



EXPERIENCE IN A STRATEGIC PARTNERSHIP: PROFESSIONAL MASTER'S IN AERONAUTICAL ENGINEERING, ITA-EMBRAER

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***Summary:** Before the several challenges particularly faced by the aeronautical and defense industries these days, the consolidation of strategic partnerships to guaranteeing a solid technical and technological background for the involved human resources constitutes an essential key-factor for the entrepreneurship success. For both ITA and EMBRAER, organizations with a common historical link of pioneering and close cooperation for the last 30 years, the investment towards the creation and implementation of the Professional Master in Aeronautical Engineering Program stands right now as a major asset. With its nearly 300 students registered and with a first class up to concluding the program credit courses, all involved in the development of their final work---all of them applied directly to aircraft projects within EMBRAER's portfolio of programs---this partnership can already being considered a real success. This article is focused into the main points of the program as for example how the multidisciplinary curriculum phases were tailored, involving a suitable corps of faculty and administrative staff, along with the contribution of professionals from well-recognized international educational and aeronautical industry organizations in order to accomplish the set goals. One believes that such an experience can serve as a model for upcoming strategies envisioning the assurance of lasting competitive differentials for both the aeronautical and the defense industries in Brazil.*

***Key-words:** Aeronautical Engineering, Aircraft Design, Professional Master Program*

1. REASONS BEHIND THE PROFESSIONAL MASTER'S PARTNERSHIP

The Brazilian Aircraft Corporation (EMBRAER) has become one of the largest aircraft manufacturers in the world by focusing on specific market segments with high growth potential in regional, military, and corporate aviation. The company, after its privatization in 1994, adopted the strategy of developing and adapting successful aircraft platforms and by judiciously introducing new technology whenever it creates value by lowering acquisition price, reducing direct operating costs, or delivering higher reliability, comfort, and safety. As a consequence, EMBRAER's aircraft provide excellent performance with day-in and day-out reliability, while being economical to acquire and cost-effective to operate and maintain. And there is a worldwide logistics network to guaranteeing this: equally important, EMBRAER provides a superior product package, with comprehensive aircraft and after-sales support for



parts, services, and technical assistance. The company was Brazil's largest exporter from 1999 to 2001 and the second largest in 2002. It currently employs 12,161 people (data from September 30, 2002), and contributes to the creation of more than 3,000 indirect jobs.

But the current position, allowing a close international market competition within this sophisticated high-tech industry, can be guaranteed only with a combination of solid technical and business background of its human resources. The aeronautical industry has its ups and downs, with periodic crises affecting its scenario. Right now, the current crisis, as observed as a whole, has involved effects from four major international events: terrorist attacks on September 11, 2003; the Afghanistan War; The Gulf War II (USA and England against Iraq); and, lately, the SARS (Severe Acute Respiratory Syndrome). Market analysts say that the last event has had the worst impact comparatively. Fortunately, SARS effects are fading away in the most recent weeks, due to the vanishing number of affected victims in both China and Singapore. The fact that EMBRAER is overcoming superbly this scenario is demonstrated by the well-publicized purchases coming from the US Airways and JetBlue Airways involving hundreds of aircraft.

Over six to seven years overlapping the privatization period, prior to and after it, the scenario was not so good for EMBRAER. Sales were well below the forecasts, and, as a direct consequence, the company had to get rid of a lot of its important engineers, an event that created a real experience gap within the company. Things started to change by June 1999, when the ERJ-145 brand-new regional jet tour through North America and Europe became a real marketing success. The need of hiring engineers in large numbers came and from June to October 1999 the company received more than 700 young engineers and job shoppers. The former, normally to work filling the gap for junior engineers and the latter, most of them experienced engineers coming from all around the world, to work as consultants either on a personal or on a subcontractor company basis, in any case supposedly to keep the company's technological leading edge. With the high international demand for providing the ERJ-145 to the airlines, a big effort to face the new challenges was just starting. After some successful experiences in offering isolated training courses, a systematic and strategic program was established: EMBRAER's Engineering Specialization Program (PEE), also known as its Corporate University, which started its activities in January 2001. The first trial for this program involved a specialization course, which prepared a class of 165 students, all of them engineers (known as PEE C-1). They are now composing the company workforce since July 2002. Under this model, for the 18-month period, all the full-time students involved were also EMBRAER employees, receiving their salaries and all the social benefits. Its costs became very high for the company. And it looked for a different approach, which coincided with the establishment of the Professional Master's, a CAPES (Brazilian Graduate Studies and Research Council) just-created option for a *stricto-sensu* graduate program. So, an alliance with the Technological Institute of Aeronautics (ITA) and the Casimiro Montenegro Filho Foundation (FCMF) was sought and sealed.

