

# Training for development of space vehicles: the first step to space

*Formación para el desarrollo de vehículos espaciales: el primer paso al espacio*

*Capacitação para o desenvolvimento de veículos espaciais: o primeiro passo na conquista do espaço*

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## ABSTRACT

The training of human resources is essential for investing in development of high technologies. In the space area, it isn't different, since there is a need for qualified personnel in areas related to the research and development of space vehicles. Thus, this article proposes a structuring of postgraduate courses at Instituto Tecnológico de Aeronáutica, in order to attend the need for qualified and suitable labor to the interests of the Brazilian Space Program. To support the proposal of this work, there is, at first, an approach on the need to integrate teaching with research and development, in order to get the suitable training of human resources regarding the space area. The second approach of this work is the need for the training addressed to postgraduate courses, considering the complex nature of the topic. Therefore, based on the approaches mentioned before, the tendency is that the lack of qualified personnel becomes minimized and the national demands of the space sector are attended. Finally, this article would not only contribute to the space area, but it could serve as a reference for any area that involves high-tech items.

**Keywords:** training; human resources; development; space vehicles.

## RESUMEN

*La formación del recurso humano es fundamental para invertir en el desarrollo de altas tecnologías. En el área espacial no hay diferencia, ya que se necesita personal calificado en áreas relacionadas con la investigación y desarrollo de vehículos espaciales. Así, este artículo propone una estructuración de cursos de posgrado en el Instituto Tecnológico de Aeronáutica, con el fin de atender la necesidad de mano de obra calificada y adecuada a los intereses del Programa Espacial Brasileño. Para sustentar la propuesta de este trabajo, se plantea, en un primer momento, la necesidad de integrar la docencia con la investigación y el desarrollo, con el fin de conseguir la adecuada formación de los recursos humanos en el ámbito espacial. El segundo enfoque de este trabajo es la necesidad de la formación dirigida a los cursos de posgrado, considerando la naturaleza compleja del tema. Por lo tanto, con base en los enfoques mencionados anteriormente, la tendencia es que se minimice la falta de personal calificado y se atiendan las demandas nacionales del sector espacial. Finalmente, este artículo no solo contribuiría al área espacial, sino que podría servir como referencia para cualquier área que involucre elementos de alta tecnología.*

**Palabras clave:** capacitación; recursos humanos; desarrollo; vehículos espaciales.

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The acronyms and abbreviations contained in this article correspond to the ones used in the original article in Portuguese.

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## RESUMO

*A capacitação de recursos humanos é essencial quando se pretende investir no desenvolvimento de tecnologias de ponta. Na área espacial não é diferente, visto que há a necessidade de pessoal extremamente qualificado em áreas relacionadas com a pesquisa e o desenvolvimento de veículos espaciais. Sob esse aspecto, este artigo propõe a estruturação de cursos de pós-graduação no Instituto Tecnológico de Aeronáutica, com o intuito de atender a necessidade latente quanto à mão de obra qualificada e adequada aos interesses do Programa Espacial Brasileiro. Para suportar a proposta deste trabalho, há, primeiramente, uma abordagem sobre a necessidade da integração do ensino com pesquisa e desenvolvimento, vislumbrando a capacitação adequada de recursos humanos para a área espacial. A segunda abordagem se traduz na necessidade de que a capacitação abordada na primeira análise seja de pós-graduação, dada a natureza complexa do tema. Assim, baseando-se nas abordagens apresentadas, a tendência é que a carência de pessoal qualificado seja minimizada e as demandas nacionais do setor espacial atingidas. Por fim, o presente artigo contribuiria não somente com a área espacial, mas poderia servir de referência para qualquer área que envolva itens com complexidade tecnológica.*

**Palavras-chave:** capacitação; recursos humanos; desenvolvimento; veículos espaciais.

## 1 INTRODUCTION

The history of the Brazilian Space Program - PEB is directly related to that of the National Institute for Space Research - INPE and the Department of Aerospace Science and Technology - DCTA, which includes the Institute of Aeronautics and Space - IAE (SILVA, 2012). The purpose of the IAE is to carry out research and act in the development and management of aerospace projects. Among them, the strategic project of the Microsatellite Launch Vehicle, the VLM-1, stands out.

