

THE BENEFIT OF BILATERAL RESEARCH NETWORKS - THE SARC AND BARINET INITIATIVES AND THE BRAZILIAN SWEDISH COLLABORATION IN AERONAUTICS

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Abstract

In this paper the creation and maintenance of a bilateral network is presented. Sweden and Brazil have a long standing relation stretching far beyond aeronautics. However, it was intensified with the acquisition of the Swedish Saab Gripen combat aircraft for the Brazilian Air force. This led to an intense build-up of industrial collaboration and in the wake of this, also a bilateral academic network was formed to both take advantage of this, as well as support the process and encourage spin-off effects to other parts of society. To be sustainable it is argued that a network needs the right support and encouragement to be able to grow organically in a sustainable way, based on personal relations. Once this is in place, an academic bilateral network can be formed that can be maintained effectively over time at a low cost.

Keywords: bilateral collaboration, academic network, internationalization

1. Introduction

In 2013, Brazil and Sweden agreed upon the acquisition of Gripen fighters and signed a long-term contract, with an expected duration of 35 years. As a consequence of a so-long agreement, both countries manifested an interest in establishing cooperation in research and development of future aircrafts, exploring complementary expertise existing in each country. The expectation was that this cooperation should follow the triple helix model for innovation, involving universities, industry and government, and could cover topics with different technologies readiness level.

In order to identify challenges and areas of common interest, as well as researchers willing to engage in the cooperation, both countries set off a number of joint activities, including a series of joint workshops. With the support of the Swedish-Brazilian Research and Innovation Center (CISB), short, medium and long missions ensured that researchers from both countries visit each other and interact. In parallel, on the government level, a High-Level Group on Aeronautics (HLG) was established as a commitment of the Swedish Prime Minister and the Brazilian President, supported by an Executive Committee (EC).

From the beginning, it was clear that universities have a key role in the process of building up the cooperation. Universities are naturally open to collaboration and usually work at low Technology Readiness Levels (TRLs), where issues related to intellectual properties are not so frequent and the knowledge developed is usually translated into publications.

Considering this historical background, this paper discusses and contextualizes two national initiatives: the Swedish Aeronautics Research Center (SARC), in Sweden, and the Brazilian Aerospace Research and Innovation Network (BARINet), in Brazil. Both can be considered spill-over of the Brazilian Swedish collaboration in Aeronautics.

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In the next section, the Brazilian Swedish collaboration is analyzed under the causation-effectuation framework. Among the important causation elements, we introduce the Swedish Brazilian Research Center (CISB) and the Swedish Professor Chair Program at ITA, which in a certain way, triggered the creation of SARC and BARINet. As another key causation element, the coordinating and funding organizations are also presented, as well as some of their initiatives. Following, we introduce SARC and BARINet, emphasizing their role in fostering cooperation within each country. The joint activities performed so far by SARC and BARINet feeds back the bilateral cooperation. Finally, in order to give a comprehensive picture of the bilateral collaboration, we present also other important examples of effectuation, such as SC2C.Aero and workshops in different areas other than Aeronautics.

2. Scientific Framework

International collaboration has long been associated with benefits in terms of scientific impact, with the vast majority of collaborations resulting in gains for both sides [1]. Collaborations among researchers from different countries, organizations and areas are essential for addressing complex challenges and achieving significant technological advances [2].

Many studies have analyzed the building of international scientific collaborations based on publication data, usually collected over decades and organized in broad knowledge areas [3], [4]. A common, and expected, finding of these studies is the constant growth in international co-authored papers across all domains, with prevalence of English-speaking countries. More recently, a new research field has emerged under the name of "science of team science" to discuss conceptual and methodological strategies related to collaborative research, with focus on evidence-based analysis [5], [2].

Among the myriad of approaches that could be used to analyze Brazil-Sweden collaboration in Aeronautics, we opted to apply the concepts of causation and effectuation, from entrepreneurial studies. As argued by Ahoba-Sam et al [6], the process of building academic networks can be considered as an entrepreneurial activity. Basically, causation is when we focus on a predefined goal and then work on the available means to achieve that goal. On the other hand, effectuation is when we start from the available means and then work to achieve a goal that was not necessarily known at the beginning, exploring the opportunities with more flexibility.

As detailed in the next section, it can be argued that the initiation of Swedish Brazilian Research Center (CISB) and, subsequently, the Professor Chair Program represents causation where an intentional effort was made to instigate collaboration and to create a domain where network can grow through effectuation, that is through more spontaneous and organic growth. As will be shown, that has very much been the case here.