ITA accepted the challenge to create a Professional Master's in Aeronautical Engineering Program, and this decision comes into terms with its mission, whose legal commitments, enacted into law on January 5, 1954, establishes that the institution, established formally in São José dos Campos, SP, was been created to:

1. Provide higher education in fields of interest to the aeronautical (today's aerospace) sector;
2. Provide undergraduate, graduate and extension courses; and
3. Contribute---thru education and research---for the progress in aeronautical (today's aerospace)-related science and technology.



EMBRAER'S demand for engineers forecast initially established for the 2002-2006 timeframe, is shown in "Figure 1."

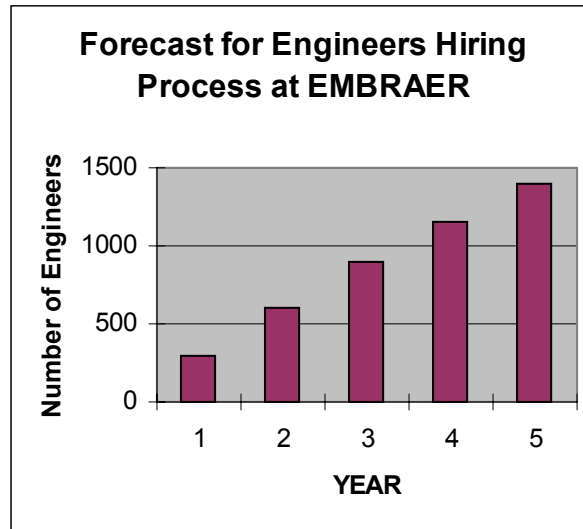


Figure 1. EMBRAER's demand for engineers, 2002-2006.

2. ITA-EMBRAER PROFESSIONAL MASTER PROGRAM

2.1 Major features of the program

Even before the last two years downturn in the international aeronautical sector, EMBRAER had decided for a strategic investment in order to keep a steady flow of prepared engineers coming into its ranks, to attend especially its particular growing demand over the last 5-year period, while taking care of the make-up process to face the retirement of some of its senior engineers. In consequence, an appropriate financial support is guaranteed for at least the 5-year period involvements in this alliance with ITA for the Professional Master In Aeronautical Engineering Program.

From the beginning, the program was conceived taking into account very important baselines, so high level technical academic standards could go along with the offering of a real hands-on experience for its new engineers. The most important baselines are:

1. A very competitive entrance exam, taken by engineers nationwide in Brazil (somehow similarly to what have been done to admit ITA undergraduate Engineering students);
2. Once selected, the engineer becomes a full-time Master student, receiving a scholarship from Casimiro Montenegro Filho Foundation.
3. EMBRAER guarantees hiring whoever succeeds in this program to work in the company in his specialization area.

As an example, the complete selection process for the third class of students that began the Master program in March 2004 (PEE C-4) started with an Internet enrollment of around 3,500 high-qualified senior engineering students graduated (or about to be graduated) in the most important universities in Brazil. They went through an online English test, and 2,000 of them stepped forward to take a test applied simultaneously in several cities of Brazil. 600 of them were then selected for personal interviews with the PEE decision-makers, who personally went to their universities to meet them. 200 were then selected for interviews with



EMBRAER's Technical Engineering Directory (DTE) managers, who ultimately decided for the 84 admitted students. For the last part of this complete process, the managers decided upon the candidates' résumés, psychological profiles and teamwork skills. The overall process was developed under the supervision of ITA's Graduate School and involved a rate around 41 candidates per enrollment.

2.2 Other characteristics, concentration areas

ITA's Professional Master in Aeronautical Engineering Program, in this partnership with EMBRAER, was certified by CAPES in March 2003. Its modus operandi involves a quarter-basis courses' system, which brings flexibility to the overall dealing logistics. The number of class-hours depends on the program phase. A total of 30 credits are required—where 16 class-hours are equivalent to 1 credit. This keeps a similar pattern already used by ITA with the institution's other *stricto sensu* programs, MSc and Doctoral.

