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# An Evaluation of the Argentinean Basic Trainer Aircraft Domestic Development Project

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AN EVALUATION OF THE ARGENTINEAN BASIC TRAINER AIRCRAFT
DOMESTIC DEVELOPMENT PROJECT

THESIS

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## Abstract

The Argentine Air Force (AAF) increasingly faces challenges in maintaining and sustaining trainer aircraft. The current trainer aircraft used by the AAF face obsolescence issues and decreased serviceability. Argentina used to have the largest aircraft industry among Latin America countries. A number of factors such as not maintaining objectives and policies over time undermined its consolidation and were instrumental in losing its leader position. In order to meet Air Force requirements and revive the domestic aircraft industry, an indigenous basic trainer aircraft project is considered. The purpose of this thesis is to evaluate the project viability by applying a multi-criteria analysis methodology approach. An evaluation of the project reveals which areas and actions contribute toward the AAF goal of increasing training aircraft availability. The technical analysis includes utilization of a multi-criteria analysis methodology approach. The economical analysis perspective includes both cost-benefit and cost-efficiency approaches. Alternative solutions are considered as well as key aspects for their comparison. Finally, the proposed option minimizes aircraft inventory diversity, while maximizing consistency, sustainability and versatility.

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*To my family*

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Guillermo A. Stahl

## Table of Contents

Page

Page

## List of Figures

## List of Tables

**List of Equations**

AN EVALUATION OF THE ARGENTINEAN BASIC TRAINER AIRCRAFT DOMESTIC DEVELOPMENT PROJECT

# I. Introduction

## Background

Among all Latin America countries, Argentine was the first to develop the Aerospace Industry. It used to be at the forefront of production in the region. This "state-owned industry" for most of its history has been rich in a number of projects, technological milestones and outstanding personalities.

Since the birth of aviation in Argentina, when the Military Aviation Academy was created in 1912, the State has actively participated in supporting the aeronautical activity. Moreover, it has been crossed by political vicissitudes, opposing ideological beliefs about the state's participation in the domestic industry, the passion that aircrafts awake in men's minds and the deep desire of sharing the great dynamics of this activity.

The aerospace industry in Argentina traces its roots to October 10th, 1927, when the former Military Aircraft Factory - FMA (*Fábrica Militar de Aviones*) was created and started assembling European aircraft under license. But as early as 1931, it began with the design and manufacturing of national own-designed aircrafts. The aviation industry was developed first before the automaker industry ratifying its deep commitment to this activity.

FMA has gone through various organization types from Argentine Army facility, Argentine Air Force facility, Agency of the Ministry of Aeronautics, State enterprise, joint stock Company with State participation, concession to a corporation without State participation, and since 2010, to an Argentina's State-owned aerospace manufacturer renamed FAdeA S.A.

FAdeA S.A. was born after the Argentinean government re-nationalized the company after a 15-year ownership by Lockheed Martin. This is the first step in the government's attempted revival of a domestic aerospace industry. In this sense, some 25 years after it began work on its last aircraft design project, the Advance Jet Trainer IA-63 Pampa shown in Figure 1, Argentina's FAdeA has disclosed plans to develop a new basic trainer, the IA-73 Project. (Flight International, 2011:19).


**Figure 1: Advance Jet Trainer IA-63 Pampa (FMA's Archive, 1980's)**

The IA-73 is aimed at first replacing the service's Beechcraft T-34/B-45 "Mentor" as the initial trainer. The IA-73 depicted in Figure 2 is also expected to later succeed the Embraer EMB-312 "Tucano" currently operated at the Air Force Academy (Flight International, 2011:19).


**Figure 2: FAdeA S.A. IA-73 Project (FAdeA S.A., 2011)**

## Scope of this study

The scope of this thesis is to develop and discuss a conceptual methodology to assess and evaluate the indigenous project of developing a new basic trainer aircraft, referred as IA-73, domestically in Argentina.

Aircraft manufacturing is a key industry with significant achievements and strategic significance. Aircraft manufacturing contributes to research and development, exports and international trade, and has fast growth. However, it is also one of the most cyclical, technologically-sophisticated, and capital-intensive industries. Therefore aircraft manufacturing is an unlikely place for a developing country to compete (Hira, 2007).

Aircraft manufacturing's leading role derives from the fact that the sector can act as a major employer of manufacturing labor, and its importance in easing balance of payments. However, the connection between demand and technical change determines aircraft enterprises emergence, expansion or contraction. As a creature of technology, the aircraft industry is very sensitive to technical change (Todd, 1986).

The aircraft industry in its present form cannot be only focused on the airframe producers. It includes many high technology components and systems, processes and highly qualified man labor from different companies in a very competing and challenging global market sector.

It is worth stressing that the aircraft airframe industry is not necessarily the most important of the aerospace sector. Just to mention a few examples, aero engines, navigation and flight systems, and aircraft flight simulators are looked upon to counter the country's balance of payments deficit in finished aircraft (Todd, 1986).

The Aerospace Industry Sector is depicted in Figure 3. It shows three tiers following different activities and parts composing their technological complex vehicles. In order to narrow this study, this analysis considers only the TIER I Airframe Manufacturing sector and its necessary integration and relationships with the other ones.

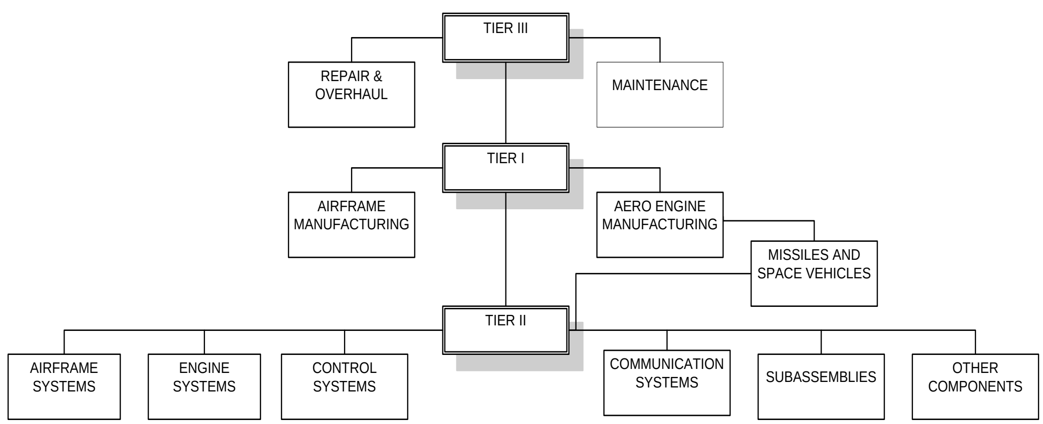


**Figure 3: The Aerospace Industry Sector (Todd, 1986)**

The production patterns of the aircraft industry vary according to the source of demand: markets for civil aircraft behave in a markedly different manner from those regulating demand for warplanes (Todd, 1986).

In this sense, a different taxonomy considers Civil Aerospace Sector (CAS) and the Military Aerospace Sector (MAS), defined and segmented into the following sub-sectors (Deloitte, 2010):

- Aircraft and aircraft part manufacturers (A&AP) (including avionics and electronics)
- Engine and engine part manufacturers (E&EP)
- Maintenance, repair, and overhaul (MRO)
- Space (satellite and space vehicle manufacturing, including guided missiles for the MAS and /or launch service providers for the CAS only)
- Training and Simulation (T&S)

## Problem Statement

The problem statement for this research is:

Is the IA-73 Argentinean Basic-Initial Trainer Aircraft Program a viable option for the Argentine Air Force?

## Research Questions

For this specific research, the IA-73 Basic-Initial Trainer Aircraft Program raises questions about its associated cost, the need for the aircraft, the number of planes needed to meet military requirements, the capabilities it would have, and demand forecast for this kind of trainer, just to mention a few.

Considering that, the following questions arise:

1) How should this IA-73 project be evaluated?

2) What analytical tools are available?

3) What are other project alternatives?

4) What are the key aspects for the alternatives comparison?

Within the spectrum of possible responses, this study is focused on evaluating the project by mean of current methodologies. Some relevant existing and potential factors affecting or limiting the success of the project are addressed.

All private and state participants to include economists, politicians, engineers, etc., industry production, international affairs, objectives and policies framework are considered in order to rule, develop and leverage the project in a systemic and sustainable way.

**Importance of the Problem**

The Argentine Armed Forces have missions and training requirements that impact the country's economics. They increasingly face difficult challenges to maintain and sustain their weapons systems, struggling against diminishing systems lifecycle and rapid technology advancement. In this sense, the Argentine Ministry of Defense and other Organizations / Agencies has wondered about how to maintain defense and training capabilities with low defense sector budgets.

As components in aircraft have become increasingly advanced, so have the costs associated with manufacturing projects. Methods use to evaluate projects are very important especially during their first stages.

An evaluation of the project has to reveal which are those related areas and actions that contribute toward seeking its goals. In the case of this study the Argentine Air Force is seeking to increase aircraft availability (flight hours) to complete pilot basic training courses. Besides that, project evaluation results are useful in understanding which are those links and relationships among strategies, tactics, resources, capabilities, policies, goals, activities, etc., determinant of project success in the short, mid and long term.

Along with what is mentioned, there is a political and strategic state vision looking for developing indigenous industries and encouraging buying domestic products.

Therefore, how projects are analyzed plays a vital role in how wisely Argentina's resources are managed and enhanced, determining demand requirements and evaluating sustainment cost over time, etc.

**Research Limitations**

This research study only focuses on the analysis of comparable technical projects and / or solution alternatives. Inflationary effects analysis, operational and capital costs, etc., are not within the scope of this thesis. Thereafter, the study explores the need for better economic decision support tools in the evaluation, design and development of new projects.

Based on literature surveys, available data, and time frame, the research work focuses mainly on qualitative aspects of the alternative solutions selected for the analysis.

**Preview**

This chapter describes the background, research scope of this study, general problem statement, and research questions. It continued with the importance of the problem and research limitations. Chapter II describes different stages through the Argentine aerospace and defense industry history, pointing out which of those determinant factors contribute or delay the industry maturation and development. It also covers aircraft industry strategic planning, IA-73 program's details, and analyses of trainer aircraft market. Chapter III presents some definitions and the proposed methodology to study the defined problem. Chapter IV applies the previously presented methodology to the proposed defense investment project. Different alternative solutions are compared with a baseline situation where no project is implemented. The analysis of the obtained results looks for satisfying Argentine Air Force requirement of increased aircraft availability (flight hours) to complete pilot basic training courses. Finally, Chapter V discusses conclusions and suggests future research areas.

## II. Literature Review

### Chapter Overview

The first part of this chapter provides a synopsis of the Argentine Aircraft and Defense Industry, describing different stages through its history, pointing out which of those determinant factors contribute or delay the industry maturation and development. Besides that, the chapter details the current Argentine aircraft industry scenario and its Strategic Planning. Many IA-73 program's related issues are covered also as the integrated training system concept, and military pilot's primary-basic training scheme. Finally, some market analyses are presented that can be considerate closely related to this project.

### History

#### *Defense Industry in Argentina*

Argentina is one of the Latin American countries that has shown sustained military industrial activity over a number of years, providing for its own defense needs by stimulating and supporting the local manufacture of arms (Varas, 1989; Maldifassi, 1994). This country was one of a handful of developing nations to aspire to produce the full range of military systems (Ball, 1988). Argentina has attempted to become self-sufficient in arms provision, developing many indigenous projects. Argentina also enjoys a relatively educated and technically sophisticated workforce (Markusen et al., 2003).

The defense industry was established in 1941 by the armed forces after the Second World War embargo on Argentina. The defense industry was composed of three major industries that groups together 48 enterprises (Markusen et al., 2003).

Countries procuring arms for their armed forces from foreign producers are said to be, or to become, dependent on the supplier of arms. Dependence always refers to a relationship established by interaction between two or more actors. Moreover, some arms producers and suppliers themselves are reported to be dependent on arms exports. Arms transfers are important both for avoiding and for creating dependence. First of all, it is a way for governments of states not producing the whole range of armaments to acquire the means they consider necessary for self defense (Catrina, 1988).

Early in the 19th century, the arms industry in Argentina was considered an important driving mechanism of the national industrialization process and also part of the overall economic development strategy adopted by many Argentinean administrations. The main objective of Argentinean arms production was to increase political independence, and the creation of an arms industry was regarded as part of the development strategy adopted by Argentina in the 1930s (Millán, 1986; Landaburu, 1986; Maldifassi, 1994).

However, arms-producing corporations have to be economically viable if they are to exist. If they lose too much money, they have to close. To the degree that export orders keep production running, arms supplying countries are dependent on their customers for the continued viability of their defense industries (Catrina, 1988).

According to Todd (1986), developing countries promoted the aircraft industry for two reasons: in order to further export-led manufacturing expansion in the first place, and to safeguard the supply of military hardware in the second. All those countries persisted in aircraft manufacturing notwithstanding excessive cost and often inefficient production methods because national security concerns are paramount. Dependence of foreign suppliers carries with it an element of vulnerability to embargoes of spare part (Todd, 1986).

After the Cold War, in the subsequent rethinking of national security and institutional context, Argentina first turned to peacekeeping policies. It sought agreements to solve conflicts arising from territorial claims and power struggle issues with its neighbors (Markusen et al., 2003).

### *Argentine Aircraft Industry Genesis*

The aerospace sector, to which the aircraft industry remains central, plays a leading role in the economies. Such a role derives, in the first place, from the fact that the sector can act as a major employer of manufacturing labor (Todd, 1986).

The first milestone in the history of the Argentine aviation industry began in 1908 when the *Aero Club Argentino* was founded at El Palomar. Its workshop facilities were ceded to the Army as a donation for the creation of the military aviation. Later, the Military Aviation School was founded at this location on August 10th, 1912.

At the time of World War I, the country was struggling to acquire flight material. Taking this fact into account, Argentina considered the benefits of having its own aviation industry in order to avoid dependency from international politics.

After sharing a Service Commission in France, Major Engineer Francisco de Arteaga and Marcelo Torcuato de Alvear, at that time Argentine ambassador and afterwards Argentina's President combined efforts to create on October 10th, 1927 the Military Aircraft Factory (hence the acronym FMA- *Fábrica Militar de Aviones*) at Córdoba province, under the presidency of the later.

The FMA mission was not only to manufacture aircraft, but also to industrialize the country, balancing the well known Argentine agricultural, in order to develop the country with its own technologies, manufacturing and exportation of final products (Bonetto, 2004).

On July 18th, 1928 FMA facilities were completed and FMA began to domestically produced aircraft under European licenses: the Avro 504 Gosport training aircraft equipped with a 100 hp (75 kW) Gnome engine. It had a speed of 140 km/h with a flying endurance of 2 hours. But as early as 1931, FMA began with the design and manufacturing of the Ae.C.1 and Ae.C.2 aircraft. The Ae.C.1 made a historic flight between Buenos Aires and Rio de Janeiro in 1933.

In 1944, after Engineer Major Juan Ignacio San Martin took office as company director, the factory took a huge leap forward leading to the employment of 9000 workers in an industrial complex that manufactured not only aircraft, engines, propellers and accessories, but also utility vans, cars, tractors and motorcycles.

The Argentine aircraft IAe DL 22 is shown in Figure 4 and Figure 5. The IAe DL 22 was the driving force of such a significant growth with the manufacturing of two series of 100 aircraft each. The aircraft was equipped with the “gaucho” engine, also manufactured in Córdoba.


**Figure 4: IAe DL 22 (Leonardi, 2003)**

**Figure 5: IAe DL 22 and its engine “gaucho” (Leonardi, 2003)**

The mass production of the Ae.22 "DL", as part of the First Five Year Plan, allowed the FMA to outsource manufacturing of many of its parts setting the grounds for the origin of 107 factories and shops which would later end up as more than 300 with the *Instituto Aeronáutico* (IA) providing technical and economic support whenever necessary. These first companies were the foundations for the automobile industry which later settled in Córdoba.

FMA's vertical integrated strategy played a critical role in order to provide itself with inputs that were strategic for its business. Nowadays, this strategy could appear to be out of synch with the globalized market era. However, at that time, it provided support against dependency, macroeconomic instability, cost swings and political turmoil.

The FMA factory is known for producing the first fighter aircraft in Latin America: the Pulqui I (1947) is shown in Figure 6 and was designed under the direction of the French engineer Emile Dewoitine.

**Figure 6: First Argentine Jet Aircraft IAe 27 Pulqui I (FMA's Archive, 1948)**

The FMA IAe 33 Pulqui II (1950) was a jet fighter aircraft designed under the direction of the German engineer Kurt Tank and it is shown in Figure 7. The political, economic and technical challenges faced by the project meant that the IAe 33 was unable to reach its full potential, and the Argentine government ultimately chose to purchase F-86 Sabre from the United States in lieu of continuing development of the indigenous fighter to production status (Green, 1979).

**Figure 7: IAe 33 Pulqui II (FMA's Archive, 1951)**

Since 1927 over 1500 own-designed and under license aircraft (58 aircraft types have been designed, 25 of which were mass-produced) have been built there, testifying a fruitful and prolific work in the aeronautical field. Nobody can argue its growing influence on the country's industrialization, especially in the province of Córdoba.

Different stages during its history did not change the essence, but undermined its consolidation in an environment where the objectives and policies, when existing, were not maintained over time.

During the 1970s, as in many other countries, there was a trend toward more indigenous designs and productions (relative to licensed production), toward a broader range of products, and toward products of intermediate technological content (Catrina, 1989).

Once a decision to embark on domestic arms production has been taken, it becomes natural to stress the economic benefits that will accrue: foreign exchange savings, export earnings, and improve balance of payments (Catrina, 1989). However, this was not the case.

### *The dismantling of the Argentine Aircraft and Defense industry*

Although Argentina was one of the world's most prosperous developing economies up through the Second World War, it experienced slow economic growth from the 1940s until the start of convertibility Plan in 1991. By the mid-1970s, its economic growth rate had declined significantly and was interpreted widely as a failure to transform the country into a fully integrated global market economy (Markusen et al., 2003).

The end of the Cold War did not precipitate a defense conversion process as in many other developing countries. Rather, it triggered the collapse of the Argentine Defense Industrial Complex – the only wholly owned national heavy industry – through national economic and institutional restructuring (Markusen et al., 2003).

In 1995, FMA was given under concession to Lockheed Martin, one of the largest defense contractors. The same period the Brazilian company Embraer successfully competed with aircraft companies in the developed world, it witnessed the dismantlement of the Argentine aircraft company FMA, which had once been the fifth largest in the world and was organized earlier and had a technological lead on Embraer (Hira, 2007).

Nations with relatively integrated civil/military sectors have found it easier to shift gears than those with defense-specialized firms. Private sector ownership, in most cases, has made it easier for governments to cut spending faster and redirects resources, although aggressive defense industrial lobbies slow down the process (Markusen et al., 2003).

Countries who have expertise in relatively specialized and higher technology markets in aerospace and defense electronics find it easier to shift. However, geographical isolation has made it more difficult to move people and facilities into new activities (Markusen et al., 2003).

Not aiming to go deeper into the causes of the Argentine Defense Industry economic collapse and the dynamics of the implemented defense restructuring through the privatization process, Argentine industry history shows the reasons why a state-owned industry running by the armed forces did not ensure efficient levels of military and civil production to provide adequate national defense (Markusen et al., 2003).

According to G. Caviccia, "…history documents the relative failure of the Argentinean regimes of the 1990s to extract technologies and human skills from the Defense Industry in ways that might have increased the productivity and performance of the Argentinean economy" (Markusen et al., 2003:101).

In 2010, as a final epitaph of the defense restructuring conversion through privatization process -after 15 years of private administration- the concession to Lockheed Martin ended and the National Government purchased the company stocks and set up the new "*Fábrica Argentina de Aviones Brig. San Martín*" FAdeA S.A. which is now wholly owned by the Argentine government.

The United States Department of State Directorate of Defense Trade Controls (DDTC) announced that effective December 18th, 2009, Lockheed Martin Aircraft Argentina would be renamed to *Fábrica Argentina de Aviones "Brigadier San Martin" S.A.* and divested to the Government of Argentina.

***Argentine Aircraft Industry Stages and Production***

The FMA was named through its history stages in different ways:

- Military Aircraft Factory (FMA-*Fábrica Militar de Aviones*)
- Aero Technical Institute (IAE-*Instituto Aerotécnico*).
- Aeronautical and Mechanical State Industries (IAME-*Industrias Aeronáuticas y Mecánicas del Estado*).
- Aeronautical Research and Manufacturing National Direction (DINFIA-*Dirección Nacional de Fabricaciones e Investigación Aeronáutica*).
- Córdoba Material Area (AMC-*Área de Material Córdoba*).
- Aeronautical Material Argentine Factory S.A. (FAMA S.A.-*Fábrica Argentina de Material Aeronáutico S.A.*).
- Lockheed Aircraft Argentina S.A. (LAAS).
- Lockheed Martin Aircraft Argentina S.A. (LMAASA).
- FAdeA S.A. now known as (*Fábrica Argentina de Aviones "Brigadier San Martín" S.A*).

Despite the fact the FMA has produced numerous innovative aircraft prototypes; the state of the Argentine economy has usually prevented most of them from entering large-scale production. Nevertheless the FMA has managed to put several aircraft types of more conventional designs into full productions and licensed aircraft from other countries as well.

Besides aircraft manufacturing, the Argentinean Aerospace Industry has developed many products such as launchers, rockets and missiles, and has performed different activities in the area.

The prefixes used for the aircraft locally developed are:

- **Ae**, for "*Dirección General de Aerotécnica*", on the first period (1927–1936);
- **F.M.A.**, for "*Fábrica Militar de Aviones*", on the second period (1938–1943);
- **I.Ae.**, for "*Instituto Aerotécnico*", on the third period (1943–1952);
- **IA**, (following the production prefixes the former aircrafts used to have), on the fourth (current) period (1952 to present).

The *Instituto Aerotécnico*'s (IA) aircraft production and projects in this first stage from 1927 to 1936 are shown in Table 1.

**Table 1: IA's production and projects (Adapted from MINCYT, 2007).**

| Year | Model | Type | Number Built | Observation |
|---|---|---|---|---|
| 1928 | Avro 504K Gosport | Biplane basic trainer | 31 | License-built. |
| 1930 | Dewoitine D.21 | Biplane fighter | 35 | License-built. |
| 1931 | Ae.C.1 | Civil tourism aircraft - basic trainer | 1 | 1st national design. |
| 1932 | Ae.C.2 | Civil tourism aircraft | 1 | National design |
| 1932 | Ae.M.E.1 | Basic military trainer | 1 | National design |
| 1933 | Ae.T.1 | Transport/commercial aircraft | 3 | National design |
| 1934 | Ae.M.O.1 | Observation monoplane | 41 | National design |
| 1934 | Ae.M.Oe.1 | Observation and training | 6 | Ae.M.O.1 Variant |
| 1934 | Ae.M.Oe.2 | Observation and training | 14 | Ae.M.O.1 Variant |
| 1934 | Ae.C.3 | Civil aircraft | 16 | National design |
| 1935 | Ae.M.B.1 Bombi | Bomber | 1 | FMA's 1st bomber |
| 1935 | Ae.M.B.2 Bombi | Bomber | 14 | National design |
| 1935 | Ae.M.S.1 | Sanitary aircraft | 1 | National design |
| 1936 | Ae.C.3.G | Tourism aircraft | 1 | National design |
| 1936 | Ae.C.4 | Ae.C.3G's improved prototype version | 1 | National design |

The FMA's aircraft production and projects from 1940 to 1950 are shown in Table 2.

**Table 2: FMA's production and projects 1940-1950 (Adapted from MINCYT, 2007).**

| Year | Model | Type | Number Built | Observations |
|---|---|---|---|---|
| 1940 | Curtiss Hawk 75 O | Monoplane fighter | 20 | License built |
| 1940 | Focke-Wulf Fw-44J | Biplane trainer | 190 | License built |
| 1940 | IAe20 Boyero | Tourism aircraft | 130 | National design |
| 1943 | FMA 21 | Advanced trainer | 1 | Prototype |
| 1943 | IAe 22 DL | Advanced trainer | 206 | National design |
| 1945 | IAe 23 | Basic trainer | 1 | Prototype |
| 1945 | IAe 25 Mañque | Assault/Transport glider | 1 | National design |
| 1946 | IAe 24 Calquín | Attack/Light bomber | 100 | National design |
| 1947 | IAe 27 Pulqui I | Jet fighter | 1 | Prototype, 1st jet built in Latin America |
| 1947 | IAe 31 Colibrí | Two-seat Trainer aircraft | 3 | National design |
| 1948 | IAe 30 Ñancú | Fighter/Attack prototype | 1 | National design |
| 1949 | IAe 32 Chingolo | Tourism/Trainer aircraft | 1 | National design |
| 1949 | IAe 34 Clen Antú (Horten XV and XV) | Glider with flying wing | 7 | Designed by Reimar Horten |
| 1950 | IAe 33 Pulqui II | Fighter/Attack prototype | 5 | First swept-wing jet fighter designed in Latin America |

The FMA's aircraft production and projects in the time period from 1953 to early 1960's are shown in Table 3.

