gob.mx/wb/Promexico/aeroespacial>

Autonomous University of Chihuahua. Aerospace Engineering. 2008.

http://www.uach.mx/academica_y_escolar/carreras/airplanes/2008/11/04/ingeniero_aeroespacial/#

Autonomous University of Nuevo León. 2010. Oferta

Educativa. <http://www.uanl.mx/oferta/licenciatura/facultades/fime/ia.html>

University of Washington. 2010. Certificate Program in Aircraft Composite Structural

Analysis & Design <https://www.aa.washington.edu/courses/compCert.html>

Wikipedia 2010. Aerospace Engineering.

http://en.wikipedia.org/wiki/Aerospace_engineering Wikipedia 2010. Catia.

<http://es.wikipedia.org/wiki/CATIA>

Wikipedia 2010. Computer Numerical Control.

http://es.wikipedia.org/wiki/Control_numérico_por_computadora

Wikipedia 2010. European Aviation Safety Agency

http://en.wikipedia.org/wiki/European_Aviation_Safety_Agency

Wikipedia 2010. Aerospace Industry. http://es.wikipedia.org/wiki/Industria_aeroespacial

10. Annexes

10.1 Methodology of the Study

To properly understand the needs of the industry and how these should be addressed by the national educational system, the following activities were carried out:

Collection and review/analysis of data, literature and news about the industry to understand the general characteristics, identify the principle areas of the value chain for the industry and understand its relative or absolute importance and its perspectives for growth in Mexico.

Collection of information about the skills needed and required by each area of the value chain for the industry by reviewing the literature and websites related to the subject matter in addition to the interviews given by experts and executives of the industry.

Analysis of the educational programs and certifications that are offered and relevant for the industry, by reviewing the statistical data that are available as well as interviews to faculty, experts and industry of the industry. Information was collected, both quantitative (how many individuals who were trained are or will be available in the market) and qualitative (how adequate is the formation with respect to the industry's demands). Comparisons were also made with international programs, based on the information that was available online.

Preparation of conclusions and recommendations, based on the information described above.

10.2. Comparison between the University Syllabus for Aerospace Engineering (national and international)

10.2.1 General Considerations

The text below compares the syllabus of certain universities in Mexico that offer the option of Aerospace or Aeronautical Engineering with those of foreign institutes that are recognized for their quality or whose context has characteristics in common with the Mexican syllabus.

Programs in Mexico include those of the IPN (the only program established decades ago), UACH and UANL, which initiated in 2007-08 and UNAQ, a university that has the characteristic of offering programs from the vocational to postgraduate that focus exclusively on the aerospace industry.

These universities compare, at an international level, with MIT and the University of Delft in Holland, since they are recognized as the two best programs in the world as well as with ITA in Brazil, whose context may be considered similar in terms of the industry, which has a recent development; in addition to the fact that the country has an economic and social development level similar to Mexico.

The most important conclusion for this section of the study is that Mexican institutions are still lacking with respect to the options to gaining practical and professional experience during universities studies. Furthermore, despite the fact that incentives and projects already exist with some universities, the international offer seems to be more related to projects in the industry. In addition to encouraging practical learning, projects and practices may become catalysts for learning transversal skills such as responsibility, team work, punctuality and communication.

The Aeronautical Engineering Program of IPN is imparted in two locations: at the School for Mechanical and Electrical Engineering of the Ticomán Unit and at the Professional Interdisciplinary Institute of Engineering of Guanajuato. Students may choose either option for specialization: design and construction and air transportation operation; both share the same subjects (including humanity courses) until fourth semester.

The Aeronautical Engineering Program of UACH offers, in theory, an overview of the engineering basics; the aeronautical specialization starts after the seventh semester. Therefore, the graduates' profile allows them to be employed in other sectors, such as the automobile or metallurgical. English is taught during five semesters and offers the option to certify this skill in the university to students who are not proficient prior to entering the program. The syllabus for the Aeronautical Engineering Program of the UANL is

characterized by its vast number of optional and supplementary classes, including those of humanities (such as Selected Topics for General University Formation or the subject matter of Art Appreciation), which complements the technical and scientific profile of its graduates. Additionally, it identifies the current social context of the profession, which permits students to understand the importance and impact to its career. The program also identifies the current social context of the profession, which allows the student to understand the relevance and impact to its career. Unlike the syllabus of UACH, an English course is not taught; however, the prerequisite for acceptance into the program is to have command of second language, preferably English, which is evaluated by an EXCI exam and a personal interview with the program's acceptance board.