The Professional Master in Aeronautical Engineering Program is part of ITA Aeronautical and Mechanical Engineering Graduate Studies Course. From the five specialization areas involved in that course, three of them are contemplated in the program: (1) Aerodynamics, Propulsion, and Energy; (2) Solid Mechanics and Structures; and (3) Mechatronics and Dynamics of Aerospace Systems.

2.3 Curriculum structure, phases

The overall program shall be completed in 24 months, and is composed by four distinct phases (see "Figure 2"): Initial phase: Familiarization Phase (15 days, no credits); Phase 1: Fundamental Courses (3 and 1/2 months, 12 credits); Phase 2: Specialization Courses (5 months, 5 credits); and Phase 3: Professional Internship (9 months, 6 credits) + Dissertation Preparation. The last 6 months are reserved for dissertation defense/presentation.

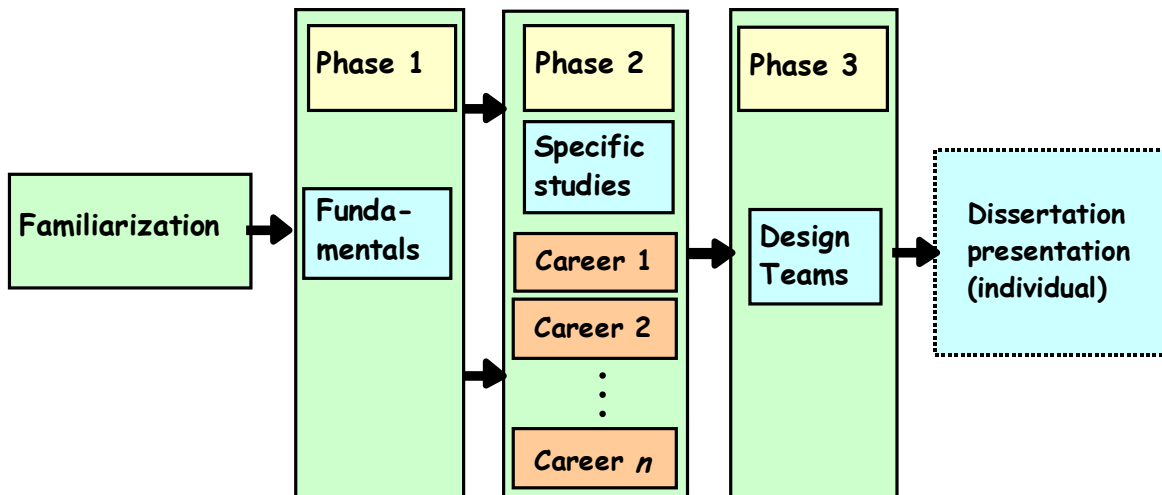


Figure 2. Phase structure for ITA's Professional Master's in Aeronautical Engineering.

It follows a detailed description of the academic work during each of the phases of the program. All the examples shown in the "Tables 1 to 3" refer to PEE C-2 and C-3 curricula.



Integration Phase

In this phase, besides the familiarization with ITA and EMBRAER done through meetings, lectures, and visits, there are two basic non-credit courses taken, “Table 1.”

Phase 1

Phase 1 contains a set of courses with mandatory disciplines tailored to the aeronautical background education, for most of the coming students have other engineering majors but aeronautical. There are also the professional disciplines taught by EMBRAER. For accreditation purposes eight (8) mandatory disciplines are taken (those marked in yellow), each involving 24 class-hours, a total of 192 class-hours, for which up to 12 academic credits can be offered during Phase 1A. In Phase 1B two non-credit professional disciplines are offered, under EMBRAER’s operational care. The respective courses are summarized in “Table 2.”

Table 1. Courses, Integration Phase.

Integration Phase	Operational Coordination	Workload (Class-hours)
PEEIN01 - Fundamentals of the Aeronautical Engineering	ITA	40
PEEIN02 - Control Theory / MatLab	ITA	40
	Total: 80 (ITA: 80 / EMBRAER: 0)	
Total Credits for the program in this phase: 0		

Table 2. Courses, Phase 1.