**Table 3: FMA's production and projects 1953-1960's (Adapted from MINCYT, 2007).**

| Year | Model | Type | Number Built | Observations |
|---|---|---|---|---|
| 1953 | IAe 35 Huanquero | Transport aircraft | 36 | National design |
| 1953 | IAe 41 Urubú (Horten XVc) | Glider with flying wing | 4 | Designed by Reimar Horten |
| 1953 | IAe 43 Pulqui III | Swept-wing supersonic jet fighter | N/A | Project not built |
| 1953 | IAe 44 DL II | Advanced trainer | N/A | Project not built |
| 1954 | IAe 36 Cóndor | Civil transport | N/A | Project not built |
| 1954 | IAe 37 | Supersonic delta-wing interceptor (Glider, unpowered prototype only) | 1 | Designed by Reimar Horten. |
| 1957 | IAe 46 Ranquel | 2-seat utility aircraft | 217 | National design |
| 1959 | IAe 45 Querandí | Executive transport | 2 | Prototypes only |
| 1960 | IAe 38 Naranjero | Flying-wing transport/cargo | 1 | Designed by Reimar Horten |
| 1960 | IA 35 Guaraní I | Transport aircraft | 1 | Derived from the I.Ae. 35 |
| 1960's | Beechcraft T-34 Mentor | Trainer | 75 | License built |
| 1960's | Morane-Saulnier MS-760 Paris | Trainer | 48 | License built |

The FMA's aircraft production and projects in the time period from 1963 to 1990 are shown in Table 4.

**Table 4: FMA's production and projects 1963-1990 (Adapted from MINCYT, 2007).**

| Year | Model | Type | Number Built | Observations |
|---|---|---|---|---|
| 1963 | IA-50 Guaraní II | Transport aircraft | 26 | Derived from the IA 35 Guaraní I |
| 1975 | FMA IA-58 Pucará | Counter-insurgency/light attack aircraft | 120 | National design |
| 1978 | FMA IA-62 | Military trainer | N/A | Project not built |
| 1983 | FMA IA-66 Pucará II | Counter-insurgency/light attack aircraft | 1 | Improved Pucará's version |
| 1984 | FMA IA-63 Pampa | Advanced trainer | 32 | Currently under production |
| mid-1980's | IA-67 Córdoba | Light attack bomber | N/A | Project not built |
| mid-1980's | FMA SAIA 90 | Supersonic air superiority jet fighter | N/A | Project not built |
| 1990 | Embraer/FMA CBA 123 Vector (IA-70) | Turboprop 19-passenger regional airliner | 2 | Only prototypes built |

The activity performed by Lockheed Martin Aircraft Argentina S.A. during the FMA's privatization stage is shown in Table 5.

**Table 5: LMAASA's activity (Adapted from MINCYT, 2007).**

| Year | Model | Task performed | Observations |
|---|---|---|---|
| 1999 | A-4AR Fighting hawk | Upgrade | Resting fleet aircrafts upgraded by Lockheed Martin in the US |
| 2003 | B-45/T-34 Mentor | Refurbishment | Argentine and Bolivian Air Forces' aircrafts |
| 2006 | C-130 Hercules | Refurbishment | Argentine and Colombian Air Forces' aircrafts |

**Current Aircraft Industry with FAdeA S.A.**

As mentioned before, FAdeA S.A. was revived after the Argentinean government re-nationalized the company after a 15-year ownership by Lockheed Martin. The company traces its roots to 1927, when the former FMA began building European aircraft under license (Armada International, 2011).

Argentina's state-owned FAdeA S.A is funded to manufacture 10 AT-63 Pampa II basic trainers with de-rated Honeywell TFE731-40 turbofans, hoping for sales to Chile and Uruguay. The Argentine Air Force's existing IA-63 Pampas are to be similarly re-engined. The Argentine Navy is also interested in the AT-63 (Armada International, 2011). The activity performed by FAdeA S.A. during current re-state-owned era is shown in Table 6.

**Table 6: FAdeA S.A. activity (FAdeA S.A, 2011).**

| Year | Model | Task performed | Observations |
|---|---|---|---|
| 2009 | FMA IA 63 Pampa | Power plant change | -- |
| 2010 | FMA IA 58 Pucará | Power plant change | -- |
| 2013 | IA 73 | Basic trainer project | T-34/B-45 Mentor's replacement |

Some 25 years after FMA began works on its last aircraft - the IA-63 Pampa -. FAdeA S.A. has disclosed plans to develop a new primary-basic trainer, aiming at rescuing former industrial capabilities and recovering its role as technological leader (Flight International, 2011:19)

The company's board gave the go-ahead for the new IA-73 program for the Argentine Air Force. Aimed at first replacing the service's Beechcraft B-45/T-34 "Mentor" as the initial basic trainer, the IA-73 is also expected to later succeed the Embraer EMB-312 "Tucano" currently operated at the Air Force Academy in Córdoba.

The Argentine Air Force, the Army and the Navy are looking for merging their training syllabus. In this scenario, the IA-73 is also being tailored to replace other fixed-wing trainers such as the Beechcraft T-34C Turbo "Mentor", developing a single-platform training package (Flight International, 2011:19).

The IA-73 is intended to become a training system meeting domestic and South America's training aircraft needs. FAdeA S.A. plans to conclude the IA-73's design definition this year (2012) and to achieve a first flight in early 2013. The company expects to launch production of the aircraft in late 2014 or early 2015 (Flight International, 2011:19).

FAdeA S.A. infrastructure and resources provides capability to build and equip this new aircraft project. Measuring and managing these capabilities and relationships, however, is not as easy. Argentina has also committed to join the Embraer KC-390 twin-jet airlifter program. The arrangement would include a deal allowing FAdeA S.A. to supply spoilers, flap fairings, tail cone, electronic cabinets and doors for the nose landing gear and ramp for all KC-390s. Thus, it would be reinserting FAdeA S.A. and Argentine Aircraft Industry back into the international market and providing access to key production technologies (Flight International, 2011:19).

**Strategic Planning**

Aircraft production is not only one of the most technologically complex sectors. It requires heavy financial investment and suffers from business cycles. It is also incredibly competitive and heavily protected, especially by northern countries (Hira, 2007).

The aircraft industry is capital-intensive and utilizing increasingly advanced and complex products. The reduced lifecycle time and obsolescence costs of these complex products have not only complicated sustainment, but also the manufacturing cycle to the point that new aircraft designs face challenges of obsolescence within, and in some cases before, manufacturing even begins.

A large percentage of the projected cost can be allocated to maintenance and support activities associated with keeping the production facility at a desirable operational state. The cost of system maintenance and support can often be in the range of up to 75 % of the total life-cycle cost of the given system (Blanchard et al., 1995).

Therefore, this industry demands a strategic vision in order to be successful. At the same time, the Argentine Air Force is faced with difficult decisions concerning force structure and resource needs to enable its mission as it is transformed, consolidated, and realigned.

Now more than ever, Project Managers must be able to provide support for planning and decision-making with defensible cost/benefit, operational risk, and compliance risk analyses of different management alternatives.

The analysis and comparison of different strategies have to provide a framework to evaluate long-term cost for specific system projects and to develop an attainable low-cost sustainment strategy. This demands to strive towards increasing efficiency and reducing costs associated with project management, while improving the cooperation and interaction among stakeholders.

The results of inadequate strategic planning in the long range can vary from seasonal to permanent operational and logistic constraints. They can include, for example, maintainability/availability and related mission sustainability limitations, operational restrictions such as limiting flying hours, restrictions in support functions, training limitations, etc.

The IA-73 program is discussed next in order to build a foundation for this study.

## The IA-73 Program

### *IA-73 Operational Requirement*

The IA-73 is a light military training aircraft being designed and assembled in Argentina by FAdeA S.A. and scheduled to enter service by 2015. In December 2009, FAdeA S.A. started the project assessment phase. The IA-73 is a replacement for the Beechcraft B-45/T-34 “Mentor” and the Embraer Emb-312 “Tucano” military trainer aircrafts operated by the Argentinean Air Force. The IA-73 project was launched in September 2010 using company's own funds and sales planned for the Argentinean Ministry of Defense and export customers worldwide. Universities, research centers and small businesses across the Cordoba region are expected to get involved in this project.

#### Purpose

Primary-basic trainer aircraft for Argentinean Armed Forces pilot officers, Security Forces and partner countries designated in the development of the Basic Course Curricula for Joint Military Aviators (CBCAM), Pilot's Course (CAV) and the Military Aviator Course (CAM), respectively.

#### Fundamentals

Both platforms on which currently pilot flight training is based (one for the Primary stage and one for the Basic stage) have serious problems of availability for different reasons.

The primary trainer B-45 “Mentor” has accumulated more than 700,000 flight hours in fifty-three (53) years of service in the Air Force, mainly based in the Argentine Air Force Academy.

In August 2008 it was requested a B-45 “Mentor” structural airframe inspection in order to check the overall status of the material. As a result of this inspection, it was determined that there were cracks of different sizes, both in the longitudinal plane of the fuselage frames in most of the aircraft in the fleet and that these cracks were the result of material fatigue.

After evaluating many repair schemes the Argentine Material Command determined in December 2008 as an alternative method, the main spar change and new inspection cycles on certain fuselage parts (Alternative Method of Compliance-AMOC AD 2001-13-18 Federal Aviation Administration Service Bulletin). It was presented by Blackwell Aviation Company, which was hired for this repair using LMAASA facilities (now FAdeA S.A.)

With this repair implementation, there was an increase in aircraft empty weight that affects the acceleration limit margins allowed (force "G"). The work plan has not been finished yet and the result has been an aircraft availability reduction.

The “Tucano” EMB-312 aircraft trainer, which is used in the basic stage, is in the middle of its life and has had serious maintenance problems that have compromised its availability. It is critical to obtain a number of parts because Embraer has discontinued the manufacturing line and market and international suppliers have not shown interest in meeting the Air Force needs.

As a result of maintenance problems and lack of supply spare parts, the resulting low aircraft availability makes achievement of pilot training difficult. In some cases training has been suspended for failing to maintain an acceptable degree of continuity, which allows students a gradual and sustained process of learning.

Faced with this situation and budgetary constraints, it has been agreed at the restructuring of the whole pilot course curricula, maintaining the skills and competencies that determine the profile of trainees and conducting the entire course based on a single platform (primary-basic training).

For detailed information, refer to **Appendix A. Operational Requirements for the IA-73**

***IA-73 Program details***

- **Program acquisition cost**: The total program cost of 52 aircrafts (50 production units and 2 prototype units) is estimated around $115 million then-year dollars (actual amounts spent in prior years and estimated expenditures in future years, based on current assumptions about inflation rates and annual production rates in the out-years). The estimated development cost is around $10 to $12 million.
- **Planned Procurement Quantity**: As currently projected, the Argentine Air Force plans to procure 50 production aircrafts.
- **Unit cost**: It is estimated at $1.8 million then-year dollars per plane in a 50-aircraft program (2 development and 50 production aircraft as currently projected by the Argentine Air Force) estimated operational in 2015.

- **Funding:** By IA-73 project Military Investment Data Base (BIM) (*Banco de Inversión Militar*) as previous instance to include IA-73 project into the national budget. Project is funded by the National Treasury. Cash flow through 15 year project, after all IA-73 units are released to service and "Mentor" and "Tucano" airplanes are removed from operational service. A Joint venture strategy could also be applicable.
- **Project tangible aspects**: low fuel consumption, autonomy, operational cost, load factor and Maximum Takeoff Weight (MTOW), overall efficiency improvement and decreasing training costs.
- **Project Intangible aspects**: maintainability, reliability and resulting availability.
- **Expected Operational Life Time Cycle**: 18,000 Flight hours.

***The IA-73 Integrated Training System concept***

The IA-73 Integrated Training System (ITS) is composed of the following components:

- **Multirole airplane**: primary-basic pilot training (from elementary skills to navigation system operation, and basic aiming and shooting)
- **Platform for flight simulation**: simulation training that facilitates primary-basic pilot skills at the Academy, enabling training in a digital environment.

Among its benefits, it increases the effectiveness and reduces costs throughout the military pilot basic training system.

Airplane Key Features:

- Aerobatic - Category (A) according to FAR Part. 23.
- Versatile configuration (tandem / side by side).
- Integrated expandable Avionics Glass Cockpit (digital panels).
- Virtual / real weapons system incorporated depending on version.
- Versatile powered (Turbo-prop - Different power ratings) (Jet A1 / Bio-fuel).
- Kinematics Command System adaptable by mean of external adjustments.
- Adjustable Wing load – by interchangeable wing tip kit.
- Low weight Marti Baker (MB) Ejection Seat (depending on version).

***Military Pilot's Primary-Basic training scheme***

Any military pilot training scheme must highlight the importance of effective pilot training in order to reduce general aviation fatality rate and to promote sustainable growth and skill proficiency.

Pilot training is generally performed in three stages, described as elemental, primary-basic and advanced (Figure 8). The first stage is used to weed out those students who lack the aptitude to quickly become military pilots. It is generally performed in fixed-gear piston-engine aircraft with side-by-side seating.

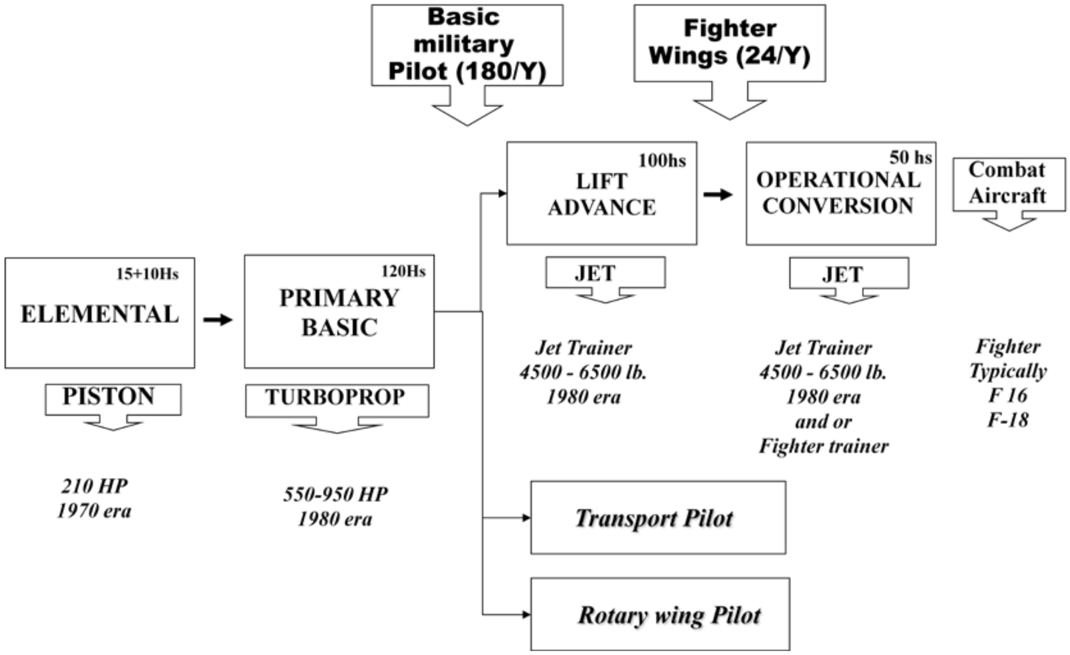


**Figure 8: Pilot's training stages – Actual worldwide concept (FAdeA S.A., 2011)**

Therefore, an applicant seeking to become a military pilot would initiate the process by flying piston-engine aircraft in the elemental pilot training stage. The next stage is primary-basic training by turboprop-engine aircraft. After completing the basic military pilot training requirements, pilots are selected to continue training as fighter jet, transport or rotary wing pilots, providing the officer meets the appropriate requirements to be eligible.

Regarding the Argentine scenario, Figure 9 shows that specialization stage starts after completion of basic military pilot training requirements flying Beechcraft B-45/T-34 “Mentor” and EMB-312 “Tucano”, gaining experience in aerobatics, instrument flying, formation, navigation, and weapons delivery.

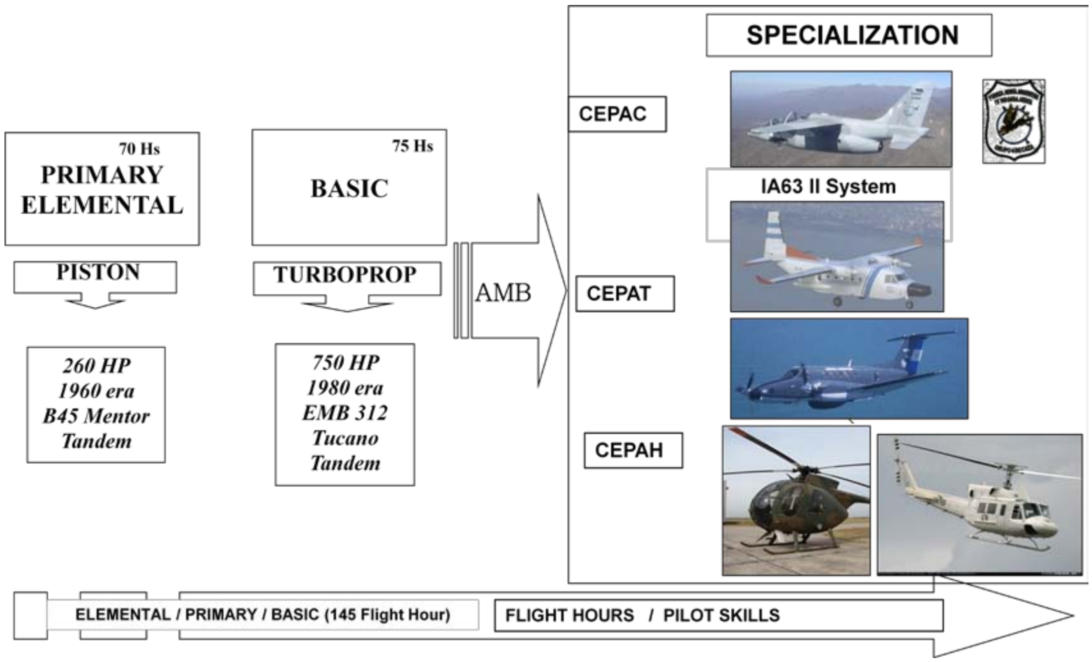


**Figure 9: Pilot's training stages –Actual concept in Argentina (FAdeA S.A., 2011)**

Advanced training begins when pilots successfully complete initial training and are awarded their "wings." This advanced training consists of flying instruction on particular type of aircraft. It is performed on the argentine jet aircraft IA-63 Pampa, Argentine Navy aircraft or rotary wing aircrafts as depicted in Figure 9. After finishing it, the new aviators are assigned to operational aircrafts.

However, the established training scheme has to evolve over a period during which the Argentine Air Force has seen considerable changes in its aircraft inventory, seeking to improve the quality of the training process and aircraft availability, while the government seeking to cut costs.

To fully appreciate the scale of this change, Figure 10 shows a coming concept in military pilot's elemental primary-basic training, by means of Integrated Training System (ITS).

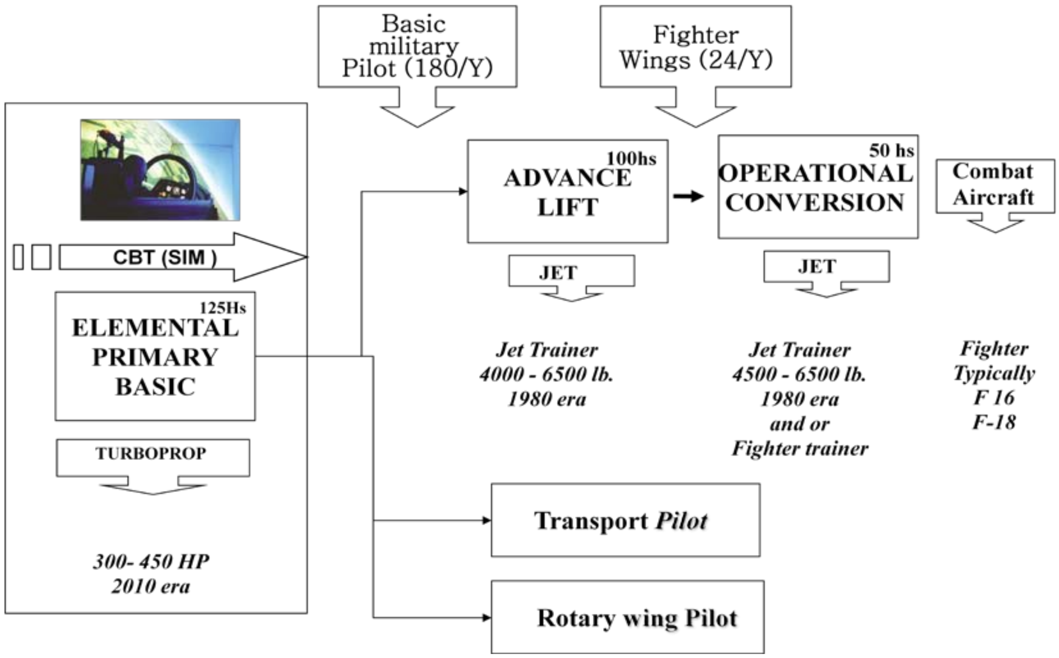


**Figure 10: Military Pilot's Basic Training – Future Concept (FAdeA S.A., 2011)**

ITS is constituted by multirole turboprop airplanes for primary-basic pilot training (from elementary skills to operation of navigation systems and basic aiming and shooting) and platforms for flight simulation training that facilitates primary / basic pilot skills at the Academy level, enabling training in a digital environment.

Using a Computer Based Training (CBT) curriculum to meet the required standards, there are many benefits associated with a CBT syllabus in aviation training program, including transparent, objective standards published for all flying sequences to be taught. This leads to improved application and interpretation of standards and a meta-level standardization of training and testing outcomes.

Applying this concept and considering its strengths and weaknesses without suffering a decline in the quality of Armed Forces graduates, FAdeA S.A. is introducing the IA-73 Training System as a basic training stage core. This is in order to improve efficiency and decrease training costs previous to starting the specialization stage flight courses, as it is shown in Figure 11.

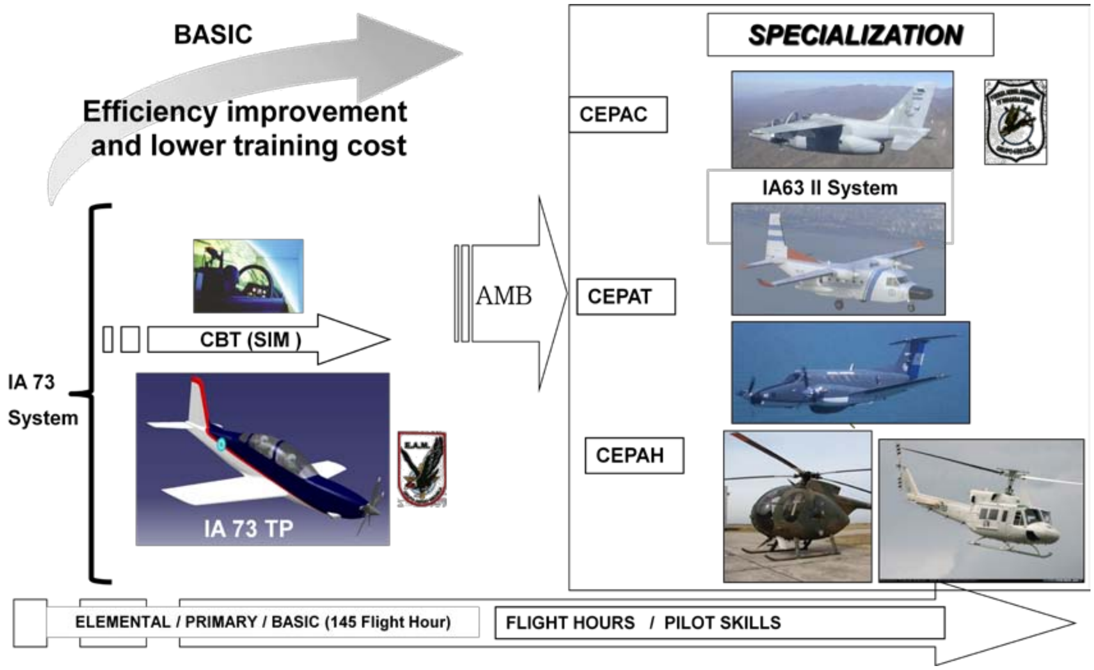


**Figure 11: IA-73 Training System (FAdeA S.A., 2011)**

## Market Analysis

### *Aerospace and Defense Equipment Market in Argentina*

Considering the economic and product market forecast for selling aerospace and defense equipment in Argentina, Table 7 presents estimated and historical information about total business amounts (in US $ millions) for Argentina, Latin America and the world in the period from 2003 to 2013.

