Evaluation of Spillover Effects

Case: Swedish-Brazilian Research and Innovation Centre (CISB)

Produced by CISB

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Summary

1. Introduction

Spillovers refer to the voluntary or involuntary transfer of technologies and knowledge (or know-how) within organizations, such as firms and R&D institutions as well as between creative individuals and organizations.

It is widely believed that spillovers drive indirect impact on regional growth through its positive influence on employment, innovation, creativeness, entrepreneurship, investments and territorial attractiveness.

At individual level, literature shows the following common determinants for creation of spillovers:

- Networking: suppliers and producers, subcontractors;
- Cooperation;
- Knowledge transfer and the ability to absorb and disseminate

These determinants of the innovative environment can be found within “triple helix” arrangement. However, connecting and coordinating actors from industry, academia, and government is a complex process of collaboration and discovery. Also, little is known, or even tested, regarding new combinations of university and/or industrial partnerships for spillover effects at individual level.

Since its creation in 2011, CISB has been acting as a facilitator of dialogue between “triple helix” (academy, industry and government) individuals and organizations from both Sweden and Brazil. For several years, CISB has been promoting different initiatives in order to create and foster a healthy and fruitful Ecosystem environment for innovation.

The conditions for leveraging spillover opportunities are induced by Swedish–Brazilian Cooperation agreement for Science & Technology (2009). Influenced by Gripen deal with Brazil (2014), aeronautics is one of the few high-tech sectors where both Brazil and Sweden are specialized and where complementarities are likely to emerge.

Further, aeronautics is known as broad-based technology driver sector which a cloud of technology and knowledge is available to be transferred to other sectors. Complementary to this, one of the main objectives of CISB is to promote the expansion of the Brazilian Swedish bilateral cooperation beyond the aeronautical sector, using its expertises on other types of industries such as mining, forestry, energy and transportation.

1.1 CISB Aeronautics Arena History

The Aeronautics Arena was launched in November 2014 during the 4th CISB Annual Meeting, with the objective of connecting actors, discussing the main technological challenges, creating a bilateral research network, fostering the creation of a portfolio of projects and paving the creation of a strategic long-term cooperation agenda between the two countries in the sector.

The launch of the Arena was accompanied by the Composites & Manufacturing Workshop in São Paulo and the 1st Brazilian Swedish Workshop in Aeronautics at ITA

in São Jose dos Campos. In these initial workshops, the actors had the opportunity to get to know each other and discuss ideas for solving the industries challenges, end-user and possibilities of government support for bilateral cooperation under construction.

In order to stimulate the continuity of the discussions initiated in the workshops and the assembly of proposals for bilateral projects, CISB launched two innovative calls in parallel that resulted in 40 international missions between researchers from both countries. From these missions, more than 50 ideas were generated, which evolved into project proposals and became part of Arena's project portfolio.

CISB as a facilitator of cooperation and through the support of its members and partners has developed several tools to foster a collaborative environment between Sweden and Brazil.

As result of the Arena creation it emerged a portfolio that includes 28 projects in aeronautics. Within the projects, 28 institutions of the two countries are partners, some of them participating in more than one project; 14 of these projects have funding and activities in both Brazil and Sweden and 5 have funding on at least one side. Fourteen researchers from the Joint Calls CNPq-CISB-Saab are also part of project portfolio.

The Arena's project portfolio has given strong support to the formation of the international consortia of bilateral calls coordinated by the Swedish agency Vinnova with FINEP, SENAI or FAPEMIG. Recently, 4 projects were approved in the FINEP-Vinnova Call, 3 in the SENAI-Vinnova Call and 1 in the FAPEMIG-Vinnova Call.

CISB monitors and disseminates project portfolio results through a variety of tools, such as workshops, newsletters, social media, report and special articles, as well as ongoing monitoring of project funding opportunities

1.2 Existing initiatives to stimulate spillovers

Literature suggests that, from the international perspective, spillovers are transmitted through the following channels:

- International trade in final goods, intermediate inputs, capital goods and high-tech products in particular;
- Foreign Direct Investment (FDI), especially if this comes with manpower training to operate the new machines and assimilate new production and management techniques;
- The migration of scientists, engineers, educated people in general, or their attendance at workshops, seminars;
- Publications in technical journals and scientific papers, invention revelations through patenting and patent citations;
- International research collaborations or international mergers and acquisitions,
- Foreign technology payments (including the financing of R&D conducted abroad).

From the aeronautic industry perspective, there are three different general ways that technological development can be "spilled" over to both national and international actors:

- The spillovers created in joint projects through R&T and R&D in the specific development of the project
- Corporate–Academic collaborations: Technology development leads to spillovers through:

    1) direct project participation by different companies,

    2) indirect participation in various projects, and

    3) joint scientific publications.

- Employees leaving the firm, together with the skills and knowledge they have acquired from the procurement project, who can either establish their own businesses or be employed by other firms.

As a facilitator between Swedish and Brazilian actors, CISB initiatives involve some of the above-mentioned topics making use of the following tools to stimulate cross-disciplinary exchange for innovation and spillover's creation as well:

- **Matchmaking and connection** – mapping, workshops, seminars, study visit, missions and training programmes
- **Mobility** - scholarships, research chairs and travel grants
- **Institutional Relationship** – MoU, expansion of *the Brazilian Swedish Aeronautical cooperation through the Swedish Endowed Professor Chair program*
- **Project Portfolio** - follow up of projects status, funding monitoring, spillovers monitoring, etc.

Figure 1 - Connection & Co-creation summarizes main events organized or supported by CISB for aeronautics sector since its creation. The size of circles refers to the total of participants in each event.

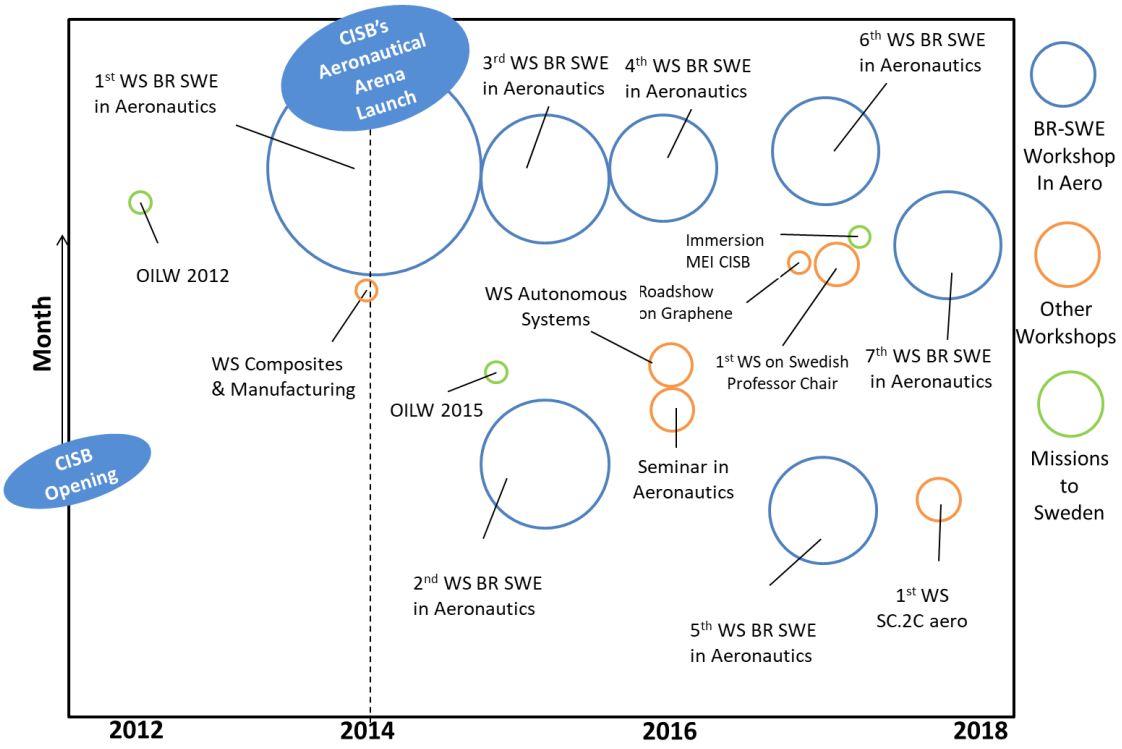

Figure 1 - Connection & Co-creation

From the perspective of CISB, there are several ways that technological development can be "spilled" over to both national and international actors. According to its experience and database, CISB has defined three different general categories of spillovers:

- **Multiple Uses Spillover**: refers to technologies that are investigated specifically for the aeronautical sector, but they have the potential to further investigated in order to be applied in other related sectors; one example is the use of composite materials in the automotive and oil & gas industry.

