Transfer and Absorption of Spillover Effects of the Joint Brazilian-Swedish Cooperation in Aeronautics Following the Gripen Export

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* The present paper only reflects the individual view points of the author and does not represent opinions by the organizations mentioned above.

Introduction

As a result of the Gripen export to Brazil, under direct contract to Saab, a number of joint activities between the two countries have been initiated and are still under development. Saab has a private contract that includes technology transfer to Brazil including the set-up of a factory in Brazil with capacity for producing part of the one seater aircraft and all two seater aircraft. However, the Swedish Government prioritizes Brazil within its Export Strategy, and the Brazilian Government expects other outcome of the Gripen export apart from the obvious strengthening of their Air Force capability.

The present paper focuses on how these two additional aspects can best be handled by various bilateral agreements and actions that will ultimately be beneficial for both countries and that will form the basis for a long term strategic collaboration in research and innovation, in joint industrial collaboration, and in defence and security related matters.

The Aeronautics Case

A high level group (HLG) with responsibility for setting up, funding, directing, and following up joint activities in long term research and innovation in aeronautics was proposed during Minister Damberg's delegation to Brazil in May 2015. The HLG was formally set up with an inaugurating meeting during President Dilma Rouseff's delegation to Sweden in December of the same year. The HLG is operating on state secretary level, with several ministries involved, and with participation of heads of agencies under the various ministries.

Under the HLG a bilateral Executive Committee (EC) has been set up as a facilitator for handling decisions by the HLG and also to propose mechanisms for setting up joint calls for proposals in research and innovation (R&I), setting up the funding for such activities, and to set up a long-term strategy for expanding the bilateral cooperation in order to reach long term goals, yet to be defined.

The setting up of HLG and EC has reached a stage where most key players in both countries are defined with formal points of contacts on EC level identified. However, until now *no formal joint decision has been taken in setting up a Working Group* (WG) with members in both countries. Such a group is needed in order to handle all operational issues set up by EC, or having been proposed by HLG for EC to execute.

During the early phases of the on-going cooperation CISB (Centro de Pesquisa e Inovação Sueco-Brasileiro – the Swedish-Brazilian Research and Innovation Centre, originally set up by Saab but now expanded to include companies as Scania, Volvo, and Brazilian Akaer, some eight universities in both countries and also Brazilian SENAI – a huge institution for training specialized work forces in various disciplines) set up an Aeronautics Committee with members from both countries in order to facilitate actions for initiating and growing joint activities in aeronautical R&I. Until now, three professors from three different Swedish Universities have acted as endowed professors in ITA (Instituto Technológico de Aeronáutica – an elite university in Sao Jose dos Campos for aeronautics operating under DCTA, Departamento de Ciência e Tecnologia Aeroespacial – the Department of Aerospace Science and Technology, subordinated to the Brazilian Air Force, and tasked with all technical and scientific activities in the aerospace sector with interests by the Department of Defence) and a number of pilot projects between the two countries have been set up within already existing national programmes. *The role of CISB within the continued bilateral R&I activities in aeronautics is yet unclear*. However, until now the organization has been instrumental in setting up meetings, working as a bridge between Swedish and Brazilian actors, and also in setting up pilot projects etc. At the same time, CISB is sometimes looked upon as too close to Saab due to the original formation of the centre. Today, however, many more actors from the transportation area and from academia are involved. Yet, Swedish participation is larger than Brazilian ones. CISB should, in this author's opinion, continue to be used for purposes similar to those mentioned, but also be expanded to even more technical fields of interest for joint bilateral cooperation. Perhaps the best way would be for our two governments to jointly own, direct and operate CISB as a means to set up strategies, handling practicalities and maintain contacts within the ever-expanding network between the countries. Such a joint ownership involves certain problems but offers even more advantages and should be considered by HLG members.

However, until now *no specific funding exists* for establishing long term R&I programmes between our two countries. In Sweden, it is expected that a significant increase in funding for the 7th National Research Programme for Aeronautics (NFFP7) will be granted in order to facilitate also international R&I with the two prioritized countries of Brazil and UK. It also remains to raise such funding in Brazil to balance the funding in Sweden.

