Ecosystem and actors

An excerpt from

NRIA Flyg 2020

innovair

Perspective: Ecosystem and actors

The aeronautical innovation area's results and challenges are perhaps most easily viewed from an actor's perspective – how is everything related?

THE AERONAUTICS ECOSYSTEM

Sweden is unique in regard to its heavy reliance on exports and high number of large companies per capita. This provides us with unique conditions, not least because the small number of actors gives us excellent opportunities to collaborate. We have a competitive advantage that we must safeguard, but globalisation also presents us with a challenge, particularly in the long-term perspective.

The Swedish aeronautics industry has evolved from the development of aeronautical systems for the Swedish armed forces. Today, civil and military development must act together to ensure that Sweden is able to maintain its capabilities and critical mass in terms of competence, personnel and infrastructure with adequate breadth and depth.

The aeronautics sector is ideally suited to the implementation of advanced system integration where a multitude of technologies and systems, with extremely high security requirements, work together. However, increasingly fast development of technology means that the lead times for product development – civil around 15–20 years and military up to 40 years – must be shorter than those of today for aircraft, systems and products to remain relevant and functional. Such progression requires a well-structured innovation system to stay competitive.

As we shall see later in the document, Innovair and all of NRIA Flyg's actors within the aeronautical triple helix come together in increased collaboration towards common goals that are nationally and internationally recognised.

SWEDEN'S ROLE IN THE WORLD

The small number of fully-fledged developers of aircraft in the world shows that there are really only a few countries with truly developed expertise in the field. Sweden fares favourably in competition in relation to its population: no other country with the same number of citizens has such a position. Even in absolute terms, regardless of the population, Sweden is ranked somewhere between 5 and 7, depending on how one calculates the figure.

#5–7

IMPACT LOGIC REQUIRES STABILITY

Effective innovation generally requires that the lead time from concept to product is reduced so that we can bring solutions based on Swedish technology content to the market faster. Shorter lead times also normally lead to reduced total costs. These gains are achieved by the fact that the innovation takes place in a coherent innovation system.

The figures on page 10 show the various financing programmes, both Swedish and international, used for technology development by both the large companies GKN Aerospace and Saab (see also pages 18–20). The figures show how technology programmes result in product applications in the market – and in turn, business and revenue. Observe how today's products are based on technology that was on a low TRL about 15 years ago. The technology that will go into tomorrow's products is now on TRL 5–6 in order to be demonstrable and certified for use in these products. However, the research that is now underway on low TRL will only be used in upcoming