Table 1 lists a number of bilateral initiatives and classifies them as either causation or effectuation. On the left side, we placed initiatives that were created purposely to initiate and establish bilateral research collaboration in Aeronautics. These initiatives were created aligned to or as part of a commonly agreed roadmap between the two countries. On the right side are initiatives that we classified as effectuation. They were not initially planned for, or were not part of the primary bilateral collaboration goals, but arose when researchers involved in the collaboration explored available opportunities.

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Table 1. Classification of Brazilian-Swedish initiatives.

<i>Causation</i>	<i>Effectuation</i>
CISB	SARC and BARINet
High Level Group (HLG) and Executive Committee (EC)	SC2C.Aero
Professor Chair Program	IDEAS conferences
Brazilian-Swedish Workshops in Aeronautics	WIEFP workshops
Air Domain Study (ADS)	BIOGAS initiatives
FINEP-VINNOVA and SENAI-VINNOVA projects	Development of assistive technologies

Much as observed by Galkina and Jack (2021), the combination of causation and effectuation when building the Brazilian Swedish collaboration network has had a synergistic effect boosting the development of new opportunities.

3. CISB and the Swedish Endowed Professor Chair Program at ITA

The Swedish Brazilian Research Center (CISB) was created in 2011 at the initiative, and financial support, of Saab AB to become a non-profit organization to promote Swedish-Brazilian collaboration through networking events and scholarship programs. In 2015, following a successful model that was already in place at the Aeronautics Institute of Technology (ITA), SAAB, CISB, Linköping University (LiU), Chalmers University of Technology (CTH) and the Royal Institute of Technology (KTH), created the Swedish Endowed Professor Chair Program at ITA in the Honor of Peter Wallenberg Sr., with the support of VINNOVA, INNOVAIR and the Swedish universities.

The idea of the program is to have Swedish professors spending a significant time per year in Brazil (e.g., 8 weeks, split over different trips) during a relatively long period (e.g., 3 years). This would allow the establishment of strong links between the research groups in Brazil and Sweden, which would act as a catalyst to the creation of new links. One key feature of the program is that it is not restricted to funding the travel expenses of the professors, but allows each professor to use part of his grant in related activities, such as the organization of workshops or the mobility of other researchers to/from Brazil and Sweden.

Initially, the chair was implemented for three professors: Petter Krus (Linköping University, LiU), Tomas Grondsted (Chalmers Technical University, CTH) and Dan Henningson (The Royal Institute of Technology, KTH). All of them already have contacts in Brazil and some ongoing collaboration. It was later expanded to Ragnar Larsson (Chalmers Technical University, CTH). The commitment to the Brazilian collaboration led to an informal network also between the professors that became the foundation to build a national network in aeronautics in Sweden, that became SARC.

4. The role of coordination and funding organizations

INNOVAIR is a strategic innovation program in Sweden funded by the The Swedish Agency for Innovation Systems, VINNOVA. In addition, it coordinates the National Aeronautics Research Program (NFFP) that provides funding for Aeronautics research. It channels funding both from VINNOVA (85%) and the Swedish Armed Forces (15%). Another very important role is to regularly (every three years) update the National Research and Innovation Agenda (NRIA). This is an important document to lay the foundation for e.g., for calls for the NFFP research program and other activities.

INNOVAIR controls funding for aeronautics research in Sweden and has an important role in funding strategic projects for the Swedish Professors in Brazil, providing possibilities to extend the collaboration. INNOVAIR have also been instrumental in managing the High-Level Group between Sweden and Brazil with representatives from ministries and air force from both countries. The

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Wallenberg Professors have been part of the INNOVAIR working group which has made communication very effective. Hence, the role extends beyond providing funding and strategic plans for Swedish aeronautics research, since it is also an important informal network of all actors in the Swedish innovation system for aeronautics. Therefore, the role of INNOVAIR in coordinating activities in Aeronautics research both in Sweden and for international collaboration is very important. A consequence of the close ties between the Wallenberg Professors as a result of the collaboration in Brazil, was the creation of the Swedish Aerospace Center SARC (described later in the text), on the initiative and support from INNOVAIR.

From the Brazilian side, two entities have a leading role in structuring and coordinating the Brazilian-Swedish research collaboration in Aeronautics: EMAER and MCTI. EMAER, from the Portuguese acronym of “Estado Maior da Aeronáutica”, which could be translated as Chief of Staff Department of Brazilian Air Force, is responsible for elaborating the high-level strategic planning in order to assure the accomplishment of the Brazilian Air Force's mission. Besides having a key role in defining priority areas for the collaboration, it also coordinates the Air Domain Study. On the other hand, the Ministry of Science, Technology and Innovations, known as MCTI, is responsible for the formulation and implementation of the National Science and Technology Policy in Brazil. MCTI has given an invaluable contribution in obtaining funding for the development of relevant research projects within the scope of cooperation.

