IMPACTS OF THE AIRCRAFT AM-X´s ACQUISITION PROGRAM (1982-1994) ON TECHNOLOGICAL MANAGEMENT CAPABILITY OF THE BRAZILIAN AERONAUTICAL COMMAND

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ABSTRACT

The AM-X Program (1982-1994) was an important military aircraft acquisition program developed with the aim of empowering the development of the Brazilian aeronautical industry. The program was carried out in partnership with the Italian Ministry of Aeronautics and its aviation industry. Brazil and Italy were the program holders, and they had the industrial property of the program and neither one predominates over the other. The program occurred at the moment that Brazilian Aeronautical Command (COMAER) was developing its own capabilities to manage the acquisition program. It was considered that partnership with Italy could be very important to build the Brazilian structure of project management in the handling of cutting edge technologies. In fact, the growth of the number of complex programs managed by COMAER makes believe that the learning of AM-X Program has been relevant for such achievement.

However, few studies have examined the relationship between the development of acquisition programs and the constitution of technological management capabilities in COMAER. In general, the literature focus on project management (PMBOK, 2004; CMMI, 2010; and PRINCE, 2009) and on acquisition system (Directive 5000.01 and Instruction 5000.02; Defense Acquisition Guidebook, 2012; Department of Defense Extension to PMBOK Guide, 2003; and Brown, 2010). There is scarcity of studies that connect cases of defense programs and the building of management technological capabilities in the main responsible organization. So, a retrospective analysis was carried out based on the negotiation model used in the AM-X program, the structure built by COMAER to manage the program, field research, and the law background of the Brazilian acquisition system. A documentary survey was conducted in 2011 to analyze the Memorandum of Understanding between Brazil and Italy, the main contracts, other regulations

and the documents available at the central library of the Coordinating Committee of the Combat Aircraft Program (COPAC) and at the office management of the AM-X program. Open interviews with the Manager of the AM-X program and his team were performed, aiming to raise the general program guidelines.

The main results showed that relevant management capabilities constructed at COPAC could be attributed to the learning processes achieved through the AM-X Program, which were reflected mainly on the development of the integrated lifecycle management process of aeronautics system and materials, which was documented at DCA400-6 (1992). This process is highly complex and set the base for a systematic methodology for military acquisitions that continues to evolve as more programs are developed.

1. INTRODCUTION

Historically, defense acquisition programs have been using by developed countries to empower aeronautics industry. In the Brazilian case, AM-X Program (1982-1994) was an important acquisition program developed with the specific aim of catching up the development of the national aeronautics industry. It occurred at the moment that Brazilian Aeronautical Command (COMAER) was developing its own capabilities to management the acquisition program. It was considered that partnership with Italy could be very important to build the structure of project management at the national innovation frontier. Brazil and Italy had the industrial property of the program and no one predominates. Thus, it was possible integrated Brazil to the program by EMBRAER. The program has already been developed in Italy. In fact, the growth of the number of complex programs managed by COMAER makes believed that the learning of AM-X Program has been relevant for such achievement.

There is a scarcity of studies have examined the relationship between the development of acquisition programs and the constitution of management technological capabilities in COMAER. In general, the academic literature focus on project management and on acquisition system, there is no link between cases of defense programs and the building of management technological capabilities in the main responsible organization. It was believed that COMAER could have an unique opportunity to absorb technological management knowledge at the national innovation frontier as well as improve its workforce qualification in the handling edge technologies.

The PMBOK (2004) was the main guide used by project managers to develop their categories of analysis and following in complex projects. CMMI (2010) was another guide used to manage the maturity of the organization in its technological path. PRINCE (2009) was an adaptation of the both guides used on public acquisitions. Even though, there aren´t enough to explain how a military organization can build their own capabilities to manage a complex project (PÉREZ, 2011). The literature of acquisition systems develop by United States of America provides the crucial questions that have to be considered in a development of complex defense project. There are a several guides in the Department of Defense to help acquisition managers to control the life cycle of a complex product or a system and to build a technological structured to support it. It's a reference in the whole world: Directive 5000.01 and Instruction 5000.02; *Defense Acquisition Guidebook* (Defense Acquisition University, 2012); Department of Defense Extension to PMBOK Guide (2003), Brown, 2010; and others.

The academic literature of the evaluation of technology investment programs shows that programs can be evaluated by their direct and indirect impacts. The direct impacts refers to program objectives are defined in the contracts and indirect, the spinoffs, are the new combinations of existing knowledge in the program that overflow into other areas and activities generating positive impacts to the organization as a whole, such as unpredictable product, new technologies, organizational changes, new methods, new techniques, new technological capabilities, etc. According to Furtado *et al* (2008), the spinoffs are resulted of learning process which is deriving from sedimentation of organization´s technological capacities, and in Bach (1992) framework, the spinoffs are a broader phenomenon than the process of technology transfer and can generate as or more important economic impact than innovation provided.