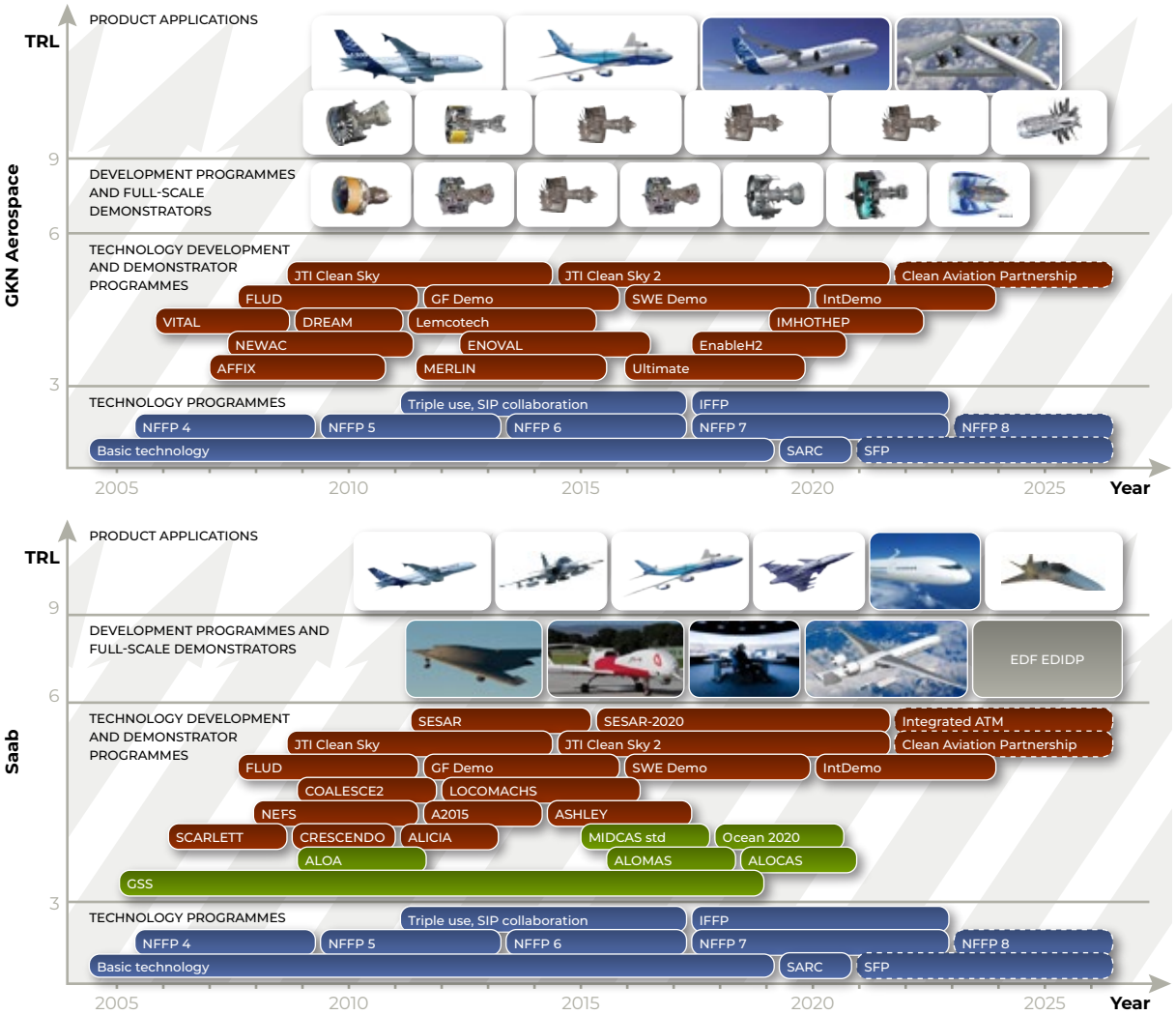
TECHNOLOGY DISSEMINATION

Aeronautical innovation lies at the forefront of technology, not least because the environments for which technology is created are so demanding in many different ways. Many technical solutions therefore have their origins within aeronautical technology. But the underlying technology is, of course, often useful in other areas entirely outside the world of aviation.

These include, for example, computational technology, systems design, communications solutions, digitalisation, lightweight design, materials technologies and the like; solutions and technology areas that are particularly relevant in other fields of application, such as vehicle technology or information and communication technology (ICT).

The benefits are not only a flow of technology and solutions to other areas, but also increased collaboration in the field of research between disciplines and the areas of application. The dissemination phenomenon also leads to an increased production of PhDs and engineers that are useful for large parts of Swedish industry.

RESULTS AND CHALLENGES DESCRIBED IN SUMMARY ON PAGES 38–41

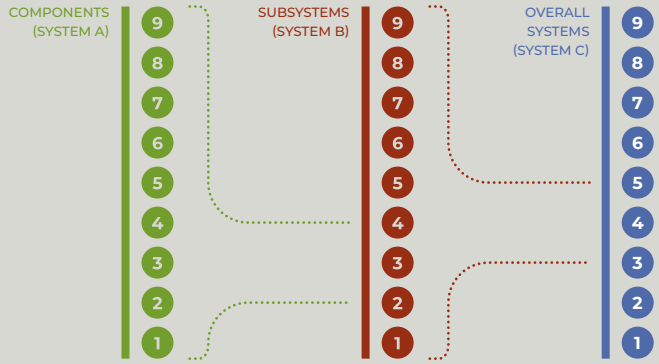


A schematic diagram of our common innovation system and the various Technology Readiness Levels (TRLs) showing which research and innovation tools we use to systematically introduce new basic technology into progressively more complex demonstrated technology levels to ultimately result in finished, sold and used products. GKN Aerospace above, Saab below. Please note that the diagram is schematic and does not show actual lead times.

TRL – AT DIFFERENT LEVELS

The Technology Readiness Level (TRL) concept is a nine-point scheme developed by NASA which aims to illustrate how far research on a particular technology has come before the innovation is fully developed into a produced, sold and used product. TRL 1 represents the first research steps based on an original idea, TRL 9 represents a proven product on the market – and completed innovation. Different research and development actors are normally located at different levels on the scale.

With reference to the term TRL it must also be pointed out that this is dependent on different levels of the concept of the system. TRL can be used to describe, for example, a blisc (blade-integrated disc in an aircraft engine) that is included in the compressor module system, which in turn is part of the complete engine system, which in turn is part of the aircraft system which, on the civil side, is part of the overall transport system for aviation which embraces operators, airports and traffic-management systems. In a military context, a fighter aircraft is part of a system of systems that includes, for example, combat control, communication and collaboration with other aircraft and other platforms (ships, submarines, tanks).



The ambition of adding system aspects to our traditional innovation system in a structured manner is to demonstrate the progressively increased benefit of the developed technology and to guide future technology development towards the most relevant technology areas for Swedish industry and the customers for their products.

generations of products.