However, currently there is also a growing demand for nanosatellite launches. These, in turn, could be launched through adaptations of established national vehicles, such as the VSB-30 solid propellant two-stage sounding vehicle (VILLAS BÓAS, 2020). This vehicle was developed in partnership with the German Space Center - DLR and currently has more than 30 successful launches at the Alcântara launch centers in Maranhão, Esrange in Sweden, Andoya in Norway and Woomera in Australia. The VSB-30 is also the only certified space product, a certification granted by the Institute for Industrial Development and Coordination – IFI, according to Brazil (2022a).

Given that there is a need for specific knowledge and a high degree of complexity to be able to work with Research and Development - R&D of complex vehicles such as the VLM-1, it is clear, as highlighted by Amaral (2011), the fundamental importance of investment and production of extremely qualified human resources in the different areas of knowledge of a space vehicle. Among these areas, we can mention: project management, systems engineering, aerodynamics, propulsion, on-board electronics, materials chemistry, mechanical processes and software engineering.

In order to meet the demand for skilled labor in the space area, as in the areas mentioned above, there is a fundamental need for the planning and execution of periodic public tenders, which, in turn, in the DCTA, has not happened since 2014, the year of the last public tender with 241 vacancies for admission of specialized labor (BRASIL, 2013). There is then a growing and latent need for specialist professionals to fill gaps in the space sector. Additionally, most of the professionals who enter via public tenders to work as specialists do not have knowledge and experience in such specific areas, since there is no significant demand for professionals like that in the market that justifies a higher number of postgraduate courses in national institutions.

Thus, in this article it is considered that the structuring of postgraduate courses at the Technological Institute of Aeronautics – ITA, at the *lato* and *stricto sensu* levels, with the categories of specialization, master's and doctorate is necessary for the improvement of the Brazilian Space Program. Program that is captained by the Brazilian Air Force - FAB and by the Brazilian Space Agency - AEB.

Access to space is fundamental for the development of the Brazilian state, as described by the National Space Activities Program - PNAE for the period from 2022 to 2031, according to the Brazilian Space Agency (2022), and also for the FAB, based on the Air Force Military Strategic Plan for the period from 2018 to 2027, which contains, as one of the strategic objectives, the need to intensify research and development of science, technology and innovation in the aerospace field, which is verified in the figure of the VLM as a strategic project (BRASIL, 2018).

In order to substantiate the thesis of this article, two main arguments will be addressed. Aiming to meet the demands of the PEB, the first aspect addresses the adequate preparation of specialized human resources, through courses at ITA, focusing on the core activity, the development of space vehicles. The next aspect will be based on the importance of postgraduate

higher education as a necessary tool for the production of a critical mass of qualified personnel in complex teaching areas, such as engineering related to rocket launching.

At the end of this article, it will be possible to discern the need for training human resources aimed at R&D of space vehicles, which demands high qualification in specific areas, thus pursuing the much-desired “conquest of space”.

It is noteworthy that the proposed agenda of this text, the structuring of postgraduate courses, necessarily, and with a focus on the core activity, the development of spatial vectors, will be valid for the category of servers, which are part of the body of qualified professionals through public tenders and for the category of military officers in the engineering officers formed by ITA or by the Aeronautics Instruction and Adaptation Center – CIAAR.

This mixture of categories of professionals, civil and military, was the scope of the construction of the DCTA, and continues to be so, for the training and maintenance of the specialized workforce, in areas of cutting-edge technology. The effort and method for creating the scientific and technological hub in São José dos Campos in the state of São Paulo was planned, architected and executed by the visionary of ITA's history, Air Marshal Casimiro Montenegro Filho (SILVA; FISCHETTI, 2006).

## 2 TRAINING AND THE BRAZILIAN SPACE PROGRAM

In general, Veloso (2017) presented the concept of intellectual capital and demonstrated the difference that investment in this asset represents for modern organizations that are affected by rapid and constant technological evolution. In this way, HR training shapes the intellectual assets for the competitiveness of a company, or for the differential of organizations that work with technological innovations.

The training in this document is based on national needs linked to space activities, as Moreira and Velho (2009, p. 263) explain about INPE: “From the beginning, the institute pursued the objectives of interacting with the national reality, research and teaching alliance, and training of human resources to work in space activities that, if not complete, are mainly Brazilian”.