- **R&D Spillover**: refers to new R&D projects in a different area that were generated from the initial collaboration (research network) in a R&D Project within the aeronautical sector; and

- **Other Spillovers**: refers to other initiatives that are not directly related to the development of research or technology, but have a positive impact in other areas, such as Education, Innovation and creation of Research Networks

2. Measuring spillover effects

The entire process of spillover effect emergence is naturally influenced by a number of factors: therefore, it is difficult to find one universal method for measurement. For this reason, it is possible to encounter various studies investigating different factors and their influence on spillover creation, the resulting innovation creation, improving company performance, and economic growth.

Spillover effects appears in many forms and for various reasons – many of them, so far, not discussed. Considering the existence of spillovers at the micro level – among inventors, scientists and researchers - the focus in this report is on spillovers that occur through direct interaction between (a team of) individuals who work together on the same R&D project. Working in teams involves exchanging ideas and sharing information. Whenever co-workers collaborate on a joint R&D project, they create knowledge spillovers. Participants of such research teams carry over their knowledge to other teams and other projects that they are involved with.

During the past few years, an increasing number of actors in Sweden and Brazil have made impressive efforts to collaborate in ways that could foster spillover potential according to CISB monitoring process.

In order to understand possible spillover effects, this study proposes:

1) Identify and categorize different kinds of spillover effects derived from CISB initiatives;
2) Relate spillover effects to different sectors other than aeronautics;
3) Discuss the benefits of identified spillover effects; and
4) Present study cases.

Thus, a structured questionnaire (survey) was therefore sent out to Brazilian researchers from academic institutions or other organizations which had cooperative R&D projects completed or have been running for some years. What this means is that, by talking to specialists and leading engineers, the study tries to identify the various ways in which ongoing research and technology development can generate innovations and entirely new applications, some of which might apply in industries outside the aeronautics sectors.

The survey was consisted of two sections:

- first section aimed to assess the existence of potential applications in other sectors of a technology developed within the aeronautical sector. In the case that this potential application was identified, it was also questioned if the respondent was performing or knew anyone who was performing research in order to investigate that possible application in other sector. Therefore the projects reported in this section were classified as “Multiple use spillover”.

- second section of the questionnaire aimed to investigate the creation of new R&D projects or other initiatives that were initiated in the aeronautical cooperation promoted by CISB. Therefore, the projects and initiatives reported in this section were classified as “R&D spillover” or “Other spillover”.

CISB invited 36 interviewees/researchers from 16 Brazilian institutions to participate in the survey. The participants were selected from CISB database and consisted of researchers that have been supported by CISB initiatives in the past and that maintained a close relationship with the Centre, thus facilitating the findings. From this total, 30 interviewees responded. From the data gathered, the study develops an empirical model to estimate different types and characteristics of spillover in a unified framework in order to provide reliable analysis and interpretation.

3. Results and discussion

As result of the findings in the survey and in CISB database, it was identified 28 spillover projects/initiatives that have initiated or are completed, 3 that are in discussion and 7 that have the potential to become a spillover but were not investigated yet. For a full list of the spillovers, please refer to ANNEX I.

The first section responses describes that 90% (27) of respondents understand that their R&D projects in aeronautics have potential to become spillover to other industrial areas and, of these, almost half of them (27) have investigated, at some level, its application to other industrial sectors.

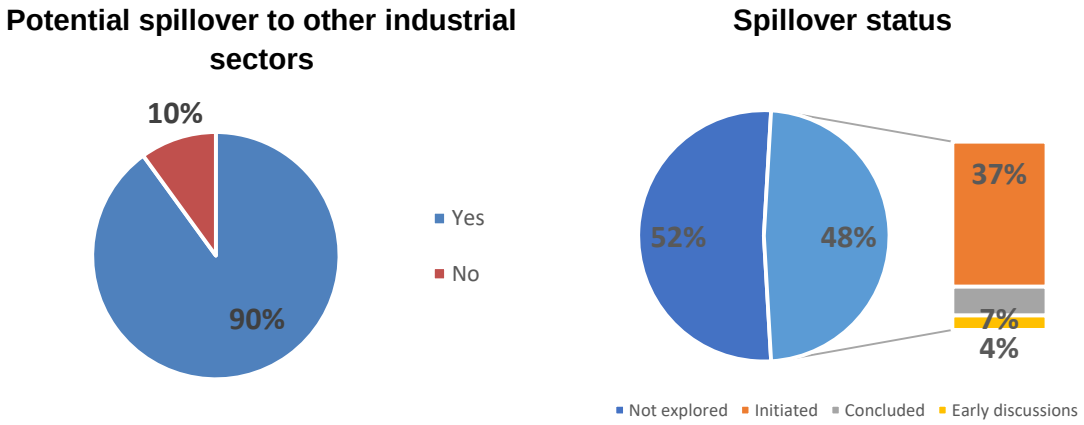

Figure 2 - First section responses

In the second section, 60% of respondents are also involved in additional Collaborative Projects among universities, applied Research projects to solve industry-based problems and/or training and skills development (i.e. PhD programs, short courses or internships). In each project exists a linear connection of accumulated knowledge which diffuses in transboundary academic and industrial- business projects.

Other R&D project/initiatives derived from original aeronautical project

Status of projects/initiatives

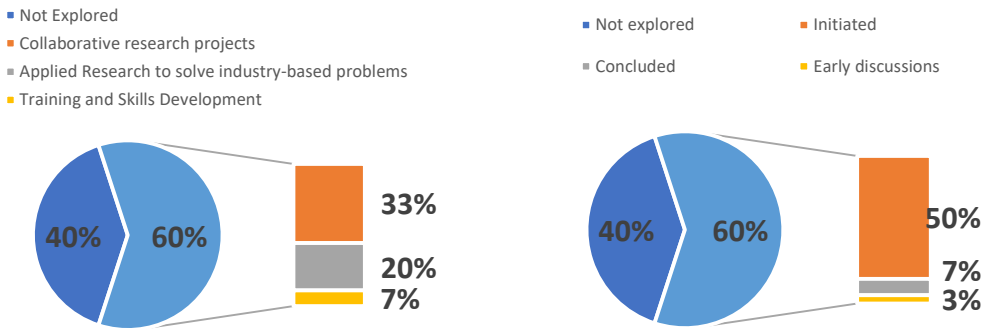

Figure 3 - Second Section of Responses

The continuation of projects presents a strong network with high absorptive capacity, that is, the ability of researches to absorb the technology and/or knowledge coming from aeronautic sector and different sources and successfully reusing for another R&D initiatives.

3.1 Spillovers origins

CISB has promoted several initiatives to stimulate the Brazilian Swedish cooperation in aeronautics along the years. Among them, mobility tools proved to be essential for the establishment and consolidation of these bilateral collaborations and according to the finding in this study, it was observed that they were also a determinant factor for the generation of spillovers.

CISB mobility tools available can be divided 5 categories:

- **CISB Grants – International Mission**: Calls of innovative projects that provided funding for one week international missions between Brazil and Sweden, aiming to promote ideas discussions and or project start.