Phase 1 A	Operational Coordination	Workload Class-hours
AA - 701 Aerodynamics	ITA	24
AB - 701 Aircraft Performance	ITA	24
AB - 702 Aircraft Stability and Control	ITA	24
AC - 701 Propulsion Systems	ITA	24
AE - 701 Aeronautical Structures	ITA	24
AP - 701 Aircraft Design Fundamentals	ITA	24
AP - 702 Aircraft Systems	ITA	24
MT - 701 Materials and Manufacturing Processes	ITA	24
PEE1A01 - Applied Statistics	EMBRAER	40
PEE1A02 - Introduction to Integrated Development of the Product	EMBRAER	40
	Total Offer: 272 c.h. (ITA: 192 / EMBRAER: 80)	
Fase 1 B	Operational Coordination	Workload Class-hours
PEE1B01 - System Safety Assessment	EMBRAER	40
PEE1B02 - Familiarization with the ERJ-145	EMBRAER	40
	Total Offer: 80 c.h. (ITA: 0 / EMBRAER: 80)	
Total Credits for the program in Phase 1: 12 (ITA's courses)		



Phase 2

Phase 2, summarized in “Table 3,” has a set of disciplines directed to the Master Program’s careers, according to the professional demand of EMBRAER’s DTE. Students are split into the associated careers, for which they are going to work afterwards. For PEE C-2, a total of 14 careers are offered: Theoretical Aerodynamics, Applied Aerodynamics, Propulsion, Loads, Structures, Landing Gear, Flight Commands, Environmental Systems, Interiors, Noise and Vibration, Electric and Electronic Systems, Flight Tests, Certification, and Product Development Support.

A set of required and elective disciplines is established for each professional career. During phases 2A and 2C the students have to enroll themselves in a total of at least five (5) 40-class-hours disciplines, corresponding to a minimum of 200 class-hours, for which up to 12 credits can be attributed (they are marked in yellow in “Table 3”). The required disciplines are indicated in black whereas the electives are indicated in gray. During Phases 2B and 2C there are disciplines taught by international institutions, like University of Kansas, Embry-Riddle, Cranfield University, and by specialized companies like the USA CDC, Tannas Electronics, Lightning Technology, the Russian TsAGI and the British ERA Technology. English is the language for these courses.

Table 3. Courses, Phase 2.

careers	Theoretical Aero	Applied Aerodyn	Propulsion	Loads	Structures	Landing Gear	Flight Commands	Environm Systems	Interiors	Sound & Vibration	Elect & Electron	Fligh Tests	Certification	Product Dev Sup.	Op	(c.h)
Phase 2A																
AA - 702 Basic Aerodynamics															ITA	40
AB - 703 Aircraft Optimal Performance															ITA	40
AB - 704 Aircraft Simulation & Control.															ITA	40
AB - 707 Classic Control Systems															ITA	40
AE - 703 Aeronaut Structures Stabil															ITA	40
AE - 705 FEM and Structures Modeling.															ITA	40
AE - 711 Structure Dynamics															ITA	40
AC - 702 Propulsion I															ITA	40
MP - 720 Modern Control Systems															ITA	40
MP - 701 Intr. to Systems Simulation															ITA	40
MP - 740 Optimization in Engineering															ITA	40
ME - 701 Environmental Systems I															ITA	40
MP - 791 Mechanical Systems II															ITA	40
PEE2A02 - Introd. to Aircraft Certification															EMB	40
															Total Offer: 560 (ITA: 520 / EMBRAER: 40)	

Phase 2B																
PEE1B01 - A/C Design Engineering Insights															EMB	40



PEE1B02 - Aircraft Design Quality																		EMB	24
PEE1B03 - Introd. A/C Flight Test																		EMB	30
PEE1B04 - Introd. Avionics Systems																		EMB	40
PEE2B01 - Flight Control, FBW																		EMB	40
PEE2B02 - Topics on A/C Structures																		EMB	40
PEE2B03 - Cabin Safety																		EMB	40
PEE2B04 - Fuel Systems																		EMB	40
PEE2C02 - Special Topics in Aeronautical Eng.																		EMB	40
PEE2C04 - Advanced Topics ICE/O2																		EMB	32
PEE2E07 - Boarded Electronic Systems																		ITA	40
Total Offer: 446 (ITA: 40 / EMBRAER: 406)																			