Aerospace and defense equipment segment includes all commonly understood products falling within this broad category, such as equipment and parts for civil and military aerospace and defense, space equipment, and electronics used in defense.

Companies participating in this industry include The Boeing Company, United Technologies Corporation, Lockheed Martin Corporation, Northrop Grumman Corporation, Honeywell International Inc., BAE Systems PLC, and Airbus S.A.S. (ICON Group International Inc., 2007).

**Table 7: Argentina Aerospace and Defense Equip. Market (ICON Group Inc, 2007)**

| Year | Argentina | Latin America | The World |
|---|---|---|---|
| **2003** | 23,769.76 | 185,003.42 | 2,562,957.77 |
| **2004** | 23,633.29 | 190,212.36 | 2,637,184.81 |
| **2005** | 23,488.75 | 195,537.48 | 2,714,584.91 |
| **2006** | 23,607.66 | 201,603.79 | 2,808,361.73 |
| **2007** | 25,323.24 | 211,203.58 | 2,978,628.74 |
| **2008** | 27,446.87 | 221,861.41 | 3,172,404.96 |
| **2009** | 29,748.60 | 233,101.19 | 3,379,689.87 |
| **2010** | 32,243.34 | 244,958.00 | 3,601,480.62 |
| **2011** | 34,947.30 | 257,467.35 | 3,838,851.62 |
| **2012** | 37,878.02 | 270,669.89 | 4,092,960.84 |
| **2013** | 41,054.51 | 284,607.00 | 4,365,056.63 |

### *Defense Industry Equipment Market in Argentina*

Regarding defense industry equipment segment, including all commonly understood products falling within this broad category, such as military ships, tanks, airplanes, weapons, artillery, explosives, and all other military vehicles and defense equipment which are usually designed and developed by companies with government contracts, irrespective of product packaging, formulation, size, or form (e.g. the retail sales of products or brands such as ADI Technologies, Inc. and Honeywell Inc.), economic and product market information is presented in Table 8.

This estimated and historical information is also in US $ millions for Argentina, Latin America and the world in the period from 2003 to 2013 (ICON Group International Inc., 2007).

**Table 8: Argentina Defense Industry Equipment Market (ICON Group Inc., 2007)**

(US $ mln: 2003 - 2013)

| Year | **Argentina** | **Latin America** | **The World** |
|---|---|---|---|
| **2003** | 6,180.51 | 48,201.71 | 676,625.29 |
| **2004** | 6,009.80 | 48,432.84 | 677,630.17 |
| **2005** | 5,843.46 | 48,672.53 | 78,891.79 |
| **2006** | 5,743.28 | 49,046.09 | 683,171.84 |
| **2007** | 6,018.82 | 50,170.10 | 704,129.77 |
| **2008** | 6,373.93 | 51,454.70 | 728,703.98 |
| **2009** | 6,750.00 | 52,782.68 | 754,305.86 |
| **2010** | 7,148.25 | 54,156.00 | 780,985.46 |
| **2011** | 7,569.99 | 55,576.22 | 808,795.67 |
| **2012** | 8,016.62 | 57,045.75 | 837,792.33 |
| **2013** | 8,489.60 | 58,566.58 | 868,034.49 |

### *Market Analysis for Military Fixed-Wing Trainer Aircraft*

Trainers are used to prepare flight crews for combat operations. Market Analysis for military fixed-wing trainer aircraft is complex due to volatility caused to economical and financial crisis. However, forecast studies covering a 10-year demand period (2010-2020) are suitable to briefly estimate the trainer segment.

Analyses cover active programs within the fixed wing military training market, including aircraft powered by jet, turboprop, and piston engines. Forecasting military trainer demand and production entails analyzing military inventories by type of trainer and age. Military expenditures, and research and development plans have to be evaluated against future military budgets and military equipment priorities. When the total trainer demand curve is established, each aircraft program is studied to ascertain competitive advantage and disadvantage and any political, societal, or economic factors that ultimately determine the marketing and sales success or defeat of a particular trainer family. This is obviously a subjective methodology and one that changes with the overall assessment of worldwide defense spending (Forecast International, 2011).

According to in-depth overviews of the principal market motivators and constraints, and calculations of projected manufacturer market shares by units and value, FAdeA S.A. estimates that there are potential markets in the single piston/turboprop engine airplane sub sector in South America, Europe, Asia and Africa.

The operational roles of these aircraft are basic military pilot training and primary-basic training. They typically are turboprops that can replicate the characteristics of jet aircraft and are instrumented for specialized military missions.

Table 9 shows potential forecast demand and acquisition/replacement causes as average age of military trainer aircrafts is increasing and aircraft are becoming increasingly expensive to maintain and operate. The high and growing cost of replacing equipment is forcing governments to spend more resources on Maintenance, Repair, and Overhaul (MRO).

**Table 9: Estimated Primary-Basic Trainer Demand Forecast (FAdeA S.A., 2011)**

| Geographic Area | Actual Trainers Remaining life/ /Acquisition purpose | Number of Aircraft |
|---|---|---|
| Global | 25 year-remaining life<br>- Replacement and new | 2200 |
| Latin America | 20 year-remaining life<br>- Replacement<br>- New<br>Total | 200<br>90<br>290 |
| Argentina | Short and medium term<br>- Replacements (Argentine Air Force) | 50 |

However, at the same time, many other developing countries are leveraging their aerospace industries with a desire for increased self-sufficiency and to economic grow. They constitute competitors in this trainer market segment.

It is important to see how the Training and Simulation (T&S) sub-sector is experiencing growth in virtual simulation and training. New simulation technologies and virtual training have gained an increasing market among countries willing to reduce costs and enhance pilots' skills (Deloitte, 2010).

According to Visiongain's definition quoted in Deloitte (2010:59) Virtual T&S can be thought as "an environment with operators feeling that they are operating real equipment in an authentic environment, but are actually operating realistic equipment in a virtual environment. A virtual environment is also a computer simulated environment, in which the user trains in a simulator that looks like an actual piece of equipment". Virtual simulation is an important growth market because of significant cost savings offered over traditional T&S in light of contracting defense budgets (Deloitte, 2010).

***Aircrafts in the same IA-73 turboprop basic trainer segment***

The lower end of the turboprop engine range is dominated by the Rolls-Royce Model 250. The Rolls-Royce 250 would also be a rational choice for the IA-73 trainer being developed by FAdeA S.A. for first flight in 2013. Among the turboprop basic trainer aircrafts in the same IA-73 segment it can be mentioned the Alenia Aermacchi SF-260TP and the Grob G-120TP.

## Alenia Aermacchi SF-260TP

The Alenia Aermacchi SF-260TP shown in Figure 12 is the turboprop variant of the SF-260 which has accumulated over two million flight hours with 27 Air Forces and civil operators. Some 50 SF-260TPs have so far been sold as new-build aircraft, and 12 more converted from piston engine SF-260s for the Philippines Air Force (Armada International, 2011:25).


**Figure 12: The SF-260TP (Armada International, 2011)**

The SF-260 family offers proven and field experience as a fully aerobatic screener-primary trainer. In addition the SF-260TP also offers excellent teaching effectiveness and unbeatable cost/effectiveness in the basic training role (Alenia Aermacchi, 2012).

Powered by the Rolls-Royce (Allison) 250-B17D 420 SHP turboprop engine, flat-rated at 350 SHP, the SF-260TP takes advantage of excellent flying qualities and flight control harmonization to offer outstanding performance in hot and high altitude conditions and uses cheap and widely available jet fuel, simplifying logistics. Field-verified military mission mix and recorded load spectrum allowed the SF-260TP airframe to be optimized to raise fatigue life up to 15,000 flight hours as well as aerobatics up to the 1,200 kg maximum clean take-off gross weight. The enlarged canopy offers much more room for pilots wearing modern military type helmets while also improving lateral and downward visibility. A completely automatic fuel system provides easy and safe operation (Alenia Aermacchi, 2012).

Further flexibility comes from the availability of the “Warrior” version, configured to carry up to 300 kg of external stores on two under-wing pylons with standard NATO 14" racks. The basic SF-260TP version is certified to FAR Part 23 (Aerobatics Category) by the Italian Civil Aviation Authority (ENAC) and is covered by a US FAA Supplemental Type Certificate. Table 10 shows SF-260TP technical specifications. It is designed to accomplish the following training tasks (Alenia Aermacchi, 2012).

- Primary training (navigation, instrument flying)
- Aerobatic
- Formation flying
- Night flying
- Weapons training

**Table 10: SF-260 TP Technical Data (Alenia Aermacchi, 2012)**

| | |
|---|---|
| **Dimensions** | |
| Span | 8.35 m (27.4 ft) |
| Length | 7.40 m (24.3 ft) |
| Height | 2.41 m (7.9 ft) |
| Wing area | 10.10 sq meter (108.7 sq ft) |
| | |
| **Weights** | |
| Maximum Takeoff, Aerobatics | 1,200 kg (2,645 lb) |
| Maximum Takeoff, External stores | 1,350 kg (2,976 lb) |
| | |
| **Power Plant** | |
| Rolls-Royce (Allison) | 250-B17D Turboprop |
| Power, SLS, ISA | 350 SHP (flat-rated from 420 SHP) |
| Hartzell propeller, 3 blades | HC-CB3TF-7A/T101 73-25R |
| | |
| **Performance (ISA, SL)** | |
| Max level speed (10000 ft) | 228 KTAS |
| Cruise speed (10000 ft, normal cruise) | 215 KTAS |
| Maximum Operating limit speed | 236 KEAS |
| Stall speed (full flaps) | 61 KCAS |
| Rate of climb (SL) | 2,200 ft/min |
| Max service ceiling | 25,000 ft |
| Range, Clean / 2 ext. tanks (10% reserve) | 530 nm / 840 nm |
| Endurance, Clean / 2 ext. tanks (10% reserve) | 4 hours / 6 hours |
| Takeoff run | 275 m (900 ft) |
| Landing roll (with reverse application) | 300 m (980 ft) |
| Limit Load Factor, Aerobatics | +6.0/-3.0 g |
| Limit Load Factor, Ext. stores | +4.4/-1.76 g |

### Grob G-120TP

The other aircraft that can be considered in the same IA-73's segment is the new 1590-kg **Grob G-120TP,** depicted in Figure 13, manufactured by the German company GROB Aerospace. It combines the attractions of the 340-kW Rolls-Royce 250 B17F turboprop (over 29,000 produced) with Elbit's "glass" cockpit avionics and displays, and Martin-Baker Mk15E lightweight ejection seats (Grob Aircraft, 2012).

**Figure 13: The Grob G-120TP (Grob Aircraft, 2012)**

The G-120TP is expected to be certificated in 2012, and to sell for around $ 3.5 million, compared to $ 1.3 million for the piston-engine G-120. It is marketed initially in India, aimed at a 75-aircraft order to replace the (currently grounded) piston-engine Hindustan Aeronautics (Hal) HPT-32, with Hal license-production of 106 to follow (Armada International, 2011). Table 11 shows Grob G-120TP's technical specifications.

**Table 11: Grob G-120TP technical specifications (Grob Aircraft, 2012)**

| | |
|---|---|
| **Weights** | |
| Max. take-off weight (utility) | 1590 kg |
| Max. take-off weight (aerobatic) | 1550 kg |
| Max. zero fuel weight | 1390 kg |
| Basic empty weight | 1095 kg |
| Max. landing weight | 1550 kg |
| Max. usable fuel capacity | 288 kg / 360 Liters |
| Max. crew / boarding weight | 295 kg |
| Max. baggage weight | 50 kg |
| **Power Plant** | |
| Max. continuous power (MCP) | 380 SHP |
| Max. power (MP, 5 min limit) | 456 SHP |
| Flat rated versions on request | |
| **Miscellaneous** | |
| Max. load factors aerobatic | +6 / -4G |
| Max. operating altitude | 25.000 ft |
| Operation: VFR day/night, IFR, non-icing conditions | |
| **Performance** | |
| **Operating speed range** | |
| Max. operating speed $V_{MO}$ MSL up to 10,800 ft | 245 kcas |
| Max. mach number $M_{MO}$ above 10,800 ft | 0.45 |
| Stall speed $V_S$ (MSL landing configuration., utility) | 58 kcas |
| | |
| **Take off and landing distances (MSL, ISA)** | |
| Take off distance over 50 ft (MTOW, no wind, no slope, utility) | 374 m |
| Landing distance over 50 ft (MLW, no wind, no slope) | 497 m |
| | |
| **Cruise speeds, rate of climbs, sustaining g (ISA, MTOW)** | |
| Max. cruise speed (MSL, MCP, utility) | 218 ktas |
| Max. cruise speed (10,000 ft, ISA, MCP, utility) | 237 ktas |
| Rate of climb (MSL, MP, aerobatic) | 2772 ft/min |
| Sustained g (MSL, MCP, 1500 kg aircraft weight) | 2,78 g |
| | |
| **Range / Endurance (SA, MTOW, 45 min reserve fuel, maximum fuel, utility)** | |
| Range (5,000 ft, 75% MCP) | 580 NM |
| Range (10,000 ft, 45% MCP) | 735 NM |
| Endurance (10,000 ft, max. endurance power) | 6 Hrs |

According to the manufacturer, it is a mission training platform that can accommodate typical elementary, basic and advanced pilot training segments, for learning the first steps of flying all the way to pushing the envelope at 6g during the aerobatic training phase (certified full aerobatic and military training capability) (Grob Aircraft, 2012).

The G 120TP cost efficiency redefines training cost and budgets. High performance, full Virtual Tactical Training capability including HOTAS, combined with high dispatch reliability make the G120 TP not only the most cost efficient solution for the future, but also the best integrated training system overall. It is equipped with the new light weight Ejection Seat by Martin Baker, securing the operators future pilot investment (Grob Aircraft, 2012)

**Chapter Summary**

This chapter presented and discussed relevant facts concerning the Argentine aerospace industry as well as the defense industry. The FMA history was reviewed along different stages and various organization types, mainly as a state-owned industry. In this sense, the review establishes the crucial role of the State on FMA activity. Despite the amount of resources invested and the variety of prototypes developed, they were not often transformed in series production. Changing or weak aeronautical policies, strategies and objectives undermined the industry maturation and leaders' ability to get sustainable progress. Moreover, sometimes strategies were conceived as tactical decisions without any consideration of the dynamically changing nature of international markets and internal political situation. Thus, industry demands a strategic vision in order to be successful. Besides that, the chapter details the current Argentine aircraft industry scenario and the need of strategical planning. Especifically, the IA-73 basic-primary trainer aircraft is presented as well as the integrated training system concept behind the project. Finally, some market analyses were presented as well as demand forecast and other possible competitors in the international scenario. Technical data from manufacturers allows comparison among aircraft in the same IA-73 segment.

The next chapter will address the methodology about how to evaluate the IA-73 project beyond exclusively quantitative metrics. This is in order to satisfy Argentine Air Force requirement of increased aircraft availability (flight hours) to complete pilot basic training courses. Besides that, methodology analysis provides insights about action areas which may contribute to the wanted aircraft industry long term success.

# III. Methodology

## Chapter Overview

Every organization is different, maintaining different levels of human capital, resources, infrastructure, etc. Under this premise, established and reliable methodologies are the heart of a successful project environment. Furthermore, developing a methodology for evaluating a project could be considered as a project by itself.

Considering the National Defense area, it permanently demands project investments for the replacement, expansion and / or innovation of capabilities to fulfill their duties. Thus, beyond a classification budget, the industry claimed the definition of a methodology guiding to achieve the most rational allocation of national resources.

In this sense, it is essential the correspondence between the Investment Projects in Defense, Defense Policy and Military Policy, through the implementation of methodological procedures ensure an efficient and transparent evaluation according to the law and regulations in force.

The legal framework governing the National Public Investment System seeks a standardization of identification, formulation and evaluation processes. The objective goes beyond a merely project efficiency-assessment, trying to combine economic rationality with higher strategic objectives.

At this point, the problem from Chapter I is revisited. Based on proven maturity models and techniques, a methodology for analyzing the project is analyzed. Organization culture is considered for this project. A number of related definitions are also covered in this chapter.

## Methodology Issues

While there are many factors to be considered when analyzing a new project, the methodology presented in this chapter does not pretend to be generally applicable. Thus, it cannot be used directly on each project case without previous careful considerations about its applicability and convenience. Any methodology demands flexibility when applying it in a specific project analysis. Moreover, project data is not always provided in the same standard format as there are many government agencies and management practices and procedures. Those agencies provide data in different formats, as well as use specific tools and techniques. Any methodology has to take into account all these factors in order to properly understand the results.

## Definitions and Concepts

Following a general methodology implemented in the Argentine Ministry of Defense (MINDEF) for analyzing investment projects, a number of definitions and concepts are presented.

### *Investment project (IP)*

Investment Project (IP) (see Figure 14) is a productive -financial enterprise is established in order to provide objective goods that satisfy actors' needs in some specific context, following a commercial and /or social objective, which requires capital goods, where some durable inputs are obtained by an investing process, in order to use them to operationally produce objective goods or end products (MINDEF, 2009a:82).

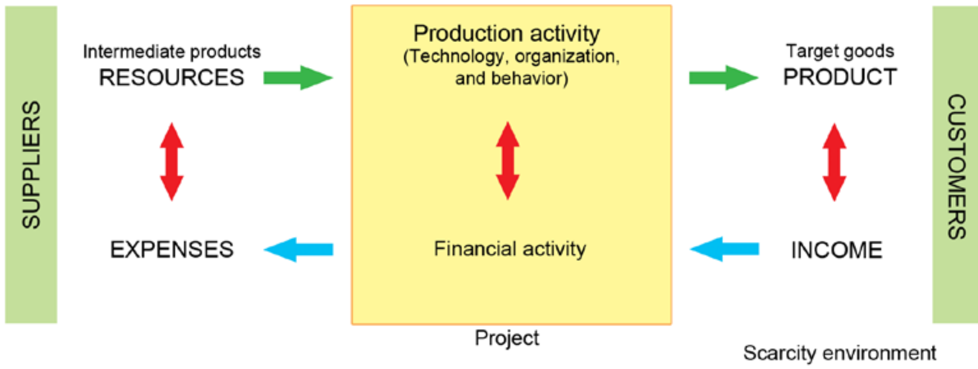


**Figure 14: IP Systemic Approach (Adapted from MINDEF, 2009a).**

### *Defense investment project (DIP)*

Defense Investment Project (DIP) (see Figure 15) is a production-financial proposal, analyzed and presented by any Defense System agency, which requires certain own capital goods to produce goods or services intended to achieve some military effect (military impact) and in order to contribute to the protection of the nation and its vital interests (social impact) (MINDEF, 2009a:84).

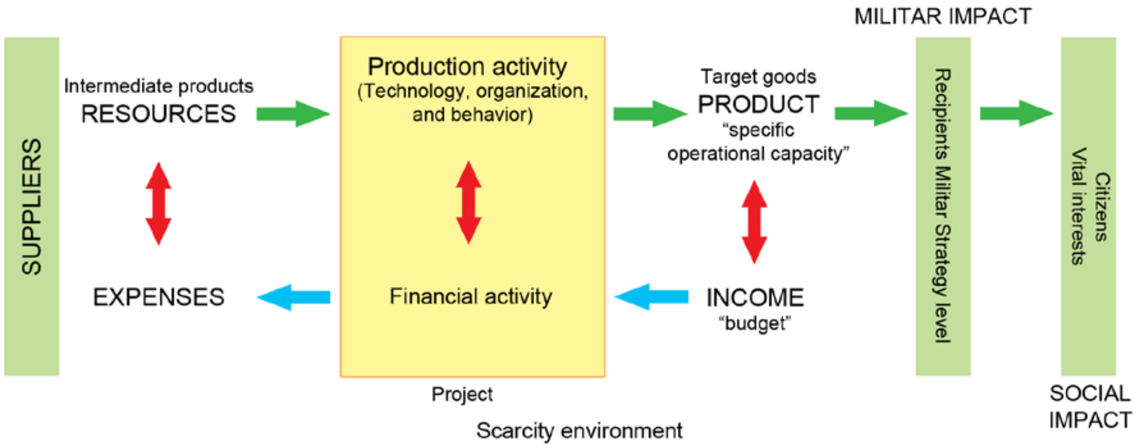


**Figure 15: DIP Systemic Approach (Adapted from MINDEF, 2009a).**

The DIP's flow can be represented following a systemic approach. Interrelationships among investment and production DIP, national budget from the GNP, production and financial activities, suppliers and customers are shown in Figure 16. All this process and its resulting defense spending represent a social impact on taxpayers that has to be assessed in advance at the earliest project stages.

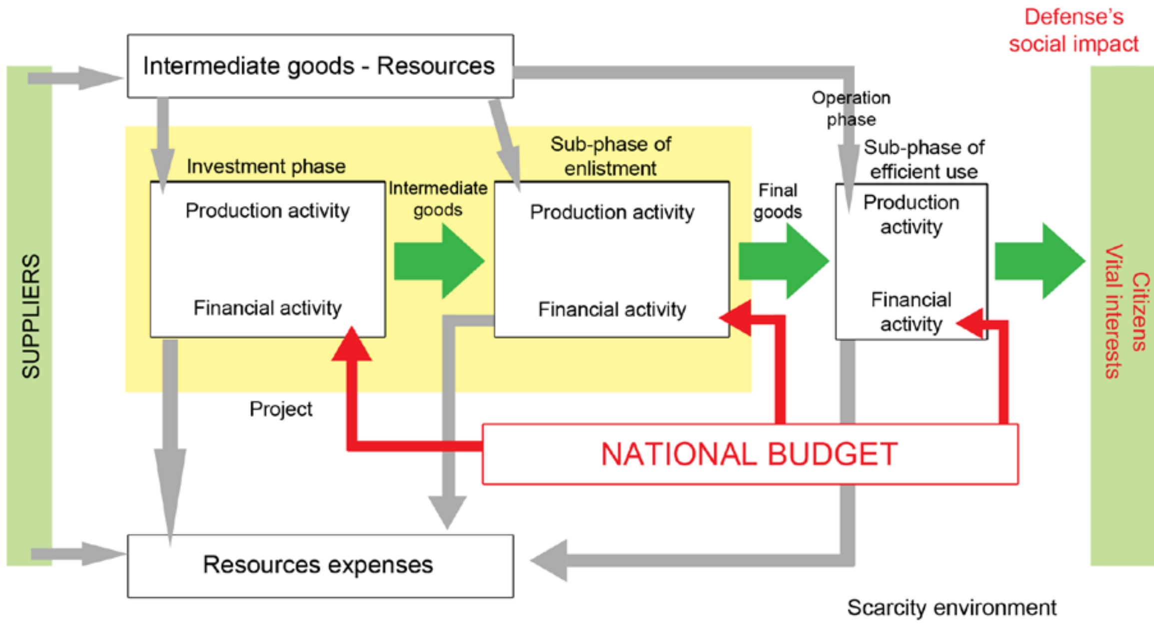


**Figure 16: DIP flow phases (Adapted from MINDEF, 2009a).**

***Sustaining DIP in developing defense industries***

As it has previously stated, any defense spending represents a social impact on taxpayers that has to be assessed in advance at the earliest project stages. At this point a very interesting perspective is introduced by Matthews & Maharani in *"Beyond the RMA: Survival Strategies for Small Defense Economies"* (2008). This article analyzes particular challenges that small countries have in creating and sustaining defense industry capacity in the highly competitive post-Cold War era:

> "Aside from the high cost of procurement, if arms production is left in the hands of government, the danger is that the defense economy will suffer from malaise, low productivity, inefficiency, and poor competitiveness. Thus, from a policy perspective, if defense is viewed as a public good, and arms are produced in the public sector, then the inevitable increased costs will be a burden that is borne by the taxpayers" (Matthews & Maharani, 2008: 68-69).