This clearly illustrates how an innovation system must be stable over a long time with activities at all TRL levels. Collaboration between the parties in the innovation system eliminates the traditional competitive situation between basic and applied research. Instead, it becomes clear that all actors are needed, but that the system requires consensus regarding information dissemination and technical direction for whatever research is needed in the future. 1

This common approach is ensured in specific terms by Innovair creating a programme for joint training of industrial cluster leaders, from the two major industries, within (currently) 18 prioritised technology areas. However, a challenge is still to look at the matter from a systems perspective, where these technology areas work together; the need for an ability to evaluate future systems – planned but not yet realised – is growing ever stronger.

1 **RESULTAT: PRIORITISED TECHNOLOGY AREAS AND CLUSTERS** Swedish innovation actors within aeronautics have agreed on prioritised technology areas and have formed clusters to drive the areas forward.

RESULTS AND CHALLENGES DESCRIBED IN SUMMARY ON PAGES 38–41

ACTOR: ACADEMIA

Role

Academic actors in Sweden consist of universities that normally conduct research at lower TRLs, although some actors in certain niches have resources to develop technology at higher TRLs, usually together with industry.

The purposes of academia's activities are twofold: on the one hand to create conditions for systematic development of completely new technologies for future products, without which Swedish industry would lack the ability to be competitive; on the other hand to ensure the future supply of a highly educated workforce (through both graduate education and research training), which is naturally of critical importance to Innovair's partners.

RESULTAT: FUNDING PROGRAMMES The research and demonstrator programmes are continuously developed. 2

CHALLENGE: DIVIDED AND UNCLEAR FUNDING The funding split between Vinnova and VR builds walls between research contexts and inhibits innovation, especially those of a disruptive character, and may mean that funds do not end up where they are of most use in the TRL chain. A

Funding

Aeronautical research at TRL 1–3 is normally funded by the National Aeronautics Research Programme NFFP (see fact box) under the responsibility of Innovair. This programme is constantly evolving in step with international demand and Sweden's ambitions. This funding is aimed at addressing research issues with high relevance for industry, thereby benefitting Swedish innovation; the implementation of the research should always be free and based on scientific excellence, but the focus is directed towards the estimated maximised benefit for Sweden according to the national declarations of intent on which Swedish innovation is based. 2

In the aeronautics field, Innovair is the unifying actor that governs the focus of innovation. Of all the Swedish authorities, at present it is primarily Vinnova, under the Ministry of Enterprise and Innovation, that funds aeronautical innovation. As the only strategic innovation programme, Innovair also receives funding from the Ministry of Defence via the Swedish Armed Forces.

Some aeronautical funding may occur through the Swedish Research Council (VR), but then based on individual researchers' applications without the directional influence of Innovair. This funding is essentially governed by the level of scientific excellence attained by different applicants, which means that this research lacks the incentives and mechanisms to take the results forward to higher TRLs in the innovation chain. Within the innovation system, there is a gap between the basic research studies financed by VR and the more applied projects financed by Vinnova; this gap partly reduces the efficiency with which research results can be utilised, and partly reflects the problem that the research-funding authorities currently do not really communicate and create synergies. As a result, Sweden is at a A

GERMANY'S COMPETITIVE ADVANTAGE

Germany, one of Sweden's prioritised partner countries for aeronautical innovation, has redefined the boundaries between its two major aeronautical innovation funding sources Deutsche Forschungsgemeinschaft (DFG, comparable with Sweden's VR) and Luftfahrtforschungsprogramm (LuFo, the German equivalent to NFFP). The effect of these changes is that an overlap has now been created between basic research and applied research instead of the gap experienced up until now. A large part of the gap was explained by the traditionally distinct target objectives for the funding agencies: for DFG, academic excellence and scientific publishing have been the goals, whereas LuFo aims to make research available for demonstration and product development. The situation is thus very similar to that in Sweden, and the solution to allow the two forms of funding to unite and work alongside one another to a greater extent is very appealing. To take inspiration from a German solution is an opportunity that is particularly interesting as Innovair, via the international part of NFFP, has commenced a close collaboration with Germany.

NFFP – A WELL-FUNCTIONING FUNDING PROGRAMME EVALUATED IN 2018

The National Aeronautics Research Programme (NFFP) is a funding programme for aeronautical research co-funded by the Ministry of Enterprise and Innovation (via Vinnova) and Ministry of Defence (via the Swedish Armed Forces). NFFP is an important link in national collaboration within aeronautical research, and also lays the foundation for further research within European and other international programmes. Moreover, the programme includes an international assignment complement from Vinnova with focus on internationalisation called IFFP. The research funded through this branch is conducted with a number of selected partner countries (for further information see chapter Perspective: Internationalisation on pages 22–25).

NFFP was evaluated in 2018 by Faugert & Co Utvärdering (part of the Technopolis Group) on behalf of Innovair. The report states,"With such a well-functioning and well-managed programme as NFFP that has been continuously improved over 25 years, it is a challenge to formulate meaningful recommendations."