Lastly, the UNAQ offers an Aeronautical Engineering Program in Manufacturing. Its syllabus includes an internship and a project during the last year. The university encourages graduates not only to have technical skills and abilities to develop in the aerospace industry, but also requires knowing English and project management skills.

In general, the syllabus of the Delft programs includes many projects, practices and exercises to enrich the theoretical subjects. Sustainable development is an innovative class that is offered as well as the possibility of specializing in this area after the third year. This course addresses the current trend of making engineering (aerospace, specifically) a sustainable activity.

Moreover, at MIT, the Aerospace Engineering Program is divided into Aerospace Engineering and Aeronautical Engineering with IT. An important characteristics of these programs is their extensive computer content and, as a result, their focus towards design, implementation and operation, more than on maintenance. Additionally, it offers students internships in companies during the summer. These internships are taken into account as college credits. This is an opportunity for students to gain work experience in the field they are interested in and to apply their know-how in the class in a real-life project.

Finally, the Aeronautical Engineering Program of ITA in Brazil focuses the first two years on basic course work for various engineering programs and, subsequently, students choose their field of specialization. All the programs include English courses as well as having elective courses in the humanities and a sporting activity. Specifically, the aeronautical engineering program requires students to do internships in Brazil or abroad for a certain amount of hours (between 380 and 500).

10.2.2 Program Syllabus

Aerospace Engineering of the Autonomous University of Chihuahua (UACH)

First Semester:

Advanced Algebra; Differential and Integral Calculus; Drawing; Basic Physics, English III; Physics Lab; Society and Culture, technology and Information Management.

Second Semester:

Lineal Algebra; Applied Calculus; English IV; Introduction to Economic Development; Chemistry Lab; Language and Communication; General Chemistry; University and Knowledge.

Third Semester:

Business Administration; Accounting, Differential Equations; Electricity and Magnetism

Lab; Advanced English I; Static Lab; Programming.

Fourth Semester:

Vector Calculus; Analysis of Electric Circuits; Electric Circuits Lab; Dynamics; Dynamics Lab; Material Mechanics; Material Mechanics Lab; Numerical Methods; Probability and Statistics I; Advanced English II.

Fifth Semester:

Metallurgy; Metallurgy Lab; Material Mechanics II; Material Mechanics Lab II; Advanced Drawing I; Probability and Statistics II; preparation for TOEFL exam.

Sixth Semester:

Thermodynamics; Thermodynamics Lab; Elective I; Elective Lab I; Project Management; Elective II; Quality Systems; Electives.

Seventh Semester:

Aerodynamics I; Orbital Mechanics and Environmental Space; Writing and Comprehension (SPCD); Aerospace Structures.

Eighth Semester:

Aerodynamics II; Flight Dynamics and Control; Aerospace Engineering Systems; Verbal Communication; Propulsion.

Eighth Semester:

Heat Transfer; Aerofluids Lab; Aerospace Cover Design; Aerospace Production and Manufacturing.

Aerospace Engineering of the Delft University of Technology (TU Delft) of Holland

First Year:

Introduction to Aerospace Engineering Project; Computer Aided Design; Spatial Insight and Computer Application; Aerodynamics Project; Introduction to Aerospace Engineering Lab Exercise; Introduction to Aerospace Engineering Course; Projection Methods and Introduction to Engineering Drawing; Structures project; Introduction to Aerospace Engineering I; Introduction to Aerospace Engineering II-B; Introduction to Aerospace Engineering II-A; Aerospace Materials & Manufacturing I; Space Engineering & Technology I; Delft Applied Mechanics Course: Statics; Delft Applied Mechanics Course: Dynamics; Delft Applied Mechanics Course: Mechanics of Materials; Introduction to Computer Programming; Introduction to Computer Programming (Lab); Refresher Track; Calculus; Linear Algebra.