The public procurement programs such as military acquisition programs have an explicit objective to develop defense products. However, the spinoffs generated during the course of the program create new technological capabilities that are relevant to the technological progress of the country. The evaluation of these indirect results can be performed using the methods of evaluation of impacts of large programs developed by the *Bureau d'Economie et théorique Apliquée* (BETA), which decomposes the indirect results of a program in four types of impacts: technological impacts, commercial impacts, organizational impacts, and impacts on human resources (BACH, 1992). However, it is difficult to implement in the case of military acquisition programs, due to the difficulty of obtaining data of the set of impacts that need to be assessed, taking into account that such impacts occur in companies that develop products purchased. So it was credited that these perceived difficulties may explain the scarcity of academic literature of the evaluation of acquisition programs in Brazil.

So, it seems appropriate identify the organizational impacts that AM-X Program could bring to the Coordinating Committee of Combat Aircraft Program (COPAC),[1] especially to allow the construct of the document of the lifecycle management of aeronautics system and materials and to promote their technical evolution. In this context, the aim of this paper is to make a retrospective analysis of technological management impacts that AM-X Program could cause in the Brazilian Aeronautical Command. The sources of this work were the results of research field. A documentary survey was conducted in 2011 to review the Memorandum of Understanding between Brazil and Italy, the main contracts, regulation and other documents available in the central library of COPAC and in the management program office. The manager of AM-X Program and his team were interviewed, it have searched about general directives of the program and the evidences of it importance for aeronautics development industry.

This article was divided into seven sections, beyond this introduction. The second section presents the theoretical framework that supports this work. The third will present the results of research field and the analysis of COMAER´s technological path based on in their main document. The fourth section will discuss about the importance of program for the development of management capabilities to COMAER. The fifth section concludes and proposes the future possible works. The section six does an acknowledgement and the seven section presents the bibliography references.

[1] COPAC is the executive body in the field of aircraft purchases, subordinate to the Department of Aerospace Science and Technology (DCTA). (PÉREZ, 2011)

2. THE CONCEPTUAL FRAMEWORK

The evaluation method of Development and Research large programs impacts developed by *Bureau d'Economie Théorique et Apliquée* (BETA) was initially developed to capture the indirect impacts of major investments that were made in the European space sector (BACH, 1992). It was also shown very suitable for capturing the effects of investments in projects to develop specific technologies for the oil industry (FURTADO et al, 1999). And also in very specifics Development and Research projects, like the breeding program PROCANA (HASEGAWA, 2005) and research and sanitation program PROSAB (FURTADO *et al*, 2008).

The BETA decomposes the indirect results of a program of technological investment in four types of impacts: technological impacts, commercial impacts, organizational impacts, and impacts on human resources. Soon, provides a wide range of variables that can be analyzed in models of impact evaluation of large programs. The technological impact refers to the transfer of knowledge that was not originally planned (new products, new processes, technology, patents). Commercial impacts analyze network impacts from the relationships between participants (collaboration ties into the project, impacts of reputation from greater recognition and project outward visibility, quality certificate); and competitive impacts result from new partners and opportunities in learning function of the project. The organizational and methods impacts refer to marks that the project has left on the culture of the organization and organizational structure (ability to manage projects, changes in organizational structure, implementing a quality department and research and development department, new methods are transferred to other activities). And the impact on human resources relate to new hires that were made during the projects and specific training, beyond the learning processes during execution of the project. (BACH, 1992)

Furtado *et al* (2008) and Urbina and Lima (2009) help us to understand that it is possible to evaluate the programs through their impacts, they are manifested as a creation and strengthening of technical, organizational and technological capabilities. In the context of technological programs, technological capabilities created and developed by the program are a key aspect to evaluate the investment. Hasegawa (2005) goes further and analyzes the process of creating spinoffs and shifts attention to the intermediate results that are created by the program. These interim results are precisely those generated capabilities that make possible spinoffs.

Hasegawa (2005) provides a typology of capability.[2] 1) Organizational capability: capability of the institution to organize internally to optimize the learning process, internal knowledge base and still be able to make changes. 2) Relational capability: ability to establish and maintain contacts with external actors to interact, learn collectively and share tangible and intangible assets. It includes the ability to spread knowledge, to choose partners, to encode "know who" and to gain visibility and reputation. 3) Scientific and technological capability: ability to use scientific and technological knowledge to assimilate, use, adapt, and change existing technologies; and developing new technologies, products and processes. It also includes the absorption capability (ability to absorb external knowledge and use them for the benefit of the

[2] Hasegawa (2005) makes no distinction between the terms capability and capacities and also uses the term as a synonym for competence. Urbina and Lima (2009) also develop from Hasegawa (2005) an evaluation method of capability for the management of innovation projects.

firm). This categorization approaches is near from the functions of the Matrix Technology Capabilities of the Lall (1992)[3] and differs because it includes an organizational function.

The construction of the technological capabilities in late industrializing countries involves a deliberate process of acquiring knowledge and skills. It what can configure a very critical task for organizations since starting its activities from the imported technology. The acquisition of equipment abroad does not incorporate technological knowledge and knowledge transfer arising it is not explicit in their instructions or patents. In this scenario, questions relating to learning towards international technological frontier process are reinforced. Technological learning is an intrinsically evolutionary and cumulative process and can only be developed at the local level. (LALL, 1992, LEE, 2000; TEECE, 2000; FIGUEIREDO, 2004 and ROSSITZA, 2008).