One of the early joint activities that can be clearly classified as causation is the set of jointly funded research projects that resulted from two bilateral calls: the FINEP-VINNOVA projects and SENAI-VINNOVA projects. Both calls act as a testbed for experimentation, particularly on how to overcome the necessary bureaucracy for running bilateral projects. It is interesting to note that most of the approved projects were proposed by researchers and institutions that were already involved in the collaboration through CISB and the Endowed Professor Chair Program.

Another important initiative that has been key to structure and consolidate the bilateral collaboration is the Air Domain Study (ADS). It is an on-going initiative that aims at identifying future military scenarios and operational needs that are common to both countries and developing technologies and solutions to support these scenarios. ADS encompasses a number of research projects that cover topics such as autonomous and cooperative systems, application of artificial intelligence techniques and human-machine interface. As a next step, the solutions and technologies developed by each ADS project will be integrated in a virtual demonstrator.

5. SARC - The Swedish Aeronautics Research Center

SARC was created in 2018 as a network for universities in Sweden with substantial aeronautics research. This was originally Linköping University and Chalmers Technical university and subsequently KTH and Luleå Technical University. This also included the extension to Space and SARC now stands for Swedish Aerospace Research Centre. SARC is formally a project under the INNOVAIR program funded by Swedish Agency for Research and Innovation Vinnova and the Swedish Air Force.

5.1 Activities

From the start SARC has activities in three areas: SARC Research, SARC Academy and SARC Internationalization. Internationalization is very important since a major enabler for SARC was that the holders of the Wallenberg Chair in Brazil were also the original director and co-directors of SARC.

5.2 SARC Course in Brazil

SARC Academy is a graduate school for PhD students from the different universities and it offers PhD courses related to aerospace that are available for all PhD students in the network. The first course was in Aircraft Design with Daniel P. Raymer from the US as a lecturer. This course was held in Brazil with local support from SC2C.Aero with fifty delegates equally distributed between Sweden and Brazil. SARC Research is a collaborative project that has involved both PhD students and researchers from the different universities. It was to elaborate on a hydrogen powered aircraft that

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had been initiated during the introductory course. This has been very useful in order to exchange knowledge and experience from different tools and methods as well as forging the network stronger.

6. BARINet - The Brazilian Aerospace Research and Innovation Network

Following the example of SARC, a group of Brazilian professors that were collaborating with the Swedish professors from the Chair Program started to discuss among them how they could also strengthen internal collaboration in Brazil. In 2019, with the belief that they could contribute to the development of Brazilian research and innovation in Aerospace, they decided to create BARINet - the Brazilian Aerospace Research and Innovation Network.

BARINet aims at fostering collaboration and cooperation among its members and with external actors, both national and international, with the purpose of enhancing the excellence of Brazilian research and contributing to its transformation into innovation.

The model adopted by BARINet is inspired by the National Combustion Network (RNC). The participation of any researcher and organization in BARINet is voluntary. All the information exchanged in the context of BARINet is open and all collaboration should be conducted in accordance with ethical principles, regulations and laws.

The kick off of BARINet is marked by the signing of a Statement of Intention among four professors from the Aeronautics Institute of Technology (ITA), Federal University of Santa Catarina (UFSC), Federal University of Minas Gerais (UFMG) and University of Sao Paulo (USP). Not coincidentally, it happened at the 2nd Workshop on Swedish Professor Chair Program at ITA.

7. Joint SARC-BARINet Activities

7.1 Joint Workshops

Workshops have been organized jointly by SARC and BARINet. There is an annual workshop that has been very successful with an emphasis on PhD students and active researchers. Despite or because of the pandemic, there has been a very good attendance since they have been online. There have also been smaller, more topic-oriented workshops.

The pandemic initially was a big setback for the collaboration. However, since a network was already in place, the collaboration was eventually continued very effectively on digital platforms. It was realized that this meant that contacts could be much more frequent and this was used to its full potential. There were many more delegates on the events organized since there were no travel involved and especially the participation of students could be made stronger. Nevertheless, it was a setback especially for PhD students and young researchers not to be able to travel and meet physically to engage in more in-depth discussions and get feedback and inspiration at conferences.

The 1st SARC-BARINet Workshop was held in 2020. Its program was composed of six keynote speakers and around twenty-seven PhD presentations, approximately half from each country. The presentations were organized in six thematic sessions: low emission, aerospace systems, system engineering and system of systems, subscale testing and small UAV, and small satellite. Additionally, the program included presentations from three Brazilian universities that were not strongly active in the BR-SE collaboration, with the purpose of motivating them to increase participation.