- **CISB Grants – Senior Internship Abroad:** Calls of innovative projects that provided funding for one month stay in Sweden, aiming developing and/or executing R&D&I projects, encouragement of partnerships and start/consolidation of an existing research network.

- **CISB Grants – SWE and PDE:** Calls of innovative projects that provided funding for six months scholarships of Sandwich PhD and Post-doc, aiming to the formation of highly qualified human resources, promoting the internationalization of the Brazilian science and technology and offering condition for the Brazilian researchers involved in the Brazil-Sweden cooperation in the aeronautic sector to develop their studies and researches.

- **CNPq-CISB-Saab:** Joint calls of CNPq, CISB and Saab provided funding for up to twelve months scholarships of Sandwich PhD and Post-doc, aiming to the formation of highly qualified human resources, promoting the internationalization of the Brazilian science and technology and offering condition for the Brazilian researchers involved in the Brazil-Sweden cooperation in the aeronautic sector to develop their studies and researches.

- **Swedish Professor Chair Program:** Endowed Chair for four important academics from LiU, KTH and CTH to stay at ITA for a period of 3 years, aiming to promote joint education, bilateral research, support to the research agenda in aeronautics sector and expansion of cooperation.

The figure 4 summarizes the different CISB mobility tools along the years, where the size of the circles is proportional to the duration of the support provided.

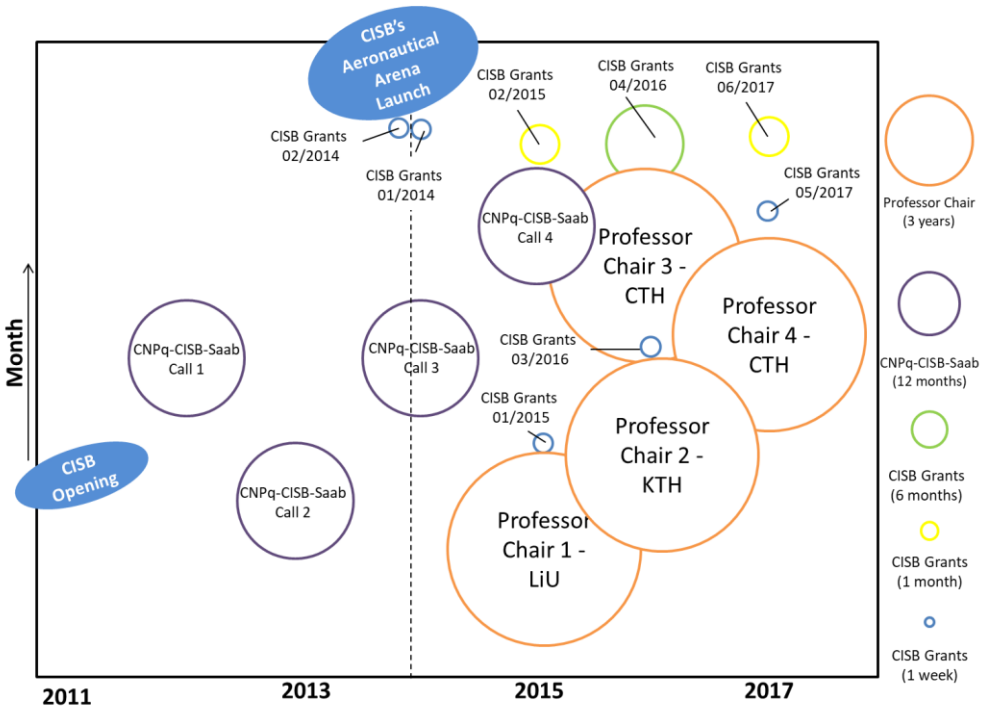

Figure 4– CISB Mobility tools

Then, according to the data collected in the survey and in CISB's database, we identified several spillover projects and initiatives that had origin in one or more of these mobility tools. These results are summarized in figure 5.

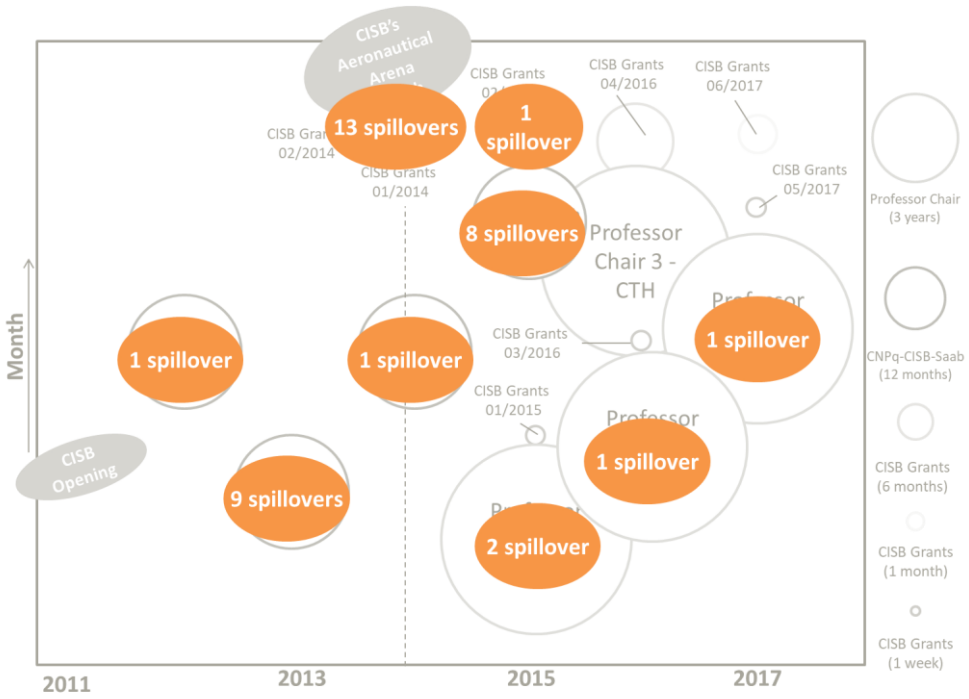

Figure 5 – Spillovers generate by the CISB mobility tools

At first glance, it can be observed that the majority of the spillovers were generated from the international mission's calls (grants 01/2014 and grants 02/2014) and from the CNPq-CISB-Saab joint calls (call 2 and 4). However, it is important to notice that these calls were only the starting point for the collaboration created and consequent spillover effect.

Most of the researchers that reported spillovers have continued their collaboration and have been supported by other subsequent CISB mobility tools. Also, in the first two international missions and in the CNPq-CISB-Saab calls 2 and 4, **47** researchers were supported in total, whereas in the Swedish Professor Chair Program, the funding is concentrated in the **4** Professors.

Another important finding is the time between the start of the project and the start of the spillover. It is known that the process of spillover generation takes time, so the elapsed time between the aeronautical project start and the spillover project or initiative start were also measured. The results are summarized in the histogram in figure 6, were the elapsed time were grouped in periods of 12 months (or one year). The data shows that the average time for the spillover generation is 29 months, whereas the majority of it where generated between 25 and 36 months and less than 20% of the spillovers took more than 36 months to start.