Second Year:

Second Year Project Part I; Second Year Project Part II; Aerodynamics B; Thermodynamics and Compressible Aerodynamics; Low Speed Wind tunnel Practical; Supersonic Wind Tunnel Exercise; Airplane Performance II; Test Flight; Aircraft Stress Analysis and Structural Design; Aircraft Structural Analysis I; Aerospace Materials and Manufacturing II; Practical Materials Science; Vibrations of Aerospace Structures; Probability and Observation Theory; Introduction to Earth Observation; Space Engineering and Technology II; Differential Equations; Technical Writing

Third Year: mandatory subjects:

Design Synthesis Exercise; Low Speed Wind tunnel Test 3; Thermodynamics and Gas Turbines; Flight Dynamics I; Exercise Flight Dynamics and Simulation; Dynamics and Stability; Sustainable Development for Aerospace Engineers; Oral Presentation

Third Year: electives (optative):

Minor Aerospace Analysis and Development

Computational Fluid and Solid Mechanics; Computational Fluid and Solid Mechanics Practical; Constitutive Modeling in Aerospace Engineering; Aerospace Systems and Control Theory; Aerospace Systems and Control Theory Practical; Systems Engineering and Technical Management Techniques; Modern Materials for Aerospace Applications Part A; Modern Materials for Aerospace Applications Part B; Partial Differential Equations

Minor Aerospace Design and Technology

Aircraft Design; Computational Fluid and Solid Mechanics; Computational Fluid and Solid Mechanics Practical; Space Engineering and Technology III; Exercise Space Engineering and Technology; Systems Engineering and Technical Management Techniques; Aircraft Systems; Electronic Circuits

Minor Aerospace Operation and Exploitation

Air Transportation and Systems I; Air Transportation and Systems II; Strategic Planning for Airport Systems Practical; Aerospace Systems and Control Theory; Aerospace Systems and Control Theory Practical; Space Engineering and Technology III; Exercise Space Engineering and Technology; Systems Engineering and Technical Management Techniques; Numerical Methods for Differential Equations; Numerical Mathematics (Lab); Business Economics for Aerospace Engineers

Minor Aerospace for Sustainable Earth

Aircraft Design; Earth and Planetary Observation; Systems Engineering and Technical Management Techniques; Practical Electrical Power Generations Storage and Usage; Present Interest in Sustainable Engineering; Electrical Power Engineering; Case Study/Mini Project; Introduction to Wind Energy

MIT Aerospace Engineering (USA)

Core Subjects

Fundamentals of Engineering Design: Explore Space; Sea and Earth; Introduction to Aerospace and Design; Dynamics; Principles of Automatic Control; Introduction to Computers and Engineering Problem Solving; Probabilistic Systems Analysis; Differential Equations

Aerospace Engineering

Aerodynamics: Special Subjects in Fluids and Propulsion; Flight Vehicle Aerodynamics; Compressible Internal Flow and Aero-acoustics; Advanced Special Subject in Mechanics and Physics of Fluids (1); Advanced Special Subject in Mechanics and Physics of Fluids

(2)

Structural Mechanics: Special Subject in Materials and Structures; Manufacturing with Advanced Composite Materials; Structural Dynamics and Vibrations; Mechanics of Heterogeneous Materials; Computational Mechanics of Materials; Plates and Shells; Materials and Processes Micro-electromechanical Devices and Systems; Advanced Special Subject in Materials and Structures (1); Advances Special Subject in Materials and Structures (2)

Introduction to Propulsion Systems: Aircraft Engines and Gas Turbines; Rocket Propulsion; Space Propulsion; Internal Flows in Turbo-machines; Ionized Gases; Aircraft Gas Unit Structures; Advanced Special Subject in Propulsion and Energy Conversion (1); Advanced Special Subject in Propulsion Energy Conversion (2)

Computational Methods in Aerospace and Engineering: Numerical Methods for Partial Differential Equations; Advanced Topics in Numerical Methods for Partial Differential Equations; Advanced Special Subject in Computation (1); Advanced Special Subject in Computation (2)

Aeronautical Engineering with IT

Feedback Control Systems: Special Subject in Control; Dynamics and Automation; Feedback Control Systems; Stochastic Estimation Control; Principles of Optimal Control; Aircraft Stability and Control; Spacecraft and Aircraft Sensors and Instrumentation

Real-Time Systems and Software: Concepts in the Engineering of Software

Communication Systems and Networks: Data-Communication Networks; Statistics for Engineers and Scientists; Principles of Wide Bandwidth Communication; Advanced Special Subject in Information and Control (1); Advanced Special Subject in Information and Control (2)

Human Factors Engineering: Special Subject in Communication and Software; Robotics: Science and Systems I; Robotics: Science and Systems II

Principles of Autonomy and Decision Making: Cognitive Robotics; Principles of Autonomy and Decision Making; Planning Under Uncertainty; Human Supervisory Control of Automated Systems; Aerospace Biomedical and Life Support Engineering; Sensory-Neural Systems: Spatial Orientation from End Organs to Behavior and Adaptation; Human Factors Engineering; Biomedical Signal and Image Processing; Bioengineering Journal Article Seminar; Statistical Methods in Experimental Design; Human-Computer Interface Design Colloquium; Advanced Special Subject in Humans and Automation (1); Advanced Special Subject in Human and Automation (2)

Flight Vehicle Engineering/Space Systems Engineering: Experimental Project Laboratory; Experimental Project; Space Systems Development; Flight System Development

Aerospace Engineering of the National Polytechnic Institute (IPN)

OPTION: DESIGN AND CONSTRUCTION

First Semester:

Differential Calculus; Classical Physics; Fundamentals of Algebra; Fundamentals of Programming; Humanities I: Engineering, Science and Society; Basic Chemistry.