However, it should be noted that the investment in intellectual capital is in line with a response to the fatal accident that occurred on August 22, 2003, when the VLS-1, the Satellite Launch Vehicle, was

fired at the Alcântara Launch Center - CLA, with the loss of 21 qualified and experienced professionals (BASE..., 2022). Brazilian society lacks a response worthy of the State and, thus, the PEB tries to pursue the path of evolution and envisages the launch of the VLM-1.

In this context, two arguments will be presented in order to defend the proposal of this article to structure postgraduate courses at ITA aimed at the objectives of the PEB, with regard to suborbital rocket launches and micro and nanosatellite launchers.

### 2.1 Preparation of human resources with a focus on the development of space vehicles

According to Gill et al. (2008), space education can be provided internally to an organization, such as an agency or a company, or carried out by sending individual professionals to short-term programs and courses as a specialization, motivated by the fact that the space sector requires, recently, more and more managers, engineers and scientists with a broad overview of the space arena, a system vision and a business instinct capable of working in a multidisciplinary and multicultural environment.

Problem-based learning is a current trend and represents a widespread teaching methodology in disciplines, in which students must learn to apply knowledge, not just acquire it. This methodology is a reality in several educational institutions around the world. The Massachusetts Institute of Technology - MIT is an example. In addition, this perspective tends to reinforce the point of view of the need for professionals, in the space vehicle development area, with multidisciplinary knowledge (BRODEUR; YOUNG; BLAIR, 2002). And, for this case, the option of specialization courses at ITA, lasting from 12 to 18 months, will cover areas that require broad knowledge in different areas without much depth of content, such as project management, in addition to providing a leveling of more superficial knowledge in all fields.

Since the 1970s, ITA, with the support of the IAE, has trained specialists in the field of defense through the Specialization Course in Air Weapons Engineering - CEEAA, which has the main task of leveling and providing comprehensive knowledge in all areas necessary for the development of defense items. This course, in turn, can be the model for the implementation of an analogue in the space area focused on the development of suborbital and orbital vehicles.

On the other hand, master's and doctoral courses are appropriate for cases in which there is a need for specific and in-depth knowledge in certain areas of interest in the aerospace sector. Preparing HR to delve deeper into cutting-edge technology areas does justice to another approach.

Since the 1960s, INPE has decided to invest in preparing qualified human resources to work in R&D in the space area, more specifically in satellites, motivated by the lack of qualified labor. Then came the graduate program at INPE, which established an intimate relationship between R&D and teaching. This alliance came to fruition successfully, as the evaluated model of training researchers from the Institute itself, as teachers for future professionals, proved to be effective in terms of training professionals suited to the Institute's demands, as there was an increase in the number of masters and doctors and an increase in the number of scientific publications until 2005 (MOREIRA; VELHO, 2009).

Previously, Bastos (1981) presented a similar result when he demonstrated, through an evaluation methodology of a nursing HR training program for the Bahian countryside, that the integration of health and education services was fundamental for the creation of a training center for qualified personnel in the area of nursing. Thus, the result was an improvement in the qualification of the workforce providing health services, in addition to presenting a positive result regarding the organizational structure of nursing services.

With regard to more in-depth courses in specific knowledge, masters and doctorates, it will be up to ITA to make use of analogous or similar methodologies for structuring courses in the space area with a focus on R&D of space vehicles. That is, knowing and evaluating the organization or institute whose mission is to develop these vehicles to map specific needs. It is not a simple task, but it has proven to be effective. To this end, ITA will rely on IAE collaborating professors to implement courses and teach classes, which is already a reality in other areas, including those linked to the Space Sciences and Technologies Program.

It is worth mentioning that the ITA does not present, in its grid of disciplines offered in postgraduate courses, according to Brazil (2022b), contents that contribute in a complete way to the development of space vehicles. In this same context, it is noteworthy that INPE does not present, in its grid of disciplines offered, technical subsidy aimed at the development of space vehicles, even because it is not the scope of this institute, since its focus is the development of satellites, as found by Moreira and Velho (2009).