Table 3. Courses, Phase 2 (cont.'d).

careers	Phase 2C													Op	(c.h)				
	Theoretical Aero	Applied Aerodyn	Propulsion	Loads	Structures	Landing Gear	Flight Commands	Environm Systems	Interiors	Sound & Vibration	Elect & Electron	Fligh Tests	Certification			Product Dev Sup.			
AA - 703 Applied Aerodynamics																		ITA	40
AA - 704 Experimental Aerod Methods.																		ITA	40
AA - 705 Numerical Methods in Aerod.																		ITA	40
AB - 706 Flight Tests Instrumentation																		ITA	40
AE - 702 Aeronautical Struct Analysis.																		ITA	40
AE - 704 Aeronautical Struct Fatigue.																		ITA	40
AE - 712 Introd to Aeroelastic & Loads																		ITA	40
AC - 703 Propulsion II																		ITA	40
AP - 703 Aircraft Mantenabil Planning																		ITA	40
AP - 705 Aircraft Operatinal Analysis.																		ITA	40
ME - 702 Environmental Systems II																		ITA	40
MP - 730 Mechanical Systems I																		ITA	40
MP - 724 Hydraulic Control Systems																		ITA	40
MP - 702 Simulation II - Applied Simul																		ITA	40
MP - 750 Vibration Control & Acoustic Noise																		ITA	40
MP - 715 Product Integrated Developm																		ITA	40
EA - 701 Special Topics in Electron Syst																		ITA	40
ET - 702 Special Topics in Avionic Syst																		ITA	40
PEE2C01 - Aircraft Design II																		EMB	40
PEE2C03 - Spec Topics, Aeroel & Loads.																		EMB	40
PEE2C05 - Avionic Systems Architectur																		EMB	40
PEE2D01 - System Safety Assessment																		EMB	40

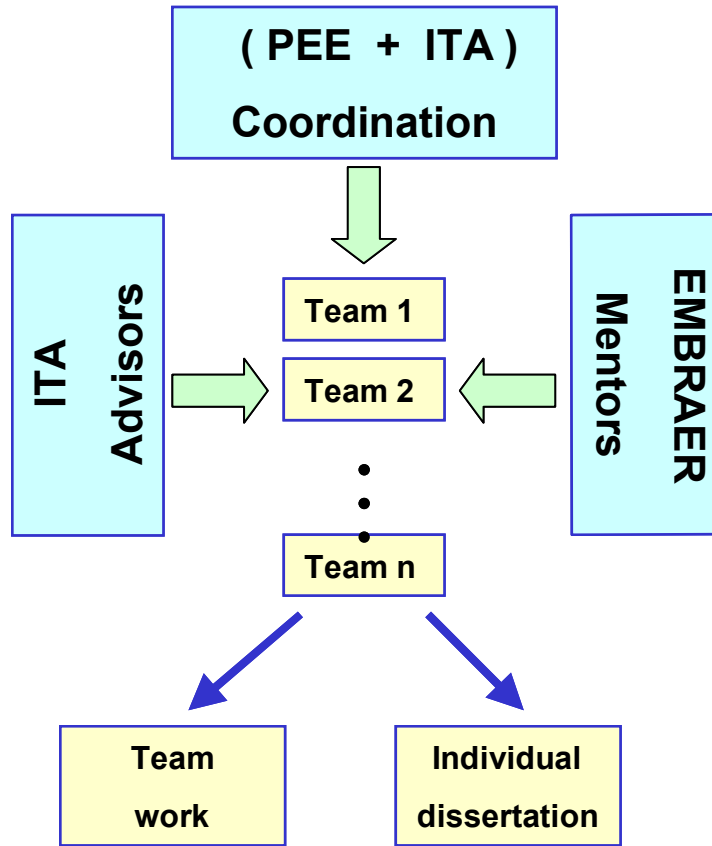


Figure 3. Schematics for Phase 3 of the Professional Master's program.

During this phase there also some courses taken, to help along the projects. "Table 4" next page shows the disciplines taught in this phase of the program for PEE C-2.



Table 4. Specifics on Phase 3.