Second Semester:

Vector Calculus; Differential Equations; Electricity and Magnetism; Humanities II: Communication and Engineering; Programming Geared Towards Objects; Applied Chemistry.

Third Semester:

Numerical Analysis; Fundamental of Electrical Circuits; Engineering of Materials; Introduction to Modern Physics; Advanced Mathematics; Mechanics of Solids; Thermodynamics and Principles of Heat Transference.

Fourth Semester:

Dynamics of Fluids; Computer Design; Flexion; Metallurgy; Probabilities and Statistics; Aircraft Electrical Systems; Propulsion Systems.

Fifth Semester:

Aerodynamics; Matrix Analysis of Structures; Analogical and Digital Devices; Fundamentals of Internal Combustion Engines; Humanities III: Human Development, Manufacturing Processes.

Sixth Semester:

Design of elements of machines; Thin Wall Structures; Mechanics of Flight; Systems of Internal Combustion Engines; Digital Electronic Systems.

Seventh Semester:

Flight Dynamics; Humanities IV: Humanism in light of Globalization; Research Methodology or Select Topics in Engineering I; Composite Materials; Structures Optative I; Thermal Engineering Optative I; Administration Theory.

Eighth Semester:

Database Design; Aerodynamic Optative II; Thermal Engineering Optative II; Project Planning and Evaluation; Structure Optative II; Aircraft Control Systems.

Structure Optative I:

Aero elasticity; Structural Dynamics; Fracture Mechanics.

Thermal Engineering Optative I

Design of elements for Alternative Engine; Design and Technical Information Management for Engines; Thermo fluids.

Aerodynamic Optative

Experimental Aerodynamics; Supersonic Aerodynamics; Dynamics Computational Fluid; Aerodynamic Design, Engineering Project or Selected Topics of Engineering II.

Engineering Optative II

Experimental Analysis of Efforts; Aeronautical Constructions, Structural Mechanics of Composite Materials, Engineering Project or Selected Topics of Engineering II.

Thermal Engineering Optative II

Dynamics of Internal Combustion Engines; Design Elements for Aero reactor Engines;

Engineering Applied to Engine Construction; Engineering Project or Selected Topics of Engineering.

Technological Optative

Analysis of Dynamic Systems; Corrosion of Metals in Aeronautics; Applications of Software for Engineering, Hydro-Pneumatic, Aeronautical Communications; Engineering Project or Selected Topics of Engineering II.

OPTION: AIR TRANSPORTATION OPERATION

First Semester:

Differential and Integral Calculus; Classical Physics; Fundamentals of Programming; Humanities I: Engineering, Science and Society; Basic Chemistry.

Second Semester:

Vector Calculus; Differential Equations; Electricity and Magnetism; Humanities II: Communication and Engineering; Programming Geared Towards Objects; Applied Chemistry.

Third Semester:

Numerical Analysis; Fundamental of Electrical Circuits; Engineering of Materials; Introduction to Modern Physics; Advanced Mathematics; Mechanics of Solids; Thermodynamics and Principles of Heat Transference.

Fourth Semester:

Dynamics of Fluids; Computer Design; Flexion; Metallurgy; Probabilities and Statistics; Aircraft Electrical Systems; Propulsion Systems.

Fifth Semester:

Aerodynamics; Database Design; Fundamentals of Internal Combustion Engines; Humanities III: Human Development, Aeronautical Legislation; Navigation Area.

Sixth Semester:

Humanities IV: Personal and Professional Development; Engineering of Operations; Flight Mechanics; Optative I, Systems for Internal Combustion Engines, Aircraft Systems.

Seventh Semester:

Avionics; Humanism in light of Globalization; Research Methodology or Select Topics in Engineering I (5 or 6), Optative II (5) or (6); Structural Repairs; Administration Theory

Eighth Semester:

Aeronautical Manufacturing; Optative IV (5) or (6); Engineering Project or Selected Topics of Engineering (5) or (6); Quality Systems; Technology of Composite Materials (5); Aeronautical Operations Project (6); Aeronautical Maintenance Project.