The defense industry development is influenced by critical factors such as research and development, scale, the possession of subcontractor networks, the levels of defense expenditure, and globalization and open defense trade. (Matthews & Maharani, 2008:68). Under this scenario any indigenous defense industrialization development faces challenges about how to initiate, foster and sustain the process. Among four possible options that go from radically relinquish defense ambitions to build a non-dependent defense industry, the rationalities behind intermediate options like purchasing "off-the-shelf" (OTS) systems and / or accessing defense technology through offsets seem to be more applicable in developing countries (Matthews & Maharani, 2008).

Offsets are arrangements made whereby recipient countries require a kind of compensation conditioned to the purchase of military related equipment, aiming to creating benefits for the buyer (Martin, 1996). In the case the offset agreements like countertrade, technology transfer, licensed production and / or coproduction they can benefit defense technology production and innovation against financial problems a developing country has to face. This is in order to compensate the burden on taxpayers and other national sectors, all of them immersed in a scarce environment.

Offset provides "a more measured approach to domestic defense industrialization. It facilitates the build-up of defense capacity through a tagged process of modular equipment assembly through licensed production, involving progressively more intensive local production and sub-assemblies over time" (Matthews & Maharani, 2008:78).

However, Argentine defense acquisition regulations have not explicit provisions about compensation by offset negotiation, at the time that arms procurement contracts are signed, looking for generating additional contribution to the national economy development, industrial production strategic plans, and research and development to get sustainable industrialization (MINDEF, 2009b).

***DIP's decisional instances***

Project analysis and evaluation process is done through four decisional instances, which are related to the four phases of project development and differentiated by the corresponding study area: idea, profile, pre-feasibility and feasibility (MINDEF, 2009a).

In the preliminary pre-investing stage, studies about context, demand and supply, technical-economic-legal-organizational aspects, etc., are all carried out aiming at determining the optimal solution. It also covers the study of potential funding. Information developed in each study is incorporated into the project analytical document (DIP feasibility study) for appropriate authority analysis and decision.

It is advisable to gradually analyze the information and tasks, going deeper as issue complexity is addressed, available data confidence is obtained and intrinsic relationship among components is determined. This is done by developing four basic stages as defined below:

- Idea (*IDEA*)
- Profile (*PERFIL*)

- Pre-Feasibility (*PREFACTIBILIDAD*)

- Feasibility (*FACTIBILIDAD*)

At each stage, DIP is identified, developed, evaluated and analyzed about its financial convenience, gaining knowledge of desirability to carry it out. Actually, passing to a subsequent stage requires increasing application of analytical resources. The analysis finishes if a stage analysis concludes that the project must be rejected (MINDEF, 2009a).

The DIP's process phases are represented in Figure 17 in two Cartesian axes: cost - knowledge. As the analysis goes through the stages, it gains in depth and converges toward the center of the graph when the feasibility stage is completed, increasing both costs and knowledge (variables and relationships) of the problem (MINDEF, 2009a).

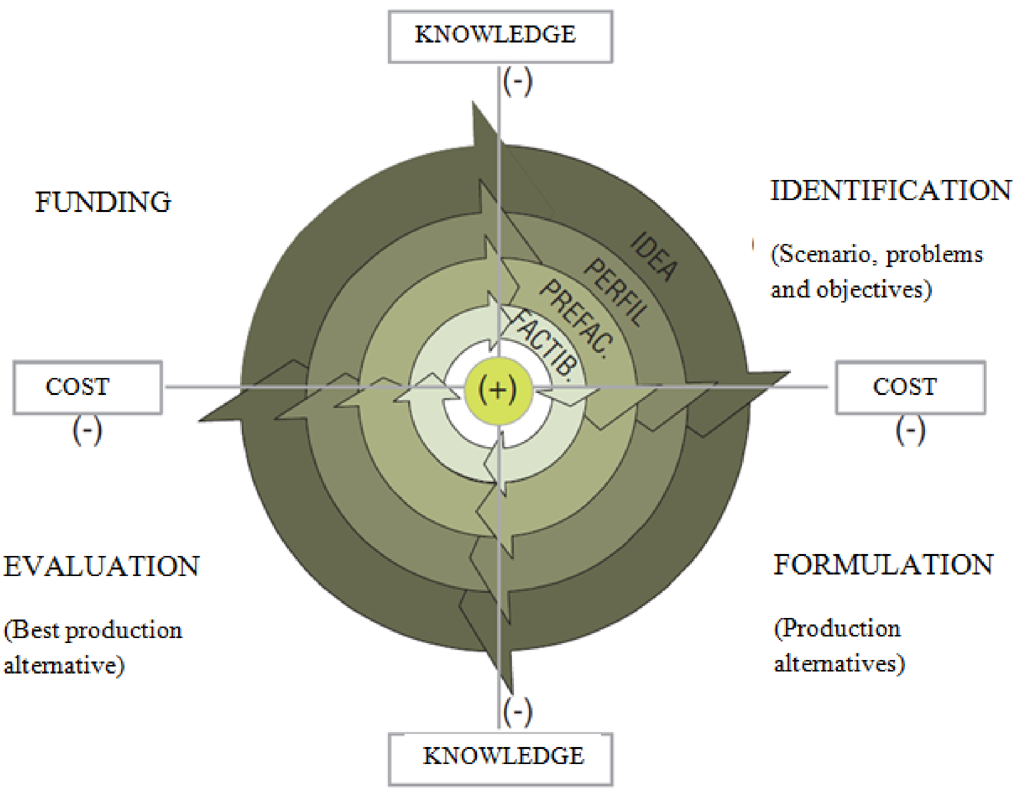


**Figure 17: DIP decisional instances (Adapted from MINDEF, 2009a)**

The Profile Stage includes a study of the project, based on supplier Preliminary Rough Order of Magnitude (ROM) technical and economic information. In the Pre-Feasibility Stage study, the source of information should correspond, at least, to a Request for Information document (RFI). The Feasibility Stage includes a detailed analysis of final solution alternatives, which allows the greatest degree of technical-economical certainty (MINDEF, 2009a).

## Research methodology objectives

The research process assumed that the problem of evaluating the project of domestically designing and manufacturing an Argentinean basic training aircraft (IA-73) described in Chapter I is valid and that a methodology for evaluating this project could provide a reasonable amount of information in order to analyze it.

As **general objectives**, the methodology to be applied to DIPs studies has to:

- Evaluate the correspondence between the project and defined capabilities.
- Technically evaluate DIP associated with military and support capabilities.
- Systematically evaluates investment projects during their life cycle.

Among the **specific objectives**, a methodology looks for:

1. Setting up the sequence in which investment project study has to be analyzed and presented.
2. Defining investment project study areas and structure at each decision-making stage.

3. Establishing the analytical process for elaborating, presenting and evaluating the following aspects of the project study:

    a) Problem definition, identifying which capabilities have to be replaced, maintained or bought.
    b) Identification of possible alternatives to solve the defined problem, including an optimized base situation.
    c) Technical analysis about the effectiveness of each operational alternative solution, by mean of operational performance and availability criteria.
    d) Strategic and operational fundamentals that support it.
    e) Determining both technical and economical project desirability, by economic analysis of each feasible alternative, using a cost-benefit approach or a cost-efficiency approach, depending on whether it is possible to quantify and / or assess the benefits.
    f) Prioritized selection of alternatives according to the economic analysis approach adopted.

4. Define a proposal related to the investment project.

## Project analysis

### *Analysis Structure*

This analysis structure follows general project analysis concepts at Argentine Ministry of Defense (MINDEF, 2009a) and Chilean Ministry of Defense (Chilean MINDEF, 2007) (Chilean MINDEF, 2010). The general structure establishes common analytical process steps for elaborating, presenting and evaluating different type of projects. This thesis applies the presented structure to defense investment projects (DIP).

1. **General Information**

a) Project designation
b) Primary and secondary project related field areas.
c) Project type (replace, maintain, complement or acquire a new capability), stating which are those project capability characteristic.
d) Agencies involved in preparing and analyzing the project.
e) Rank and name of who is in charge of the project.

2. **Problem Identification**: The problem that gives rise to the project idea has to be identified. Despite the fact an analyzed situation could have several problems, it is necessary to focus on the key issue, stating:

a) Causes which originate the problem and its effects.
b) Target location**,** i.e., the desired situation after implementing the project, determining means to achieve it and sought purposes.
c) Preliminary alternative solutions through the formulation of actions items in order to solve the problem.

3. **Current situation diagnosis:** It provides a description and analysis of key issues related to the defined problem. Different forms of obsolescence have to be considered also. The obsolescence can be:

a) **Tactical obsolescence**: generated, among other aspects, by changes in the skills required for using the specific device/system.
b) **Technical obsolescence:** which occurs when systems do not reach design yields or they have been overtaken by new technological developments in a given area.
c) **Logistics obsolescence:** when it is not feasible to support the system due to lack of spare parts or components on market.

4. **Optimization of the baseline situation:** Identify low-cost actions or initiatives that could improve the current situation, partially or totally eliminating the detected capability gap. By solving part of the calculated deficit, project costs should be less than the ones originally considered. Along with this, benefits and positive externalities attributable to the project can also vary as they can be part of the solved gap. Among small investment actions or initiatives it can be mentioned improvements, repairs or upgrades on infrastructure and / or existing equipment and / or administrative management measures.
5. **Capability gap identification and projection:** The gap or deficit is obtained from the comparison between the current situation and the expected optimized situation achieved after implementing the project. The magnitude the gap reaches should be quantified in a reasonable time horizon projection accordingly to the project type, considering no actions to solve the problem are taken.
6. **Alternative solutions identification and definition:** Alternative mutually exclusive solutions have to be proposed. Each one should address the following issues:

a) Identification and detailed description of the alternative solution.

b) Identification of specific risks: technical and economic ones and measures to mitigate them. Among others: trade, budget and financial manufacturer's reliability, quality standards and operation.

c) Estimation of the output gap percentage coverage: It must identify the coverage gap achieved by implementing the alternative solution under analysis.

d) Identification of proposed funding sources and conditions: must identify the sources of resources to finance analyzed alternative solution life cycle costs.

e) Description of alternative solutions externalities: Identify all the effects (externalities) that positively or negatively fall outside the specific project but that are generated by it, and the factors that determine their implementation as well.

f) Schedule: Estimate time for implementing alternative solutions and stages for getting full operation capability.

g) Identification of recurrent costs: Estimate recurrent expenditure flow, identifying the impact they could have over future spending.

h) Identification of internal impacts: logistical, organizational and administrative, non-quantifiable and quantifiable ones.

7. **Compatibility analysis and dependence with other initiatives:** It has to analyze current available capabilities in terms of complementarities and / or substitution.

8. **Technical Analysis:** Using a methodology approach based on multi-criteria analysis, called "Analytical Hierarchy Process" (AHP). An operational effectiveness analysis through performance criteria and operational readiness has to be applied. For the sub-criteria definition the following areas have to be considered:

a) System capabilities characteristics needed to met the objectives.

b) Restrictions affecting their applicability.

c) Reliability/Maintainability parameters that determine operational readiness and availability.

d) Logistic support according to demanded operational readiness.

Once alternatives have been identified and defined, their viability is determined taking into account the technically optimized baseline situation, which is the comparison reference for all the solutions.

9. **Economical analysis** It consists in developing an analysis of the estimated cash flow for each technically feasible alternative solution, prioritizing them according to approaches set in "Economic analysis" of this methodology. Cost estimates will take into account the complete project life cycle, i.e., acquisition, operation and removal, and considering benefit estimates also, if any.

10. **Comments and recommendations:** It should include a ranking of the considered alternatives, according to the previously mentioned technical and economic analysis.

Some technical and economical analysis perspectives are presented next to build a foundation for this study. These analyses are applied respectively in steps 8 and 9 of the previously presented analysis structure.

The technical analysis perspective includes the full or partial utilization of the multi-criteria analysis methodology approach. The economical analysis perspective includes both cost-benefit and cost-efficiency approaches.

## Technical analysis

### ***Multi-criteria Technical Analysis: Analytical Hierarchy Process (AHP).***

The Analytical Hierarchy Process (AHP) is a theory of measurement through pairwise comparison and relies on the judgments of experts to derive priority scales. It is these scales that measure intangibles in relative terms. The comparisons are made using a scale of absolute judgments that represents how much more one element dominates another with respect to a given attribute (Saaty, 2008:83).

For the purposes of this study, the multi-criteria analysis approach is used when considering project operational effectiveness through performance criteria and operational availability.

The first level criteria to determining operational effectiveness are operational performance and operational availability. Their weights (percentage) are calculated through the method of hierarchical analysis.

> **Operational performance:** ability of each alternative solution to meet defined objectives at any scenario, considering all subsystems integrated.
>
> **Operational availability**: each alternative solution inherent quality, which determines its ability to be available to meet its objectives at any time.

The second level criteria and below, are determined considering the following:

a) System features and capabilities to meet what is expected from it.
b) Restrictions affecting or conditioning their applicability.
c) Reliability parameters that determined operational availability.
d) Logistic support according to the operational availability required.

This AHP analysis can be fully or partially applied on pairwise comparison:

**a) Fully Utilization**

Comparisons between pairs are carried out for obtaining the following:

a) Criteria and sub-criteria assessment weights

b) Alternative solutions assessment

That is, the alternatives are compared to each other using the grading scale from Thomas L Saaty's Hierarchical Analysis Method (Saaty, 2008) shown in Table 12.

**Table 12: Hierarchical Analysis Method grading scale (Saaty, 2008)**

| INTENSITY | DEFINITION | EXPLANATION |
|---|---|---|
| 1 | Like | Two criteria or sub-criteria equally contribute to achieve the target. |
| 3 | Moderate | Experience and professional judgment slightly favor a criterion or sub-criterion approach over the other. |
| 5 | Strong | The experience and professional judgment strongly favor a criterion or sub-criterion approach over the other. |
| 7 | Very strong or demonstrated | A criterion or sub-criterion approach is much more favored than the other; its prevalence is demonstrated in practice. |
| 9 | Extreme | The evidence favoring one criterion or sub-criterion over the other is absolutely and totally clear. |
| 2, 4, 6, 8 | | Between the above values, when parties commitment is required to trade between adjacent values. |

**b) Partial Utilization**

Comparisons between pairs are used only for obtaining criterion and / or sub-criterion weights and then, for assigning a "note" to each alternative solution, quantifying the degree of satisfying compliance against each requirement or goal.

In this study, the grading scale used for the AHP hierarchical analysis method is the Modified Cooper-Harper's scale. An application of the scale for project analysis is shown in Figure 18.

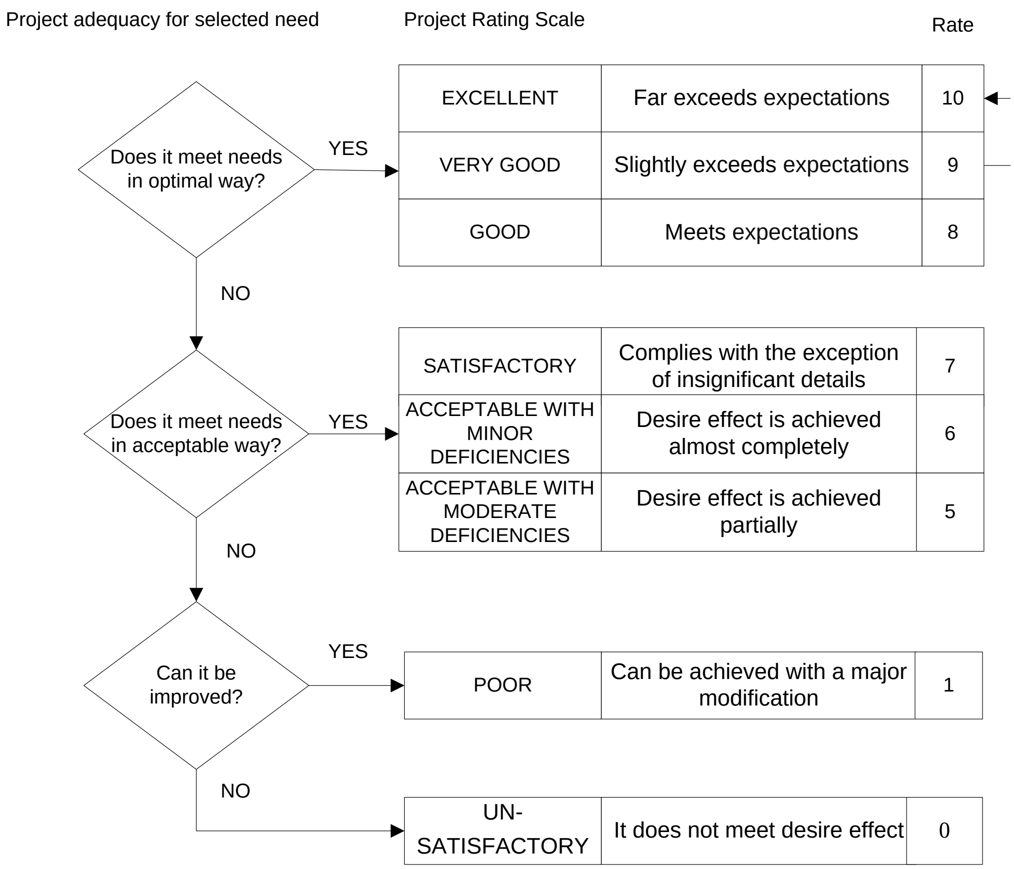


**Figure 18: Modified Cooper-Harper's scale**

Where:

**Score 8 to 10**: Applies when requirement is fully satisfied or exceeded.

**Score 7 to 5**: Corresponds to a partial requirement fulfillment. Although it has flaws, it is considered acceptable.

**Score 1**: Applies when the evaluated system does not meet the requirement, but it could meet the terms only through a couple of major modification. Therefore it is considered not acceptable.

**Score 0**: It is used when there is no possibility of meeting the requirement or when the requested information was not provided by the manufacturer.

**Score 4, 3, and 2**: Not used in qualifying but product calculations and weights can result below 5 and greater than 1. These ratings are considered unacceptable.

## Economic Analysis

Economic analysis only proceeds for those alternative solutions which have been technically selected, that is, for those which meet the minimum required in terms of operational effectiveness.

It develops a cash flow estimate (profits and / or costs) for the entire project life cycle, i.e. the stages of acquisition, operation and removal, estimating benefits, if any.

When project costs and benefits can be expressed in terms of money, a cost-benefit analysis approach should be adopted. When it is not possible to express project cost and benefits in monetary terms, or when the effort to achieve that has a high cost, a cost-effectiveness analysis approach should be adopted.

### *Cost-Benefit Analysis approach*

A cost-benefit analysis is as systematic process for calculating and comparing benefits and cost of project. This analysis finds, quantifies, and adds all the positive factors (the benefits). Then it identifies, quantifies, and subtracts all the negative ones (the costs). The difference between the two indicates whether the planned action is advisable.

In this study, it provides a basis for comparing projects. It involves comparing the total expected cost of each option against the total expected benefits, to see whether the benefits outweigh the cost and by how much. Therefore, it compares acquisition, operation and removal costs with benefits it generates. It is necessary to identify and include all the costs and all the benefits quantifying them properly, taking into account that:

- Costs and benefits identification implies considering all positive and negative impacts generated by the project in a qualitative form.
- Costs and benefits measure is referenced by quantitative metrics.
- Costs and benefits valuation means transforming physical units in monetary values, considering produced goods prices and resources used.

Once identification, measuring and assessment process is completed, the comparison of costs and benefits (expressed in present value terms) has to be performed. Finally, these results are translated into profitability indicators, as Net Present Value (NPV) and Internal Rate of Return (IRR).

NPV is an indicator of the value or magnitude of an investment. It measures the excess or shortfall of cash flows, in present value terms, once financing charges are met. NPV is a standard method to appraise long-term projects. It is defined as the sum of the present values (PV) of the individual cash flows of the same entity.

IRR is a rate of return used in capital budgeting to measure and compare the profitability of investments. It is an indicator of the efficiency, quality, or yield of an investment. An investment is considered acceptable if its internal rate of return is greater than an established minimum acceptable rate of return or cost of capital.

### *Cost-Efficiency Analysis Approach*

Cost-Efficiency Analysis applies when project benefits are difficult to quantify and assess, especially when it involves application of judgment values. In this case, the criteria to be applied shall be the minimum cost.

This approach is based on the assumption of equal benefits from the alternatives considered. Thus, benefits are expressed in terms of the minimum required operational effectiveness. Additional benefits provided by each alternative are considered as not relevant.

Once processes of identifying, measuring and assessing the entire project life costs are completed, the costs have to be compared by expressing them in Present Values, which ultimately result in economic efficiency indicators. Indicators used in this evaluation approach are Present Value of Costs (PVC) and Equivalent Annual Cost (EAC). EAC is the cost per year of owning and operating an asset over its entire lifespan. It is often used as a decision making tool when comparing investment projects of unequal lifespan. EAC is calculated by dividing the NPV of a project by the present value of an annuity factor. The use of the EAC method implies that the project will be replaced by an identical project.

### *DIP' Final Product Supply Offer*

Product supply offer per given project period is expressed as the relationship between the product price (calculated from production cost) and the amount of product produced.

The price for the total amount of product z offered ($p_z of$) per given period, is defined as:

**Equation 1: DIP's total production price**

$$p_z of >= ALCC \left( _{z,of} \right)$$

Where:
$p_z of$ = price of the offered amount of product z
ALCC = Average Life Cycle Cost
z= Product type
of= offered quantity of z

**Chapter Summary**

Following a general methodology structure implemented in the Argentine Ministry of Defense (MINDEF) for defense investment projects (DIP) analysis, a number of definitions and concepts were presented in this chapter. This methodology provides a useful framework in order to analyze defense investment projects from many different perspectives. It also provides transparency and standardization ensuring an efficient project evaluation process according to the law and regulations in force. Besides that, methodology analysis provides insights beyond exclusively quantitative metrics about action areas which may contribute to the Argentina aircraft industry long term success. In the next chapter, different solution scenarios are considered in order to satisfy Argentine Air Force requirement of increased aircraft availability (flight hours) to complete pilot basic training courses. The methodology presented will be used as a flexible and useful tool when analyzing and comparing these options.

# IV. Analysis and Results

## Chapter Overview

The first part of this chapter defines the scope of the program related Defense Investment Project (DIP) and introduces three possible alternative solution scenarios in order to satisfy Argentine Air Force requirement of increased aircraft availability (flight hours) to complete pilot basic training courses. These three scenarios are compared with a "status quo" optimized baseline situation. The optimized baseline situation without project (SSP) is assumed to be the worst case where no new trainers are incorporated to the Argentine Air Force inventory. The purpose of this comparison is to find out which one is the best solution. Basically the first scenario considers developing and acquiring the Argentinean trainer IA-73. The second one considers buying the Italian trainer SF-260 TP. Finally, the scenario of buying the German trainer Grob G-120TP is analyzed. Each alternative solution provides more training flight hours that the baseline situation but with different aircraft quantities, costs and time horizons.

The second part of this chapter analyzes the previously mentioned aircraft procurement scenarios using the methodology presented in Chapter III as a general rule. This methodology is embedded in many data base spreadsheets generated by the Argentine Ministry of Defense providing the basis for the alternative solution options comparison. Necessary flexibility has to be considered when applying the methodology on each specific scenario.

The last part of this chapter compares alternative solution analysis results determining which option better meets Argentine Air Force requirement for increased number of training flight hours. Research questions in chapter I are revisited and answered.

## Defense Investment Project (DIP)

### ***DIP's scope***

The present defense investment project (DIP) is generally stated as:

> Incorporate primary / advanced trainer aircrafts to the Argentine Air Force inventory to meet joint military aviator pilot basic training course (CBCAM) requirements, replacing current "Mentor" B-45 and Emb-312 "Tucano" aircrafts. (Note: CBCAM is the Spanish acronym for *Curso Básico Conjunto de Aviador Militar*)

Considerations about Operational Requirement (OR), number of training flight hours (TFH) to meet CBCAM training demand, time, and resources involving each option implementation are taken into account in this analysis. Project evaluation is performed according to the methodology established by the Argentine Defense Ministry (MINDEF).