In this context, it must be mentioned that the current strength in Swedish Aeronautics (one of the five or six leading nations in the world in absolute terms and the best one related to competence per capita) derives from the military sector due to Swedish neutrality during the cold war and the decision to build a strong national defence industry in general with special focus on aeronautics. However, since the fall of the Berlin wall in 1989 the funding for military R&I has fallen drastically. Only in the last 10 years overall R&I funding within the Armed Forces (FM) has been cut with almost two thirds. This has resulted, for example, in significant loss of aeronautical capability within the Swedish Defence Research Agency (FOI) which has traditionally maintained long term competence is basic aeronautics like aerodynamics, structures and materials, and flight mechanics. With the establishment of the strategic innovation programme for aeronautics, Innovair, attempts to coordinate all other funding together with military contracts still provides Sweden with a reasonable base of national funding for aeronautics, but compared to competitive nations we are currently under funded and todays funding is dominated by programmes from the Swedish Innovation

Agency Vinnova complemented by funding from the Armed Forces. It *remains for the Department of Defence to provide the Armed Forces with instructions* for relations with Brazil, such that also the support agencies of FOI and FMV (The Defence Materiel Administration) can get actively involved in the build-up of long term relations.

One issue which is left outstanding, that the HLG needs to address is the need to produce a bilateral strategy for aeronautical R&I cooperation leading to well defined long term joint goals and with specific mention of what benefits will be achieved in both countries in the short and long term by working together. This must ultimately be decided by the HLG but a personal reflection on what might be both a challenge and a motivation is to aim for the long term goal of designing, producing and selling the next generation aeronautical defence system following the generation of Gripen currently being developed for use in both countries. Such an endeavour is extremely challenging both in terms of technical complexity but also in terms of shaping a joint business case that will benefit both countries long term. However, the existing situation with Embraer being the third largest civil aircraft manufacturer in the world and the strength of Saab in the military sector makes a "marriage" of these two entities almost perfect. Perhaps a joint company can be set up where both governments may own a golden share such that neither party can sell out without the consent of the other party.

Whatever long term goals will finally be defined by HLG it will take time to build up mutual trust through joint programmes initially at low TRL (Technology Readiness Levels) and then by stepwise increasing TRL to technology demonstrator levels, production of substructures or subsystems, and finally to full scale structures and/or systems. The figure below shows the Saab logic for working at different TRL levels through different national and international programmes. The so-called principle of the slanting wave (indicated by arrow in the picture) explains that today's products (TRL9) derive from activities started some 15-20 or more years ago, whereas the new Generation of Gripen, for example, must be based on technologies at mature TRL of 5-6 or the new products will not be developed in time. Hence, if Gripen C/D are considered generation N, the next generation of Gripen are generation N+1, and the products developed thereafter, Generation N+2, will be based on R&I with TRL 2-4 of today. A mature company must have activities at all these TRL in order to sell something today, be competitive tomorrow, but also the day after tomorrow.