Optative I: Airports; Maintenance Engineering

Optative II: Airport Engineering; Engine Engineering

Optative III: Civil Aviation Safety; Avionic Maintenance

Optative IV: Aircraft Performance; Performance and Tests to Propulsive Systems

Aeronautical Engineering of the Autonomous University of Nuevo León (UANL)

First Semester:

Translational and rotational Mechanics; Algebra for Engineering; Differential Calculus; Drawing for Engineering; General Chemistry; Application of IT; Communicative Skills.

Second Semester:

Waves and Heat; Basic Programming; Calculus, Integration Workshop; Science of Materials, Social Context of the Profession; Art Appreciation.

Third Semester:

Probability and Statistics; Electromagnetism; Differential Equations, Static, Manufacturing Processes, Fluid Mechanics, Introduction to Aerospace Science.

Fourth Semester:

Basic Thermodynamics; Electrical Circuits; Fourier Series and Laplace Transformers; Dynamics; Mechanics of Materials, Fluid Power, Complementary of Basic Sciences.

Fifth Semester:

Thermodynamics of Gases and Vapors; Electrical Machines; Aerospace Materials; Mechanical Vibrations; Workshop of Computer Aided Design; Complementary of Basic Science (1), Complementary of Basic Sciences (2).

Sixth Semester:

Compressible Fluid; Aerodynamics I; Control Engineering; Heat Transfer; Mechanics of Materials; Complementary to Engineering Sciences; Complementary to Other Courses; Selected Topics in General University Formation.

Seventh Semester:

Combustion, Measurement Techniques, Flight Dynamics, Design of Aerospace Structures; Complementary to Engineering Sciences; Selected Topics in General University Formation.

Eighth Semester:

Aircraft Propulsion Systems; Structural Dynamics, Regulations and Legislation; Complementary to Applied Engineering; Selected Topics in General University Formation (1); Selected Topics in General University Formation.

Ninth Semester:

Project IAE I; Workshop of Aerospace Structures; Selected Topics IAE I; Environment and Sustainability; Complementary to Applied Engineering.

Tenth Semester:

Project IAE II; Ethics, Society and Profession; Selected Topics IAE II; Complementary to Applied Engineering

Supplementary Basic Sciences

Inferential Statistics; Linear Algebra; Numerical Analysis, Modern Physics, Advanced Mathematics.

Supplementary Engineering Sciences

Transport Phenomena, Introduction to Mechatronics, Instrumentation, Electronics Engineering, Dimensional Metrology, Turbo-machinery.

Other Additional Courses

Aeronautics Quality Assurance; Project Evaluation; Aeronautical International Trade; Airport Environment; Operational Safety.

Supplementary Applied Engineering

Characterization of Materials; Aerospace Materials II; Failure Analysis; Analysis of Finite Elements; Dynamics of Computational Fluid; Aerodynamic II; Aircraft Hydraulic Systems; Aircraft Conceptual Design; Management of Aeronautical Maintenance; Aircraft Maintenance; Analysis of Vibration Applied to the Maintenance; Communications Engineering; Avionics.

Selected Topics in General University Formation

Selected Topics of Foreign Languages and Cultures; Selected Topics of Social Sciences, Arts and Humanities; Selected Topics of Academic and Professional Development; Selected Topics of Human Development, Health and Sports.

Aeronautical Engineering in Manufacturing of the UNAQ

First Semester:

Mathematics for Engineering I; Electricity and Magnetism; Introduction to the Aeronautical and Aerospace Industry; Technical Communication for Engineering I; Professional Development.

Second Semester:

Mathematics for Engineering II; Descriptive Statistics; Kinematics and Dynamics; Computer Science; Regulations; Industry and Labor; Technical Communication for Engineering II.

Third Semester:

Differential Equations; Inferential Statistics; General Chemistry; Thermodynamics; Introduction to Engineering Manufacturing and Quality; Technical Drawing and CAD.

Fourth Semester:

Numerical Methods; Heat Transfer; Fundamentals of Metallurgy; Quality and Troubleshooting Skills; Inorganic Chemistry; Solid Models.

Fifth Semester:

Organic Chemistry; Fluid Mechanics; Process Control; Instrumentation; Control and Methodology; Resistance to Materials.