Source: National Aeronautics Research Programme (NFFP): Effektutvärdering av etapp 5 och 6, Tomas Åström, Markus Lindström, Torbjörn Fängström, Tommy Jansson, Hanna Engblom and Sebastian Eriksson Berggren.

innovair.org/en/nffp

competitive disadvantage compared to, for example, Germany (see fact box). The comparison with Germany is important, because Swedish researchers work in an international context on several levels, where the EU framework programme is an important funding source. This research is usually performed at some TRL level higher than the national research funded by NFFP. In addition to this, the new financial framework 2021–2027 will contain a military research and development programme, known as EDF (European Defence Fund, see page 28).

In this context, it is also important to mention that Swedish universities, and also Swedish institutes, have not been competitively neutral towards actors in other countries regarding the relative small amount of direct government funding in Sweden. This has meant that Sweden has not been able to co-fund a sufficient number of projects in the EU framework programme that are on par with our industrial strength position in the aeronautics area – and probably in other sectors as well. The ambition must be to secure Swedish funding for EU projects corresponding to at least our share of EU funding within the prioritised Swedish areas of strength.

B

B **CHALLENGE: LACK OF FUNDING FOR RESEARCH, TESTS AND DEMONSTRATION** Swedish research, tests and demonstration are currently funded mainly within individual projects, which results in a national competitive disadvantage as the research actors often lack resources for co-funding.

RESULTS AND CHALLENGES DESCRIBED IN SUMMARY ON PAGES 38–41

SARC AND BRAZIL

Four different professors from LiU, Chalmers and KTH have participated as visiting professors at Instituto Tecnológico de Aeronáutica (ITA) with co-funding by Innovair and its partners. The activities have worked very well; today Sweden collaborates with Brazilian actors in almost 60 projects with 26 universities involved.

SARC has, among other things, completed the first post-graduate course within the aeronautics field funded and organised by Swedish academia in another country, together with post-graduate students from that country, namely a PhD course in conceptual aircraft design in Brazil in March, 2019.

Inspired by the Swedish success with SARC, Brazil has now created a similar research centre in Brazil: Brazilian Aerospace Research and Innovation Network (BARINet).

Read more in chapter **Perspective: Internationalisation** on pages 22–25.

SARC

Sweden has a disadvantage due to its relative lack of size, but this also creates an advantage in that we know each other well. Innovair has used this to create and finance the Swedish Aeronautical Research Center (SARC, see **sarc.center**) that aims to structure the country's academic research and systematically monitor which new technologies are mature for industrial development. 3 1

The centre has its headquarters at Linköping University (LiU) and initially includes researchers working at LiU, Chalmers and the Royal Institute of Technology (KTH). The centre is however intended to be open to all the country's researchers regardless of organisation, and focuses on technology areas within aeronautics, based on the fundamental aeronautical disciplines such as fluid dynamics, structures and materials, and flight mechanics, and with possible continuation in other necessary disciplines such as electrical engineering, sensors, communication and so forth.

The major benefit from Innovair's viewpoint is to facilitate the integration of actors in the innovation system, to foster structured long-term co-operation, and to create increased competitiveness in relation to foreign actors to obtain international funding from EU and other sources. Consequential benefits are expected to be primarily an increased critical mass of research in Sweden, shortened lead time in the TRL chain from idea to practical benefit, production of expertise for industry, and low-TRL synergies with the space technology area.

International research collaboration is also on the agenda for SARC, as well as for Innovair, with Brazil as a prioritised partner country (see fact box above) together with Great Britain and Germany.

RESULT: SARC SARC has been formed to connect the academic actors within aeronautics. 3

ACTOR: INSTITUTES

Role

At TRL levels 4–6, various technologies are brought together in increasingly complex technology demonstrators to prepare for further industrial product development. The phase is of great importance as it links research with product development and is thereby necessary for innovation to be completed. The demonstrator phase is also essential in that it creates the conditions for Swedish actors to develop into international actors. At about TRL 5, there is often a transition from national activities to international co-operation, because the complexity and economic value of the developed systems require collaboration and cost-sharing.

In this phase, the institutes are the main actors. Following the merger of Swerea into RISE, the latter is now the institute of main importance on the civil side for Innovair's actors. A merger has also taken place on the military side, where the former National Aeronautical Research Institute (FFA), which carried out a very large part of the country's aeronautical research, and the former Swedish National Defence Research Institute (FOA) were merged to form the Swedish Defence Research Agency (FOI). The integration and subsequent reduction of research funds within aeronautics has resulted in only a small part of the country's total aeronautical research being conducted with military resources, and therefore the importance of civilian actors in universities and institutes has grown. The restructuring has also resulted in Sweden losing some critical infrastructure that must now be procured internationally or secured via strategic co-operation agreements with other countries. C

Funding

The demonstrator phase is funded by continuously updated programmes and mostly carried out by institutes but also by OEMs, both civil and military, with substantial participation from industry/SMEs and also universities. As in the case of low-TRL research funding via NFFP, Innovair is the primary manager and distributor of demonstrator funding. 2

Innovair has undertaken various demonstrator programmes with the help of funding from Vinnova. The recent demonstrator-funding programme SWE Demo ended 2019 and is replaced by the new programme IntDemo that had its first open call late 2019. The chain has been reasonably unbroken since the Aeronautical development & demonstration programme (FLUD, 2006–2010) via the Green aeronautical demonstration programme (GF Demo, 2012–2016) that preceded SWE Demo, and this has been a success factor of enormous significance for Swedish aeronautical innovation.