Phase 3																
careers	Theoretical Aero	Applied Aerodyn	Propulsion	Loads	Structures	Landing Gear	Flight Commands	Environm Systems	Interiors	Sound & Vibration	Elect & Electron	Fligh Tests	Certification	Product Dev Sup.	Op	(c.h)
PEE2A01 - Aircraft Design I															EMB	40
PEE1B05 - Avionic Displays															EMB	24
PEE1B06 - Landing Gear															EMB	24
PEE2B06 - Topics on Electronic Systems															EMB	40
PEE2E01 - Aircraft Design II															EMB	40
PEE2E03 - Flight Control Systems															EMB	40
PEE2E05 - CAD Systems (CATIA)															EMB	148
Total Offer: 356 (ITA: 0 / EMBRAER: 356)																
Total Credits for the program in Phase 3: 6 (teamwork projects, Professional Internship)																

2.5 ITA faculty and EMBRAER collaborators and staff

ITA's faculty body for this program involves professors from its Aeronautical, Mechanical-Aeornautical, Infrastructure, and Electronic Engineering Departments, along with researchers from other institutes of the Brazilian Aerospace Technical Center (CTA) working in close cooperation with ITA professors, some of them members of its collaboration faculty body. EMBRAER's PEE has also a complete body of engineers and staff dedicated to this program, most of them in a full-time basis.

The executive coordination of the program involves professionals from both institutions who are constantly interacting and dealing with the intricate logistics for running this program. The point here is to enforce the best environment for accomplishing the programs goals: it's very important that, besides the technical competence, students be constantly observed on their planning, controlling and organizing skills. This goes along with today's stimuli and prerequisites for working in a very competitive industry, for which communication, attitudes and teamwork abilities are paramount.

3. CURRENT STATUS

3.1 Where are we now?

"Table 5" summarizes the current status of the three classes going through this program. As observed before, both PEE C-2 and C-3 are in Phase 3. The projects being developed by PEE C-2 students are two corporate jets (CJs), two regional jets (RJs), and one advanced trainer (AT). PEE C-3 students just started the conceptual designs of two personal jets (PJs) and of one armed advanced trainer (AAT). Whenever two designs involving the same category of aircraft (like the two corporate and the two regional for PEE C-2 and the two personal jets for PEE C-3) are there, their teams become competitors upon the same set of specifications for the aircraft, coming from EMBRAER's DTE. The high-tech profile of current projects being carried on by the students, is a key-factor for the success of this program, and this has been well-recognized by EMBRAER's decision-makers and high staff, as manifested in several occasions.



Table 5. Summary of ITA Professional Master’s classes status.

Current status of ITA Professional Master's classes				
CLASS	COURSE STARTING	STUDENTS INITIALLY ENROLLED	STUDENTS ENROLLED TODAY	CURRENT PHASE
PEE C-2	March 2002	140	136	3
PEE C-3	July 2002	90	80	3
PEE C-4	March 2003	85	83	2C
TOTAL		314	299	

3.2 A snapshot of PEE Class 2, the first to graduate

The students of the first class to graduate, PEE C-2, are divided in 14 careers within the program, i.e., Theoretical Aerodynamics, Applied Aerodynamics, Propulsion, Loads, Structures, Landing Gear, Flight Commands, Environment Systems, Interiors, Noise & Vibration, Electric and Electronics, Flight Tests, Certification and Product Development Support. “Figure 4” shows the number of class hours shared by both ITA and EMBRAER-PEE, per career. “Figure 5” shows the class-hours offered during the program and how they are divided within the phases. Adding the work-hours for the Professional Internship plus Master’s dissertation preparation, the total goes over 3,000 per student.