Sixth Semester:

Aerodynamics and Flight Mechanics; Environmental Engineering; Plant Distribution and Handling of Materials; Polymers and Ceramics, Electrochemistry.

Seventh Semester:

Engines I; Quality Control I; Production Systems; Compound Materials; Corrosion and Protection; Devices and Mechanisms.

Eighth Semester:

Engines II; Quality Control II; Leadership and Group Management; Chemical Treatments and Electrochemical; Manufacturing Process I; Structure Design.

Ninth Semester:

Aircraft Systems; Cost Engineering; Welding; Thermic Treatments; Superficial Treatments; Manufacturing Processes II.

Eleventh Semester:

Internship

Twelfth Semester:

Project Management; Development of New Parts; Malfunction Prevention and Analysis; Non-Destructive Testing; Final Project.

Aeronautical Engineering of the Technical Institute of Aeronautics - ITA

Core Subjects:

First Semester:

Introduction to Computer Science; Differential and Integral Calculus I; Vectors and Analytic Geometry; General Chemistry I; Geometric Modeling and Descriptive Geometry; Epistemology and Philosophy of Science; Symposium; Sports.

Second Semester:

Mechanics; Differential and Integral Calculus II; Linear Algebra and Applications; General Chemistry II; Technical Design; Technology and Society; Algorithms; Data Structures; Sports.

Third Semester:

Mechanics II; Electricity and Magnetism; Ordinary Differential Equations; Vector Calculus; Introduction to Engineering, Elective Course; Computational Mathematics.

Fourth Semester:

Waves and Modern Physics; Partial Differential Equations; Functions of Complex Variance, Probability and Statistics; Elective Course; Solids Mechanics, Thermodynamics.

OPTION: AERONAUTICAL ENGINEERING

Fifth Semester:

Fluid Dynamics; Structure Theory; Applied Electronics; Engineering of Materials I; Aeronautical Propulsion I; Elective Course.

Sixth Semester:

Dynamic of Gases; Theory of Aeronautical Structures; Heat Transfer; Engineering Materials II; Aircraft Performance; Aircraft Project I; Aeronautical Propulsion II.

Seventh Semester:

Aerodynamic Propellers and Fuselage; Aeronautical Structure Theory II; Fundamentals of Theory of Control; Aircraft Conceptual Project; Aeronautical Propulsion III; Elective Course.

Eighth Semester:

Electro-Technical Applied to Aircraft; Structural Dynamics and Aero-Elasticity; Aircraft Systems; Aircraft Stability Control; Aircraft Advanced Project; Elective Course; Optative Discipline.

Ninth Semester:

Option A: Supervised internship in Brazil, 360 hours

Option B: Supervised internship abroad, 500 hours

Tenth Semester:

Graduation Project; Avionics; Principles of Economics; Principles of Law.

Elective Courses of the Humanities Department:

Ethics, Reading and Writing in Portuguese; Conversational Portuguese; Instrumental English I; Instrumental English II; Conversational English; Individual and Society; Technologies and Cultural Movements; Historical Formation of the Globalized World; Social Aspects of Production Organization; History of Science and Technology of Brazil; Brazilian Culture; Political Theory; History of Aeronautic Technology; Social Theory and Environment.

10.3 CONALEP Programs

Currently, the CONALEP offers the following programs for the aerospace industry, specifically focusing on the MRO subsector:

1. Professional Technician and Professional Technician with a Bachelor's Degree³⁴ in Engine Maintenance and Planners: focused on developing the necessary skills to maintain and repair engine systems and components of aircrafts (maintenance control, diagnostics and malfunction repairs, airworthiness assessment, etc.).
2. Professional Technician and Professional Technician with a Bachelor's Degree in Aircraft Lamination and Covering: focused on developing the necessary skills to maintain and repair metal structures and compound materials of the aircrafts (maintenance control, diagnostics and malfunction repairs, prevention of corrosion, airworthiness assessment, etc.).
3. Professional Technician and Professional Technician with a Bachelor's Degree Aviation Electronic Systems: focused on developing the necessary skills to maintain and repair the electronic systems of aircrafts (maintenance control, diagnostics and malfunction repairs, airworthiness assessment, etc.).

All of these programs are offered in Mexico City (Airport Campus). Also, the Engine Maintenance and Planners Programs are offered in the states of Jalisco, Nuevo León, Querétaro and Quintana Roo.