Arenas

Innovair has contributed greatly to refining two production arenas – for advanced composite materials in Linköping (Compraser Labs) and advanced metallic production technology in Trollhättan (Produktionstekniskt Centrum) – together with Swerea SICOMP and Swerea IVF (both now RISE), as well as local industries and universities. The objective is to retain as much of the innovation chain as possible in Sweden, and to create advanced employment within the country's borders – a recommendation put forward in NRIA Flyg 2013. 4

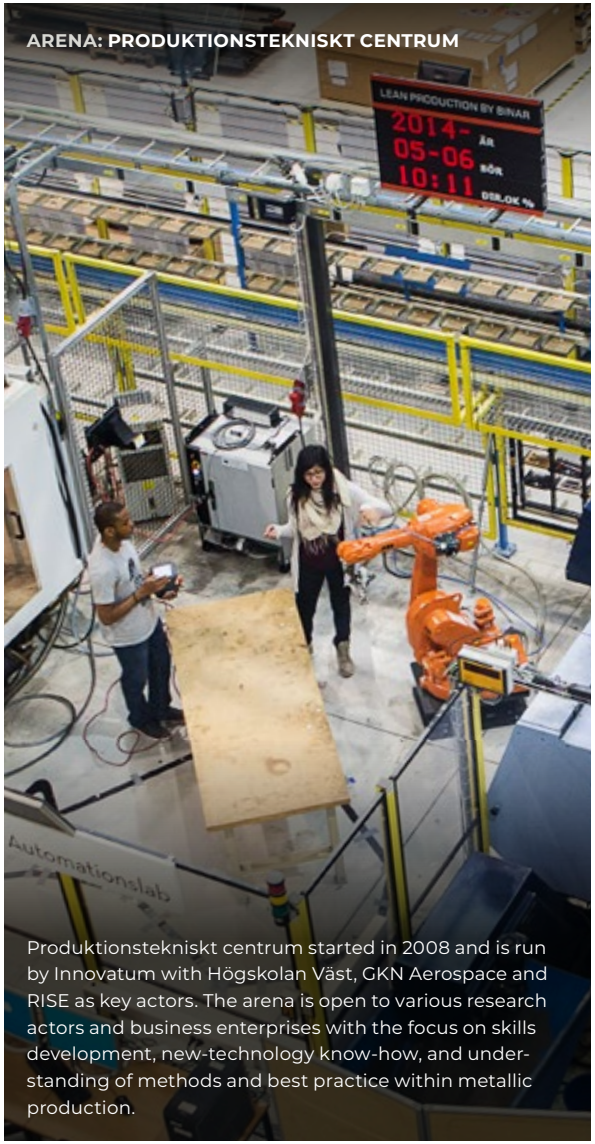
4 **RESULT: TWO ARENAS** Two production arenas have been created and further developed.

C **CHALLENGE: LACK OF BASIC AERONAUTICS RESEARCH** On behalf of the Swedish Armed Forces, FOI has reoriented its activities towards system analyses, which has led to a collective diminution of national basic aeronautics research.

RESULTS AND CHALLENGES DESCRIBED IN SUMMARY ON PAGES 38–41

ARENA: COMPRASER LABS

Compraser Labs started 2012 as a regional initiative of Linköping municipality together with a number of composite-materials companies as well as Saab and RUAG Space. Since 2014, Compraser Labs is run as a member programme within RISE with both industry and academia. Work is underway to establish Compraser Labs in the new production arena Innovative Materials Arena (IMA) which is currently being set up in Linköping.



ARENA: PRODUKTIONSTEKNISKT CENTRUM

Produktionstekniskt centrum started in 2008 and is run by Innovatum with Högskolan Väst, GKN Aerospace and RISE as key actors. The arena is open to various research actors and business enterprises with the focus on skills development, new-technology know-how, and understanding of methods and best practice within metallic production.

Our two arenas provide a clearly defined support structure that creates opportunities for SMEs to participate in development and production. The arenas provide support and resources to SMEs to make contact with the aviation industry, understand the needs of industry, and participate in the aviation industry's R&D programmes. The arenas also provide resources to develop and verify interesting (identified) technologies for the aviation industry

DUAL/TRIPLE/MULTI USE
A vital prerequisite for the arenas to achieve critical mass, access to funding from various sources, and connection to different types of industries is that they can show relevance to several different innovation areas simultaneously.