With the experience obtained with the first workshop, the 2nd SARC BARINet was quickly organized in a couple of weeks and included forty PhD presentations and eight keynote speakers. New topics of this edition were autonomous systems and AI, and aerospace structures, manufacturing and materials.

Both workshops were attended by more than eighty researchers, with balanced participation from both countries. They show how easily we can set up virtual workshops when a network of collaboration is already in place.

7.2 Joint SARC-BARINet Competition

Another joint action of SARC and BARINet is the organization of competitions. In 2021 the first competition took place with the title “Collaborative Unmanned Aerial Vehicle”. Systems-of-systems and multidisciplinary approaches were proposed as thematic due to their importance in modern aviation and applicability in unmanned aerial vehicles, especially in collaborative solutions to specific tasks. The competition consisted in presenting the best solution to a selected problem involving multiple unmanned aircraft. Participants from industry (start-ups) and graduate students from academia were eligible to join. The teams were challenged to simulate a self-defined mission where 3 or more UAVs collaborate towards completion and were required to demonstrate the mission with at least one UAV. To organize the competition, an advisory board composed of exponents from Brazil and Sweden was created. This advisory board selected and invited the members to form the Jury Board Swedish Armed Forces, SAAB, Brazilian Air Force, EMBRAER, INNOVAIR, Brazilian Navy, Swedish Society for Aeronautics and Astronautics, and Combitech. The competition was supported by CISB and an award from SAAB was offered to the winning team.

In April 2021, 18 teams registered for the competition: 6 teams from Sweden and 12 teams from Brazil. Among the teams, 5 came from companies, 12 from universities, and 1 was an independent registration. Finally, 6 teams (5 from universities and 1 independent) were able to deliver the final paper with a demonstration video according to the competition rule. The result was announced in October 2021: Team Chalmers - Sweden proposed a combination of Quadcopter, with fixed-wing, and marine drones for search and rescue, ranking second and Team Flying U2, composed of students from USP and UFSCar, Brazil, ranked first with a proposal for a multi-UAV platform to promote preventive monitoring on the identification of surface cyanobacterial blooms and aquatic macrophytes.

In 2022, the second competition kept the focus on System-of-Systems but changed the challenge to address the contemporary problem of “Fire Detection and Fighting in Forests” using multiple UAVs. This time there is the additional requirement that the UAVs should be dropped in the forest area by a cargo aircraft. The competition is open to anyone, except for employees of the Aerospace Industry, but allows participants from startup companies. Teams are limited to a maximum of 10 participants. The competition consists of two stages. Based on the outcome of the first stage, a selected number of groups from each country (Brazil and Sweden) will be invited to enter the second stage. The first stage is dedicated to Drone design, simulation, and manufacturing. A virtual environment using ROS and GAZEBO platform was provided by the organization for the mission, alongside an existing drone model for the teams to familiarize themselves with the platform (https://github.com/2nd-sarc-barinet-aerospace-competition/sarc_environment). Each team must provide a written report to compete in this first stage. Based on the evaluation of these reports of the first stage, the top-3 teams from each country (Sweden and Brazil) will progress to the second phase of the competition – a live demonstration taking place in October 2021. In this second stage, a mission is proposed consisting of a live demonstration. Test sites will be organized both in Sweden for Swedish competitors, and Brazil for Brazilian competitors. As in the first competition, the winning team will be awarded with a prize covering part of the costs to travel to Brazil or Sweden and will meet with representatives of the country’s aerospace industry.

8. Spillover Effects

Several research activities in aeronautics have been carried out for decades, and more recently also in the space area, at the Federal University of Santa Catarina, including cooperation with other Brazilian universities, such as ITA, UFMG and USP-São Carlos. The inauguration in 2009 of the UFSC Joinville Mobility Center offering an undergraduate course in Aerospace Engineering, the installation in 2017 of a Technology and Engineering Center of EMBRAER in Flororionópolis, and the creation by SENAI of the Innovation Institute in Embedded Systems in 2018 intensified the actuation of the Santa Catarina state on the aerospace field.

However, it was the cooperation of Federal University of Santa Catarina with Swedish institutions, started with Linköping University in 2012, followed by KTH and Mälardalen University, and the

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continuous interaction with CISB that stimulated the organization and strengthening of actions in this area. With support from Research and Innovation Support Foundation of Santa Catarina State (FAPESC) and, subsequently, from MCTI, the Santa Catarina's Center of Convergence for Aerospace Technologies (SC2C.Aero) was created in 2017.