The Argentine National Public Investment System requires that all public investment projects have to be analyzed by mean of specific tools. The Public Investment Project Data Base (BAPIN) (*Banco de Proyectos de Inversión Pública*) and the Military Investment Data Base (BIM) (*Banco de Inversión Militar*) are the National Public Investment System's basic tools, designed by national law 24,354. The BAPIN and BIM are designed to gather relevant information about projects investments in the Public Sector, throughout its life cycle. They allow monitoring the project to be executed by each agency at its different phases (pre-investment, implementation, operation). BAPIN and BIM are necessary instances to be completed previous to include the project into the national budget.

Considering the project under this study, it is assumed that CBCAM requires 9,000 training flight hours per year to successfully complete the syllabus. The resulting training flight hour gap has to be achieved within a period not exceeding 5 years, considered since the investment decision is taken. Necessary follow-on support has to be sustained in terms of quality and efficiency for a period not less than 10 years.

***DIP's objectives***

DIP's objectives are classified as: a) Direct Impact Objectives, and b) Production Objectives. These objectives are associated with indicators which evaluate the ability of each alternative solution to form pilots by using effectiveness index and expected training flight hour's availability, respectively.

**a)** **Direct Impact Objective (z)**: Reach the pilot training capability levels demanded by the joint military aviator course (CBCAM). Indicator: Effectiveness Index

**b)** **Production Objective (x)**: Improve CBCAM military pilot training capability by incorporating the IA-73 trainer to the Air Force Academy (EAM) inventory, beginning in 2015 until completing 50 units, once the investment decision is taken. Indicator: Training flight hours.

Direct Objective Requirements (DOR) group all capital, materials, consumables, supplies, labor, and service expenditures at each project stage. They are listed as:

- Aircraft systems to provide primary basic military pilot training.
- Infrastructure to support incorporated Aircrafts.
- Initial training for crew members.
- Initial training for maintenance technical support staff.
- Equipment for maintenance shop.
- Equipment for training centers.
- Aircraft components and parts.
- Equipment for pilots and mechanics.
- Investment phase management (Expendable goods).
- Operation phase management (Fixed Assets).
- Consumables and supplies for operation phase
- Consumables and supplies for the investment phase management.
- Supplies for crew initial training.
- Supplies for maintenance personnel initial training.
- Supplies for operational training.
- Supplies for maintenance personnel training.
- Services for outsourced maintenance and technical support.
- Supplies for operation.
- Supplies for maintenance.
- Service for flight simulator maintenance.

- Contingency reserves (transfer fees, exchange rate differences, increased economic variables and other bank charges in order to mitigate and transfer risks).
- Supplies for environmental preservation.

In order to satisfy Argentine Air Force requirement of increased aircraft availability the following guidelines are considered when analyzing possible scenarios:

- Project Life Cycle: 15 years
- Evaluation Horizon: 10 years
- Period: Annual
- Currency: Legal currency type (Argentine Peso)

At this point of the study and following the methodology presented in chapter III, it has being covered the analysis structure step 1 (general information about the project), step 2 (problem identification) and step 3 (current situation diagnosis). Information on chapter II, referenced as IA-73 Operational Requirement Fundamentals, complements the information the steps of the methodology require.

**Optimized Baseline Situation without project (SSP)**

At this point of the study the methodology step 4 (optimization of the base situation) is developed. The optimized baseline situation considers that no new trainers are incorporated to the Argentine Air Force inventory. It only recovers limited operational-logistic capabilities for some Beechcraft B-45/T-34 "Mentor" and Embraer EMB 312 "Tucano". This situation is referenced as "situation without project" (SSP).

From the analysis of this scenario results that both “Mentor” and “Tucano” trainer systems evidence technological obsolescence, very long time in service, and logistical procurement issues that are very difficult to fully repair the systems, even with the necessary financial resources.

Mentor’s performance has decreased significantly in the last 5 years due to its reduced reliability and consequently low availability. This situation is not only the consequence of aircraft structure and components aging, but also from factors like lack of component suppliers, structural problems, increased aircraft gross weight, etc. As a result, there are not enough available flight hours to complete pilot training requirements.

Similar situation applies to the “Tucano” system. A reduced number of aircraft in service are the result of increasingly supply chain and maintenance problems. Even in the origin country, Brazil, the “Tucano” has become an obsolete model, replaced by the “Super Tucano”. Without service and component suppliers’ long-term agreements, these providers find more profit in serving newer systems. As result, fewer aircraft in service adversely affect flight training activity.

Despite the mentioned problems, it is necessary to assess the SSP situation as direct consequence of new trainer aircraft’s long procurement and transition time. The SSP scenario provides partial support to maintaining “Mentor” and Tucano’s operational capabilities until those can be replaced by any of the possible aircraft analyzed in this defense investment project (DIP).

SSP option can only be considered for a maximum transition time towards the new aircraft procurement of 5 year. SSP option demands a specific 5year budget in order to engage suppliers and temporarily sustain the supply chain effort.

In this scenario there are no investment plans for incorporating new aircrafts, except the minimum necessary actions to partially recover original operational system capabilities. The minimum investment time for existing capabilities improvement will be held for the first 2 years. The operational phase starts at time t = 0 and takes place over 5 years. The retirement or final disposition phase lasts 1 year.

Methodology step 5 (capability gap identification) is considered when the DIP's direct objective (9,000 training flight hours (TFH) required by the Argentine Air Force) is compared with TFH production from the optimized base situation (SSP).

The next Table 13 summarizes general information about SSP scenario, stating the DIP (improve military pilot training capability by incorporating basic-primary training aircrafts to the AAF inventory), SSP scenario, "pre-feasibility" project analysis stage, project timing and financial aspects of the project.

Table 13: SSP option general information

| | | | |
|---|---|---|---|
| **PROJECT:** | **Improve Military Pilot Training Capability by incorporating basic-primary training aircrafts to the AAF inventory** | | |
| **Scenario:** | **Optimized Baseline Situation with Mentor & Tucano remaining potential** | | |
| **Analysis level:** | **Pre-Feasibility** | | |

**a. Analysis Time period Definition**

**Project Phases and analysis period**

| Variable | References | Unit | Qty |
|---|---|---|---|
| Period | Analysis time Interval | Years | |
| FasPINV | Pre-investment phase | Years | 0 |
| FasINV | Investment Phase | Years | 0 |
| FasOPE | Operational Phase | Years | 5 |
| FasLIQ | Retirement Phase | Years | 1 |
| HorTemp | Analysis time horizon | Years | 6 |
| Po | Initial Identified Period | Period # | 0 |
| Pn | Residual value recovery Final Period | Period # | 5 |

**b. Reference rate**

| | |
|---|---|
| r= | 12.00% |

**c. Currency unit**

| | | |
|---|---|---|
| Currency unit (UM) | 1 | u$s |
| Currency uniy (UM) | 2 | Euros |
| Currency uniy (UM) | 3 | Pesos |

| | | |
|---|---|---|
| Selected currency unit | 3 | **Pesos** |

| | | |
|---|---|---|
| | Pesos<br>u$s | Pesos<br>Euros |
| Exchange rate | 4.50 | 6.00 |

**d. Base period**

b=0

**e. Location**

| | |
|---|---|
| • Investment phase | AirForce Academy (EAM) |
| • Operational Phase | National |

Figure 19 shows how production objective estimates (measured in training flight hour's availability) are met at each project time period (in years) for the SSP scenario

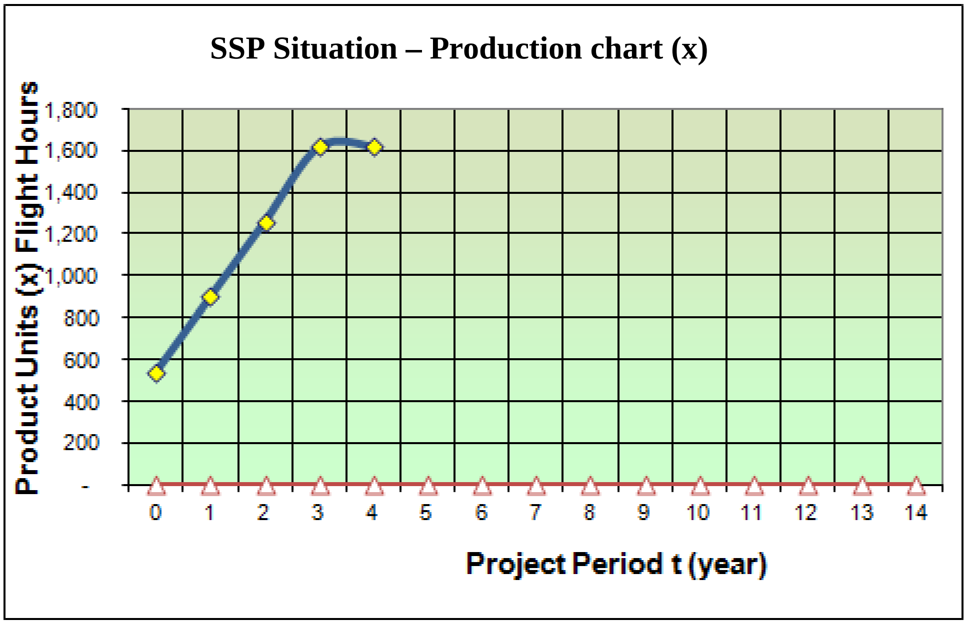


**Figure 19: SSP Production chart**

Figure 20 shows how direct impact objective estimates (measured by the effectiveness index) are met at each project time period (in years) for the SSP scenario.

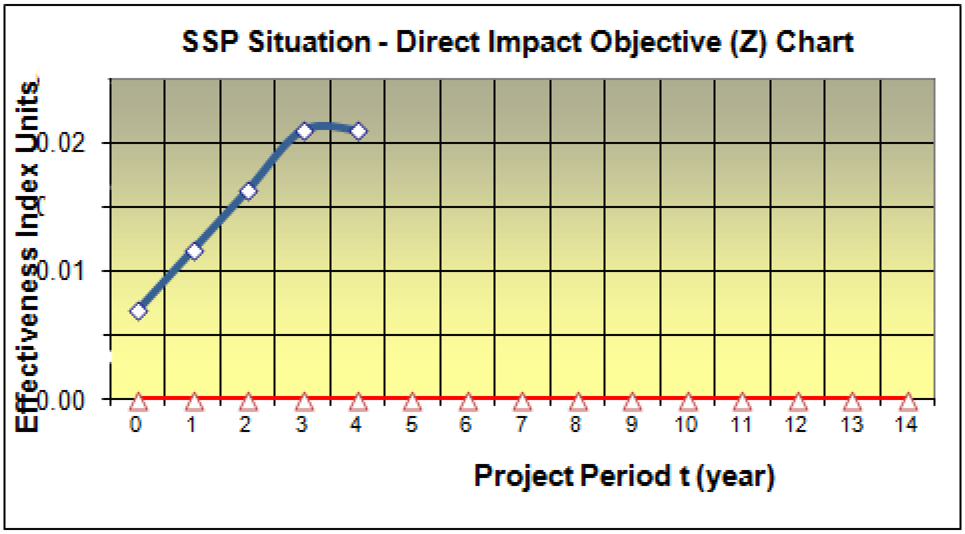


**Figure 20: SSP Direct Impact Objective chart**

Supplies expenditures for this SSP alternative arise from considering the prices and required features throughout the project evaluation period. Regarding current and future prices, market prices at constant values are considered. Cumulative supplies expenditures (market prices in Argentine Peso currency) for this SSP scenario and its related cash flow chart are presented in Figures 21 and 22 respectively.

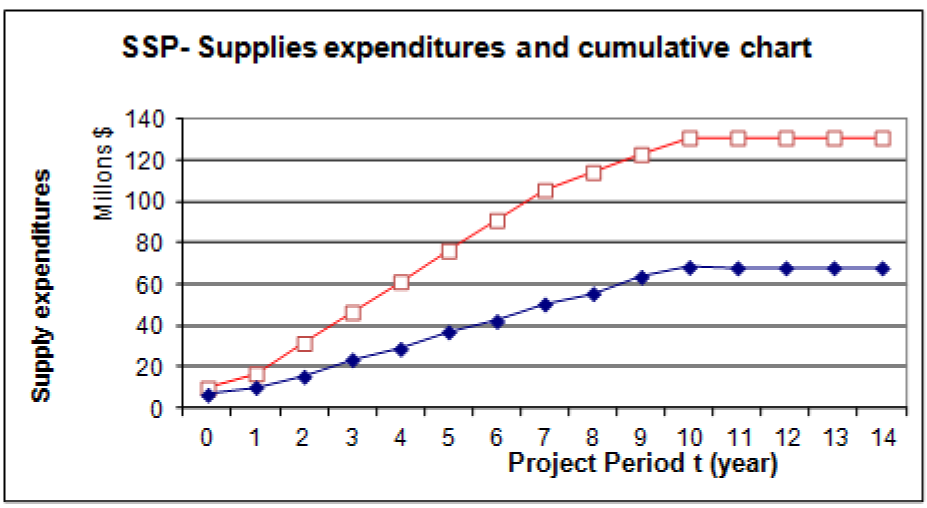

**Figure 21: SSP- Cumulative Supplies Expenditures**

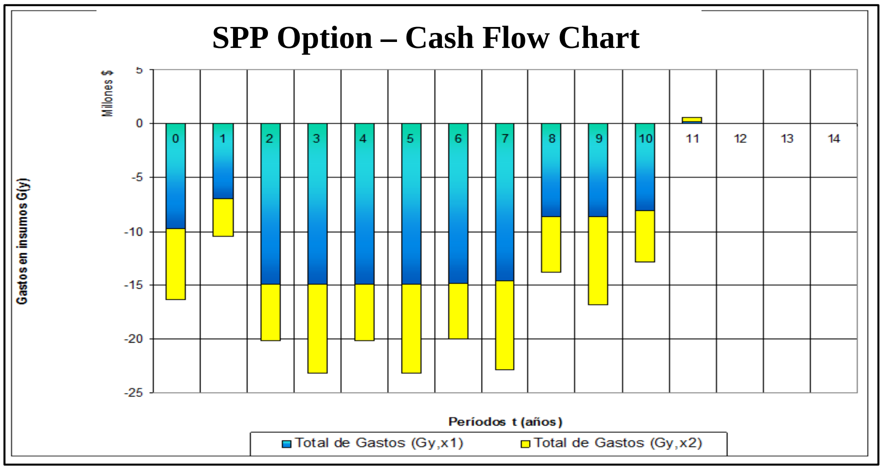


**Figure 22: SSP – Cash flow chart**

## Alternative Solution Options

At this point of the study the methodology step 6 (alternative solutions identification and definition) is applied on 3 mutually exclusive scenarios.

### *Scenario 1: IA-73 option*

Scenario 1 considers recovering limited operational-logistic capabilities for some Beechcraft B-45/T-34 “Mentor” and Embraer EMB 312 “Tucano” until they are removed from service and the IA-73 trainer is produced and operational. This option is referenced as IA-73 option (IA73).

The IA-73 Project is carried out by Argentina Aircraft Factory "Brig. San Martin" (FAdeA S.A.). The project involves the design and development of a basic training airplane intended to replace “Mentor” and “Tucano” systems. It is expected to be operational in service between t = 4 and t=5, starting its operational phase at t = 4. Its system life time goes in excess beyond the evaluation time horizon. Table 14 summarizes general information about IA-73 option.

**Table 14: IA-73 option general information**

| | | | |
|---|---|---|---|
| **PROJECT:** | **Improve Military Pilot Training Capability by incorporating basic-primary training aircrafts to the AAF inventory** | | |
| **Scenario:** | **IA-73 acquisition** | | |
| **Analysis level:** | **Pre-Feasibility** | | |

## a. Analysis Time period Definition

**Project Phases and analysis period**

| Variable | References | Unit | Qty |
|---|---|---|---|
| Period | Analysis time Interval | Years | |
| FasPINV | Pre-investment phase | Years | 0 |
| FasINV | Investment Phase | Years | 3 |
| FasOPE | Operational Phase | Years | 12 |
| FasLIQ | Retirement Phase | Years | 0 |
| HorTemp | Analysis time horizon | Years | 15 |
| Po | Initial Identified Period | Period # | 0 |
| Pn | Residual value recovery Final Period | Period # | 14 |

## b. Reference rate

| | |
|---|---|
| r= | 12.00% |

## c. Currency unit

| | | |
|---|---|---|
| Currency unit (UM) | 1 | u$s |
| Currency uniy (UM) | 2 | Euros |
| Currency uniy (UM) | 3 | Pesos |

| | | |
|---|---|---|
| Selected currency unit | 3 | **Pesos** |

| | | |
|---|---|---|
| | Pesos | Pesos |
| | u$s | Euros |
| Exchange rate | 4.50 | 6.00 |

## d. Base period

b=0

## e. Location

| | |
|---|---|
| • Investment phase | AirForce Academy (EAM) |
| • Operational Phase | National |

The number of aircraft involved in the Operational Requirement is not less than 30 units. Actually current DIP considers the manufacture of two prototypes and fifty units. It is assumed that FAdeA S.A is able to meet this demand

Similarly as it was detailed for the SSP scenario, corresponding direct objective requirements have been identified for each IA-73 project stage.

IA-73 option time projection and its compliance with expected increased training capability is shown in the following graphs. Figure 23 shows how production objective estimates (measured in training flight hour's availability) are met at each project time period (in years) for the IA-73 option.

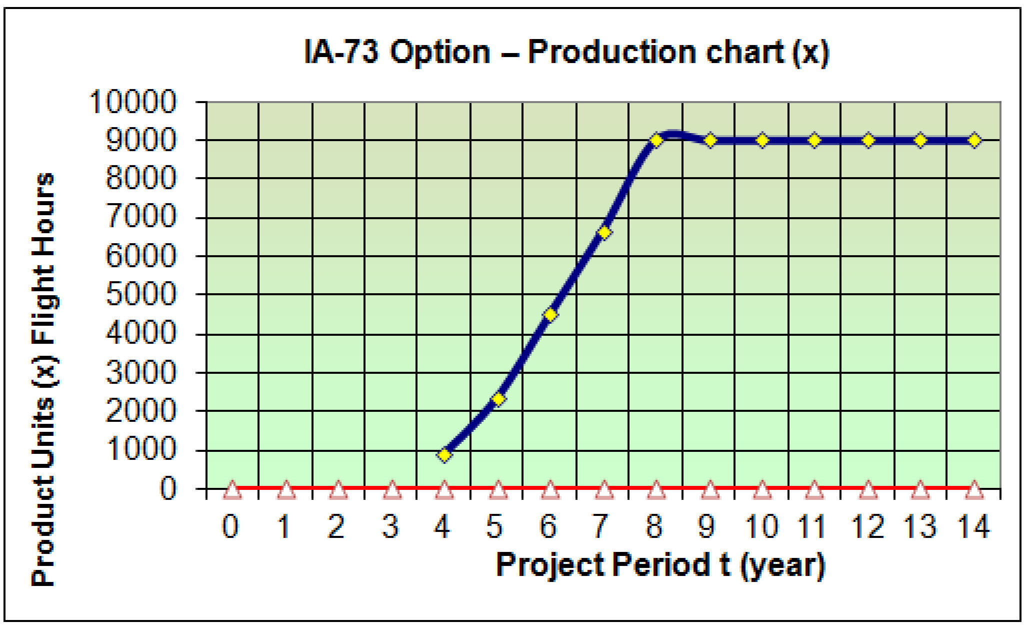


**Figure 23: IA-73 Option Production chart**

Figure 24 shows how direct impact objective estimates (measured by the effectiveness index) are met at each project time period (in years) for the IA-73 Option.

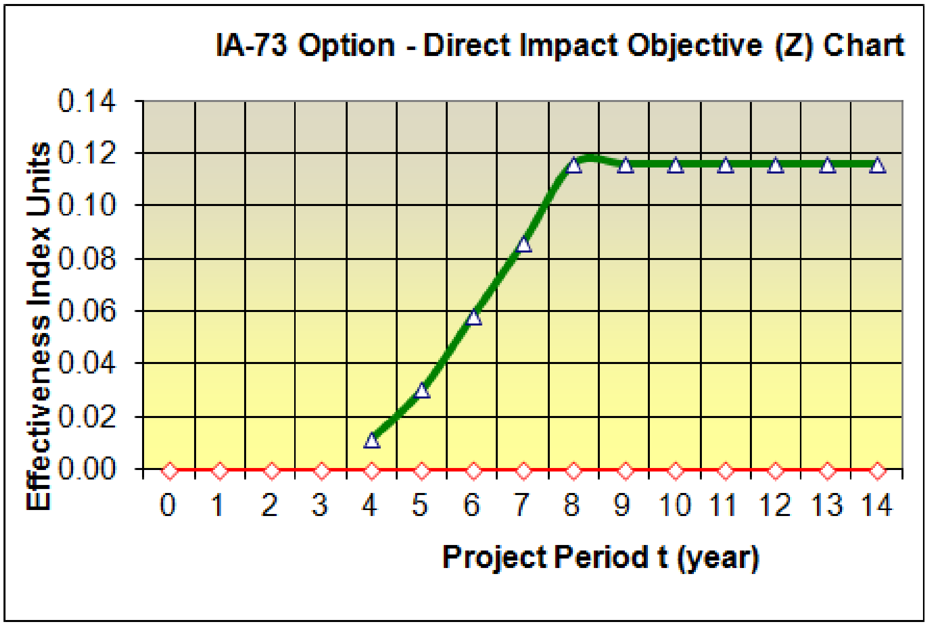


**Figure 24: IA-73 Option Impact Objective chart**

Cumulative supplies expenditures (market prices in Argentine Peso currency) for this IA-73 option and its related cash flow chart are presented in Figures 25 and 26 respectively.

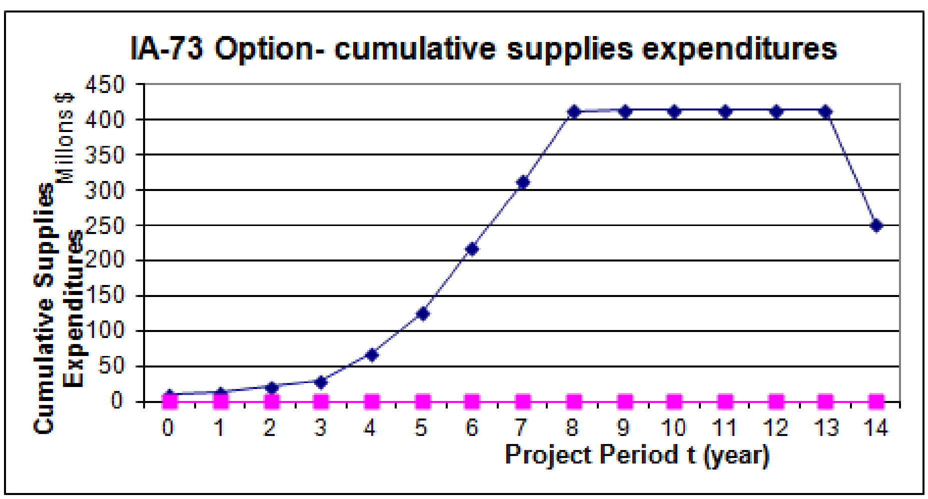


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**Figure 25: IA-73 option - Cumulative Supplies Expenditures**

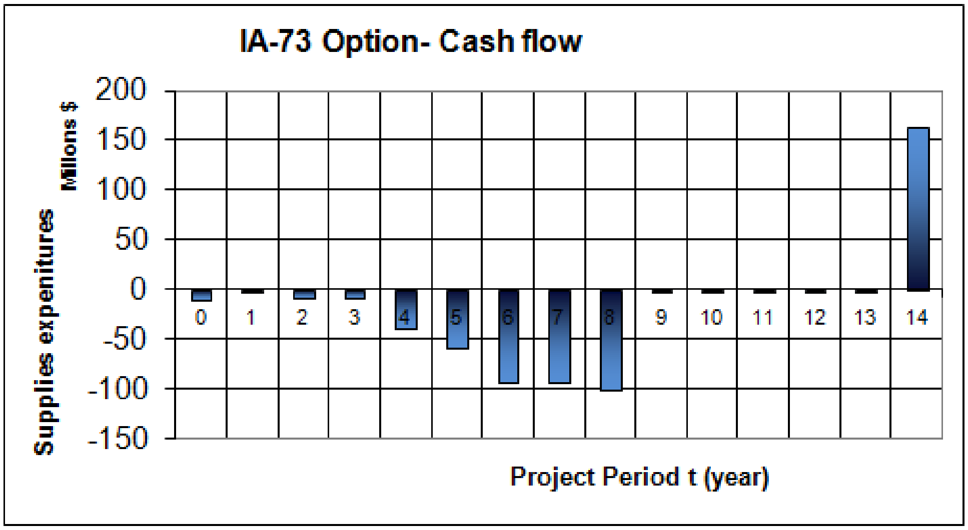



**Figure 26: IA-73 option – Cash Flow Chart**

***Scenario 2: SF-260TP Option***

Scenario 2 considers recovering limited operational-logistic capabilities for some Beechcraft B-45/T-34 “Mentor” and Embraer EMB 312 “Tucano” until they are removed from service and the Alenia Marchetti SF-260TP is acquired and operational at the Air Force Academy (EAM). This option is referenced as SF-260TP Option (SF260TP).