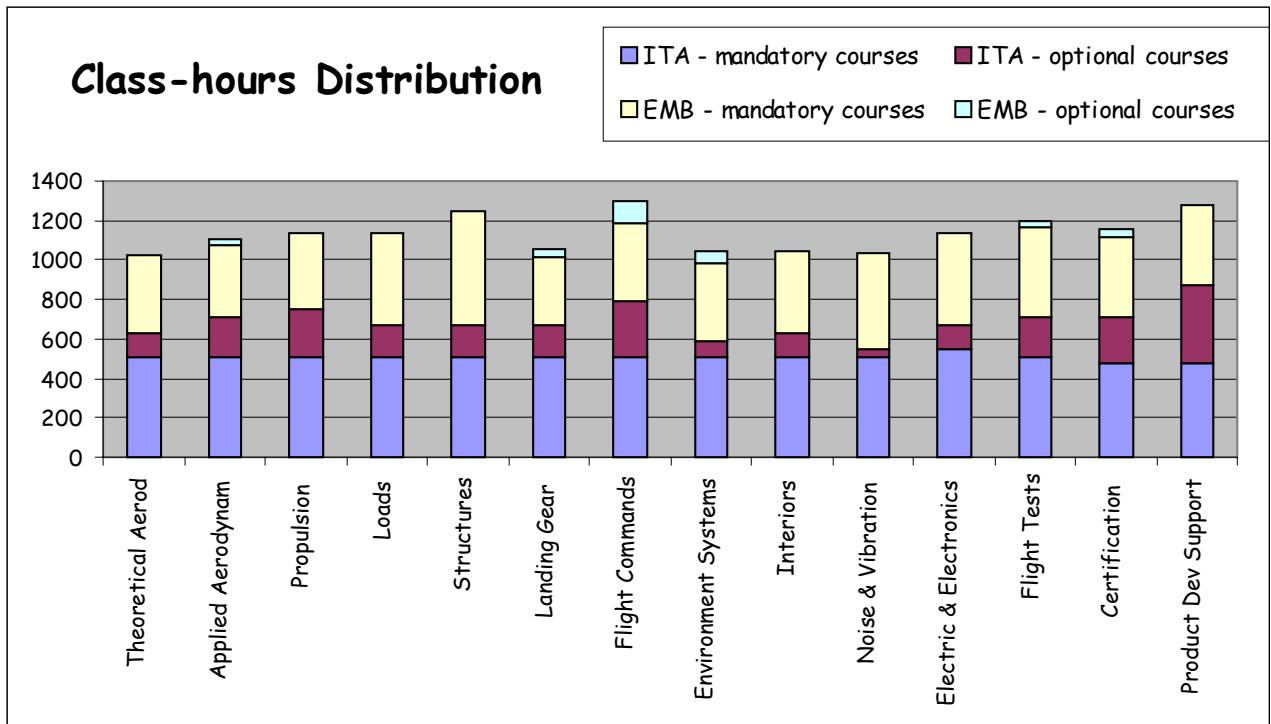
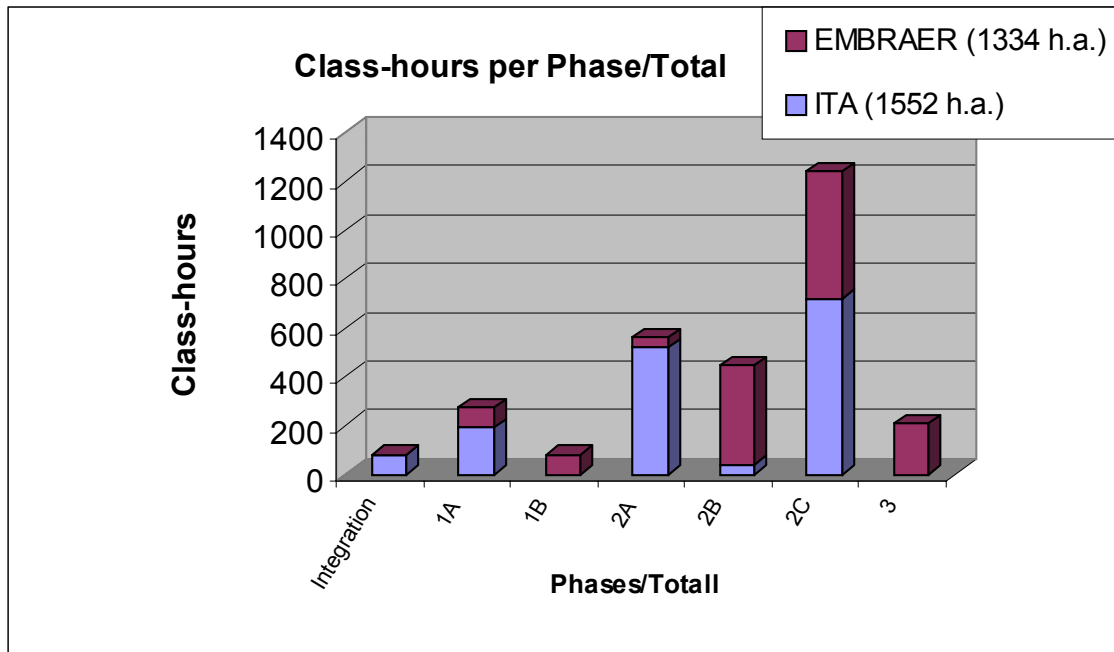