It is important to note that despite the fact that four companies develop MRO activities in Baja California, CONALEP does not offer these programs in this state. However, in Jalisco, where there are no MRO industries and in Quintana Roo, which does not have any

³⁴ The Technical Professional Program of CONALEP is geared towards individuals who wish to enter the job market after finishing their studies while the Technical Professionals with a Bachelor's Degree provides students with the skills to continue with further studies, if they so wishes.

company in this industry, the aforementioned programs are imparted by CONALEP.

10.4 European Union: Regulation for the Necessary Training to Perform MRO Operations

The European Aviation Safety Agency (EASA) is an agency of the European Union, which is in charge of regulating and certifying the training of the staff responsible for aircraft maintenance.

EASA regulation establishes three levels of training and certification³⁵:

- 1) Category A: Mechanical Maintenance Line
Licensees are authorized to certify the proper execution of certain routine maintenance and basic repairs (specified in the license, depending on the specific training that was received), which they personally performed in the authorized company/organization.
- 2) Category B: Mechanical Maintenance Line with Specialization in Mechanics (B1) or Avionics (B2)
Licensees are authorized to certify the proper execution of certain maintenance works and basic and more complex repairs (specified in the license, depending on the specific training that was received) in the authorized company/organization.
- 3) Category C: Maintenance Engineer
Licensees are authorized to certify the proper execution of all maintenance and repair operations of an aircraft in the authorized company/organization.

The licensing requirements include being minimum age (18 years), having theoretical know-how (confirmed by exams or by holding certain technical qualifications) and experience and relevant training. The effectiveness of the license is subject to the continuous execution of the maintenance work on the aircrafts (licensees need to have at least 6 months of experience within the last two years to exercise their privileges).

It is important to note that in the European Union, authorization to perform maintenance and repairs is subject not only to the certification as a mechanic, technician or engineer responsible, but also to the certification of the organization or company where the work is performed. Requirements for certification by the organizations or companies are listed in section 145 of EASA regulations.

EASA regulations also establish the minimum requirements to grant licenses for the operation of training schools in aircraft maintenance.³⁶ This includes the requirements for the staff (i.e. know-how and continuous training for the trainers), teaching spaces and equipment. Licenses are granted by the competent authorities of each state who is a member of the European Union.

10.5 Technical Skills Certification System for the Canadian Aerospace Industry

The Canadian Aviation Maintenance Council (CAMC) is a non-profit organization whose

³⁵ EASA Regulation, Section 66, published in the Official Journal of the European Union on November 28, 2003.

³⁶ EASA Regulation, Section 147, published in the Official Journal of the European Union on November 28, 2003.

mission is to develop, promote and administrate an effective human resource strategy for the aeronautical and aerospace industry of Canada. This council is in charge of publishing the National Standards of Occupations based on the registration logs and syllabus.

The Council has an Accreditation Board formed by corporate, labor, military and educational representatives who seek for the companies' training programs to be high quality and to respond to the needs and practices of the industry.

Additionally, the Certification Board issues recommendations about technical and administrative aspects of the certification system for 28 technical profiles and 1 bachelor's degree. To become certified, each candidate must be able to complete different tasks under the supervision of an independent evaluator, as well as meet certain skills and training requirements. Once all the requirements are complied with, the candidate may apply for the Council to review his/her candidature and to certify, if he/she passes, the knowledge, skills and competences of the applicant, issuing a valid document in Canada.