According to Figueiredo (2014), the accumulation of technological capabilities inside the organization generate benefits that translate into inventive or innovative activities, improving operational parameters and competitive performance, and creating standards of corporate growth. "The technological capabilities are understood as a stock, a reservoir of resources that allows the firm to perform activities of both production and innovation, and innovation in different degrees."[4] The ability of the organization to implement an innovation reflects the nature and depth of its technological capabilities. These capabilities enable innovation, and are not always a direct result of R&D activities (FIGUEIREDO, 2003 and 2014). The concept of technological capability refers to the accumulation of knowledge to generate capabilities that are accumulated and incorporated in individuals and organizational system, following the theoretical approach of Bell and Pavitt (1993). It´s intrinsically related to internal efforts to adapt and improve imported technology (FIGUEIREDO, 2004 and 2003). And to create something entirely new, it required the accumulation of innovation capabilities (FIGUEIREDO, 2014).

It´s possible to building bridges between these concepts and the changes took place in COMAER in the years of AM-X Program. The available literature was historical, without the concerning to evaluate the relevant topics of the technological point of view. It´s believed that COMAER was being able to make changes in their management process that transform the reality of the institution and aeronautics industry in Brazil. According to Hora *et al* (2005), the set of major management changes that the military organization absorbed were used on their others defense projects and in other technological activities of Aeronautical Command like a best practice and in the Ministry of Defense as a whole.

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[3] Lall (1992) based on Katz (1984 and 1987), Dahlman, Ross-Larson and Westphal (1987) and Lall (1987) presented an illustrative matrix of main technical functions that a firm would need to master to be categorized into a certain level of technological capability and advance towards the frontier of innovation. These pioneering works inspired many others among Brazilian authors include Figueiredo (2002, 2003a, 2003b, 2004, 2005, 2008 and 2014), Hasegawa (2005), Oliveira (2005), Silva (2009) and Marques (2011).
KATZ , J. (1984) "Domestic technological innovation and dynamic comparative advantage: Futher reflections on a comparative case study program", Journal of Development Economics, 16 (1): 13-38.
KATZ , J. (1987) "Domestic technology generation in LDCs : A review of research findings", In KATZ . J. (ORG) Technology Generation in Latin America Manufacturing Industries, New York: St Martin's Press.
Dahlman, C.; ROSS-LARSON, B.; WESTPHAL, L. E. (1987) "Managing technological development: Lessons from Newly industrializing Countries", World Development, 15 (6): 759-775.
Lall, S. (1987) Learning to Industrialize: the Acquisition of Technological Capability by India. London: Macmillan.
[4] This definition was given by Professor Paulo N. Figueiredo (FGV / RJ) in the qualifying examination for the Ph.D. of the first author of this article, at ITA, 12/12/2013.

3. RESTROSPECTIVE ANALISYS

This section will present a retrospective review of the AM-X Program. The general program guideline focus on the phases is created to management the program. In the following subsections, it will be describe the impacts of the AM-X program on the construction of the main document of life cycle aeronautics products and systems.

3.1 Negotiation Model

The Acquisition Program AM-X aircraft emerged from the need of the Ministry of Aeronautics in Brazil[5] (MAER) equip the Brazilian Air Force with equipment capable of operating at extremely low altitudes by day and night and in poor visibility, semi-prepared runways in long-range missions, which were the Brazilian reality, and also in terms of damage of own aircraft. An attack aircraft that would allow the tactical support of ground forces, air interdiction and armed recognition in all weather conditions, however, in the late 1970s and early 1980s, there wasn´t in production in Brazil an aircraft that would meet these requirements. Then, EMBRAER initiated a search for partners in the United Kingdom and Italy to develop an aircraft that meets the aspirations of MAER. EMBRAER had a good partnership with Aermacchi in Xavante project and this relationship opened the doors of the possibility to participate in a project that was in progress in Italy in partnership with Aeritalia, AM-X Project. (OZIRES SILVA, 1998)

The Declaration of Principles on March 21, 1980 stated the Brazilian government desire to participate in the AM-X program underway in Italy. And the Basic Agreement on Technical Cooperation between Brazil and Italy, 1972, promulgated by Decree 84,967 of July 23, 1980, established the partnership cooperation in terms of economic and social development goals. The technical cooperation would include the transfer, in the broadest sense of the term, knowledge and experience, which could be accompanied by material aid (Article I, section 2, of the Basic Agreement of Technical Cooperation). The cooperation included a provision of technicians to provide advisory and executive services, the provision of scholarships and improvement, provision of machinery and necessary equipment for the implementation of the project and any other type of material support that was agreed. The Decree 84,967 (Article VIII) also established the equipment and the materials needed for the technical execution of tasks and projects related to long term would be exempted from prior import permit, certificate of foreign exchange coverage, consular fees, taxes acquisition consumption and sale, customs duties, import duties and any other taxes, excluding storage costs and other similar.