For this reason, Innovair collaborated with the strategic innovation programme for lightweight technology, LIGHTer, in a special triple-use investment in technology 5 that was of use partly as a traditional dual-use investment, that is to say civil and military aeronautics, but also for another industry.

The project focused on composite-material development with applications mainly within aeronautics and road vehicles but also within infrastructure.

The investment yielded both direct results and accumulated knowledge which Innovair later generalised to multi use with the aim of wider collaboration between industries. For example, the aviation sector can collaborate within materials technology both at research level, for example with SIO Grafen, and in more production-oriented activities, such as SIP Metallic Materials and SIP Produktion 2030.

to the right maturity level.

Building up arena activities in this manner, with funds from local industry, regional funds, national funds from Vinnova, and international funds from the European Development Fund via the Swedish Agency for Economic and Regional Growth, has proven to be such a successful strategic effort that the model can also be of interest for other areas of innovation.

RISE and the arenas have also developed and administered "SME Aeronautics", which is Innovair's special focus on SMEs that commenced in 2013. The objective is to strengthen the competitiveness of the aerospace industry through excellence 6 from SMEs and to increase the number of highly specialised SMEs approved as certified suppliers to the aviation industry. The concept has been adopted by the strategic innovation programme for lightweight (LIGHTer) setting up a parallel SME initiative for lightweight innovation. Open calls and evaluations are synchronised between Innovair and LIGHTer.

Examples of emerging collaborative arenas outside Innovair's management, but presumed/expected to be of key importance for its future operations, are Wallenberg AI, Autonomous Systems and Software Program (WASP) for autonomous systems, software programs and artificial intelligence (AI), and the Linköping Center for Sensor Informatics and Control (LINK-SIC) for sensor informatics, control technology and cyber-physical systems.

Infrastructure

A vital part of arena development and Swedish innovation in general is the availability of and access to advanced infrastructure during the demonstration phase where technology is verified prior to the transition to high TRL. Unfortunately, the costs of large test infrastructure, typically in the order of SEK 100 million per test-bed, are too high to be funded within individual research projects, but at the same time too small to justify national investments. For this reason, Swedish actors need access to internationally financed infrastructure, which is an issue that is shared by several strategic innovation programmes within the framework of investments in test-beds.

The regions have traditionally played a role in this, but with different conditions and different results. However, a breakthrough came in 2016 as Innovair promoted a Memorandum of Understanding between the regions and Clean Sky. The 7 agreement was quite unique in Sweden and one of only a handful that had ever been drawn up. A good example of a concrete result from the agreement is the SVIFFT project (Sweden's Future Aerospace Industry) which is co-funded by the Swedish Agency for Economic and Regional Growth, via resources from the European Regional Development Fund (ERDF) and regional actors. The project pays for, amongst others, automation and manufacturing resources and equipment intended for use by SMEs within the production arenas.

5 **RESULT: TRIPLE/MULTI USE** Triple-use and multi-use concepts have been realised in specific projects.

6 **RESULT: SME AERONAUTICS** SME Aeronautics has been formed and provides open calls for development of SMEs in sync with SIP Lightweight.

7 **RESULT: REGIONAL AGREEMENTS** Two Swedish regions have signed agreements with Clean Sky which bring together Clean Sky funds with regional development funds from EU's structural funds via the Swedish Agency for Economic and Regional Growth.

RESULTS AND CHALLENGES DESCRIBED IN SUMMARY ON PAGES 38–41

OEMS

There are few real OEMs in the western world. The largest aircraft manufacturers today are, on the civil side, Airbus, Boeing, Embraer and Bombardier for aircraft, and General Electric, Pratt & Whitney, Rolls-Royce and Safran for engines. On the military side can be added Lockheed Martin, Dassault, Saab and BAE for aircraft whereas the engine manufacturers are essentially the same.

ACTOR: INDUSTRY

Role

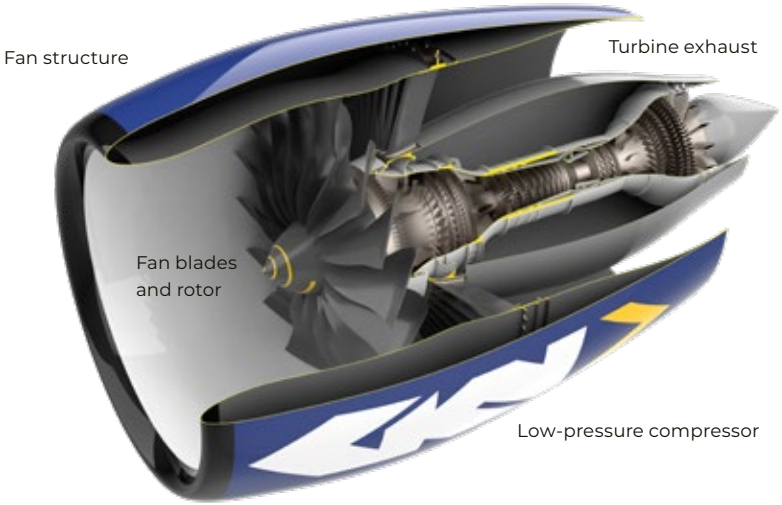
During the product development phase (TRL 7–9), the technology takes its final form and shows its function in real use. This phase is mainly undertaken by industry – both small and medium-sized enterprises (SMEs) – and begins with the development of prototypes that are tested in a realistic environment.