Image 13: Catalogue of Occupations and Requirements for Certification by CAMC

Occupation	Minimum Level of Formal Education Required	Other Requirements
Technician specializing in repairs and examinations of aircraft gas turbine engines	Vocational Junior High School	Dexterity with manuals and skills in reading compression and good physical condition. Documented three years' experience, also qualifies for certification.
Technician specializing in aircraft interiors	Vocational Junior High School	Minimum 48 month experience
Technician specializing in aircraft maintenance	Vocational Junior High School	Minimum 48 month experience, documented
Technician specializing in aircraft propellers	Vocational Junior High School	Minimum 60 months experience in the trade or 36 months in the trade and 24 in any other recognized by CAMC
Technician specializing in aircraft explosive engines	Vocational Junior High School	Diploma in aircraft maintenance, minimum 48 month experience
Technician specializing in aircraft simulators	Vocational Junior High School	4 years' experience or 2 years' experience with a degree in Industrial Engineering, Avionics or with a degree from an Electro-Technical Program
Technician specializing in aircraft structures	Vocational Junior High School	36 months training
Aircraft Maintenance Inspector	Vocational Junior High School	5 years' experience or 1 year experience and an engineering license in aircraft maintenance
Technician specializing in electrical components / electronics / aviation instrumentation	Vocational Junior High School	3 years' experience or 24 months experience with a diploma in avionics
Aviation Machinist	Vocational Junior High School	Good physical condition, coordination, dexterity and mathematical abilities; 60 months experience, documented
Technician specializing in aviation mechanical components	Vocational Junior High School	36 months experience
Technician specializing non-destructive aviation inspection	Vocational Junior High School	Accreditation of specialized training courses; passing the exam by the Canadian General Standards Board
Aviation painter	Vocational Junior High School	Good physical condition and coordination; 5,000 hours or 3 years' experience.
Technician specializing in special aviation processes	Vocational Junior High School	Minimum 2 years' experience and 6 months in any area of expertise
Technician specializing in aviation welding	High School	Good physical condition; minimum 60 months experience or 24 months of experience with a certification issued by any province
Technician specializing in avionics maintenance	Vocational Junior High School	Minimum 48 month experience
Structure assembler	Vocational Junior High School	Minimum 24 month experience
Aircraft mechanic assembler	Vocational Junior High School	Minimum 24 month experience
Electronic/electrical assembler	Vocational Junior High School	Minimum 24 month experience
Compound manufacturer	Vocational Junior High School	Minimum 24 month experience
Fuel suppliers for aircrafts	Vocational Junior High School	1 year experience, license as an operator of heavy equipment, safety training and fire control
Aviation services assistant, on land	Vocational Junior High School	1 year experience for specialists, level 1 and 2 years for specialists level 2; license as an operator of heavy equipment, safety training and fire control
Specialist in aerospace materials	Vocational Junior High School	1 year experience for specialists, level 1 and 2 years for specialists level 2
Maintenance manager	Vocational Junior High School	30 to 72 months experience depending on the management level
Engineering license for aircraft maintenance	Vocational Junior High School	Adults, certified training, 18 to 24 months experience
Aeronautical and aerospace engineering	Engineering Bachelor's Degree	3 to 4 years' experience, supervised, passing the practical portion of the professional exam
Quality control technician	Vocational Junior High School	Engineering license for aircraft maintenance, maintenance and inspection certificate, skills in technical drawing
Technician specializing in dynamic helicopter components	Vocational Junior High School	Accreditation of technical programs on helicopter components and aviation maintenance
Storekeeper of aviation tools	Vocational Junior High School	Computer and telephone skills

Source: Catalogue of aviation and aeronautical occupations of the Canadian Aviation Maintenance Council

10.6 List of Occupations in the Aerospace Industry (US).

The following table reports the main occupations of the workers in the US aerospace industry and the number and percentage of employees in each occupation in 1998.

Image 14: Occupations in the US aerospace industry, 2008

Occupation	No. of employees in 2008, '000	% over total	Change expected 2008-18, %
Management, business and financial occupations	81.0	16.1	0.2
General and operations managers	4.6	0.9	-11.3
Production managers	4.4	0.9	-2.8
Engineering managers	7.7	1.5	-2.8
Purchasing managers	10.7	2.1	6.9
Logistics personnel	6.1	1.2	6.9
Corporate analysts	8.6	1.7	-2.8
Computer and mathematical science occupations	31.9	6.3	5.1
Computer science engineers	21.0	4.2	8.4
Architecture and engineering occupations	110.4	21.9	2.7
Engineers	89.5	17.8	3.8
Office and administrative support occupations	37.2	7.4	-6.2
Employees in the planning and production	7.9	1.6	-2.8
Employees of shipments and receipts	5.8	1.2	-12.5
Administrative assistants and secretaries	7.4	1.5	-5.2
Installation, maintenance, and repair occupations	37.2	8.7	-1.5
Avionics technicians	7.9	1.3	-2.6
Aircraft mechanics and service technicians	5.8	4.7	-2.8
Workers for installation, maintenance and repair of industrial machinery	7.4	1.4	4.5
Production occupations	168.7	33.5	-1.3
Supervisors/ production managers and operators	10.8	2.1	-2.8
Structures, surfaces, and aircraft systems assemblers	39.9	7.9	8.4
Assemblers (equipment)	8.8	1.7	-0.7
Operators of machines controlled by computer (plastic and metal)	8.0	1.6	-2.5
Adjusters and Operators of Cutting Machines	11.5	2.3	-15.3
Machinists	19.8	3.9	-2.8
Inspectors and Evaluators	18.1	3.6	-2.8
Total	503.9	100%	-0.3%

SOURCE: "Developing a 21st Century Aerospace Workforce", BLS National Employment Matrix, 2008-18