Figure 4. Class-hours per career for the PEE C-2 students in the ITA-EMBRAER



Professional Master's.

Figure 5. Sharing of class-hours offered through the phases, for PEE C-2 students in the ITA-EMBRAER Professional Master's.

3.3 Learned Lessons

All the logistics involved to come up with an alliance like this brings a real new experience for both partners. Though sharing for years the same technological sector---aeronautics---, and having the same dream---to set higher and higher Brigadier Marshall Casimiro Montenegro Filho's dream of a real competitive Brazilian aircraft industry--- EMBRAER and ITA have different cultures as a consequence of the obvious differences in their core businesses. Daily relationship has demanded a great number of points which are constantly dealt with. For example:

- Adjustments to overcome the differences in the dynamics and logistics of each institution: for a company like EMBRAER, competing globally in its aeronautical niche, it's very difficult to plan ahead schedule, and everyone in academia knows that a stricto-sensu Master's Program demands a rigorous planning; especially in a case like this in which a large number of students are involved.
- A key issue has been the implementation of a program that quickly responds to EMBRAER's needs while strictly observing the regulations from Capes, the Brazilian Graduate Studies and Research Council, an agency from the Ministry of Education that supervises the national system of graduate programs. The certification of the program by this agency demanded a substantial amount of work as the proposed program has unique features at both national and international levels.
- From the beginning, ITA had to tailor its courses: this is not an academic Master's program. In this respect, an extraordinary experience has been lived by our



professors for they have had the opportunity of becoming closer to the real world that a high-tech and sophisticated aeronautical company lives every day.

- In Phase 3 despite the efforts of trying to bring together the student's participation in his teamwork conceptual design and the dissertation topics, sometimes the task is not easy at all. With time this gap must be narrowed as much as possible.
- Sharing the students projects and dissertation preparation makes ITA's advisors and EMBRAER's co-advisors to constant talking, in order to providing a good academic and professional supervision to the students, which brings along a mutual growing in several aspects which go beyond the technical and operational issues per se.
- There is an evident awareness that this program, due to its symbiotic framework, allowing the sharing of enormous technical investment along a business oriented insight for EMBRAER, can set itself as a solid benchmark for upcoming strategies envisioning the assurance of lasting competitive differentials for both the aeronautical and the defense industries in Brazil and their spin-offs. Obviously, this demands a continuous effort for both partners.
- Right now, both institutions are joining forces to come with alternatives for the consolidation of the financial fostering process for the medium and long terms involvements.

4. CONCLUDING REMARKS

The Professional Master Program in Aeronautical Engineering is a result of the alliance between EMBRAER and ITA to provide the aeronautical industry with highly prepared professionals. Transnational companies like EMBRAER have a constant need for pushing its operational and strategic standards and manpower competences. Its brand image is linked today to exceptional design solutions proved along the years and the company is now seeing as an aeronautical solution enterprise, as it looks for new partnerships worldwide to enhance and maintain its current competitive advantages. For accomplishing this critical challenge, it is strategic to foster, prepare and retain a national critical mass of engineers with an aeronautical background to face current and upcoming technological problems. For ITA, this alliance becomes a strategic milestone in the sense that this traditional aeronautical school has the opportunity to incorporate a hands-on professional visibility to its alumni, guaranteeing a constant renewal of its faculty practical experience as they have the opportunity of dealing with the industrial sector in a daily basis. Another issue here is that, right now, the regular admittance process for EMBRAER's engineers has only two doors: they either are ITA Engineering graduates and or Professional Master's receiving their degrees from this program. For each player working together in this alliance, there is a constant work to improving the program logistics and to allowing a continuous technical updating of the course contents.