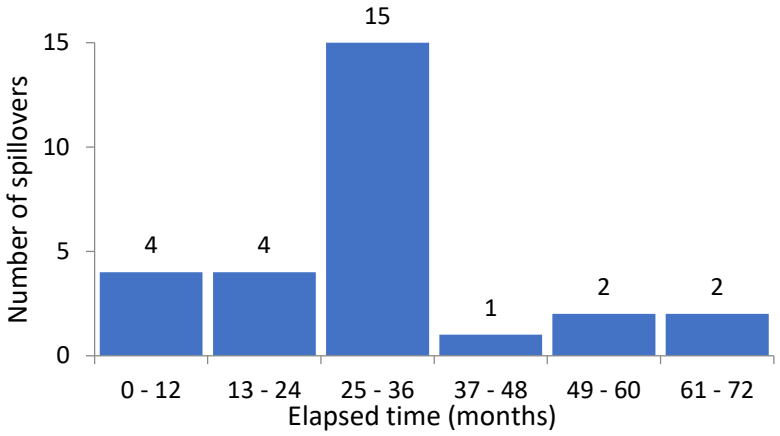

Figure 6 – Elapsed time between aeronautical project and the spillover project/initiative

3.2 Network creation

Universities and R&D participants in cooperation create synergies and knowledge, which could be also appropriated by companies (industry). This fact could then explain the generally high rate of success in R&D co-operation projects. These positive effects influence the innovation capacity of firms as well as the research capabilities of universities and R&D institutes. In other words, the factors that contribute to the creation of spillovers in other sectors are: the capacity of the industry to absorb the university knowledge, the investments of the industry in technology and R&D and the capacity of the industry to raise public funding for innovation.

Also, the creation of an ecosystem innovation is to in the near future cause indirect impact on regional growth through its positive impact on employment, innovation, entrepreneurship, investments and territorial image/attractiveness.

Table 1 presents the list of institutions that participated in the initial aeronautical project and the institutions involved in spillover generated. Regarding Universities and R&D institutes, both countries demonstrates an increase in ecosystem innovation due spillover initiatives. Regarding Industry, both countries also presents an increase of participation of companies (some Swedish headquarters and Brazilian subsidiaries) from different areas as interested parts for Applied Research Projects. In terms of areas, the industries range from automotive, oil and gas, mining, construction and services. There are many reasons why R&D spillovers differ from one project to another. Industries differ in their absorptive capacities of the technologies of their competitors. Some technologies leak out more easily, so that firms using those technologies will have higher outgoing spillovers.

Table 1 - Network for Innovation

	Aeronautics Project		Spillover		
	BR	**SWE**	**BR**	**SWE**	**Other Countries**
Universities & R&D Institutes	(18) CPqD, FMU, IFES, IME, ITA, PUC-RJ, PUC-RS, UFABC, UFES, UFMG, UFPA, UFRGS, UFSC, UFSM, UnB, Unicamp, USP, USP/EESC	(9) BTH, CTH, HIS, KTH, LiU, LTU, Lulea, SICS (RISE), ACREO AB (RISE)	(22) CPqD, Embrapa, FEI, IFES, IME, IPT LEL, ITA, Mackenzie, SENAI, UERJ, UFABC, UFAM, UFC, UFMG, UFPA, UFPE, UFSC, UFSM, UnB, Uni Nilton Lins, Unicamp	(8) BTH, CTH, HIS, KTH, LiU, LTU, RISE, Sweria	(11) International : VTT Technical Research Centre of Finland Ltd (Finland), Consorzio di Bonifica dell'Emilia Centrale (Italy) and Bolonha University (Italy), European Institute of Innovation and Technology (Europe), Hanyang University (South Korea), Korea Institute of Carbon Convergence Technology (South Korea), Université Laval (Canada), University of Rome Tor Vergata (Italy), Consorzio Nazionale Interuniversitario per le Telecomunicazioni (Italy), University of Rome Sapienza (Italy), Poznan University of Technology (Poland)
Industry		(1) Saab AB,	(11) Argo-Hytos, Autotrac, General Motors Brasil, LeverTech, Parker Hannifin, MEI/CNI, Reivax Automation and Control, Scania Latin America, Shell Brazil, Sorg, VALE SA	(7) Saab AB, Volvo Cars, Prodtex, Volvo Construction Equipment, NIRA Dynamics, Scania AB	(2) Intercrop Iberica (Spain), Quaternium Company (Spain),
Government			(4) Anatel, Brazilian Army, IAOp, IEAv	Embassy of Sweden in BR	
Countries	Brazil	Sweden	Brazil	Sweden	Belgium, Canada, Finland, Italy, Poland, South Corea, Spain

One important data to be observed in table 1 is the involvement of 12 institutions of 7 countries other than Brazil and Sweden in the spillover projects/initiatives. This results indicates that the initial collaboration between the two countries have the potential of increase the internationalization of the Brazilian institutions, in a broader perspective.

The figure 7 presents a real example of the network expansion due to the spillover effect. This picture refers to an example of applied research project (CMComp - Computational Mechanics for improved Composites) for the development of composite materials for aeronautical structures with potential application in the automotive and oil & gas industry.

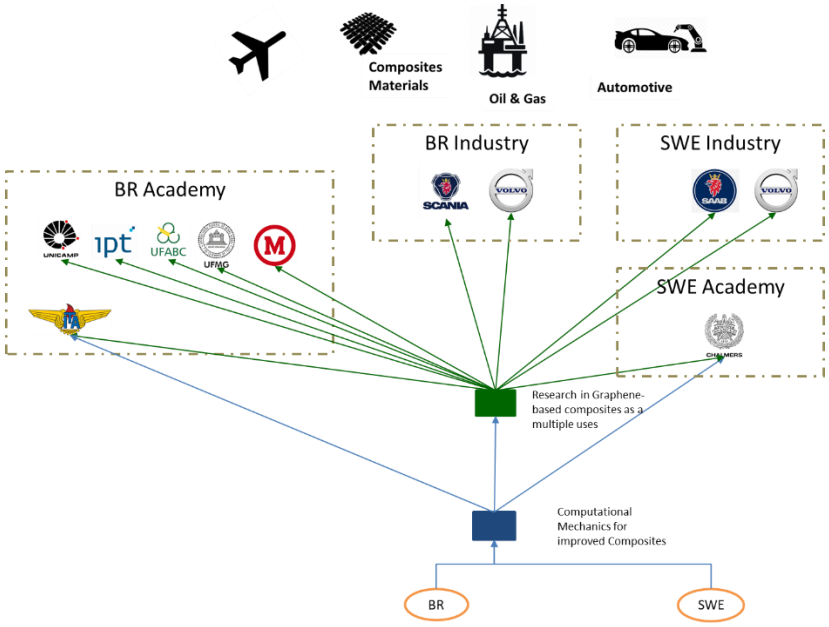

Figure 7 - Network derived from Spillover

3.3 Spillover effect extension: areas and their correlation

The aeronautical sector is well known as a driver of technology development that can be posteriorly transferred to other sectors. This capacity is illustrated in figure 8, which includes all the areas achieved by the spillover effect identified in this study. At the core it is the CISB Aeronautics Arena, stimulating the bilateral cooperation within this sector. Surrounding it, in the first circle, are present the sectors that can have a direct technology transfer process from the projects started in the aeronautical sector, such as automotive and space. In the second circle, are present the areas that are not directly related to aeronautics field, but were achieved by the spillover effect in this study, such education, human health and entrepreneurship.