For analysis purposes it was used information provided by the manufacturer during its visits to Argentina. It is considered that the system is operational in service from t = 1, and its incorporation will take place between t = 0 and 3. The system has an expected life time in excess beyond evaluation horizon. It is not expected any aircraft acquisition reinvestment during the evaluation period. Table 15 summarizes general information about SF-260TP option.

**Table 15: SF-260TP option general information**

| | |
|---|---|
| **PROJECT:** | **Improve Military Pilot Training Capability by incorporating basic-primary training aircrafts to the AAF inventory** |
| **Scenario:** | **SF-260TP acquisition** |
| **Analysis level:** | **Pre-Feasibility** |

## a. Analysis Time period Definition

**Project Phases and analysis period**

| Variable | References | Unit | Qty |
|---|---|---|---|
| Period | Analysis time Interval | Years | |
| FasPINV | Pre-investment phase | Years | 1 |
| FasINV | Investment Phase | Years | 1 |
| FasOPE | Operational Phase | Years | 13 |
| FasLIQ | Retirement Phase | Years | 0 |
| HorTemp | Analysis time horizon | Years | 15 |
| | | | |
| Po | Initial Identified Period | Period # | 0 |
| Pn | Residual value recovery Final Period | Period # | 14 |

## b. Reference rate

| | |
|---|---|
| r= | 12.00% |

## c. Currency unit

| | | | |
|---|---|---|---|
| Currency unit (UM) | 1 | u$s | |
| Currency uniy (UM) | 2 | Euros | |
| Currency uniy (UM) | 3 | Pesos | |
| Selected currency unit | | 3 | **Pesos** |

| | | |
|---|---|---|
| | Pesos / u$s | Pesos / Euros |
| Exchange rate | 4.50 | 6.00 |

## d. Base period

b=0

## e. Location

| | |
|---|---|
| • Investment phase | AirForce Academy (EAM) |
| • Operational Phase | National |

Similarly as it was detailed for the SSP scenario, corresponding direct objective requirements have been identified for each SF-260TP project stage.

SF-260TP option time projection and its compliance with expected increased training capability is shown in the following graphs. Figure 27 shows how production objective estimates (measured in training flight hour's availability) are met at each project time period (in years) for the SF-260TP option.

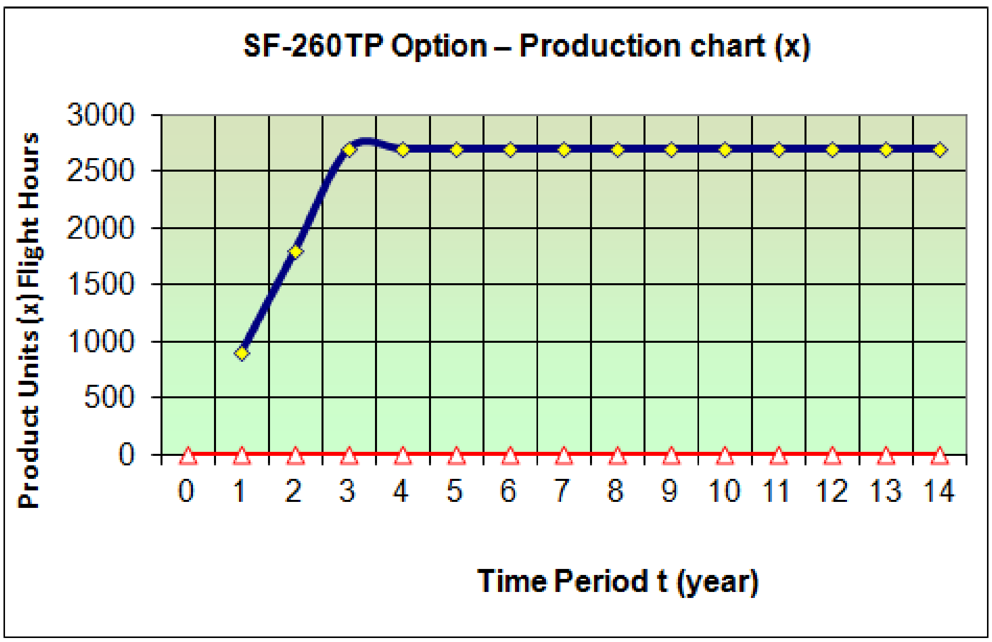



**Figure 27: SF-260TP Option Production chart**

Figure 28 shows how direct impact objective estimates (measured by the effectiveness index) are met at each project time period (in years) for the SF-260TP option.

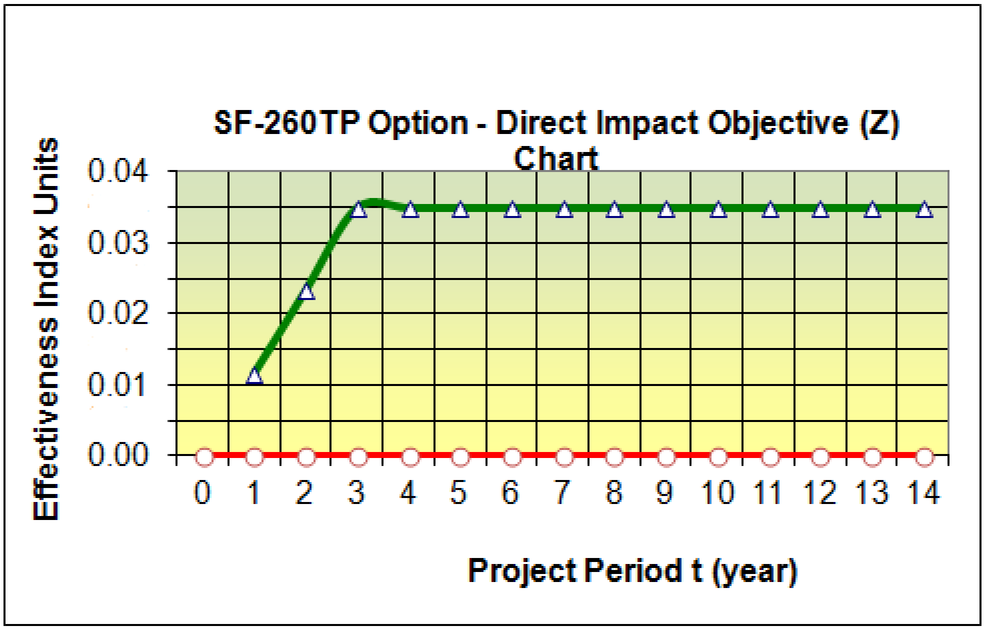



**Figure 28: SF-260TP Option Impact Objective chart**

Cumulative supplies expenditures (market prices in Euros currency) for this SF-260TP option and its related cash flow chart are presented in Figures 29 and 30 respectively.

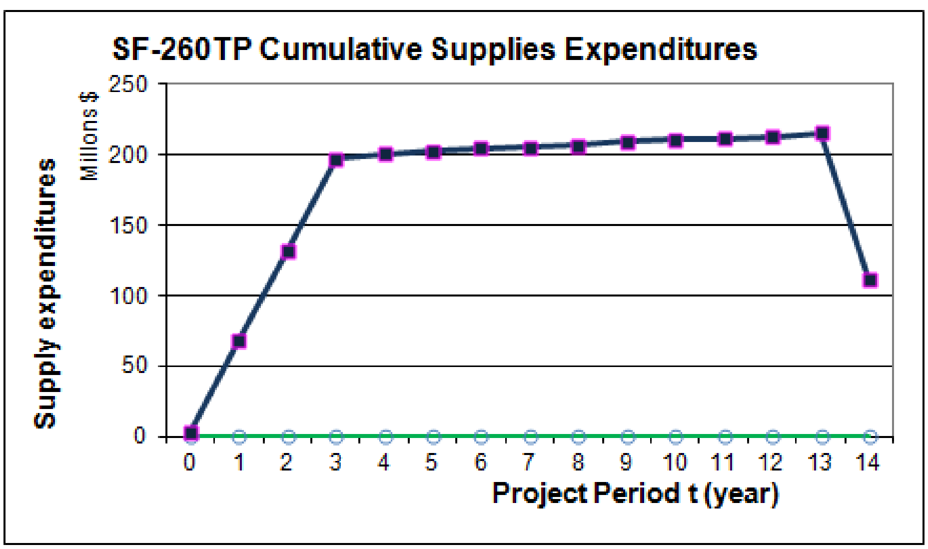



**Figure 29: SF-260TP Cumulative Supplies Expenditures**

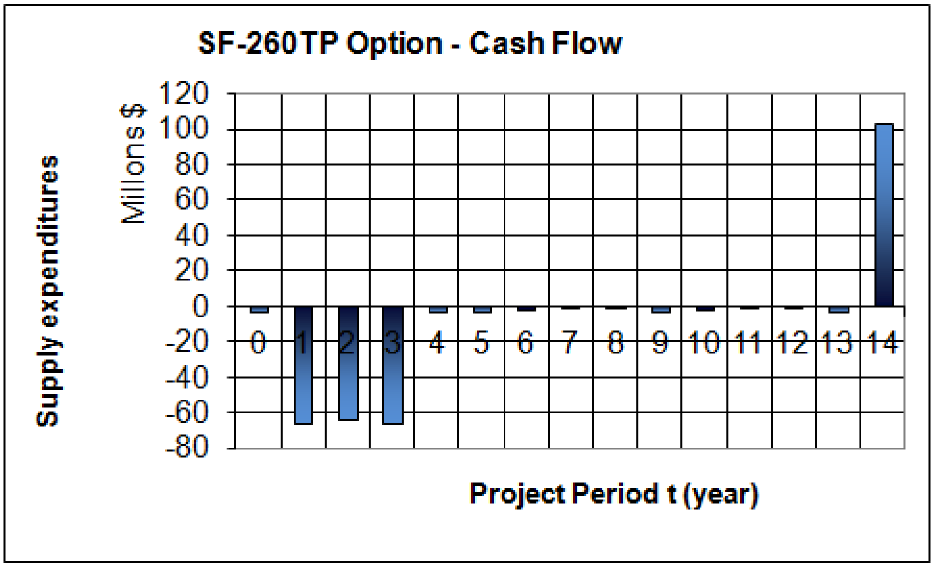



**Figure 30: SF-260TP Cash Flow Chart**

***Scenario 3: G-120TP***

Scenario 3 considers recovering limited operational-logistic capabilities for some Beechcraft B-45/T-34 "Mentor" and Embraer EMB 312 "Tucano" until they are removed from service and the Grob G-120TP is acquired and operational at the Air Force Academy (EAM). This option is referenced as G-120TP option (G120TP).

For analysis purposes, GROB offer terms are followed. Despite price differences, G-120TP option analysis follows same considerations as in the SF-260TP option analysis. It is considered that the system is operational in service from t = 1, and its incorporation will take place between t = 0 and 3. The system has an expected life time in excess beyond evaluation horizon. It is not expected any aircraft acquisition reinvestment during the evaluation period. Table 16 summarizes general information about G-120TP option.

Table 16: G-120TP option general information

| | | | |
|---|---|---|---|
| **PROJECT:** | **Improve Military Pilot Training Capability by incorporating basic-primary training aircrafts to the AAF inventory** | | |
| **Scenario:** | **G-120TP acquisition** | | |
| **Analysis level:** | **Pre-Feasibility** | | |

**a. Analysis Time period Definition**

**Project Phases and analysis period**

| Variable | References | Unit | Qty |
|---|---|---|---|
| Period | Analysis time Interval | Years | |
| FasPINV | Pre-investment phase | Years | 1 |
| FasINV | Investment Phase | Years | 1 |
| FasOPE | Operational Phase | Years | 13 |
| FasLIQ | Retirement Phase | Years | 0 |
| HorTemp | Analysis time horizon | Years | 15 |
| Po | Initial Identified Period | Period # | 0 |
| Pn | Residual value recovery Final Period | Period # | 14 |

**b. Reference rate**

| | |
|---|---|
| r= | 12.00% |

**c. Currency unit**

| | | |
|---|---|---|
| Currency unit (UM) | 1 | u$s |
| Currency uniy (UM) | 2 | Euros |
| Currency uniy (UM) | 3 | Pesos |

| | | |
|---|---|---|
| Selected currency unit | 3 | **Pesos** |

| | | |
|---|---|---|
| | Pesos | Pesos |
| | u$s | Euros |
| Exchange rate | 4.50 | 6.00 |

**d. Base period**

b=0

**e. Location**

| | |
|---|---|
| • Investment phase | AirForce Academy (EAM) |
| • Operational Phase | National |

Similarly as it was detailed for the SSP scenario, corresponding direct objective requirements have been identified for each G-120TP project stage.

G-120TP option time projection and its compliance with expected increased training capability is shown in the following graphs. Figure 31 shows how production objective estimates (measured in training flight hour's availability) are met at each project time period (in years) for the G-120TP option.

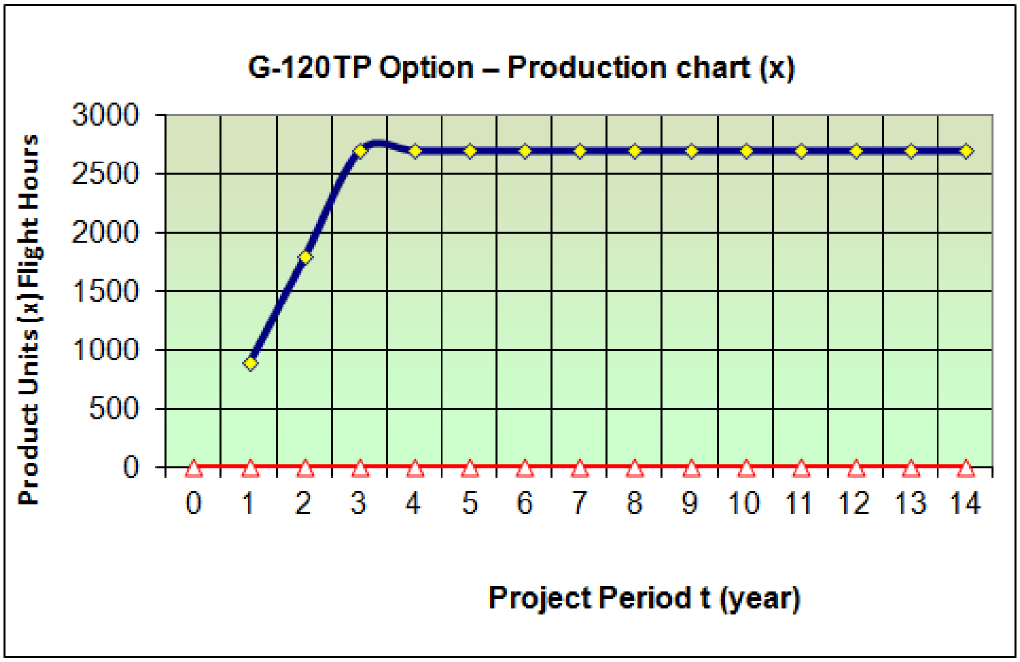



**Figure 31: G-120TP Option Production chart**

Figure 32 shows how direct impact objective estimates (measured by the effectiveness index) are met at each project time period (in years) for the G-120TP option.

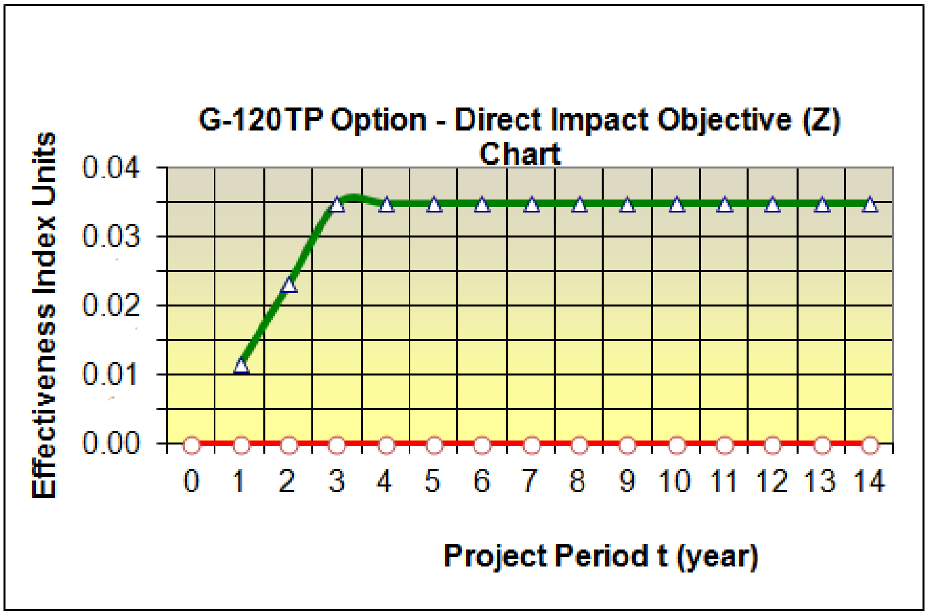



**Figure 32: G-120TP Option Impact Objective chart**

Cumulative supplies expenditures (market prices in Euros currency) for this G-120TP option and its related cash flow chart are presented in Figures 33 and 34 respectively.

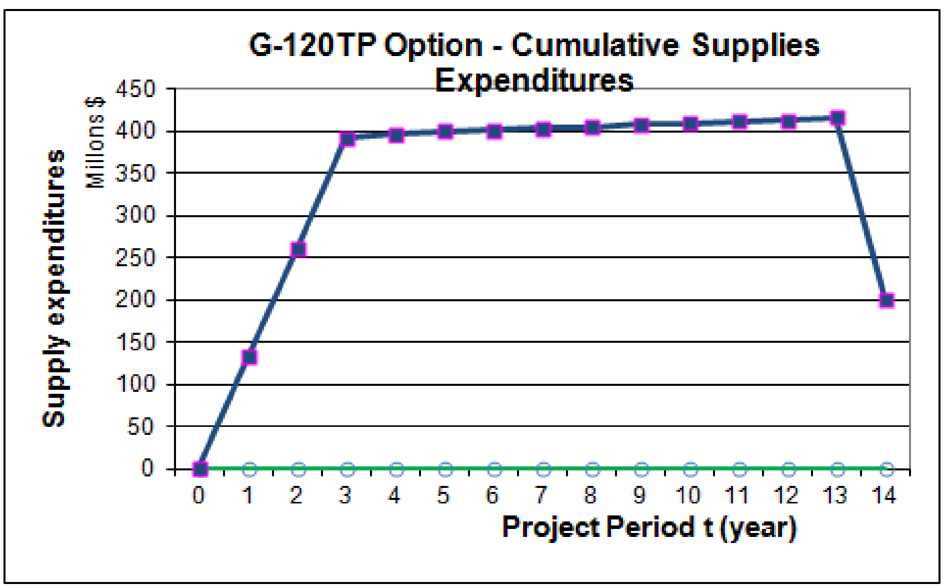



**Figure 33: G-120TP Cumulative Supplies Expenditures**

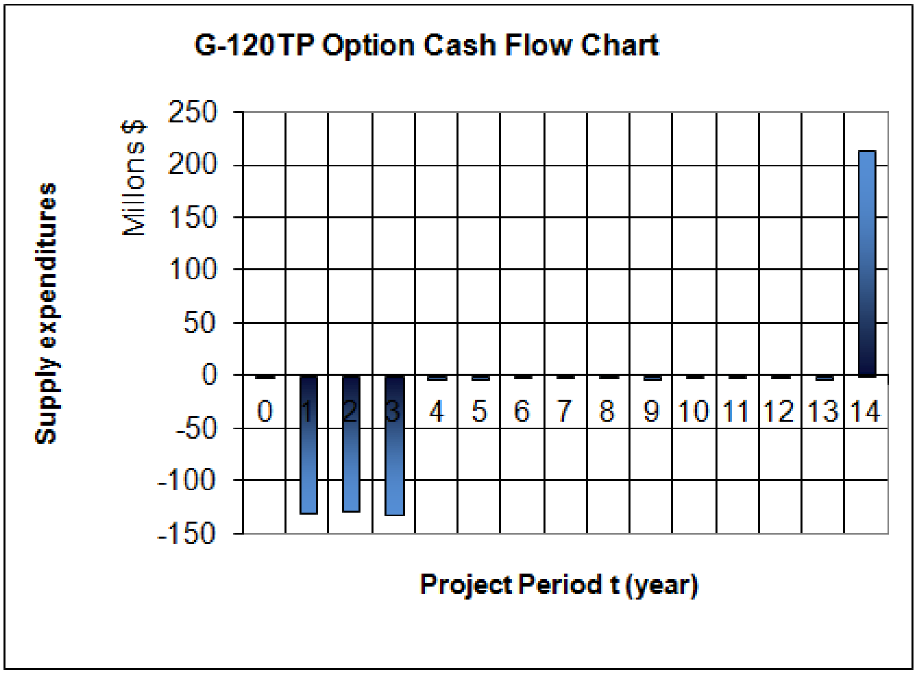



**Figure 34: G-120TP Option Cash Flow Chart**

## Comparison of Alternative Solution Options

At this point of the study, all the alternative solutions and the SSP situation without project are compared. Many technical and economical metrics are considered for this purpose. Methodology step 7 (compatibility analysis and dependence with other initiatives), step 8 (technical analysis) and step 9 (economical analysis) have been explicitly or intrinsically considered when analyzing each alternative solution and when calculating metrics embedded in MINDEF spreadsheets.

Technical-operational analyses for determining and choosing the 3 comparable training aircraft options are beyond the scope of this thesis. Only manufacturers' technical information is presented in chapter II (Aircraft in the same IA-73 Turboprop basic trainer segment) as well as in Appendix A. IA-73 Operational Requirement.

Some financial related information and cost/ price data have been omitted in this thesis observing confidentiality agreements among parties.

***Effectiveness level comparison***

The effectiveness level of each alternative option contribution (SSP, IA-73, SF-260TP, and G-120TP options), is presented in Table 17 and Figure 35. Effectiveness level is obtained from criteria and sub-criteria assessment weights on attributes and sub-attributes defined in the Effectiveness Model. The assessment is based on analyst's professional judgment and experience.

Multi-criteria analysis approach is used for the purpose of this study when considering project operational effectiveness through performance criteria and operational availability, as it is stated in chapter III.

Pairwise comparison follows the Analytical Hierarchy Process (AHP) theory and relies on the judgments of experts to derive priority scales. These scales measure intangibles in relative terms using a scale of absolute judgments that represents how much more one element dominates another with respect to a given attribute (Saaty, 2008:83).

Data obtained for each production option are normalized following selected criteria. For proper results interpretation it should be noted that stated total efficiency level values for each option, correspond to the maximum contribution that such option could provide.

