Military aeronautics technology: Defence and societal security

A new security situation in the world puts increasing demands on defence and societal security. Aeronautics technology can contribute, but the picture is complex, and Sweden has work to do.

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All text and image references in this excerpt PDF apply to NRIA Flyg 2024 in its entirety. You can download the document at **innovair.org/en/nriaflyg2024**

THE GLOBAL CONTEXT AND THE ROLE OF AVIATION

Due to changes in the world around us, issues related to defence and security in Sweden have rapidly gained top priority. Domestic capability to produce critical goods and services, combined with increased stockkeeping, are clear examples of prioritised measures currently being implemented. This also includes the ability to develop fighter aircraft, which has been identified by the government as a so-called essential security interest for our nation.

At the same time, the global situation leads to increased demands for resilience and flexibility to meet new threats and quickly translate operational experiences into action. This means that the Swedish – or for Sweden accessible – innovation system in aeronautics becomes increasingly important to preserve, develop and enhance. Also a civil development capability is thus a resilience factor. It contributes to increasing the extent of aeronautics technology development in Sweden.

For instance, the Armed Forces' Perspective Study 2022 states: "The rapid technological development places increasingly high demands on the Armed Forces' ability to develop new capabilities and utilise new technology."

The study also emphasises digitisation as a guiding trend and notes: "Where technological development was previously driven by research within the defence sector – – – it is now largely occurring in the civil sector. Access to technology is part of global competition and can be used as political and economic means of power."

Sweden's Chief of Defence stated at an IVA seminar in February 2024: "It is certain that technological development will change the operational environment. Investments in research and technological development are a way to address this change."[20] During the same event, the government

announced its mandate to the Armed Forces and Vinnova to establish a dual-use programme aimed at utilising civil-developed technology in military innovations.

The above quotes are generally valid for technological development and particularly relevant to the aeronautics sector, which is rightly often described as a cutting-edge technology area. This message is also clarified in the document "Strategic Direction for Defence Innovation[21] published by the Swedish Ministry of Defence in January 2024.

FUTURE FIGHTER AIRCRAFT

Military capability needs and subsequent requirements are greatly influenced by changes in the surrounding threat landscape as well as by general technological development. New technology areas with ever-new possibilities are interwoven in this context, affecting fighter systems. Since military aviation operations involve confrontational interactions, it creates new challenges that concern many actors in the aeronautics-related innovation system.

Tomorrow's potential adversaries are likely to possess manned aircraft with low signatures, high speed, long range and long-range weapons. They are expected to operate in AI-assisted collaboration with one another, with real-time tactical command and control, even together with unmanned platforms with various capabilities (including combat capability) – also in forms with varying sizes, degrees of complexity, and swarm behaviour, along with high-performance air defence systems.

The adversary will also likely have more efficient sensor, communication and electronic warfare systems than today. This enables the adversary to, alongside enhanced electronic warfare capabilities, achieve a better situational awareness and thus better effectiveness against Swedish targets.

The use of unmanned vehicles, particularly in new applications, will increase, and as of 2024, Sweden does not have ongoing activities on par with what we are currently seeing in parts of the world, partly because research and technological development have not yet focused on this. However, armed unmanned vehicles – both regular drones and so-called patrol robots – have been used increasingly during the 2020s in various conflict zones. The threat from a multitude of cruise missiles is already significant; technology for hypersonic missiles and manoeuvrable tactical ballistic missiles (TBM), together with increased cyber warfare capability, will further increase the adversary's ability to attack Swedish base and support systems within very short timelines. In the long term, airborne energy and directed-energy weapons are also expected to become operational. Therefore, air defence will likely face the challenge of meeting both volume threats from mass-produced cruise missiles and threats from fewer but very advanced high-performance weapons.