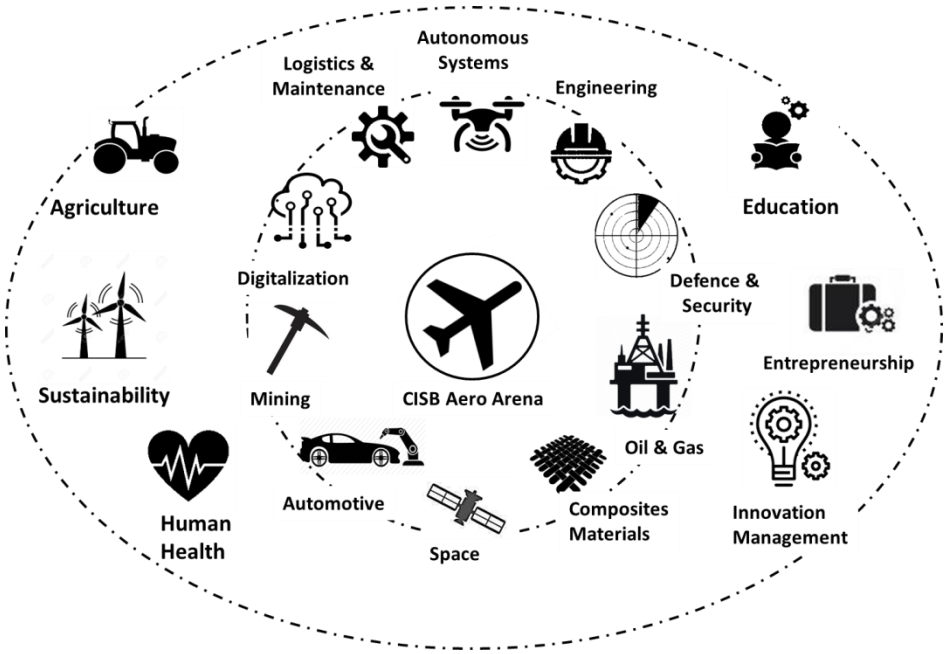

Figure 8 – Spillover industry areas derived from Aeronautic Projects

It is also interesting to notice the connection and correlation between the spillover areas, showing its interdisciplinary and transversal character. For instance, a spillover project that arise from aeronautics and it is placed in the digitalization area, can also encompass autonomous systems, agriculture and sustainability. The figure 9 presents the areas of applications of the spillover projects and initiatives reported by the researchers. Digitalization, which clusters key enabling technologies such as: IoT, ICT, Industry 4.0, Smart Cities, Automation and Robotics has the largest presence, attracting to its orbits practically all other areas. It should be pointed out that Digitalization is one of key technological areas responsible for increasing productivity/competitiveness in other industrial sectors through the development of complementary/innovative products or services. The second largest groups is automotive since it is considered as a sector which comprises several similarities to aeronautics, followed by Autonomous Systems, Mining, Oil & Gas and Composite Materials. The study also points out to the potential for extended spillover in softer, non-technological areas of knowledge creation (education and innovation management), and business development (entrepreneurship).

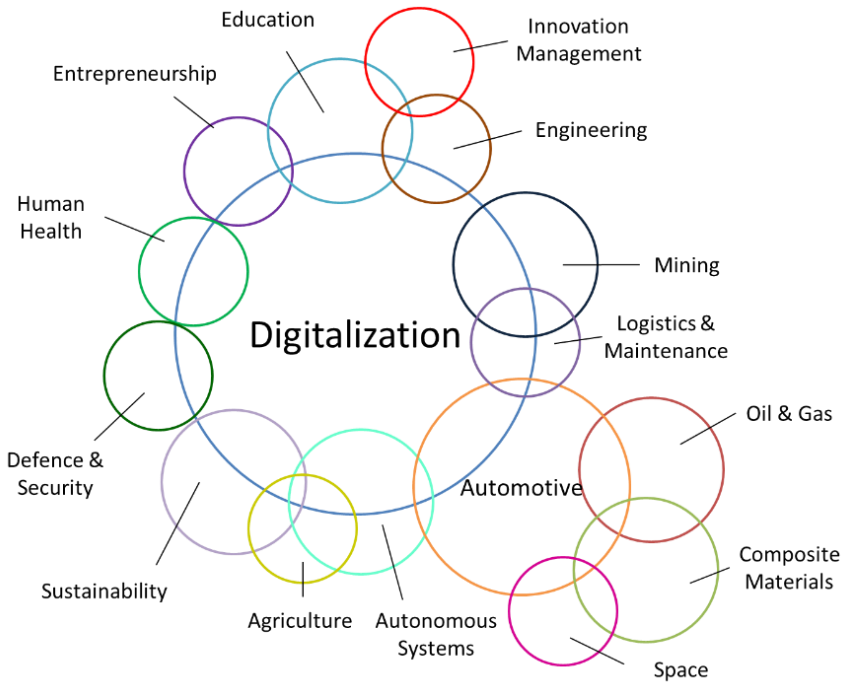

Figure 9 - Spillover areas and their correlation

4. Study Cases

CISB selected 4 study cases that will be explored in the next session. The choice of those cases was made according to the quantity and quality of information available and also their categories representativeness (Multiple Uses, R&D Spillover and Other Spillovers).

The purpose of the study cases is to show the how the collaboration starts in the aeronautical scope and how it evolves until reach the spillover effect, that means describe their history of success.

4.1 SWAMP – Smart Water Management Project

Category: R&D Spillover

Areas: Internet of Things (IoT), Sustainability, Agriculture, Autonomous Systems.

How and when it starts: The relationship between the Federal University of ABC (UFABC), FEI University Centre (FEI), Royal Institute of Technology (KTH) Clavister, Levertech and CISB started in November 2014, through the workshops "*1st Brazilian Swedish Workshop in Aeronautics and Defense*" at the Aeronautics Institute of Technology (ITA) and "*Cyber Security Workshop*" at UFABC, supported by CISB, which lead to the pre-project "*Towards SMARTer Cities*", with CISB acting as a facilitator. This initial relation generated a project idea for the CISB Call for Innovation Projects 01/2015, which was approved and allowed study visits by Professor Carlos Kamienski (UFABC) and Prof. Rodrigo Maia (FEI) to KTH in Stockholm for a period of 1 week, in April 2015. These visits in turn developed the project idea by the partners and resulted in the proposal "*SmarTCloud project (Secure and Distributed Cloud for Digital Market in Smart Cities)"* that was applied in the joint call EU-Brazil Research and Development Cooperation in Advanced Cyber Infrastructure. Although the project was not approved, the proposal generated experience and initial trust between the partners, which allowed a new application, this time with the SWAMP Project in the 4th BR-UE Coordinated Call in Information and Communication Technologies, including the collaboration of new partners in Brazil and Europe, which was then approved on August 2017. According to their expertise, CISB was invited to participate in the proposal building and the execution of the project, responsible for the work packages of dissemination and communication.

Project description: The SWAMP project aims to develop a concept of intelligent irrigation system of high precision for agriculture. The main idea is to enable the improvement of irrigation, distribution and water consumption systems based on a holistic analysis based on concept of Internet of Things that collects information from all aspects of that system, including the natural water cycle and the accumulated knowledge related to the cultivation of specific plants. It will results in savings for all parties, because, besides detecting leaks and losses, it will ensure better water availability in situations where water supply is limited.

Institutions involved: Federal University of ABC (SP – Brazil), Federal University of Pernambuco (PE – Brazil), FEI University Centre (SP – Brazil), Embrapa - Brazilian Agricultural Research Corporation (SP – Brazil), LeverTech Technology (DF – Brazil), CISB (SP- Brazil), VTT Technical Research Centre of Finland Ltd (Finland), Intercrop Iberica (Spain), Quaternium Company (Spain), Consorzio di Bonifica dell'Emilia Centrale (Italy) and Bolonha University (Italy).

4.2 CDIO Methodology in the Brazilian Universities

Category: Others Spillovers

Areas: Engineering, Education, ICT.

How and when it starts: For a few years now, the Military Institute of Engineering (IME) has been in a renewal process, seeking to meet the increasingly demanding technological challenges of the Brazilian Army and of Brazil as a whole. Part of this process involves looking at the centres of excellence world and the pursue Institute's approximation with the Brazilian Defence Industry. In this sense, Sweden emerged as a good model called Triple Helix, where government, industry and academia collaborate for social development. In 2012, one member of the Science and Technology Department of the Brazilian Army (DCT/EB) participated in the Open Innovation Learning Week, which consists of a week of program in Sweden with lectures and technical visits to several Swedish institutions, learning about its model of innovation. After that Army DCT chose CISB and Sweden as a partner in the Brazilian Army Transformation Project. In 2014, General Barroso Magno, rector of IME went to Sweden and in this opportunity, Prof. Svante Gunnarsson, leader of the CDIO (Conceive, Design, Implementation and Operate) initiative at Linköping University (LiU) presented this new framework to the IME delegation, which chose it as a new education methodology to be implemented in its courses.