The strategic management and project management of the development and production of the AM-X aircraft, with all its phases, sub-phases and activities, were conducted by Memorandum of Understanding between Italy and Brazil. The program was divided into the following phases: the Definition Phase (stages 1 and 2), the Development Phase (1st sub-phase, 2nd sub-phase, 3rd sub-phase, license purchase the engine SPEY MK-807 and extending the copyright to Brazil), Industrialization Activities and early cell production, the Production Phase (production batch of aircraft: 1st, 2nd and 3rd batch), the Employment Support Phase (activities of updating the configuration of the lots) and Post-Development Activities.

[5] Currently, the Aeronautical Command.

Aeritalia and Aermacchi were the firms that participated in Italy and EMBRAER was the firm that participated in Brazil. Aeritalia, became known as Alenia, assumed the function of the main charge firm front of Costarmaereo, the Italian Aeronautical Command. The Aermacchi and Embraer participated in the joint procurement as associated companies. In 1981, the MAER promoted the first program agreement, the contract of industrial integration of EMBRAER to AMX program that was underway in Italy. It was firmed by Italy national contracts for aircraft production between Costarmaereo Aeritalia and Aermacchi; and for engine production between Costarmaereo, Rolls Royce, Fiat Aviazione, Alfa Romeo Avio and Rinaldo Piaggio.

It was firmed by Brazil contracts between MAER or Department of Research and Development (DEPED), Aeritalia, Aermacchi and Embraer for production of the aircraft; and for the production of engines between MAER, Rolls-Royce, Fiat Aviazione (offers Alfa Romeo, Avio and Rinaldo Piaggio were presented by Fiat) and Celma. The companies responsible for engines developed their activities based on Industrial Cooperation Agreement of 1986 in which Fiat Aviazione was responsible for the coordination and control, according to the license agreements for the production of engines. Costarmaereo hired Rolls-Royce to purchase complete kits and spare parts; and Fiat, to the adequacy of drawings, tooling for performing final assembly, testing, materials of long-term supply, etc. The same activities were planned for the contracts between MAER, Rolls-Royce, Fiat and Celma.

The AM-X program was operated through joint contracts and national contracts. The joint contracts established joint activities with joint funding. The national contracts established non common activities, each country need to pay their part regardless of where the work was performed. The general criteria that guided the shares of each industry (use of industrial capacity and cost sharing) in the program was based on the number of aircraft each country was getting: of the total of 266 aircrafts, 187 were destined for Italy and 79, for Brazil, the ratio converging to 70.3% for Italy and 29.7% for Brazil. It was also established the principle of the single-source supply of components and sub-assemblies for production. The same industry was responsible for providing materials and equipment for both involved countries. And the industrial capacity of enterprises should be used until the stipulated percentage. The total production of an AM-X aircraft was divided according to the proportions noted in Tables 1, 2 and 3. Embraer was responsible for the production of the wings; Aeritalia was responsible for production of the central fuselage, and Aermacchi was responsible for production of the upper fuselage.

Table 1. Percentage of EMBRAER Production

EMBRAER	WINGS
Wings	16,8%
Air intakes	1,0%
Slats	1,6%
Flapes	2,3%
4 Pilones	3,7%
4 sublares tanks	4,3%
Total	29,7%

Source: Memorandum of Understanding between Brazil and Italy.

Table 2. Percentage of Production AERITALIA

AERITALIA/ALENIA	CENTRAL FUSELAGE
Previous fuselage	8,8%
Central fuselage	28,2%
Ailerons	0,8%
Spoilers	1,35%
Empennage horizontal	3,3%
Empennage vertical	2,5%
Twin carriers	1,6%
Total	46,5%

Source: Memorandum of Understanding between Brazil and Italy.

Table 3. Percentage of Production AERMACCHI

AERMACCHI	TOP FUSELAGE
Top fuselage	19,5%
Later fuselagem	4,3%
Total	23,8%

Source: Memorandum of Understanding between Brazil and Italy.

3.1.2 Phases, sub-phases, activities and deliverables of AMX Program

The Definition Phase of the AMX Program started on October 7 of 1981 and it was decomposed into two stages. The stage 1 constituted the base version, which resulted contracts of defining the aircraft AM-X and the adaptation and the approval of motor SPEY MK-807 in Italy. The stage 2 consisted of setting activities of the Brazilian variant and the defining activities of the joint program; was also performed in Italy. Brazil was involved defining requirements of this version. Brazil didn´t contribute with the costs of the version base. And the costs of variant version were operationalized according to the general criterion of the division of costs and work.

The Development Phase was started on June 7 of 1983, it was divided into three sub-phases of development. In these sub-phases, it were performed sets up contracts between Aeritalia, Aermacchi and Embraer to develop the aircraft; and contracts for the deployment of production engine with Rolls Royce, particularly the acquisition of license for local reproduction of engine (April 30 of 1984) and the consequent extension of rights to Brazil (October 31 of 1985). These contracts allowed the construction of parts of the engine, assembly, testing, repairs and revisions. In the first sub-phase, the development activities of the base version and the Brazilian variant were detailed. The second sub-phase started on January 30 of 1985. The additive contracts of both versions were performed related to new technical and operational requirements and to the construction of prototypes. The third sub-phase Development (August 22 of 1981) carried out the qualification of external configuration of the aircraft weaponry.