SC2C.Aero is a network of technological R&D&I groups focused on strengthening relationships with companies and government agencies for the emergence of new projects and products [12]. The operation of the SC2C.Aero is based on attracting and connecting the stakeholders from the triple helix in annual cycles.

As shown in Table 1, SC2C.Aero is an effectuation resulting from the High-Level Group (HLG) and Executive Committee (EC) activities, mainly through the MCTI efforts to expand aeronautical R&D&I in Brazil.

Another spillover of the Brazilian-Swedish collaboration on aeronautics was the creation of the Workshop on Innovative Engineering for Fluid Power (WIEFP). It started in 2012 as a Swedish-Brazilian initiative focused on promoting collaboration in the development of technologies, education, innovation management and methods and tools for the development and design of hydraulic and pneumatic systems. The organizing institutions are LiU/FLUMES and UFSC/LASHIP, both working in hydraulic and mechatronic systems, UFABC, focused on management and innovation, CISB, focused on Sweden-Brazil collaboration, and Hydraulic, Pneumatic and Industrial Automation Equipment Sectorial Chamber (CSHPA) at ABIMAQ that brings the industrial perspective.

WIEFP has occurred every two years bringing together industry and academia, from Brazil and abroad. It has been an opportunity to discuss with distinguished professors, managers, researchers and engineers working on fluid power components and systems and management and innovation, as well as with experts from motivating application fields.

Another spillover of the Brazilian-Swedish collaboration in Aeronautics is the Interdisciplinary Conference on Innovation, Design, Entrepreneurship, and Sustainable Systems (IDEAS), whose aim is to stimulate original thought-provoking debates on existing practices on how science and technology can be a source of innovation while designing socio-environmental systems. Innovations of different kinds have taken humanity to the most significant dimensions in social and environmental terms, pillars of fundamental changes in the way we live. The first edition of the conference was jointly organized in 2019 by the Federal University of ABC, Federal University of Amazonas, Federal University of Santa Catarina, and Linköping University. It was funded by the Brazilian National Council for Scientific and Technological Development (CNPq), and companies from Manaus. This effort is the result of a series of Workshops jointly organized by the Federal University of ABC, Federal University of Santa Catarina, and Linköping University between 2014-2018 with the support of the Swedish-Brazilian Innovation Center (CISB).

The ideas conference encourages the participation of undergraduate, master and doctoral students and effective interaction with senior researchers from Brazil and abroad. The conference also encourages the participants from the private and public sectors. The objective is always to combine the academic rigor necessary for the elaboration of scientific research with an arena for building informal collaboration networks that help to consolidate the training of young researchers with excellence. This conference also has an impact on the productive and public sector, as the theme of innovation is inseparable from society, whether due to the need to employ human resources capable of applying leading-edge knowledge to real-world problems. The conference also tries to fill the gap on research that creates awareness about innovation that can impact basic education, inclusion and diversity since participants know that the Sustainable Development Goals can only be achieved by valuing the society as a whole. Conference papers have been published by Springer Nature book series and a special edition of the journal Springer Nature Applied Science.

A final example of spillover of Brazilian-Swedish collaboration in Aeronautics is the research currently under development about assistive technologies for blind and visually impaired people, with participation of professors and students from UFABC, ITA and Linköping University. The main idea is to explore technologies that are commonly used in Aeronautics for the human-centered design of solutions.

9. Conclusions, Lessons Learned and Future Activities

The SARC-BARINet relation is a vehicle for international collaboration in aerospace research. The success of the collaboration is to a great deal based on personal relations that have grown organically. It is believed that the SARC and BARINet together provide a fertile ground for these relations to grow.

It should be realized that academic collaboration is only one of three pillars in a bilateral relation between two countries. In this case there are also connections between industry and governance to form a triple helix. It is important to note that during the course of a long term relationship, the intensity of involvement can vary significantly over time. Industry relations depend very much on the business relations that can vary very much and they also are costly to maintain. The relations at government level is hampered by having a rather high rate of turnover of people which prevents personal relations to be maintained over time.

In academia, however, senior staff tends to remain in place for a long time to ensure a continuity in relations, also these relations can be maintained over a long time. Finally, young people leaving universities will go into industry and chances are that they will be future decision makers, and can then use their relations and general understanding, they already built during their time at university, to nurture these relations also in their new positions. There is also some flux from university to governmental institutions who also can keep and make use of their international contact network in their new capacities.

Therefore, the academic network can be the foundation for a long term bilateral network that can build trust and understanding between two countries in a highly efficient way.

Finally, it should not be underestimated the effect bilateral collaboration has on building national networks and collaboration.

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