Through CISB network, Prof. Gunnarsson had the chance the present the CDIO framework for several stakeholders in Brazil. In June 2017 he was invited to participate in a panel about how to build convergences between Industry, Technology and Education during the CNI MEI Innovation Conference for the Industry, in São Paulo, Brazil. He also presented the framework to other representatives of Brazilian industry, academia and government, in other opportunities such as (i) directly for representatives of the University Methodist of São Paulo and FEI University Centre in June 2017, (iii) during the "*Immersion in Innovation Ecosystems: Sweden*" organized by CISB and Euvaldo Lodi Institute (IEL/CNI) in October 2017 and (i) in the seminar "*Innovative Experiences in Engineering Courses*", organized by the Entrepreneurial Movement for Innovation of the National Confederation of Industry (MEI / CNI), which counted on the participation of representatives of 16 universities to discuss the strengthening and modernization of engineering in the country.

Project Description: The CDIO initiative is an educational framework that emphasizes the fundamentals of engineering in the context of conceiving, designing, implementing and operating real-world systems and products. Throughout the world, CDIO collaborators have adopted the methodology as the framework for their curriculum

planning and results-based assessment. The CDIO approach utilizes active learning tools such as group projects and problem-based learning to better equip engineering students with technical knowledge as well as communication and professionals skills. In addition, the CDIO Initiative provides resources for teachers at the member universities to improve their teaching skills.

At IME, 4 undergraduate courses were chosen as pilots for CDIO implementation, starting in 2017 and with duration of 5 years. This process involves several steps, such as mappings, adaptations and improvements, training of faculty and students and creation of appropriate environments. To achieve that, 2 representatives of IME were selected for a post-doctoral period of 6 months (from September 2015 to February 2016) at LiU and in close collaboration with KTH, when they had the opportunity to understand in practice the characteristics, the operation of this methodology and establish an implementation plan at IME.

The Immersion, held in 2017, attracted attention to the rector of the Federal Institute of Science and Technology of Espírito Santo (IFES) and adviser to the National Council of Federal Institutes (CONIF), and Prof. Nattan Caetano Vice-coordinator of Aerospace Engineering at the Federal University of Santa Maria (UFSM), who showed interest in implementing CDIO in their respective institutions.

As consequence of the approach to the MEI / CNI provided by the CISB, Prof Svante Gunarsson took part of the working group in Brazil aiming to modify the engineering courses. As result, the CDIO methodology was part of the publication organized by this working group called "Recommendations for the Strengthening and Modernization of Engineering Education in Brazil" launched in June 2018, indicating some standards that could be applied to the Brazilian reality.

Institutions involved: Military Institute of Engineering (RJ - Brazil), CISB (SP – Brazil), Linköping University (Sweden) and Royal institute of Technology (Sweden).

4.3 Partnership between the Laboratory of Hydraulic and Pneumatic Systems (LASHIP/UFSC) and Division of Fluid and Mechatronic Systems (FluMeS/LiU)

Category: R&D Spillover and Other Spillovers

Areas: Sustainability, Automation and Robotics.

How and when it starts: The partnership started in 2011, when the FluMeS leader, Prof. Petter Krus, met with the LASHIP leader, Prof. Victor De Negri, in one of his first visits to Brazil, supported by CISB and Saab AB, with the objective of starting point of collaboration between Sweden and Brazil. Since then the Professors have established a strong connection and have developed several collaborative research projects applied in aeronautics, which also involved student exchange and collaboration with industry. Furthermore, the projects did not remain in the aeronautical sector. Because it is multidisciplinary aspect, the Professors were able to expand their collaboration to other areas of application. In these 7 years, CISB has acted as a facilitator and catalyst for this collaboration, through several actions such as seed money for missions, co-

organization of workshops, exchange graduate student funding and management of the Endowed Swedish Professor Chair Program*. All these initiatives have allowed the consolidation of this cooperation, which already has shown solid results and impact in other sectors.

Description of the project: At least 3 collaborative projects between LASHIP and FluMeS, outside the aeronautical sector, can be described. The first called "*Experimental and Theoretical Analysis of the Hydrostatic Transmission for Wind Turbines*" was supported by the industries Parker Hannifin, who collaborated with knowledge and components for the test bench, and Reivax Automation and Control, who collaborated with knowledge and components for the control and connection of the system to the electrical network. The focus of the project was to demonstrate the use of hydrostatic transmission and turbine rotor control while driving a synchronous generator with a direct connection to the grid, all using off-the-shelve components. The second project is called "*Theoretical-experimental analysis on a hydraulic press brake controlled by variable-speed pump-motor*", with the collaboration of Sorg Machinery Ind. and Com. Argo-Hytos AT Fluid Power Systems Ltda. and had the objective to carry out a theoretical and experimental analysis of a new synchronized hydraulic press for the development of more energy efficient machines. Both projects resulted in master's theses of LASHIP students with co-supervision of Prof. Petter Krus. The third project involved an internship of a LASHIP student who spent 6 months in Sweden, 3 months in Volvo Construction Equipment and 3 months in FluMeS. The name of the project is "*Investigating the potential of a hybrid loader,*" using modelling and simulation for optimization in terms of fuel consumption and operability of machines.

Institutions involved: Federal University of Santa Catarina (SC – Brazil), Parker Hannifin (SC – Brazil), Reivax Automation and Control (SC – Brazil), Sorg Machinery Ind. and Com (SC – Brazil), Argo-Hytos AT Fluid Power Systems Ltda (SC – Brazil), Linköping University (Sweden) and Volvo Construction Equipment (Sweden)

4.4 Research in Graphene-based composites as a multiple uses model

Category: Multiple Uses Spillover

Areas: Automotive, Oil&Gas, Composite Materials.

How and when it starts: In August of 2017 Prof. Ragnar Larsson, from Chalmers University of Technolgy (CTH), signed his work plan for the 4th Chair of the Endowed Swedish Professor Chair Program and started planning his first mission to Brazil in October of the same year. As part of the program, Prof. Larsson aimed to expand research cooperation between Brazil and Sweden with graphene as a common research theme. In order to support him in the search for partners, CISB, with its expertise, organized a week of visits to key institutions in Brazil that carry out research on the topic of graphene, among them: Federal University of Minas Gerais (UFMG), ITA, State University of Campinas (Unicamp) and Mackenzie Presbyterian University (Mackenzie). During these visits, with support from the CISB, Prof. Larsson presented his research and opportunities of collaboration with Brazil, visited the laboratories of the

Brazilian universities and learned about their research lines. Although the focus of the research of Prof. Larsson within the Endowed Swedish Professor Chair Program is based on the application of graphene to composites for aeronautics, this is a technology that can be used by many sectors such as automotive, energy and electronics. For this reason, Volvo Cars and Scania, CISB's members and potential technology stakeholders, were invited to the visit of MackGraphe, Mackenzie's Graphene and Nanomaterials Research Center. On the occasion the representatives of the companies had the opportunity to discuss challenges and capabilities in the area and some collaborative projects have been designed since then. In addition, as continuity of activities with Prof. Ragnar Larsson, CISB, in partnership with UFABC and Saab AB, is organizing in 2018 the Workshop *"Carbon based Nanocomposites: Cutting-edge technology for multiple use"*, which aims to bring together Brazilian and Swedish experts from both academia and industry to present the state of the art in this field and discuss future collaborations.

Project Description: Graphene is a material with potential to revolutionize the current industry thanks to its unique properties such as mechanical strength, very low density and high electrical conductivity. Combined with other materials such as carbon fibres and epoxy resin, this composite can be used in aeronautical structures that are subject to high levels of mechanical stress, resulting in improved mechanical resistance combined with electrical conductivity, all with a reduction of up to 20% of the weight in relation to the materials currently used. This same technology can be expanded to other areas such as in automobile structures where mechanical strength associated with weight reduction is crucial to achieving energy efficiency. In terms of research, there is a lot of points to be explored in terms of synthesis, processing, processing, modelling, characterization and applications. The objective is to find synergy between the actors with different capabilities to achieve the better results in several applications.