The activities of industrialization necessary for the subsequent production of the aircraft and procurement of materials were carried between the Development Phase and the Production Phase. They were started on October 31 of 1985. These activities include: the purchase of materials and long-term supply equipment, the determination of logistic support activities and the starting of production of the cell. Also they were defined the general conditions for the production of engines and equipment (May 20 of 1988). The activities of industrialization were divided into three groups: motor, cell and general equipment, avionics and accessories.

The Production Phase started on March 24 of 1987. The production of the first batch of aircraft started on May 2 of 1988. The production of the second batch was beginning on August 2 of 1991. And the production of the third batch started on August 9 of 1983. This phase also included the activities of defining production agreements, and the acquisition of spare materials, logistical support and equipment for modernization of aircraft, included the Government Furnished Equipment (GFE: the Italian and Brazilian government was responsible to buy general equipment, avionics and accessories and to pass them to the main contractors).

The Logistic Support Phase started on February 20 of 1992 and carried out the definition of the necessary arrangements for logistic support during the operation of the aircraft. There were additives activities until February 20 of 2002. The Support Phase was beginning on April 13 of 1995. It carried out the provision of technical publications and the entire weapon system upgrades as well as the technical and logistical support to ensure its operation. On February 20 of 1992, the basic arrangements for the subdivision of jointly owned property were defined. And on June 20, 1994, the general arrangements of the marketing activities of weapons AMX system were standardized.

The phases of the AM-X Program were mapped from the Memorandum of Understanding between Brazil and Italy and their contracts. It´s possible to link these documents to the program phases and observe that the phases of the AM-X Program reflect the concepts that were developed in the DCA 400-6 (1992).

This framework of management the program was the origin of the Air Force Command Directive Lifecycle of the Aeronautics Systems and Materials (DCA 400-6, 1992), which became the most important document of acquisition system in Brazil and of the COPAC´s management evolution.

3.2 Life Cycle of Aeronautics Systems and Materials

The Directive of Aeronautics Command (DCA 400-6, 1992) is the main document that regulates the acquisition of a weapon system or strategic defense equipment in the Brazilian Air Force, according to Pérez (2011). The first version of the DCA dated of 1992 and the last updated version was in 2007. DCA 400-6 orders the planning, execution phases and key events in the life cycle of a system or an aeronautical material and regulates the technical performance, integration and accountability of units of COMAER that intervenes in the acquisition process. According to DCA 400-6, the life cycle of aeronautics systems and materials consists on the phases of design, feasibility, definition, development or acquisition, production, deployment, use, revitalization, modernization or improvement and deactivation.

The decision to acquire a weapon system for the Brazilian Air Force is the Commander of the Aeronautics Command (COMTAER) advised by the Staff of the Air Force (EMAER). The overall coordination of system acquisition programs or materials is the EMAER. The direction of the program is designated by EMAER. The execution is the responsibility of the subordinate bodies and Sector Director Direct and Immediate Assistance (ODSA) of the Aeronautics Commander or hired companies or linked organizations. The management of the programs is determined by COMTAER, the program manager, aided by a team of experts, he is responsible for driving the unit and integrated program design. The manager is also responsible for establishing the functions of supervision and control until the delivery of material or system. After the deployment phase, the responsibility of management the program is transferred to the ODSA.

The process begins when ODSA detects an operational or logistics need, which is defined as a deficiency found, formalized in a specific document (Operational Need - NOP), which can only be met through the provision of a new system or equipment or modification of an existing one. The operational need may also be due to a technological innovation that allows a new mission that will boost the efficiency of existing mission, a market opportunity for replacement of a device/obsolete system or an economic opportunity. In the table below (table 4), it summarized all the phases of the DCA 400-6 (1992) and its related documents, plans and the main steps. It also presents a short description of each phase.

Table 4. DCA 400-6 (1992): Lifecycle Directive of Aeronautics Systems and Materials (Last updated 2007).

PHASE	DOCUMENT	DESCRIPTION
Conception Phase	Need Operating NOP	EMAER evaluates the NOP depending on the design and strategy of Aeronautics and outputs the ROP.
	Operational Requirement ROP	The ROP presents the initial description of the performance characteristics that the system or equipment should contain.
Feasibility Phase	Request for Information RFI	The economic and financial information related to the lifecycle, political and technical aspects, deadlines, risks, availability of time required to find the resources are compiled. It's carried out the first formal contact with companies (RFI) in order to obtain the data for the preparation of RTLI. At this time, the possibilities of production in Brazil or abroad are evaluated.
Definition Phase	Study Definition	It´s designed the staff of the project management functions (planning, execution and control) and it´s formalized the Monitoring Group and Control (GAC). Before the RTLI, a study of definition is conducted (ROP + Study definition = RTLI).
	Logistic and Industrial RTLI Technical Requirements	
	Technical Specifications	They are developed with the advice of the Department of Control and Airspace (DCTA/DECEA), the body that have the operational need and industry. In cases of acquisition, the companies can propose to the contractor.
	Development Plan	Detailed plan with goals, deadlines and costs related to technology research, research development, product engineer and the certification process.
	Plan Nationalization and Technology Transfer	Licensed production or transfer of information and knowledge in the development of a shared material.
	Plan Verification, Testing and Certification	Processes of accreditation and quality assurance.
	Public Notice or Request for Offer and Form of Contract	It is prepared based on RTLI. The companies present their proposals. In case of without bidding, the Request for Offer is sent to selected companies.
	Best and Final Offer BAFO	The companies present their best offers.
	Systematic studies of Financing	
	Project Compensation OFFSET	