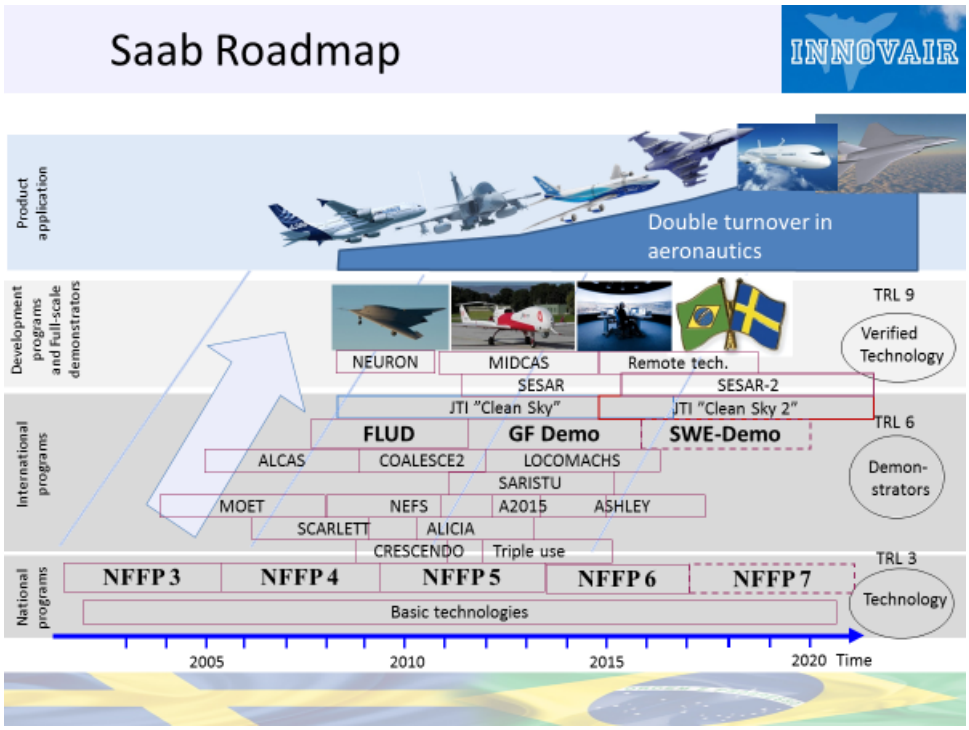

Figure 1. Saab roadmap for utilizing various national and international funding mechanisms at different TRL in order to develop next generation products. Originally shown in Brazil during Minister Damberg's delegation in May 2016.

Basically, the figure shows, at the bottom, national research programmes, and slightly above these international research programmes within, e.g. within Horizon2020. Much of this research is performed as joint projects with universities, frequently as part of Ph.D. studies, with technical goals jointly defined by industry and academia, research carried out by academics but monitored by industrial experts. At somewhat higher TRL then follows national demonstrator programmes, frequently at TRL 4-5, whereas demonstrations at TRL 6 often is part of international demonstrator programmes like the European Clean Sky or SESAR programmes. With a single engine demonstrator at TRL costing in the range of 100 million Euros, it becomes clear why cost sharing becomes continuously more important at higher TRL. At the same time, the step-wise increase in TRL becomes part of the business strategy as a successful demonstration at TRL 6 makes that participant a guaranteed subcontractor at next engine or aircraft project led by the large OEM:s.

A similar logic should be aimed for in the development of joint bilateral aeronautical R&I programmes between Brazil and Sweden. Today's pilot programmes at low TRL are very useful for building contacts, learning of any outstanding difficulties in handling either technical, personal (mobility, families), or legal (IPR-issues and classified information) questions. However, this is provided that they are followed by activities at higher TRL where cost sharing becomes important, and hopefully by eventual product development and joint business relations.

In Sweden, Innovair is the natural partner for building up these long-term relations at ever increasing TRL since all actors (industrial, academic, Armed Forces, institutes, and governmental bodies) are involved. However, no such organization currently exists in Brazil, and there must therefore necessarily be several partners from Brazil involved in the developments apart from the HLG and EC bodies.

Building innovation systems and involving other sectors

Apart from technology transfer, there is a strong interest from Brazil to build up an understanding for the Swedish Triple Helix collaboration in research and innovation. This interest stems originally from the defence sector but, in the author's understanding, has now reached the upper echelons in the Brazilian Government with the intent to initiate such activities in the aeronautical sector, but in such a general way that experiences can later be transferred also to other sectors. This latter issue rides well with the Swedish Governments interest to expand research and innovation with Brazil into sectors like forestry, mining, ICT, transport and others.

Sweden has long term experience of organizing collaboration between various actors involved in the innovation process by what frequently has been referred to as the Triple Helix System. Simplistically, this means considering a balanced cooperation at all levels of the innovation system by three different actors; namely industry, academia, and government. Being a small nation, cooperation has always been imperative for Sweden and our strength in system building derives both from non-hierarchical leadership looking for consensus solutions and from a well-educated work force actively involved in both technical and strategic decisions.