As result of the Scania visit to the MackGraphe, nowadays they are discussing a project in this field and also starting the discussion to the other important actor Institute for Technological Research - Lightweight Structures Laboratory (IPT LEL), which has been performing projects using this technology to replace steel in in wheel automotive and oil & gas (platform).

Institutions Involved: Aeronautics Institute of Technology (ITA), Federal university of ABC (SP – Brazil), State University of Campinas (SP – Brazil), Federal University of Minas Gerais (MG – Brazil), Mackenzie Presbyterian University (SP – Brazil), CISB (SP – Brazil), Scania Latin America (SP – Brazil), Chalmers University of Technology (Sweden), Saab AB (Sweden), Volvo Cars (Brazil and Sweden) and IPT LEL (SP - Brazil)

5. Conclusion

The empirical study using individual-level data describes some evidences of new forms of spillover effects that are a result of CISB initiative in bilateral cooperation in areas of technology and innovation

The results show that most of projects proactive, and able to derive new spillover effects in other sectors further than aeronautics, where arises opportunities to absorb and exploit technologies. These include technological spillovers in software, transport, energy, manufacturing, and education areas.

It is thus clear that spillovers are becoming more important: (i) at the individual levels and (ii) within cooperation between various partners providing a “multiplier effect”. The positive effect of spillovers observed in this study shows from the belief that the cooperation in R&D bilateral projects requires both intensive contacts and a high level of trust arising from previous initial relationship.

The creation, dissemination, use and especially spillover are key process that strengthen bridges among bilateral Cooperation agreements and also, help companies with their innovative activities; and CISB has been able to understand and create neutral conditions for triple helix actors leveraging co-creation and generating large amounts of knowledge and technology spillover for Brazilian surrounding ecosystems.

6. References

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7. ANNEX

7.1 List of starting projects

CISB ID	Starting Point	Origin Project Name	Start Date	Brazilian Insitution	Swedish Insitution
03-2012-A	CNPq-CISB-Saab SwB Call 1	Design and analysis of software-based mechanisms for handling hardware failures in IMA	June/12	ITA	CTH, Saab AB
04-2012-A	CNPq-CISB-Saab SwB Call 2	A reactive programming language for wireless sensor networks	April/13	PUC-RJ	CTH, Saab AB
10-2013-A	CNPq-CISB-Saab SwB Call 2	Monte Carlo based Bayesian estimation using sensor arrays	April/13	ITA	LiU, Saab AB
11-2013-U	CNPq-CISB-Saab SwB Call 2	Radio over Fibre to provide connectivity on smart cities	April/13	UFPA	KTH, Saab AB
13-2013-A	CNPq-CISB-Saab SwB Call 2	Energy efficiency in hydraulic systems using digital hydraulic principles	April/13	UFSC	LiU, Saab AB
14-2013-D	CNPq-CISB-Saab SwB Call 2	Simulation of Cyberthreats Impacts on Intent in C2 (Command and Control) Systems	April/13	ITA	HIS, Saab AB
19-2013-D	CNPq-CISB-Saab SwB Call 2	Optimized Quasi-Orthogonal Waveforms for Multi-Antenna Radar Systems	April/13	UFSM	BTH, Saab AB
26-2014-A	CNPq-CISB-Saab SwB Call 3	Improvements to the EM method in system identification	June/14	UFRGS	LiU, Saab AB
31-2015-A	CISB Grants 01/2014 - International Mission	Techniques of security and software engineering for development of aeronautics embedded systems	Dec/14	ITA	LiU, Saab AB
33-2015-A	CISB Grants 01/2014 - International Mission	Simulation of Composites for applications in the aeronautical industry	Dec/14	USP/ICMC	CTH, Saab AB
37-2015-A	CISB Grants 01/2014 - International Mission	Verification of Fault-Tolerant Embedded Systems with Reconfigurable SelfHealing Hardware using a Correct-by-Construction Design Flow	Dec/14	UnB	KTH, Saab AB
38-2015-A	CISB Grants 01/2014 - International Mission	AeroLog Lab - Logistics and Maintenance Engineering Lab	Dec/14	ITA	LTU, Saab AB
40-2015-A	CISB Grants 01/2014 - International Mission	Design and Commissioning of a Snake Robot for Aeronautical Manufacturing Operations	Dec/14	ITA	LiU, Saab AB
42-2015-A	CISB Grants 01/2014 - International Mission	Hybrid nanostructured composites for enhanced mechanical properties	Dec/14	UFABC	Saab, Saab AB
45-2015-A	Swedish Endowed Professor Chair 2 - KTH	PreLaFloDes - Laminar flow design and surface quality requirements	June/16	ITA, USP/EESC	KTH, Saab AB
46-2015-A	CISB Grants 01/2014 - International Mission	Prediction of post-cure residual stresses and distortions in the fabrication of composite structures	Dec/14	ITA	KTH, Saab AB
47-2015-A	Swedish Endowed Professor Chair 1 - LiU	MSDEMO - Methods for Future Aircraft Design Study and Demonstration	April/15	ITA	LiU, Saab AB
48-2015-A	CISB Grants 01/2014 - International Mission	Composite material 3D woven fabric for reinforcement of mechanical joints and other stress concentrations	Dec/14	ITA	Lulea, Saab AB
50-2015-U	CISB Grants 01/2014 - International Mission	Towards SMARTer Cities	Dec/14	UFABC	KTH, Saab AB
51-2015-A	CISB Grants 01/2015 - International Mission	Robustness Analysis in the Frequency Domain of Mechatronic Systems using Efficient Algorithms	July/15	UFSC	LiU, Saab AB
52-2015-A	CISB Grants 01/2015 - International Mission	Frequency Response Analysis of the Robotic Platform of SIVOR Project	July/15	ITA	LiU, Saab AB

CISB ID	Starting Point	Origin Project Name	Start Date	Brazilian Insitution	Swedish Insitution
54-2015-A	CISB Grants 01/2015 - International Mission	Data-driven fault diagnosis via causality detection methods	July/15	UFES	LiU, Saab AB
55-2015-A	CNPq-CISB-Saab SwB Call 4	The use of bi-angle laminates in the optimization of full-scale composites aircraft stiffened panel	Sept/15	UFMG	KTH, Saab AB
56-2015-A	CNPq-CISB-Saab SwB Call 4	Aircraft distributed structure health monitoring based on advanced OTDR techniques	Sept/15	Unicamp/CPqD	RISE ACREO, , Saab AB
57-2015-A	CNPq-CISB-Saab SwB Call 4	Towards Autonomous Avionics Applications using Run-time Reconfigurable SoCs	Sept/15	UnB	KTH, Saab AB
59-2015-A	CNPq-CISB-Saab SwB Call 4	Analysis of the impact of hidden failure on system reliability	Sept/15	UFSC	LiU, Saab AB
60-2015-A	CNPq-CISB-Saab SwB Call 4	Switched systems using directional hydraulic control valves and variable speed pumps for use in aircraft	Sept/15	UFSC	LiU, Saab AB
62-2015-A	CNPq-CISB-Saab SwB Call 4	Design and Commissioning of a Human Factors Laboratory for Aeronautics	Sept/15	ITA	LiU, Saab AB
63-2015-D	CNPq-CISB-Saab SwB Call 4	Robust Target Detection on SAR Images	Sept/15	UFSM	BTH, Saab AB
68-2015-A	CISB Grants 02/2015 - Senior Internship Abroad	Models of Computation (MoC) supporting Adaptively in Real Time Embedded Systems - MARTES	Oct/15	Unicamp	KTH, Saab AB
69-2016-A	CNPq-CISB-Saab SwB Call 4	Adaptive Heterogeneous System Modeling for Applications in Aviation Critics Systems using Computing Model based Platform	Sept/15	UnB	KTH, Saab AB
70-2017-A	Swedish Endowed Professor Chair 4 - CTH	CMComp - Computational Mechanics for improved Composites	Sept/17	ITA	CTH, Saab AB
-	OILW	Open Learning Innovation Week	Sept/12	CISB	-