To give a more specific example, there are disciplines at ITA offered to postgraduate students that envision the conceptual basis regarding the development of space vehicles, but there is no more in-depth and specific content, such as, for example, aerodynamics applied to space vehicles, hybrid and liquid propulsion for space access, as well as structural analysis, control and design applied to space vehicles, among other needs.

## 2.2 Postgraduate higher education as an essential tool for training specialists in the space area

Higher education in Brazil can be considered recent, since it began in the 19th century; consequently, graduate school is even more recent. Thus, the research culture that aims at the production of scientific knowledge was only rooted in Brazilian universities after the 1970s. However, the national graduate is a reality nowadays with several programs supported by public policies, such as CAPES and CNPq. Based on the recent history of Brazilian education, post-graduation has become the essential factor for the development of science and, mostly, with *stricto sensu* courses (MOROSINI, 2009).

Graduate studies in Brazil were established based on basically three guidelines: highlighting the training of faculty members to meet the evolution of higher education in terms of quantity and quality; encourage the growth of scientific research by training researchers; and to ensure that technical-intellectual professionals are properly prepared at the highest level, with a view to meeting national development demands in all sectors. Since then, HR training has been encouraged with the ability to create new techniques and production processes. Consequently, there was an urgent need to expand postgraduate courses in the country in order to produce the desired highly qualified workforce. Specifically for the case under discussion in this document, with the same general motivation and reinforced by the creation and evolution of the Brazilian Space Program, there was a dissemination of Brazilian universities offering postgraduate courses related to space sciences (MOREIRA; VELHO, 2012).

With the rise of space activities from the 1970s onwards, the CLA was created in the state of Maranhão, located in what is considered the best region for launches on the globe, due to its privileged position close to the Equator Line (CASTRO, 2007), which guarantees greater

safety, precision and economy in rocket launches, according to Romão's perception (2011). This growth determined the interest in preparing highly qualified labor, aiming to attend space rocket launches. Thus, in recent decades, the National Postgraduate System was created and contributed profoundly to the modernization of higher education (SOARES *et al.*, 2002).

It should be noted that the training of extremely qualified professionals in complex areas, such as the space area discussed in this document, basically depends on specialization, master's and doctoral courses, as noted by Velloso (2004).

Therefore, it is inferred that, for the development of space vehicles, it is essential to establish graduate programs that encourage the improvement of research engineers. Therefore, expanding the availability of graduate courses is in line with this need. Thus, it would be interesting for ITA to seek public-private partnerships with the aim of supporting its programs or absorbing new professionals, as was successfully done in the aeronautics area with the advent of Embraer.

If it were not important or lucrative in terms of technological independence, the US would not have invested so much, throughout its recent history, in the development and recovery of space vehicles, nor would it have created the American Space Force. The result was the existence of several companies with aerospace technological know-how, which aim to provide even space tourism (ORLANDO, 2021).

### 3 CONCLUSION

In a simplified way, we highlighted, in a first plan, that the training of highly qualified human resources to work in areas of recognized complexity, such as the space area, more specifically the development

of space vehicles, has its success directly related to the existence of a link between the educational institution and the developer organization.

Seeking to complement the training focus in the space area built in the first approach, the second approach became necessary, based on the following question about teaching itself: why would there be a need for postgraduate courses for the adequate preparation of resources humans to the object of desire discussed in this document, namely, the development of space vehicles? The answer to this question came from the very history of the Brazilian Space Program: there is no development without training. Therefore, due to the need for specific knowledge in complex areas, there is only the possibility of preparing qualified professionals for the development of suborbital and orbital vehicles starting from graduates in cutting-edge technology areas, such as the various engineering fields. There is no way around this trajectory so that the "conquest of space" becomes a reality.

Therefore, based on the model presented and argued in this document, it would be of great value for the Brazilian Space Program if the Technological Institute of Aeronautics, linking the expertise of developers to teaching, structure courses that are postgraduate in order to provide the specialized training necessary for spatial demands. In this way, the outcome of the proposal would minimize the shortage of qualified personnel and meet the strategic projects defined by the Brazilian Air Force.

Finally, the contribution of this work does not only affect the space area, but can serve as a model or reference for any area of knowledge that involves similar needs regarding the development and/or application of items with cutting-edge technology, such as in the area of defense and nuclear, for example.

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