Basically, in the technical disciplines collaboration between industry and academia must be considered well-functioning. However, there are also certain weaknesses in the system as found in, e.g., recent OECD studies. These involve too many uncoordinated funding agencies and academic leadership without strategic competences. One specific weakness that might be rectified within continued development of joint bilateral R&I is to coordinate funding by the Swedish Research Council (VR), under Department of Education, with that of Vinnova, under Department of Trade and Innovation. In this way, we could shape a continuous innovation system with strategic research programmes, funded by VR, connected to the existing strategic innovation programmes, funded by Vinnova.

There are very many different technologies involved in the design, manufacturing, operation, and maintenance of a modern fighter aircraft, see Fig. 2 which shows a number of areas that must be integrated into a fully functional system in order for the final product to be technically competitive, yet economical to operate. Several of the technologies shown in the boxes are hard enough to master, but the real challenge lies in the integration of all these into the "optimized" complex system that makes up a modern fighter aircraft.

It can be noted that several of the technologies shown in Fig. 2 are also studied within some of the other 15 appointed strategic innovation programmes (SIP) in Sweden, see the list in Fig. 3. Such technologies may well be chosen for expanding bilateral collaboration into areas

beyond aeronautics. By setting up arenas with critical mass in terms of both personnel and infrastructure, e.g. at research institutes or integrated into university campuses, joint funding between several SIP:s can be used to take generic research and innovation step by step up the TRL scale until at least TRL 4, after which further development may need to be individually handled by the various SIP:s in order to accommodate the various needs for specific requirements within the different industrial applications.

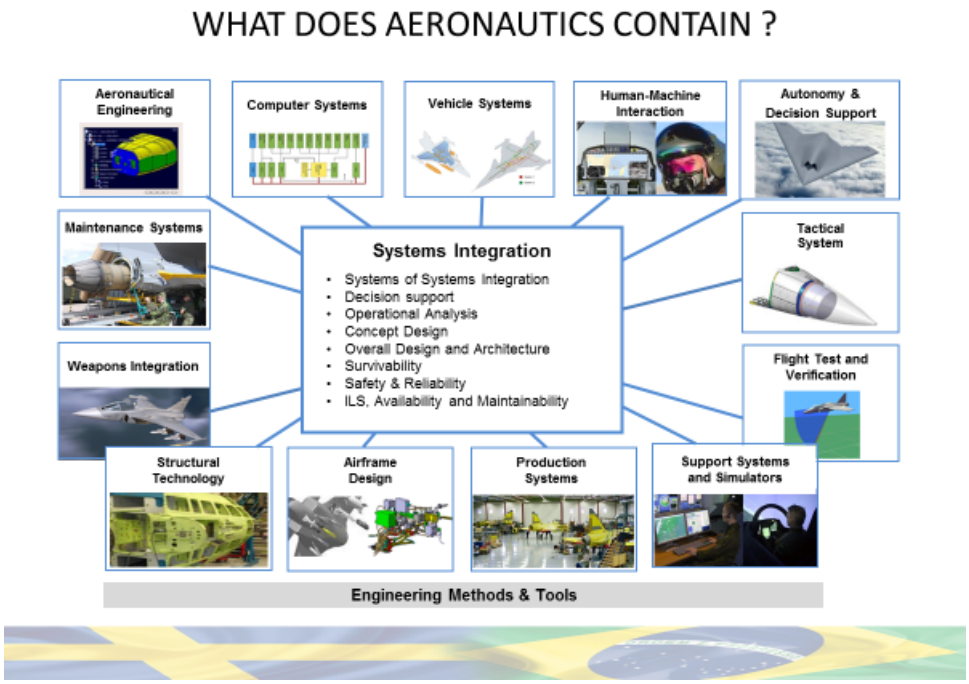

Figure 2. Technologies that must be expertly integrated into a competitive product. Originally shown in Brazil during Minister Damberg's delegation in May 2016.