7.2 List of spillover projects

CISB ID	Spillover Project/Initiative Name	Area	Start Date	Brazilian Institution	Swedish and/or International Institution	Multiple Use	R&D Spillover	Other Spillovers	Development stage
03-2012-A	DFEA2020 project and KARYON	Automotive		ITA	CTH, Scania AB, Volvo	**X**			Completed
04-2012-A	Energy Efficiency for IoT Software in the Large	IoT	Apr/18	UERJ	CTH		**X**		Ongoing
10-2013-A	Undefined	Automotive	-	UFC	LiU, NIRA Dynamics	**X**			Discussions

CISB ID	Spillover Project/Initiative Name	Area	Start Date	Brazilian Institution	Swedish and/or International Institution	Multiple Use	R&D Spillover	Other Spillovers	Development stage
10-2013-A	Bilateral research on Statistical processing of signals	Autonomous Systems	Jan/18	UFC	LiU		**X**		Ongoing
11-2013-U	The Royal Gardens Case Project	IoT	Jan/16	UFPA	KTH **International:** European Institute of Innovation and Technology (EIT Digital)	**X**			Completed
11-2013-U	BRIGHT - Bringing 5G Connectivity in Rural and Low-Income Areas	IoT, Smart Cities	Mar/18	UFPA	KTH **International**: University of Rome Tor Vergata, Consorzio Nazionale Interuniversitario per le Telecomunicazioni, University of Rome Sapienza, Poznan University of Technology		**X**		Ongoing
13-2013-A	Partnership between the Laboratory of Hydraulic and Pneumatic Systems (LASHIP/UFSC) e Division of Fluid and Mechatronic Systems (FluMeS/LiU)	Renewable Energy	May/16	UFSC, Parker Hannifin, Reivax Automation and Control, Sorg Machinery, Argo-Hytos AT Fluid Power Systems	LiU, Volvo Construction Equipment		**X**	**X**	Ongoing
14-2013-D	Personnel Training in Internet of Things	Education, ICT	Sept/18	ITA, Anatel	HIS			**X**	Ongoing
19-2013-D	High Resolution Synthetic Opening Radar: Digital Processing for Target Detection	Automotive, Autonomous Systems	Mar/15	ITA, UFSM, IEAv	BTH, Saab	**X**			Ongoing
19-2013-D	SAR System For Penetration Of Cups And Foliage For Target Detection And Obtaining High Resolution Topographic Maps	ICT, Security	-	ITA, IEAv, IAOp	BTH, Saab		**X**		Discussions
26-2014-A	-	Automotive	-	-	-	Potential			-

CISB ID	Spillover Project/Initiative Name	Area	Start Date	Brazilian Institution	Swedish and/or International Institution	Multiple Use	R&D Spillover	Other Spillovers	Development stage
31-2015-A	-	IoT, Industry 4.0, Automotive, Smart Cities, Mining	-	-	-	Potential			none
33-2015-A	-	Industry 4.0	-	-	-	Potential			-
37-2015-A	System on Chip for the Sensing and Control of a Robotic Hand Prosthesis	Human Health, Robotics	Mar/17	UnB	-	**x**			Started
37-2015-A	ForSyDe SysML	ICT	Feb/17	UnB	KTH		**x**		Ongoing
38-2015-A	AeroLogLab-ITA	Logistics and Maintenance, Industry 4.0	Feb/17	ITA, Brazilian Army	LTU	**x**			Ongoing
40-2015-A	Snake Robot for Automotive Inspection Applications	Automotive, Maintenance	Marc/17	ITA, SENAI, General Motors Brasil	-	**x**	**x**		Ongoing
42-2015-A	Study of the effects of graphene on mechanical and electrical properties in polymers for applications in artificial muscles	Automation and Robotics, Automotive	Jan/17	UFABC, Mackenzie	LU, CTH	Potential	**x**		Ongoing
45-2015-A	Developing a collaboration with Research Center for Gas Innovation (USP/FAPESP/Shell)	Oil & Gas	Jan/17	ITA, USP-Poli, FAPESP, Shell Brazil	KTH		**x**		Discussions
46-2015-A	Multigraph Light	Space, Automotive, Composite Materials	Sept/17	ITA, UFABC	CTH, Saab AB	Potential	**x**		Ongoing
47-2015-A	Masters Program in Systems Engineering and Innovation	Education, Engineering, Innovation	May/16	UFABC	LiU			**x**	Ongoing
47-2015-A	Workshop on “Digitalization of the Amazon”	ICT, Entrepreneurship	Oct/17	ITA, UFABC, UFAM, Uni Nilton Lins, Unicamp	LiU, Embassy of Sweden in Brasilia			**x**	Started
48-2015-A	-	Oil&Gas	-	-	-	Potential			none

CISB ID	Spillover Project/Initiative Name	Area	Start Date	Brazilian Institution	Swedish and/or International Institution	Multiple Use	R&D Spillover	Other Spillovers	Development stage
50-2015-U	SWAMP - Smart Water Management Project	IoT, Water Management, Agriculture, Autonomous Systems	Aug/17	UFABC, UFPE, FEI, Embrapa, LeverTech, CISB	**International:** VTT Technical Research Centre of Finland Ltd (Finland), Intercrop Iberica (Spain), Quaternium Company (Spain), Consorzio di Bonifica dell'Emilia Centrale (Italy) and Bolonha University (Italy).		**X**		Ongoing
51-2015-A	Robustness Analysis of Electrical Machines	Renewable Energy	Nov/17	UFSC	**International**: Université Laval (Canada)	Potential	**X**		Ongoing
52-2015-A	Business Development between FlexAM and Sweria	Automation and Robotics	May/18	ITA	Prodtex, Sweria	**X**		**X**	Ongoing
54-2015-A	Failure diagnostics and performance monitoring in pelletizing furnace	Industry 4.0 Mining	Oct/16	ITA, VALE		**X**			Ongoing
55-2015-A	Composite helical spring	Automotive, Composite Materials	Jun/17	UFMG	**International:** Hanyang University, Korea Institute of Carbon Convergence Technology (KCTECH)		**X**		Ongoing
56-2015-A	Distributed acoustic optical fiber sensor for conveyor belts health monitoring	Mining	May/18	CPqD	RISE	**X**	**X**		Ongoing
57-2015-A	System on Chip for satellite communications system	ICT	July/18	UnB and Autotrac	KTH		**X**		Started
59-2015-A	-	Oil&Gas	-	-	-	Potential			-
60-2015-A	Quantitative control; Control switched	Mining	Feb/16	UFSC	LiU, Saab AB	**X**			Ongoing
62-2015-A	-	Automotive	-	-	-	Potential			-
63-2015-D	-	Smart Cities	-	-	-	Potential			-
68-2015-A	Run-time Reconfiguration Techniques Analysis applied to Embedded Systems using Reconfigurable Processor	IoT, Autonomous Systems	Jan/18	Unicamp, ITA	KTH	**X**	**X**		Completed

CISB ID	Spillover Project/Initiative Name	Area	Start Date	Brazilian Institution	Swedish and/or International Institution	Multiple Use	R&D Spillover	Other Spillovers	Development stage
69-2016-A	Compilador Haskell-HW	IoT	Marc/18	UnB	KTH	**X**	**X**		Started
70-2017-A	Research in Graphene-based composites as a multiple uses model	Automotive, Oil & Gas, Composite Materials	Oct/17	ITA, CISB, Scania Latin America, Volvo Cars, UFABC, Mackenzie, UFMG, Unicamp, IPT LEL	CTH, Saab AB, Volvo Cars	**X**	**X**	**X**	Ongoing
-	CDIO Metodology in the Brazilian Universities	Education, Engineering, ICT	Nov/14	IME, CISB, MEI/CNI, UFSM. IFES,	LiU, KTH			**X**	Ongoing