There is also a significant amount of demonstration (TRL 4–6) within the industry, especially amongst SMEs. The smaller companies often serve as a complement to big industry by focusing on cutting-edge technology not developed in-house by the large companies but often required by them for the demonstration of new technology. This provides a clear role for the large companies, acting as a driving force and an aid for SMEs to build up skills and expertise so that the SMEs can ultimately be certified as suppliers to the major OEMs (see fact box) – which is not possible for SMEs on their own.

In today's Swedish aeronautics sector there are two major companies, described below.

GKN Aerospace

GKN Aerospace is a British multinational corporation with operations within the fields of airframe and engine manufacturing. GKN Aerospace Sweden has the primary responsibility for all aircraft engine operations within the group. It is a leading first-tier supplier to all major OEMs cited in the fact box, and also has the ambition to become something called a "super-tier-1" supplier with the skills and expertise to propose and implement comprehensive design and structural improvements that the OEMs do not have existing



GKN Aerospace focuses primarily on four modules in the aircraft engine: the fan structure, the fan rotor/fan blades, the low-pressure compressor and the turbine exhaust. Technology areas embraced therein are, for example, lightweight design, advanced materials know-how (both metallic and composites) and advanced production methods such as additive manufacturing, laser welding, automation and digitalisation. The military OEM responsibility gives GKN Aerospace a full-engine competence that is very valuable on the market.

competence to develop.

Within the largest business area, civil aircraft engines, focus is on developing and supplying complex load-bearing structures and larger modules such as low-pressure compressors. Today, Swedish components manufactured by GKN Aerospace are installed in more than 90% of all commercial civil aircraft. In addition to civil aircraft engines, GKN Aerospace develops and manufactures parts for rocket engines, specifically nozzles and turbines driving the pumps that provide fuel (liquid hydrogen with liquid oxygen as oxidiser) to the combustion chambers of the Ariane 5 rocket. GKN Aerospace is also type-certificate holder for the RM12 engine in Gripen C/D, and has been chosen by FMV for technical support and maintenance of the new Gripen E/F engine RM16.

GKN Aerospace's innovation system can be found on page 10 with plotted national and international programmes shown together with part of the project range.

The combination of civil, military and space-related operations is strategically important for GKN Aerospace as it inevitably entails multiple sources of revenue, but also in the long term for the company to maintain a comprehensive full-engine expertise which is important for understanding how new technology should be designed and manufactured in a competitive manner.

Saab

Historically, Saab is the company that developed the unique fighter-aircraft capability that was decided by the Government in association with the refinement of Sweden's policy of neutrality. Only the USA, Russia, France and, in the longer term, China, have an own capability that clearly exceed Sweden's in the field. Saab continuously develops the Gripen fighter aircraft, whereby the latest version E/F is a complete revision of Gripen – in exceptionally short time – that facilitates easier and faster upgrades and the introduction of new technology in a way that is unique within the industry.

Future development of military systems will continue to be costly and technically complex. It is reasonable to believe that Saab will increasingly participate in bilateral or multilateral partnerships with leading companies in other prioritised countries. An example is the T7A Red Hawk (formerly known as T-X) that is the next generation pilot-training system for the US Air Force, developed in collaboration by Boeing and Saab.

Alongside the military OEM capability, Saab is a tier-1 supplier to Airbus and Boeing regarding larger airframe structures with integrated systems but also a supplier of avionic systems and system solutions for aircraft and helicopters. In addition to aircraft, structures and systems, Saab also manufactures other system solutions for application within the air/aviation transport system, for example, the Airborne Early Warning and Control system (AEW&C) GlobalEye and the remotely controlled air-traffic-control-tower solution Remote Tower that is now in operation in Sweden and

RESULTS AND CHALLENGES DESCRIBED IN SUMMARY ON PAGES 38–41

Saab develops military aircraft and systems in their entirety and also subsystems for civil aviation. A major competitive advantage on the civil market – and naturally a prerequisite for military activities – is the knowledge of system integration of very high complexity that has been accumulated from developing fighter aircraft systems. The picture shows an example of fighter aircraft where the most difficult part is what can be seen in the centre cell, to "optimise" the complete system without any other cell becoming too weak (which would sink the system) or too dominant (which means additional costs). The same reasoning applies, of course, to the civil side, in the role of supplier.

exported worldwide. Today, Saab is a leading system integrator of exceptionally complex subsystem, both civil and military.