	Physical and Financial schedule of Aeronautics Economics Finance Bureau	The Commander of Aeronautics after all necessary revisions is who authorize the finalization of the contract.
	Contract	
Development Phase	Development Plan	The technology, development and product engineering research for the prototype are realized.
	Plan Nationalization and Technology Transfer	
	Commercial Compensation Plan	
	Plan Verification, Testing and Certification	This plan can be replaced by a Verification Plan and Acceptance
	or Acquisition Process	
	Operational Evaluation	The prototypes are evaluated and the results are considered in the planning and implementation of Operational Evaluation.
	Directive of Deployment System or Material: Supported Employment Plan (ODSA is responsible), Supply and Maintenance Plan (ODSA), Infrastructure Plan (ODSA), Operation Plan (ODSA operator), Plan Adequacy of Human Resources (COMGEP) and training Plan of Human Resources (DEPENS)	These documents will guide ODSA´s Sector Plans, especially for cases of rebuilding the fleet.
	Logistic Support Plan	This plan is the DCTA, COMGAP and DECEA responsibility. It is recommended that the initial logistical support is negotiated with the Contract Development or Production.
Production Phase	Contract	The contracts are signed.
	Execution Phase	The government provides the necessary production equipment. The set of actions related to standardization of equipment to standardization the operation and facilitating the maintenance and supply are established.
Deployment Phase		The implementation of the Directive of Deployment System or Material is carried out. The Deployment Phase need to start on the Development or Acquisition Phase according to Deployment Directive and Sectorial Plans.
Use Phase	Operating Periodic Review	The main activities are: operational and logistics activities related to quality assurance, evaluation of performance operation, technical logistical and

		doctrinal aspects, and analysis of life expectancy.
	Sub-phase Control Warranty	The operator is responsible for this sub-phase. It aims to monitor the items under warranty or supported by Logistic Support contract. It´s acquired excess items to maintain supply line (buy-back clause).
	Sub-phase of Operation	They use the system from the point of view of logistics. The difficulties that arise in the operation should be analyzed together with COMGAP/DCTA/DECEA seeking the imposition of corrective measures.
Revitalization, Modernization and Improvement Phase		The modifications in the system or material are made, especially in items that during the Phase of Use has suffered loss or degradation of its efficiency, or become technologically obsolete or outdated.
	NOP	It´s used for a modification process.
Deactivation Phase	Sub-phase of Deactivation Planning	The system or material and the support logistic is removed and disposed, or destroyed (destruction or incineration), and ended its life cycle.
	Sub-phase Execution of Deactivation	The formation and training of personnel, acquisition of support equipment, spending on infrastructure and studies on performance are ended. At this stage of the life cycle of the system, a new system or equipment should already be in production so that its substitution occurs at the appropriate time.
Source: Prepared from DCA 400-6 (1992).[6]		

This is the context in which programs are planed end executed. Currently, this managerial capability (expertise) overflows to the Defense Ministry, through the National Defense Strategy and the creation of the Department of Defense Products, which aims to be the COPAC for the three Brazilian Armed Forces.

[6] EMAER: Staff of the Air Force; DECEA: Department of Airspace Control; COMGEP: Command General Staff; DEPENS: Education Department of Aeronautics; COMGAP: General Command Support; Sector Director Direct and Immediate Assistance (ODSA).

4. DISCUSSION

4.1 The Importance of AM-X Program to the Technological Management Capabilities Accumulation of the Brazilian Aeronautics Command

In the years of AM-X Program everything was in construction, there wasn´t a model to follow adapted to Brazilian particularities. Brazilian Aeronautical Command needed to learn how to manage their defense projects efficiently. In fact, the first version of life cycle management aeronautics products and systems was printed only in 1992, ten years after the starting of AM-X Program. And it was the greatest result of AM-X Program to the building of technological management capabilities of COMAER. Thus, COMAER have been getting an important place in the Ministry of Defense, it have provided the state of art of acquisition technological programs in Brazil. The other forces, Army and Marine, haven't had these capabilities yet. The capabilities development into COMAER has been very important for the defense plans of acquisition integration of the three forces.

The AM-X program enabled the Air Force Command to the management complex projects. COPAC was created in 1981 to manage the AM-X program, so the resulting learning program has shaped the foundations of organization performance. It has been being the military organization responsible to coordinating the processes of development and acquisition of combat aircraft and, together with other institutions, it coordinate the deployment of these weapons systems. (RICA 21-235, 2010)

It´s a specific body facing the management of complex system acquisition through the management structure contracts. The creation of COPAC is a milestone in the history of the Air Force Command; it marks a structural change in the organization to focus the activities of managing complex contracts in one location as the project offices of non-military organizations. And it also marks a change in contract management from the introduction of international best practices: the program manager and the structure that provides a technical support.