**Table 17: Effectiveness level of each alternative option**

| X, Z | SSP | IA-73 | SF260TP | GROB G120TP |
|---|---|---|---|---|
| AIRCRAFTS | 0.42 | 0.55 | 0.47 | 0.41 |
| INFRASTRUCTURE | 0.15 | 0.15 | 0.15 | 0.15 |
| HUMAN RESOURCES | 0.1 | 0.13 | 0.08 | 0.08 |
| LOGISTICS | 0.01 | 0.04 | 0.03 | 0.03 |
| TRAINING | 0.02 | 0.05 | 0.05 | 0.05 |
| **TOTAL** | **0.70** | **0.58** | **0.78** | **0.71** |

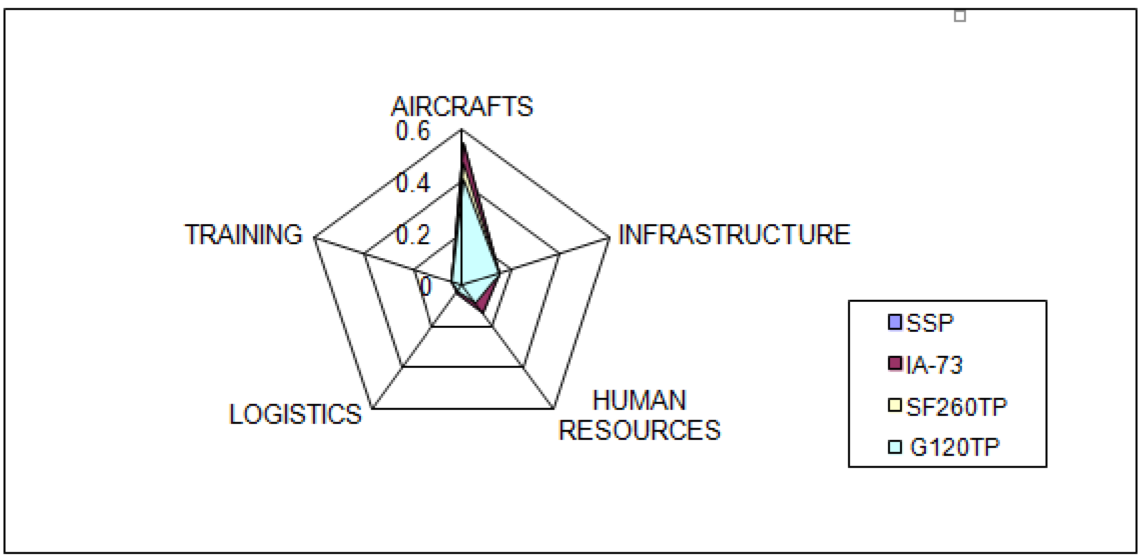



**Figure 35: Effectiveness level of each alternative option**

### *Objectives Achievement Comparison*

Both Direct Impact Objectives (z) and Production Objectives (x) from all the alternative solution options are compared. Direct Impact Objective looks for reaching CBCAM demanded capability level for pilot training purposes and it is measured by the Effectiveness Index Indicator. Production Objective (x) seeks improving CBCAM military pilot training capability by incorporating the selected trainer to the Air Force Academy (EAM) inventory. It is measured by training flight hour's equivalent indicator. Product objective and direct objective comparison among options are shown in Figure 36 and Figure 37 respectively.

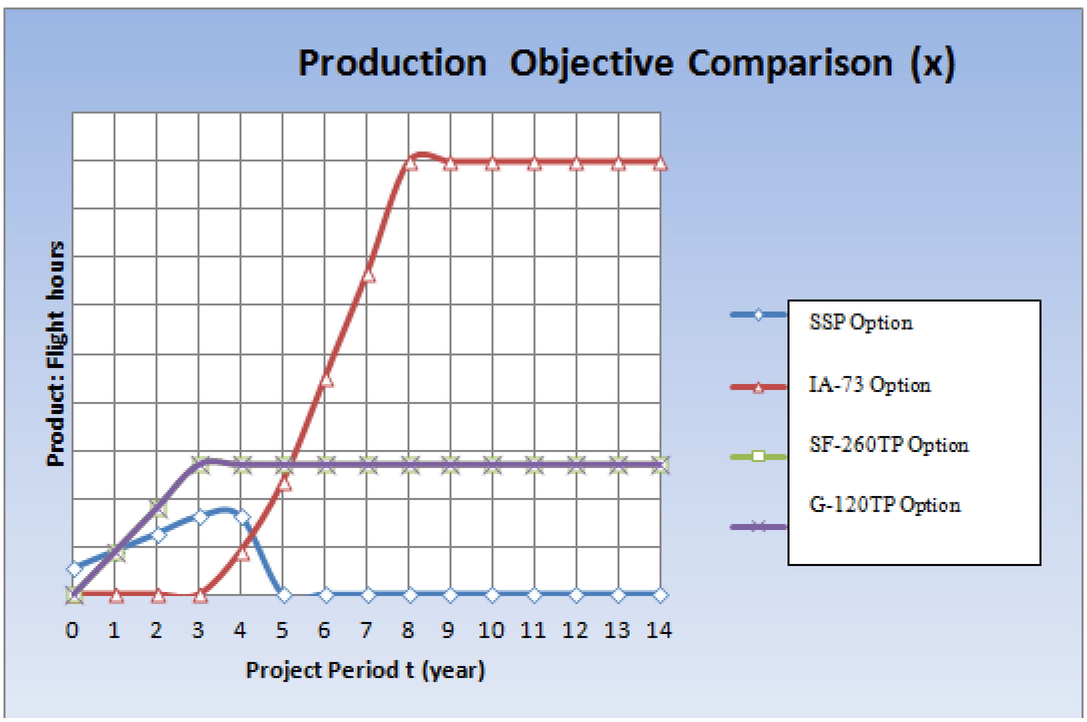



**Figure 36: Production Objective Comparison**

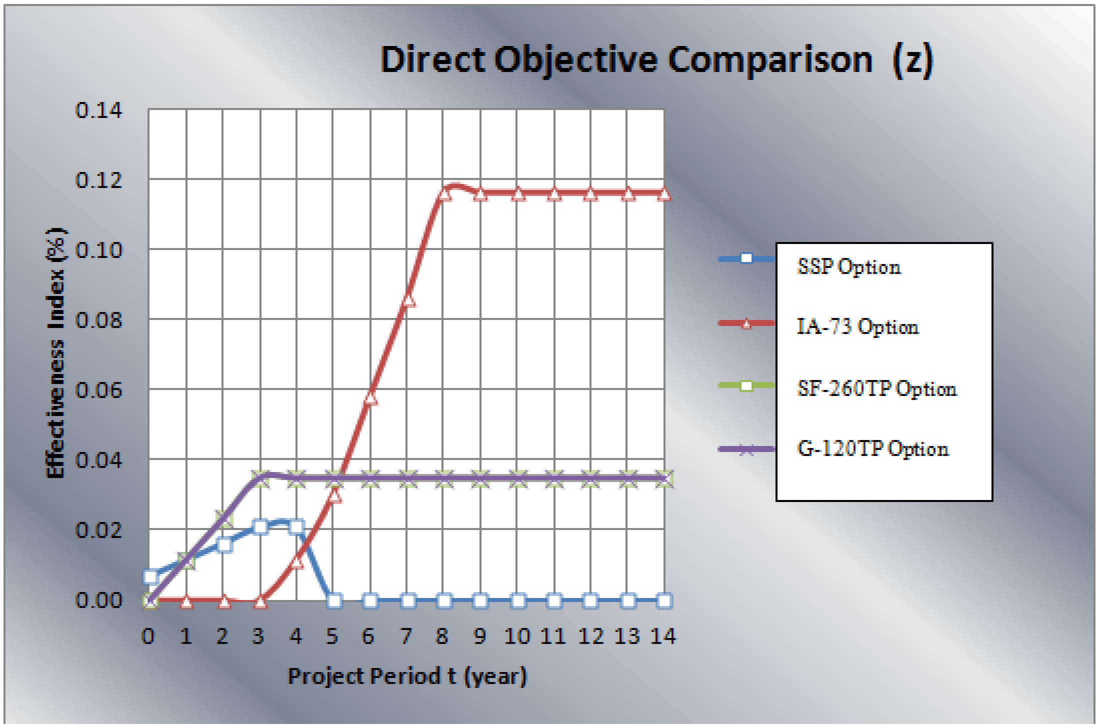



**Figure 37: Direct Objective Comparison**

***Option's Final Product Supply Offer***

Product supply offer per given project period is expressed as the relationship between the product price (calculated from production cost) and the amount of product produced.

The price for the total amount of product z offered ($p_z$of) per given period was defined by Equation 1 in chapter III:

$$p_z of >= ALCC \left( _{z,of} \right)$$

Where:
$p_z$of = price of the offered amount of product z
ALCC = Average Life Cycle Cost
z= Product type
of= offered quantity of z

Considering each option's TFH average production per period, the offered supply is defined as follows:

- **IA-73 Option**

For t= 8 $z_8$of= 9,000 p$z_8$of= ALCC ($z_8$of) = 6,955.17 $/TFH/per.

Note that for this IA-73 option, the offered training flight hours (TFH) (9,000 hours per period to be provided by the fleet) meets the Air Force demand of 9,000 hours.

- **SF-260TP Option**

For t= 8 $z_8$of= 2,700 p$z_8$of= ALCC ($z_8$of) = 9,315.67 $/TFH/per.

Note that for this SF-260TP option, the offered training flight hours (TFH) (2,700 hours per period to be provided by the fleet) is less than the 9,000 hours Air Force demand.

- **G-120TP Option**

For t= 8 $z_8$of= 2,700 p$z_8$of= ALCC ($z_9$of) = 18,131.74 $/TFH/per.

Note that for this G-120TP option, the offered training flight hours (TFH) (2,700 hours per period to be provided by the fleet) is less than the 9,000 hours requested by the Air Force demand.

*DIP's benefits estimation*

Benefits extracted from each defense investment project (BDIP) shall be expressed incrementally with reference to the baseline SSP situation (situation without project), as the Equivalent Annual Cost (EAC) with respect to the Military Capability Objective (MCO) to be implemented. EAC represents the cost per year of owning and operating an asset over its entire lifespan and it is often used as a decision making tool in capital budgeting when comparing investment projects of unequal life spans. The use of the EAC method implies that the project will be replaced by an identical project. EAC is calculated by dividing the project Net Present Value (NPV) by the present value of an annuity factor. Equivalently, the NPV of the project may be multiplied by the loan repayment factor (AF). DIP's options include scenarios "with project" (WP) and scenarios "without project" (WNP) (as in the SSP baseline situation case).

In order to determine these benefits, the **EAC**'s **C**ontribution to the **M**ilitary **C**apability **O**bjective (**EAC C MCO**) is used as military capacity indicator. Therefore, benefit calculation from each defined OCM, for each DIP Option can be calculated as:

- **IA-73 Option**

$$BDIP = EAC^{WP}_{C\ MCO} - EAC^{WNP}_{C\ MCO} = NPV^{WP} * AF^{WP} - NPV^{WNP} * AF^{WNP}$$

$$= 5.0\ \% - 1.6\ \% = \quad 3.4\ \%$$

- **SF-260TP Option**

$$BDIP = EAC^{WP}_{C\ MCO} - EAC^{WNP}_{C\ MCO} = NPV^{WP} * AF^{WP} - NPV^{WNP} * AF^{WNP}$$

$$= 3.0\ \% - 1.6\ \% = \quad 1.4\ \%$$

- **G-120TP Option**

$$BDIP = EAC^{WP}_{C\ MCO} - EAC^{WNP}_{C\ MCO} = NPV^{WP} * AF^{WP} - NPV^{WNP} * AF^{WNP}$$

$$= 3.0\ \% - 1.6\ \% = \quad 1.4\ \%$$

DIP's benefits are presented in Table 18 and represented in Figure 38:

**Table 18: DIP's Contribution with respect to SSP**

| | EAC C MCO (z) | | |
|---|---|---|---|
| | WITHOUT PROJECT | WITH PROJECT (WP) | PROJECT BY ITSELF |
| **A - IA-73 OPTION** | 0.016 | 0.050 | 0.034 |
| **B- SF-260TP OPTION** | 0.016 | 0.030 | 0.014 |
| **C- G-120T OPTION** | 0.016 | 0.030 | 0.014 |

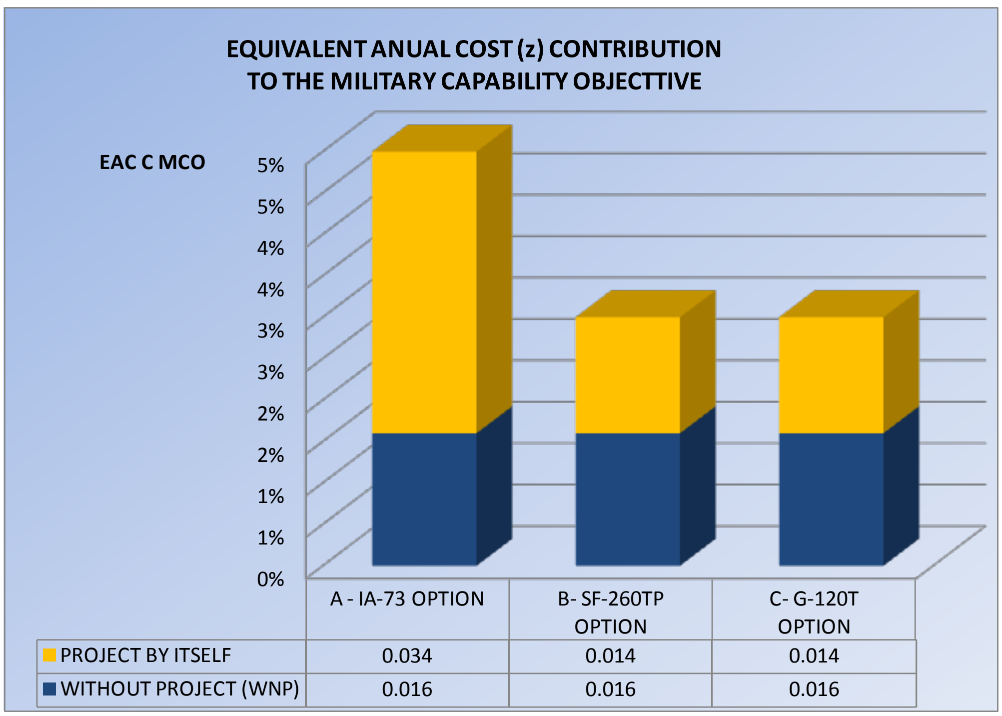



**Figure 38: DIP's Contribution whit respect to SSP**

**Selection of the Best Alternative Solution**

After extracting and comparing many different alternative solutions aspects, it is possible to select the best aircraft procurement option which meets Argentine Air Force requirement for increased number of training flight hours. Under the assumptions and conditions previously defined for this analysis, it appears that the three options (IA-73, SF-260TP and G-120TP) provide training flight hours but in different quantity and opportunity, as well as different costs.

The IA-73 project has better effectiveness score than the other two aircraft alternatives and of course against the situation without project (SSP). This high degree of contribution to the capacity is explained in the fact that IA-73 aircraft features were designed to meet operational requirement raised by the Air Force. SF-260TP and G-120TP are products on the market meeting other design criteria, but not necessarily coincident with this DIP's objectives.

The IA-73 alternative contributes to the requested 9,000 flight training hours (FTH) per period at the project operational phase t = 8, while the other alternatives contribute with an annual maximum of 2,700 FTH per period. This is basically the result of the number of aircraft acquired in each alternative, as FAdeA S.A. provides 50 IA-73 manufactured in the country against 15 of each of the other imported aircraft and at a much higher unit price.

Considering that all three aircraft options are modern systems, it is reasonable to expect that manufacturer logistics support is assured at least during the period specified in the DIP. Regarding infrastructure aspects, all three aircraft types are able to use the same facilities. Argentine Air Force Academy (EAM) facilities are large enough to house the whole fleet.

In relation to human resources (HR) perspective, the IA-73 has a noticeable advantage over the SF-260TP and G-120TP option as crew members and maintenance staff would not go abroad for training. FAdeA S.A. training would be local and HR's source for obtaining qualified manufacture and / or maintenance personnel would be less conflictive than in the case of a foreign product. Having local suppliers will always be more effective than having them thousands of miles away.

From the economic analysis point of view, the IA-73 option is also more appropriate considering both the average life cycle cost (ALCC), the net present value (NPV), benefits ( as percentage of contribution to the MCO), and the time at which the desired effect is achieved. Indeed, IA-73 ALCC is the smallest among the three alternatives. For option 1 "IA-73" the equivalent annual cost (EAC) is 5.0% against 3.0% from options 2 and 3. In terms of benefits, IA-73 option is the one that provides greater benefits in terms of contribution to the MCO with respect to the situation where no acquisition project is implemented (SSP).

The IA-73 option is the only one that achieves the Argentine Air Force's required pilot training capability effect in magnitude but it does at t = 8, when the other options reach their maximum contribution at t = 3 but with only 30% of the required effect (measured in FTH per period).

As a conclusion, the adoption of option 1 "IA-73" is recommended, which considers recovering limited operational-logistic capabilities for some Beechcraft B-

45/T-34 “Mentor” and Embraer EMB 312 “Tucano” until they are removed from service when IA-73 units are released to operational service at the Air Force Academy (EAM).

It is appropriate to emphasize that these conclusions should be considered "preliminary" given the project study “profile” level and especially considering that cost estimates directly impact on the considered best option selecting criteria.

If option 1 “IA-73” were not acceptable or inconvenient, options 2 “SF-260TP” and 3 “G-120TP” would qualify in second and third order, although it should be noted that there is no substantial differences between these last options.

The fact that IA-73 is an Argentine indigenous project should not be overlooked. The implementation of this option would revive Argentine aircraft industry capacity, allowing FAdeA S.A. to sell this product to countries in Latin America and eventually in the world.

Finally, the training system to be incorporated contributes to the objective of minimizing aircraft inventory diversity by replacing “Mentor” and “Tucano” aircraft systems in the short term, maximizing consistency, sustainability and versatility.

**Chapter Summary**

After introducing the defense investment project (DIP) related to incorporating primary / advanced trainer aircrafts to the Argentine Air Force inventory to meet training requirements and replacing current obsolete systems, three alternative solution scenarios were presented. The scenarios which are related to three different aircraft procurement options (IA-73, SF-260TP, and G-120TP) were compared with a “status quo” optimized baseline situation. This optimized baseline situation is assumed to be the worst case (SSP) where no new trainers are incorporated to the Argentine Air Force inventory. The purpose of this comparison is to find out which one is the best solution.

Considerations about Operational Requirements (OR), number of flight hours to meet CBCAM training demand, time, and resources involving each option implementation were taken into account in the further analysis. This analysis is based on analytical procedures established by the Argentine Defense Ministry (MINDEF).

The analysis includes comparison about direct options and production objective achievement, cash flow and expenditures, effectiveness level, offered production supply, benefits, and contribution to the Military Capability Objective (MCO).

The last part of this chapter determines that the IA-73 alternative solution is the best option. This option is the only one that achieves the Argentine Air Force's required pilot training capability effect in magnitude.

In the Chapter 5, the research questions are revisited and answered. This chapter addresses conclusions and recommendations applicable to the IA-73 project and to the Argentine aircraft industry where this indigenous project is developed.

# V. Conclusions and Recommendations

## Chapter Overview

This final chapter synthesizes information about the IA-73 basic trainer aircraft project evaluation. It addresses conclusions and recommendations applicable to this project and to the Argentine aircraft industry where this indigenous project is developed. This domestically developed Argentinean airplane is not only intended to meet Air Force training capability requirements, but also to revive the former FMA which was renamed as FAdeA S.A.

This chapter summarizes the findings, answers the research questions, and suggests areas for further research. It also presents research limitations, research significance and recommendations for action.

## Answering the research questions

In this part of the study, the research questions in chapter I are revisited. The research problem asks if the IA-73 Argentinean Basic-Initial Trainer Aircraft Program is a viable option for the Argentine Air Force: The term "viable" involves considerations not only about how easy project implementation could be but also about how sustainable and beneficial the project is in the long-term. Therefore, problem analysis has to consider aspects as its associated cost, number of aircrafts needed to meet training flight hours (TFH) AAF requirement, funding issues, similar products in the market, estimated flight hour availability, and the capabilities required.

***First research question***

Considering the first question: **How the IA-73 project should be evaluated?** The answer is that the project has to be evaluated by means of a defense investment project (DIP). DIP is the Argentine MINDEF's established procedure when evaluating projects related to defense. DIP is a production-financial proposal, analyzed and presented by any Defense System agency, which requires certain own capital goods to produce goods or services intended to achieve some military effect (military impact) and in order to contribute to the protection of the nation and its vital interests (social impact) (MINDEF, 2009a:84).

Considering the project under this study, DIP is generally stated as:

> Incorporate primary / advanced trainer aircrafts to the Argentine Air Force inventory to meet joint military aviator pilot basic training course (CBCAM) requirements, replacing current "Mentor" B-45 and Emb-312 "Tucano" aircrafts. (Note: CBCAM is the Spanish acronym for *Curso Básico Conjunto de Aviador Militar*)

It is assumed that CBCAM requires 9,000 training flight hours per year to successfully complete the syllabus. The resulting training flight hour gap has to be achieved within a period not exceeding 5 years, once the investment decision is made. Necessary follow-on support has to be sustained in terms of quality and efficiency for a period not less than 10 years.

Therefore, DIP's direct impact objective (z) looks for reaching pilot training capability levels demanded by the joint military aviator course (CBCAM). Indicator: Effectiveness Index. DIP's production objective (x) looks for improving CBCAM military pilot training capability by incorporating the IA-73 trainer to the Air Force

Academy (EAM) inventory, beginning in 2015 until completing 50 units, once the investment decision is taken. Indicator: Training flight hours (TFH).

***Second research question***

Considering the second question: **What analytical tools are available to evaluate the project**? This study focused on evaluating the project by means of current methodologies. MINDEF has a common analytical process for elaborating, presenting and evaluating defense investment projects (DIP). Analytical process structure steps are followed when evaluating this project:

1) General Information.
2) Current situation diagnosis.
3) Optimization of the baseline situation.
4) Capability gap identification and projection.
5) Alternative solutions identification and definition.
6) Compatibility analysis and dependence with other initiatives.
7) Technical Analysis.
8) Economical analysis.
9) Comments and recommendations.

Some technical and economical analysis perspectives are applied respectively in steps 8 and 9 of the analysis structure. The technical analysis perspective includes the full or partial utilization of the multi-criteria analysis methodology approach. The economical analysis perspective includes both cost-benefit and cost-efficiency approaches.

### *Third research question*

Considering the third question: **What other project alternatives can be taken into account?** The answer is that according to the methodology step 6 (alternative solutions identification and definition) some alternative solutions are identified, analyzed and compared with a "status quo" optimized baseline situation (SSP) where no aircraft procurement project is implemented. The SSP is assumed to be the worst case where no new trainers are incorporated to the Argentine Air Force inventory. The purpose of this comparison is to find out which one is the best solution. Each of the three recognized alternative solutions represent mutually exclusive scenarios. Basically the first scenario considers developing and acquiring the Argentinean trainer IA-73. The second one considers buying the Italian trainer SF-260 TP. Finally, the scenario of buying the German trainer Grob G-120TP is analyzed.

### *Fourth research question*

Considering the fourth question: **What key aspects there are for the alternatives comparison?** The analysis results come from comparing relevant factors affecting or limiting the success of the project. Under the assumptions and conditions defined for this analysis, each alternative solution provides more training flight hours than the baseline situation (SSP) but with different aircraft quantities, costs and time horizons. In this sense, alternative solution key aspects allow selecting which aircraft procurement option better meets Argentine Air Force requirement of increased number of training flight hours. Among these key determinant aspects it can be mentioned the project production (measured in TFH), effectiveness scores, degree of contribution to the capacity, number of produced/acquired aircraft, and time horizon (project time period) at which the desired effect is achieved (release to service at Argentine Air Force Academy).

From the economic point of view, comparison key aspects include average life cycle cost (ALCC), net present value (NPV), costs, benefits ( expressed as percentage of contribution to the MCO), and equivalent annual cost (EAC)

**Research Significance**

The Argentine aircraft industry long term success relies on choosing appropriate strategies, making smart decisions and sustaining effort in the right direction. The fact that the IA-73 is an Argentine indigenous project should not be overlooked. The implementation of this option would revive Argentine aircraft industry capacity, allowing FAdeA S.A. to sell this product to countries in Latin America and eventually to the world. Along with what is mentioned, there is a political and strategic state vision looking for developing indigenous industries and encouraging buying domestic products.

An evaluation of this project reveals which are those related areas and actions that contribute toward seeking its goals. In the case of this study the Argentine Air Force is seeking to increase aircraft availability (flight hours) to complete pilot basic training courses. The training system to be incorporated contributes to the objective of minimizing aircraft inventory diversity by replacing "Mentor" and "Tucano" aircraft systems in the short term, maximizing consistency, sustainability and versatility.