Saab's innovation system can be found on page 10 with plotted national and international programmes shown together with part of the project range.

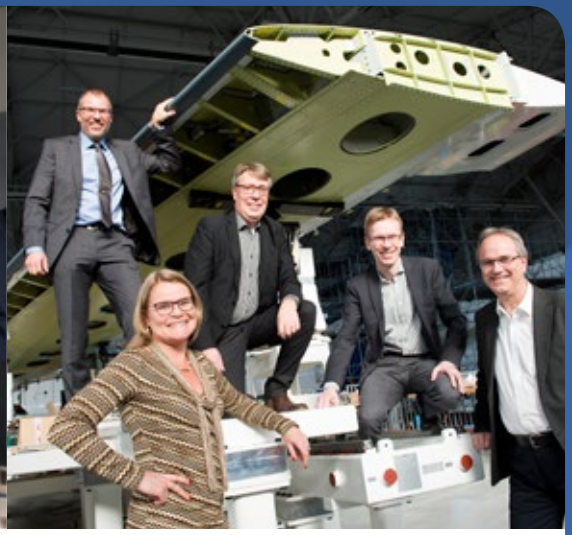
Saab faces challenges in maintaining both breadth and depth with regard to all the technologies required to remain a competitive international systems supplier. In this regard, the continued development of the Swedish innovation system is essential, as is the growth of skills and expertise required to maintain and develop Swedish aeronautics industrial capability.

RESULT: ACS WITH THREE NODES ACS has expanded to a national network with three nodes. 8

Aeronautics- and space-technology clusters

Aerospace Cluster Sweden (ACS) is originally a network organisation based in Linköping with the goal of increasing business for companies and organisations in, or on their way into, the aerospace industry. At the initiative of Innovair, the cluster has been expanded to other parts of the country and has become a national aerospace cluster with two key nodes: one eastern and one western. Today, the network also has a northerly node that concretises the organisation's ongoing expansion, this time together with the space sector. 8

ACS focuses on supporting SMEs but also the larger companies GKN Aerospace, Saab, Swedish Space Corporation (SSC) and others included in the cluster. The cluster is financed via funds from companies and public actors, but ACS also runs projects granted by the Swedish Agency for Economic and Regional Growth, in other words with funds allocated via the European Regional Development Fund (ERDF). This upscaling of funds originally generated by Vinnova with other funding is an important ongoing challenge for Innovair. 7



ACTOR: INNOVAIR

Role

With the common aeronautics innovation strategy NRIA Flyg, the technology area's actors have created and refined a successful concept for strategy development – in terms of both product and process. The 2010 edition, which was the first of its kind in Sweden, caught Vinnova's interest and became something of a model for the call to create strategic innovation agendas that Vinnova launched in 2012 together with the Swedish Energy Agency and Formas. In all its incarnations, NRIA Flyg has been extremely well structured around "the strategic journey" from the present to the future as defined by stated objectives. 9

When NRIA Flyg 2013 resulted in the aeronautical innovation area being awarded one of Sweden's six strategic innovation programmes, Innovair was created as the organisational body managing the programme. Innovair brought together all the actors in the area and – with NRIA Flyg as a cohesive strategy – quickly contributed to a drastically increased collaboration within the innovation area's entire triple-helix system. Thanks to Innovair, the aeronautical innovation area can now be considered as completely coherent from microscale (between "internal" actors) to macroscale (via national level towards the globalised world). 1 10

The common factor shared by all the above actors is that Innovair provides the national common superstructure that exists in many of our competitor countries as a result of their stronger public support for aeronautical innovation. Instead of the innovation actors acting independently, through Innovair they can increase their credibility and thereby gain simplified entry into international contexts. This increases, for example, the Swedish chances of participation in Clean Sky. With this role, Innovair qualifies as a pioneer amongst the Swedish strategic innovation programmes. 11

Another example is the international organisations and associations where Sweden is represented by Innovair while other countries are represented by authorities. Whilst a greater distance to decisive powers is a disadvantage for Sweden, the shorter distance to innovation is a clear advantage.

9 **RESULT: NRIA FLYG** NRIA Flyg serves as a common strategy for both civil and military aeronautical innovation.

10 **RESULT: COHERENT INNOVATION SYSTEM** There is consensus and collaboration (within the triple helix including the Swedish Armed Forces and its support authorities, and, for example, with other Strategic Innovations Programmes, from local to global level) providing a complete coherent innovation system.

11 **RESULT: CONDITIONS FOR INTERNATIONAL COLLABORATION** Sweden has created enhanced national opportunities for international collaboration and influence throughout the whole innovation system, not least strategically within the EU.

RESULTS AND CHALLENGES DESCRIBED IN SUMMARY ON PAGES 38–41

EXCERPT FROM NRIA FLYG 2020

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