According to Hora *et al* (2005), the creation of COPAC turned possible to establish the guidelines of the management of AM-X Program, which allowed the extension of this systematic to other fields of Aeronautical Command. The Directive of Aeronautics Command (DMA 400-6, 1992) was created in this context. It´s the guideline of life cycle of aeronautics systems and materials that stipulated the tasks and organized the activities by defining "who" and "what to do". The Sub-department of Development Program (SDDP) was responsible to introduced "how to do". DCA 400-6 (1992) is the main document that contains the phases inherent a process of acquisition defense systems (design, feasibility, development/acquisition, production, deployment, use, upgrading and decommissioning), with its principal documents, activities and responsible agents. This guideline is based on best practices have already established, especially in the United States. The last date updated version was in 2007.

According to Amaro (2012), the Brazilian Army employs a decentralized vision in the operationalization of their purchases from the establishment of committees to support negotiation. The model used by the Army summed up in just three steps: specification, procurement and employment. The practices operationalized in the Air Force Command are considered the best available practices and it´s a benchmarking to others Armed Forces and to the

Ministry of Defense itself, which seeks a greater integration and rationalization of military purchases of complex nature through the Secretary of Defense Products (BRAZIL, 2008).

The phases of the AM-X Program were mapped from the Memorandum of Understanding between Brazil and Italy and their contracts and it´s possible to observe that the phases of the AM-X Program reflect the concepts that were developed in DCA 400-6 (1992). The AM-X Program enabled Aeronautics Command to management complex projects and it can be considered one the most important results of this program.

5. CONCLUSION

The AM-X Program granted a great learning in development of management capabilities of complex products to Aeronautics Command. It was the data source to build the Lifecycle Directive of Aeronautics System and Materials adapted to the Brazilian reality. In fact, the joint partnership with Italy enabled Brazilian government to test this framework of management complex products in very different situations. They built a strong capability to control the relationship with EMBRAER and other companies and to keep their power decision in the negotiations with Italy. The Memorandum of Understanding between Italy and Brazil was a major example of a joint integration negotiation, according to Ozires Silva (1998) much of what was done was designed and specified for the first time together, the solutions applied were innovative and were not based on an existing installation.

The phases of AM-X Program revealed a deep perception related to the need of controlling the lifecycle of product and system as a whole and it was determined all the evolution tasks of Lifecycle Directive. This process of management capabilities accumulation was supported by targeted efforts inside the organization to code all the things that they have learned. COMAER struggled to reach more advanced managerial levels.

One complementary work could present how the Defense Acquisition System of the United States of America was structured. This is an important step for the composition of a set of capabilities that can align the strategic component of the military to a policy of encouraging national aviation industry policy purchases.

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REFERENCES

AERONAUTICS COMMAND (1992 [2007]) Directive of the Lifecycle Aeronautics Systems and Materials (DCA 400-6).

AERONAUTICS COMMAND (2005) Policy and Compensation Commercial, Industrial and Aeronautical Technology Strategy (DCA 360-1).

AMARO, Lucio Pinheiro (2005) Proposal of a Model for Pre-Acquisition Products Defense Organizations in Armed Forces in the Early Maturity Levels. Master Dissertation, ITA/São José dos Campos.

BACH, Laurent; COHENDETM P.; LAMBERT, G.; LEDOUX, M. J. (1992) Measuring and Managing Spinoffs: The Case of the Spinoffs Generated by ESA Programs.

BELL, Martin and Pavitt, Keith (1993) "Technological accumulation and industrial growth: contrast between developed and Developing Countries", Industrial and Corporate Change, 2(2): 157-210.

BRAZIL, Decree No. 6,703, of December 18, 2008. Approves the National Defense Strategy and other matters. http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2008/Decreto/D6703.htm (accessed March 2013).

BROWN, Bradfort (2010) Introduction to the Defense Acquisition Management., Virginia: Defense Acquisition University Press, tenth edition, august.

CARNEGIE MELLON UNVERSITY (2010) Capability Maturity Model Integration - CMMI for Acquisition – Version 1.3, nov.

CHAGAS JR., Milton F. (2005) The Evolution of Management Models of Technological Innovation Process of Firms: The Case EMBRAER. Master Dissertation/ITA, São José dos Campos.

COORDINATING COMMITTEE OF COMBAT AIRCRAFT PROGRAM (COPAC) (2010). Bylaws of the Coordinating Committee of Combat Aircraft Program (RICA 21-235).

DEFENSE ACQUISITION UNIVERSITY (DAU) (2012) Defense Acquisition Guidebook, 12 jan.

FIGUEIREDO, Paulo N. (2014) "Beyond technological catch-up: In the empirical investigation of outcomes further innovative capability accumulation in latecomer firms with evidence from Brazil", Journal of Engineering and Technology Management, 31: 73-102.

FIGUEIREDO, Paulo N. (2008) "Industrial policy changes and firm -level technological capability development: evidence from northern Brazil", World Development, 36 (10): 55-88.

FIGUEIREDO, Paulo N. (2005) "Technological accumulation and industrial innovation: concepts, measurement and evidence in Brazil", Sao Paulo in Perspective, 19 (1): 54-69.

FIGUEIREDO, Paulo N. (2004) "Technological Learning and Industrial Innovation in emerging economies: a brief contribution to the design and implementation of strategic and empirical studies in Brazil", Brazilian Journal of Innovation, 3 (2): 323-361.