Innovair has set up two production arenas, for advanced composites in Linköping and advanced manufacturing of metals in Trollhättan. Both these arenas have collaboration also with the transportation area, in order to share funding and to transfer results to several sectors, and also collaborate with universities and institutes. Local universities are heavily involved in R&I projects at these arenas, but the infrastructure is open for access by researchers at any national university. Also, memorandums of understanding (MoU) have been signed between the two local regions where these arenas are operating and the Joint Technology Undertaking Clean Sky within the European Framework programs. Clean Sky2 is the largest research programme ever in Europe and by signing these MoU:s both parties show their interest in obtaining synergies by working together. In this way Sweden use both local regional funding to build up SME activities in aeronautics and also obtain support from the European structural funds. Regional strengthening of the supply chain directly contributes to creating advanced jobs and increased export. Our larger companies get access to skilled companies that can deliver selected parts or products, and the European Union

also benefits by building up a broad supply chain such that large OEM will not be dependent on delivery from a single over-priced supplier.

Table 1 – Current Swedish Strategic Innovation Programmes

- Innovair – Aeronautics
- Graphene
- ICT Electronic Components and Systems
- Internet of Things
- Bio innovation – new bio-based materials, products, and services
- Life Sciences – human diseases
- Mining and Metals Production
- Lighter – Light Weight Technology
- Process Industrial IT and Automation
- Production Technologies
- Metallic Materials
- Medical Technology
- Smart Built Environment
- Resource and Waste Management
- Automated Transport System
- Transport Infrastructure

By having other SIP:s taking responsibility for setting up arenas in their areas of expertise, e.g. in electronics, sensor systems, cyber security, communication systems etc. synergies like those mentioned can be obtained by having also other SIP:s funding and utilizing part of the built up infrastructure and expertise. Such an endeavour may very well be undertaken bilaterally with Brazil in areas of common interest. Hence, all arenas do not necessarily need to exist in both countries, but may be based where the overall best possibilities for successful growth exist. With mobility programs where both scientists and other technical personnel can stay for prolonged periods in the other country a win-win situation will be obtained for both countries.

The two governments have already agreed to perform bilateral joint R&I in Forestry and Mining, apart from Aeronautics. Considering which further Swedish industries are already well placed in Brazil, it would seem logical to also involve the transportation sector and ICT related industries in the bilateral cooperation.

Technology transfer from Sweden to Brazil will initially be expected in several sectors. However, Brazil has high technical competence in many sectors, good universities, and a large well educated work force. Long term collaboration needs a flux of competence and personnel in both directions and in certain areas Sweden may clearly benefit from Brazilian technology transfer already now. One such area might be the development of alternative fuels for both aeronautics and transportation in general. Here, not only technical competence, but also the possibility to produce large quantities enough are of paramount importance to build a competitive industrial base.

Within the on-going collaboration in aeronautics, specific issues like handling IPR and classified information is currently dealt with. All agreements should be designed in such a general way that they can be transferred to any other technical area for use in future new collaboration.

Actions needed to further the bilateral cooperation in R&I

Aeronautics

We already have much in place, but the HLG needs to secure domestic funding in both countries for specific bilateral collaboration. Initially, at low TRL, the costs are not large to set up a number of projects or programs. However, the cost for mutual activities at higher TRL will increase, but so will the benefits by working together both in terms of technical expertise, but also by cost-sharing in demonstrator activities.

The Swedish Department of Defence needs to give clear instructions to the Armed Forces and their related sub-agencies for how to interact within the new bilateral R&I activities.

In Brazil, it is imperative to define specific points of contact matching those which exist among the various partners in Innovair, i.e. large companies, SME's, universities, institutes, etc.

Both countries should try to set up agreed bilateral long term goals for the cooperation and a joint strategy for how to reach these.

Technology transfer and absorption

Apart from sectors already defined by the two governments (forestry and mining) natural technical expansion will be to the transportation industry and ICT related industries.

Cooperation between existing SIP's in Sweden, in a number of possible technical permutations, may be used to set up arenas with critical mass, both in competence and infrastructure, that can form the centre for bilateral cooperation between our two countries.

Such arenas may very well be placed in either country depending on the specific set of requirements to make the arenas internationally competitive.

All practicalities involved in handling IPR and classified information, and similar issues, should be handled in general terms, such that new technical cooperation may adopt the agreements already produced.