## Recommendations for Action

Developing and developed countries need to have efficient industrial bases ruled by competitive design and production standards. The world is mainly structured around an industrial development concept. Therefore it is increasingly difficult to be free of dependences from technological leaders in the world

It is imperative to have a clear aircraft and aerospace industry policy based on sustainable strategies, being aware of domestic issues that impact the activity. The principal purpose of the policy should be tied to areas as research and development (R&D) investment, job creation and emerging market growth.

In this sense, the intuitive function of the state is stressed when protecting and promoting advanced industries which are essential for national development. Strategic industries such as aerospace should be protected and promoted. In recognition of the importance and value of having this industry, the state has to open channels for stimulating industry prestige and promoting investments on this sector.

## Research Limitations

This research study focuses on the analysis of comparable technical projects and / or solution alternatives. Based on literature surveys, available data, and time frame, this research work focuses mainly on qualitative aspects of the technical solutions selected for the analysis.

Inflationary effects analysis, operational and capital costs, etc., are not within the scope of this thesis. Thereafter, the study explores the need for better economic decision support tools in the evaluation, design and development of new projects

**Further Research**

The intent of this thesis was to evaluate the IA-73 project viability by applying the proposed methodology. This methodology could be improved to assist future project evaluation efforts in the Argentine Ministry of Defense.

An area for further research could examine application of sensitivity analysis on specific project variables in order to verify methodology robustness and results validity. Performing a classical one-dimensional sensitivity analysis on project variables like reference rate, currency type exchange rate, main raw material cost, etc., it is possible to see how production related estimates are affected. Sensitivity analysis can be continued to find any input variable whose variation generates significant variations in the results. Inflationary impact analysis on industry operational and capital costs is also suggested for further research, as better economic decision support tools are of upmost importance under economically unstable scenarios.

Another consideration is regarding the crucial need of performing appropriate risk management and market analysis on this high technology aircraft industry sector. There are many dynamically changing worldwide scenarios demanding continuous risk assessment. Competing manufacturers, supplier and customer relationships, merging and joint venture strategies, analysis of complementary and substitute products on the market, etc., are only a few of the factors to be taken into account when analyzing projects like the one presented in this study.

Finally, this study provides an opportunity for future evaluation about how the IA-73 project short-term gains and losses can be translated into a sustainable long-term aircraft industry success.

**Final Thoughts**

Argentine aircraft revival strategy cannot rely exclusively on the IA-73 project. There are a number of domestic aerospace industry issues that have to be addressed in order to be successful. While some challenges are the result of either dynamically changing externalities, many other problems have to be internally evaluated as their effects have been repeated throughout the Argentine aircraft industry.

By solving these problems and planning effectively and efficiently, Argentine aircraft industry could specialize in niche high-value added sectors and create more opportunities in front of domestic and regional emerging markets.

**Acronym Glossary**

| | |
|---|---|
| A&AP | Aircraft and aircraft part manufacturers |
| AAF | Argentine Air Force |
| AD | Airworthiness Directives |
| AF | Annuity Factor |
| AFIT | Air Force Institute of Technology |
| AHP | Analytical Hierarchy Process |
| ALCC | Average Life Cycle Cost |
| *AMB* | *Adiestramiento Militar Básico* |
| *AMC* | *Area de Material Córdoba* |
| AMOC | Alternative Method of Compliance |
| *BAPIN* | *Banco de Proyectos Públicos de Inversión* |
| BAPIN | Public Investment Project Data Base |
| BDIP | Benefits extracted from Defense Investment Project |
| *BIM* | *Banco de Inversiones Militares* |
| BIM | Military Investment Data Base |
| CAM | Military Aviator Course |
| CAS | Civil Aerospace Sector |
| CAV | Aviator's Course |
| *CBCAM* | *Curso de Básico Conjunto para Aviadores de Militares* |
| CBCAM | Joint Military Aviators Flight Course |
| CBT | Computer Based Training |
| *CEPAC* | *Curso de Estandarización para Aviadores de Combate* |
| *CEPAH* | *Curso de Estandarización para Aviadores de Helicópteros* |
| *CEPAT* | *Curso de Estandarización para Aviadores de Transporte* |
| DDTC | Directorate of Defense Trade Controls |
| *DINFIA* | *Dirección Nacional de Fabricaciones e Investigación Aeronáutica* |
| DIP | Defense Investment Project |
| DOR | Direct Objective Requirements |
| E&EP | Engine and engine part |
| EAC | Equivalent Annual Cost |
| EAC C MCO | EAC's Contribution to the Military Capability Objective |
| EAM | Argentine Air Force Academy |
| *EAM* | *Escuela de Aviación Militar* |
| EMB | Embraer |
| ENAC | Italian Civil Aviation Authority |
| *FAdeA S.A.* | *Fábrica Argentina de Aviones S.A.* |
| FADEC | Full Authority Digital Engine Control |
| *FAMA S.A.* | *Fábrica Argentina de Material Aeronáutico S.A.* |
| FAR | Federal Aviation Regulations |
| FMA | Aircraft Military Factory |
| *FMA* | *Fábrica Militar de Aviones* |
| HAL | Hindustan Aeronautics |

| | |
|---|---|
| HDBK | Handbook |
| HP | Horsepower |
| HR | Human Resources |
| HS | Hours |
| *I.Ae.* | *Instituto Aerotécnico* |
| *IA* | *Instituto Aerotécnico* |
| *IAE* | *Instituto Aerotécnico* |
| *IAME* | *Industrias Aeronáuticas y Mecánicas del Estado* |
| IFR | Instrumental Flight Rule |
| IP | Investment Project |
| IRR | Internal Rate of Return |
| ISA | International Standard Atmosphere |
| ITS | Integrated Training System |
| *IUA* | *Instituto Universitario Aeronáutico* |
| KCAS | Calibrated Airspeed |
| KTAS | True Airspeed |
| LAAS | Lockheed Aircraft Argentina S.A. |
| LMAASA | Lockheed Martin Aircraft Argentina S.A. |
| MAS | Military Aerospace Sector |
| MB | Martin Baker |
| MCO | Military Capability Objective |
| MCP | Maximum Continuous Power |
| MIL | Military |
| *MINCYT* | *Ministerio de Ciencia y Tecnología* |
| MINDEF | Ministry of Defense |
| MLW | Maximum Landing Weight |
| MP | Maximum Power |
| MRO | Maintenance, Repair, and Overhaul |
| MSL | Mean Sea Level |
| MTOW | Maximum Takeoff Weight |
| NPV | Net Present Value |
| OR | Operational Requirement |
| OTS | Off-the-Shelf |
| PTT | Push To Talk |
| PV | Present Value |
| PVC | Present Value of Costs |
| PZOF | Price of the Offered Amount of Product Z |
| RFI | Request for Information |
| ROM | Rough Order of Magnitude |
| *SA* | *Sociedad Anónima* |
| SHP | Shaft Horsepower |
| SL | Sea Level |
| SSP | Situation without Project |
| STD | Standard |
| T&S | Training and Simulation |

| | |
|---|---|
| TFH | Training Flight Hours |
| TP | Turbo Prop |
| US | United States of America |
| VFR | Visual Flight Rules |
| VHF | Very High Frequency |
| WNP | With No Project |
| WP | With Project |

## Appendix A. Operational Requirements for the IA-73

1. OPERATIONAL FEATURES

The aircraft must have adequate flying qualities maintaining an acceptable safety level and reliability to meet pilot course curricula requirements, while ensuring a high availability from their maintenance and logistic support.

2. GENERAL FEATURES

Configuration

- Single-engine, low wing, tandem seating for two (2) occupants (student pilot and instructor in the rear seat) with a raised rear seat available (must be such as to permit unrestricted vision in final approach and flight instrument panel).
- At least two (2) load points under the wing to withstand weapons (mandatory) / additional fuel tanks (desirable).
- The aircraft must be based on the concept of interchangeability of parts and subdivided into components that allow easy maintainability.
- For weight calculation purposes, one hundred kilograms are estimated per crew member.
- Retractable tricycle landing gear with drive and position indication in both cabins and guides in the arms / pivots for locked position.

  Mandatory capability for operating with 1 single-pilot at front seat, in all possible configurations and missions.
- Capability to operate on paved and unpaved runways, with an extension of eight hundred (800) meters for takeoffs and landings in setting MTOW, ISA +25 conditions.
- Capability to perform at least two sorties of one hour in clean configuration within local flying area, and in compliance with flight instruction (two crew members) with forty five minimum fuel reserve minutes.

- Capability to perform at least two sorts of forty minutes in armament configuration within local flying area and in compliance with flight instruction (two crew members) with forty five minutes minimum fuel reserve.

- The aircraft has to be equipped with ejection seats providing safe ejection at speeds no greater than ten (10) KIAS above the rotational speed and configuration MTOW ZERO (0) feet above the runway.

- Longitudinal and vertically adjustable seats with harnesses of four (4) or five (5) point quick release buckle.

- It has to allow to open canopy from both seats and from outside interchangeably without selection of priority, allowing the drive without endangering the pilot / ground rescue team after a crash. It has to have a rapid release device that allows abandon the cabin from the inside (emergency).

- Must have a mask oxygen supply to the crew allowing safe operation throughout the flight envelope. It also must have a system to ensure supply in case of emergency.

- Cargo bay for a weight of at least TWENTY POUNDS (25 Kg) and at least fifteen ZERO POINT CUBIC METERS (0.15 $m^3$).

- It has to allow inverted flight for at least ten (10) seconds.

- The aircraft must be capable of withstanding at least +6 and -3 G in configuration without loads and +4.5G and 2G in MTOW.

- Capability to store flight data (in standard removable memory unit) for later use.

<u>Flight control and engine control</u>

- In both positions, the stick has to be placed at the center of the cockpit from the cabin floor, allowing free movement of the control surfaces. Equipped with ergonomic grip for one hand, the same shall have controls to trim the longitudinal and lateral axes, and trigger for the weapon system.

- Adjustable pedals distance to control the rudder, brake wheel drive on top of them and directional capability for nose wheel during ground taxiing and control during takeoffs and landings.

- Main surface controls (ailerons, elevators and ruder) moving by mechanical devices.

- Compensatory secondary surfaces in elevators, ruder and flaps, electrically operated, set in any intermediate position between neutral (zero displacement) and the maximum displacement.

- In case of malfunction, it must have an emergency shutoff system, which has to return all surfaces to neutral. It must be operable from both positions, with priority on the rear command seat.

- Ergonomic Throttle controls on the left side of both positions, equipped with command button (PTT) to operate both VHF equipments and communication between the two posts.

Flaps surfaces

- The aircraft must have flaps surfaces, electrically driven, as mandatory requirement.

- They should have simple drive controls in both cockpits and instrument provided with markings intermediate indicators according to the requirements and performances of the aircraft.

- They must have a system that avoids the asymmetrical movement of the surfaces.

- The aircraft must be able to approximate and land with the flaps in fully retracted position.

Aircraft certification

- The aircraft must be certified under the standard FAR / DA 23 acrobats.

- The aircraft must meet the requirements of Military Airworthiness Regulations.

- It is suggested to use MIL-STD-1797 for the evaluation of flying qualities.

- Resilience from spiral spin with output controlled without application of commands.

- Evaluate the flying qualities using the Cooper - Harper scale.

- The following specifications will be taken as a reference guide for guidance:

- MIL-F-9490 Design, installation and testing of flight control system
- MIL-D-8708 General Specification for demonstration. Aircraft weapon system
- MIL-A-8861 Flight loads
- MIL-W-25140 Weight and balance
- MIL-M-7700 Flight Manual
- MIL-E-5400 Electronic equipment
- MIL-STD-454 Requirements for Electronic Equipment
- MIL-STD-810 Environmental testing
- MIL-STD-882 Safety Program
- MIL-STD-461E Requirements and Measurement EMI / EMC
- MIL-HDBK-235-2 External Electromagnetic Environments
- MIL HDBK 1763 "Aircraft/Stores Compatibility: System Engineering Data Requirements and Test Procedures"
- MIL STD 1760 "Aircraft/Store Electrical Interconnection System"
- MIL STD 1289 Airborne/Stores Ground Fit and Compatibility
- MIL STD 8591 "Airborne/Stores, Suspension Equipment and Aircraft/Store Interface (carriage phase); general design criteria for"
- MIL – H – 5440G & H Hydraulic Systems
- MIL 7872C Warning fire detection and temperature.
- Others which will be detailed in the specifications.

<u>Engine</u>

- Turboprop-powered engine and FADEC (Full Authority Digital Engine Control).

- Power has to grant a rate of climb not less than SIX HUNDRED THOUSAND FEET PER MINUTE (1,600) at MTOW, ISA + 15 to FIFTEEN THOUSAND FEET (15,000) of altitude.

- Autonomous Starter considering ground outside temperatures from -20 º C to + 50 º C.

- Ability to perform restart in flight due to engine shutdown by simple procedures, according with the level of performance of a student pilot.

- Ability to cut fuel supply to the power plant from both seats.

- Engine Fire detection system.

- Fire extinguishing system in engine plant (desirable).

- Engine events recording system.

Fuel System

- JET A1 aviation fuel, capable of using alternative fuel for periods not to exceed ten (10%) percent of the flight time between basic inspections.

- Must be equipped with at least two (2) internal fuel cells, so as to ensure its provision to the engine, in case of emergency supply fails. Systems for fuel return to cell selected and dewatering drains / cache for maintenance.

- Rigid removable internal cells (similar to the SF-260 desirable)

- The airplane fuel system and engine controls must be in both seats.

- Fuel booster pump must have a luminous display system located in the front panel.

- Gravity fueling system simple enough for the easy operation of the aircraft.

- Fuel flow indicator for both positions.

- Autonomy of at least three hours thirty minutes (03:30), being the desirable value of FOUR (04:00) hours of flight, both in terms of optimum cruise, plus thirty (00:30) minute for limited cruise.

- Indication of amount of available fuel in the tanks in both positions. Measuring capacity of fuel tanks through formal rod in liters, from one point of each half-plane.

- Fuel Low pressure warning light for both positions.
- Indicator light for low fuel an amount equal to ten (10%) percent of the total minimum usable in the corresponding tank for both positions.
- Digital remaining fuel counter unit with the fuel flow indicator.
- Desirable capability to install additional tanks under each half-wing. This system must have a fuel transfer control from the external tanks to internal and emergency cut indication of the amount of fuel remaining in the tanks and light indication in either operation. Ability to eject the external tanks if necessary (jettison emergency).
- Additional tanks will enable to expand the autonomy in at least 2:00 hours to optimum cruise.

Landing gear system

Besides the above mentioned features, the aircraft has to have:

- Hydraulic pressure servo assisted braking system. The same system should ensure main wheels braking on the platform with the engine stopped (parking brake). Anti-lock system (desirable).
- Indication of the transition between locked position and extended up and locked down position, with light in the landing gear command.
- Landing gear retraction and extension emergency system from both seats.
- Alarm settings (light and aural) to alert pilot from abnormal approaching condition for landing, with cancellation capacity from either pilot's seat.
- Landing gear retraction protection system while the aircraft is on ground.
- Aural beep when gear is down and locked with simultaneous output in both VHF, operated from either seat position.
- Hard landing detector system.

3. AIRCRAFT ROLE MISSION

Military student pilot training for selection (screening) and acquisition of flight skills. Basic primary training level and training for military aviators and flight instructors.

Missions

- Primary Training:
  - Configuration: 2 pilots with equipment.
  - Mission: Operation altitude 10,000 ft from 1:00 to 1:20 hour flight time, speeds between 60 and 180 KIAS and load factors-3G to 6G.
  - It is required that the aircraft have the ability to perform at least two of these missions without refueling.
- Basic Training:
  - Mission: operation of the aircraft at an altitude of 20,000 ft from 1:00 to 3:00 hours flight time, with speeds between 60 and 210 KIAS and load factors-2G and 4.5 G (minimum).
  - It is required that the aircraft has the capability of repeating the flight mission without refueling if it does not exceed 1:20 hour flight time.

4. PERFORMANCES

a. Speeds:
   i. MTOW: according to FAR 23 standards.
   ii. Cruise: 165 to 180 KTAS cruise at ISA conditions.
   iii. Maximum Cruise speed: 210 KTAS.
   iv. Climb: not less than 1600 ft / min., With MTOW, at maximum continuous power up to 10,000 ft.
   v. Approaching speed no greater than 80 KIAS, in landing configuration,
b. Autonomy: THREE HOURS minimum mandatory

c. Range (with return to base) without auxiliary fuel tanks: NAUTICAL MILES hundred fifty (250 NM) in optimum cruising conditions, with forty-five (45) minutes of booking, cruise poor.
d. Minimum range without auxiliary fuel tanks for optimum cruising level 550 NM with maximum usable fuel, plus a fuel reserve of 00:15 minutes.
e. Service ceiling: Not less than 30,000 ft.
f. Operational Ceiling: Not less than 26,000 ft.
g. Stability and control:
    i. The stability and control characteristics of the aircraft must meet MIL-STD-1797 and FAR 23, throughout the operational flight envelope, allowing safe and successful completion of required tasks.
    ii. Barrel roll has to be safe with simple exit procedures, considering this maneuver as an instruction item to be developed within the training pattern.
    iii. In the case of asymmetric configuration, the qualities of stability and control must allow safe flight and landing with an asymmetry equal to the maximum load bearing per wing or fuel is not transferred.
    iv. In case of operation with crosswind, a pilot with normal skills using simple techniques has to be able of taking off and landing the plane with a lateral wind component at ninety degrees (90°) line of the runway of 25 KTS.

## 5. STRUCTURAL FEATURES

a. Structural Service life:
    i. Shall be not less than 14000 flight hours, for a fatigue spectrum in the primary and basic trainer role with low-altitude flight and predominant load factor between 3 and 4.
    ii. Total number of flights: Minimum 42,000 with a coefficient of dispersion 3.
    iii. Total number of landings: at least 53,000.
    iv. Total years of service: at least 20 years.
b. Structural design criteria, according to FAR 23 standards, Aerobatic, including parts 23-1 to 23-14 and updates as applicable.
c. Flutter: The aircraft will operate free of flutter throughout the operational flight envelope in terms of speed limits, maneuvering and loading conditions, according to MIL - A - 008870.

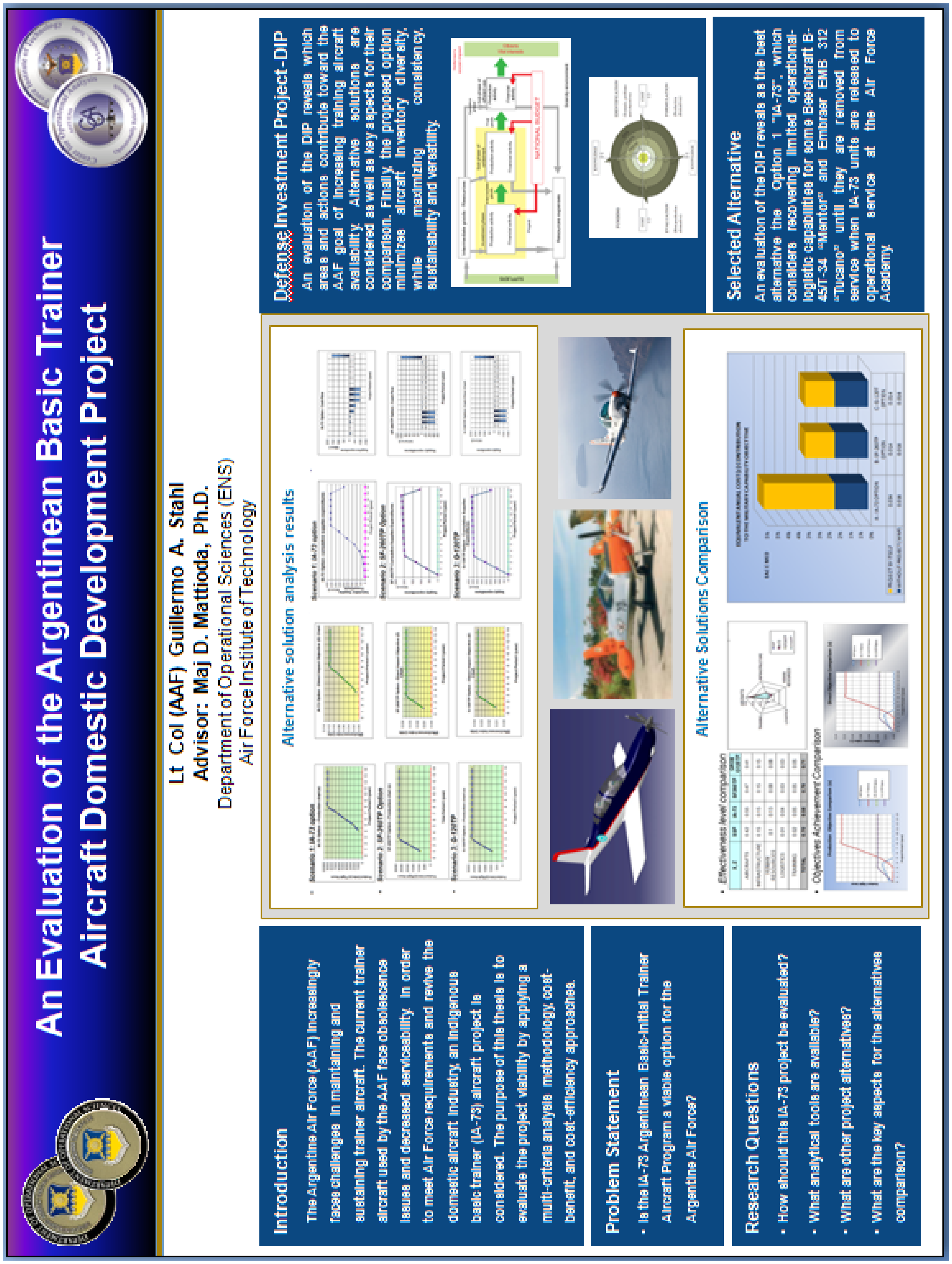
6. CAPABILITIES

a. General flight maneuvering and aerobatics (FAR 23).
b. Ability to perform formation flying, but not limited to engine operation by the type of requirement and allow full visibility to other aircraft or control the situation by the instructor.
c. Capability of performing visual navigation meeting the standards set by the curricula in force, with the expanding capacity of meeting flight by instrument requirements.
d. Capability of performing shooting and bombing according to curricula.

7. TECHNICAL DESIRABLE CHARACTERÍSTICS

Reference Aircraft: SF-260, Grob T-120.

## Appendix B. Quad Chart



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## Vita

Lieutenant Colonel Guillermo Alberto Stahl was born on October 11th, 1966 in Córdoba, Argentina. He graduated from the Argentine Air Force Academy (EAM) in 1988. He is an electronic engineer graduated from the Argentine Air Force Institute of Technology (IUA). He had several assignments in aircraft maintenance squadrons and depot level maintenance Argentine Air Force bases. He worked as engineering team member for the Argentine IA-63 advance jet trainer program. In 2004 he graduated as Major Staff Officer at the Argentine Air Force War College. He has a Master Business Administration Degree and a Master of Science in Human Resources from University "*Del Salvador*" (USAL), Buenos Aires, Argentina. He was assigned to the Argentine Presidential fleet until he entered the Graduate School of Engineering and Management, Air Force Institute of Technology in August 2010. Upon graduation he will be assigned to the Materiel Command Staff in Buenos Aires, Argentina.

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The Argentine Air Force (AAF) increasingly faces challenges in maintaining and sustaining trainer aircraft. The current trainer aircraft used by the AAF face obsolescence issues and decreased serviceability. Argentina used to have the largest aircraft industry among Latin America countries. A number of factors such as not maintaining objectives and policies over time undermined its consolidation and were instrumental in losing its leader position. In order to meet Air Force requirements and revive the domestic aircraft industry, an indigenous basic trainer aircraft project is considered. The purpose of this thesis is to evaluate the project viability by applying a multi-criteria analysis methodology approach. An evaluation of the project reveals which areas and actions contribute toward the AAF goal of increasing training aircraft availability. The technical analysis includes utilization of the multi-criteria analysis methodology approach. The economical analysis perspective includes both cost-benefit and cost-efficiency approaches. Alternative solutions are considered as well as key aspects for their comparison. Finally, the proposed option minimizes aircraft inventory diversity, while maximizing consistency, sustainability and versatility.

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