FIGUEIREDO, Paulo N. (2003a) Technological Learning and Competitive Performance. Rio de Janeiro: FGC.

FIGUEIREDO, Paulo N. (2003b) "Learning , capability accumulation and firms differences: evidence from latecomer steel . Industrial and Corporate Change", 12 (3) 607-643.

FIGUEIREDO, Paulo N. (2002) "Learning processes features and technological capability accumulation : explaining inter - diferences firms", Technovation , 22: 685-698.

FURTADO, André Tosi; BIN, Adriana; Bonacelli, Maria Beatriz Machado; PAULINE, Sonia Regina; MIGLINO, Maria Augusta; CASTRO, Paul Drummond de Felicio (2008) "Evaluation of results and impact of research and development - advances and methodological challenges from a case study", Production and Management, 12 (2): 381-392.

FURTADO, André Tosi; SULLICK, S. B; PEREIRA, N.M; FREITAS, A. S.; BACH, L. (1999) "Assessment of direct and indirect effects of large technological programmes: Petrobrás Deepwater Programme in Brazil", Research Evaluation, 8(3): 155-163.

HASEGAWA, Miriam. Evaluation of capability and spinoffs generated by R&D programs: The Cana IAC Program (2005) Doctoral Thesis, Institute of Geosciences/Unicamp, Campinas.

HORA, Rinaldo Nery; BONOTTO, Márcio Bruno; e COLNADO, Fernando José Loureiro (2005) "Gerenciamento de Projetos de Aquisição de Aeronaves". UNIFA Magazine, p. Dez: 26-33.

LALL, Sanjaya (1992) "Technological Capabilities and Industrialization", World Development, 20(2): 165-186.

LEE, KongRae (2000 [2005]) "Technological Learning and the entry of capital goods company in South Korea". In KIM , Linsu and NELSON , Richard R. (2000 [2005]) Technology , Learning and Innovation: Experiences of Recent Industrialization Economies. Campinas: Editor Unicamp.

MARQUES, Rosane Argou (2011) O Desenvolvimento da Capacidade para Inovação: As pequenas e Médias Empresas do Setor Aeronáutico Brasileiro. Doctoral Thesis/Federal University of Bahia, Salvador.

MIRANDA, Kelli Angela (2008) Purchasing Policy of the Air Force Command and Technology Learning in Providers. Doctoral Thesis/Institute of Geosciences/UNICAMP, Campinas.

OLIVEIRA, Luiz Guilherme (2005) Production Chain Aeronautics in Brazil: An Analysis of the Embraer Suppliers. Doctoral Thesis/Institute of Geosciences/UNICAMP, Campinas.

OZIRES SILVA. (1998) The Takeoff of a Dream: The Story of the Creation of Embraer. São Paulo: Lemos Editorial.

PÉREZ, Manuel Antonio Fagundes La Sagra (2011) Competency Model for Project Management of Defense Complex Systems. Master Dissertation/ITA, São José dos Campos.

PRINCE. (2009) Managing Successful Projects with Prince2. London, TSO.

PROJECT MANAGEMENT INSTITUTE (2004) A Guide to the Project Management Body of Knowledge (PMBOK Guide), Third Edition.

ROSSITZA, Rousseva (2008) "Identifying technological capabilities with different degrees of coherence: The challenge to achieve high technological sophistication in latecomer software companies (based on the Bulgarian case)", Technological Forecasting and Social Change 75: 1007-1031.

SILVA, Cassio of Garcia (2009): Government Procurement and Technological Learning: A review of Petrobras Purchasing Policy for Your Offshore Ventures, Doctoral Thesis/UNICAMP, Campinas.

TEECE, David J. (2000 [2005] "The skills of enterprises and economic development : implications for newly industrialized economies", In KIM , Linsu and NELSON , Richard R. (2000 [2005]) Technology , Learning and Innovation: Experiences of Recent Industrialization Economies of Campinas: UNICAMP.

UNITED STATES OF AMERICA. DEPARTMENT OF DEFENSE. DoD Directive Number 5000.01 The Defense Acquisition System. Nov, 2007.

UNITED STATES OF AMERICA. DEPARTMENT OF DEFENSE. DoD Instruction 5000.2 Operation of the Defense Acquisition System. May, 2003.

UNITED STATES OF AMERICA. DEPARTMENT OF DEFENSE U.S. Department of Defense Extension to: A Guide to the Project Management Body of Knowledge (PMBOK Guide). Version 1.0. Defense Acquisition University Press. June, 2003.

URBINA. Ligia Maria Soto; LIMA, Claudenete Salvato (2009) "Model for the Evaluation of Capability in Project Management for the Aerospace Sector Company", Production Management, 16 (4): 639-653.

CENTRAL ARCHIVES OF COPAC

COPAC (Coordinating Committee of Combat Aircraft Program): Contracts of Joint Purchase Program of the aircraft AM X and the Modernization Process (1981-2011); Complementary Industrialization Program (1987); Memorandum of Understanding Brazil-Italy (1981-1995). Central Archives of COPAC, Ministry of Aeronautical Command, Brasilia.