Russia's full-scale invasion of Ukraine has also taught us the importance of being able to rapidly adapt tactics, both through altered behaviour and by integrating new functionalities into systems. Examples from Ukraine demonstrate how quickly they managed to integrate Western-manufactured attack weapons into older Soviet-developed combat aircraft[22], as well as the rapid relocation to road bases that was executed during the early days of the war.

In a future with collaborating manned and unmanned systems, the need for adaptation and increased synergy in new tactical situations will demand very rapid change processes, both in terms of the functionality of subsystems and the integration of these into the overall air defence capability.

> **CHALLENGE:** Sweden needs an increased ability to rapidly develop and deploy new or updated systems/subsystems to enhance flexibility and respond to future threats. Significantly increased time requirements for tactical and functional adaptation require a faster and more parallel design process than before. New actors will likely need to be involved.

> **CHALLENGE:** Integration capability across a wide range of technologies – encompassing multiple technology areas and involving all levels of innovation – is necessary for the development of new manned and/or unmanned combat aircraft.

The Armed Forces assess that the Gripen system has the potential to remain relevant beyond the middle of the century. However, this requires continued investments in the further development of the system to address future threats.

20 iva.se/det-iva-gor/evenemang/hur-ska-sverige-hantera-forskning-som-anvands-civilt-och-militart (in Swedish)
21 regeringen.se/informationsmaterial/2024/01/strategisk-inriktning-for-forsvarsinnovation (in Swedish)
22 The attack weapon "Storm Shadow" was integrated onto the Ukrainian Su-24 system in "a few weeks". Integration onto the Eurofighter Typhoon took about 2 years. (Source: MBDA.)

CONCEPT STUDIES FOR SWEDISH COMBAT AIRCRAFT

In July 2023, the government authorised the Armed Forces to prepare a decision regarding most suitable path for a future fighter system (after 2040). The assignment includes activities for future fighter aircraft in the concept phase. This will involve knowledge-building at several defence agencies to ensure they can lead, analyse and evaluate government activities, conduct studies and outline system concepts, and develop an overarching requirement specification. Furthermore, the activities are to ensure national industrial capacity and expertise through studies, technological development and preparations for ground-based and airborne demonstrators. The assignment has been translated into a programme that also includes orders from FMV to Saab and GKN Aerospace. The programme aims to reduce risks and maintain flexibility for the three main alternatives:

- a **nationally developed fighter system;**
- a **fighter system developed in international cooperation;**
- procurement of a **foreign fighter system.**

This clarifies the need for long-term continued investments in competence development, through activities in the defence industry as well as education and top-tier research in the fields that constitute an advanced fighter system and related key technologies for the next 30-40 years. These investments are necessary to make an informed decision, by the end of this decade, about the appropriate course of action for replacing the Gripen system.

CHALLENGE: Sweden must prepare a position regarding the potential relevance of the Gripen system over time and when, how and with what the system needs to be supplemented or replaced. This requires an innovation system with distinct investments in both width and depth.

Separate from, but well-synchronised with, these concept studies, the Gripen system will be further developed to remain relevant beyond 2050.

CHALLENGE: To support the Armed Forces' concept studies regarding future fighter aircraft, continuous coordination and synchronisation need to be facilitated with FoT Aeronautical Systems, NFFP, upcoming demonstrator programmes, aviation investments in European collaborative programmes related to defence R&D, civil/military innovation and similar initiatives.

CHALLENGE: NFFP's prioritised research areas need to be reviewed to ensure they best support the concept study programme and the military capability development while simultaneously increasing the environmental focus.

THE ARMED FORCES' FOT SYSTEM

Within the Armed Forces' research and technology development programme (FoT), there is an area called Aeronautical Systems (see figure 12). At the top of the pyramid is the knowledge required to develop complex air operations concepts where advanced fighter aircraft systems form components in military air defence capabilities. Only if we have the ability to evaluate fighter systems in that context we can say that subsystems or technologies at a lower level have military utility. The development of knowledge regarding methods and tools for concept development and evaluation of subsystems and components at this level is therefore very important and aligns well with the understanding of the innovation

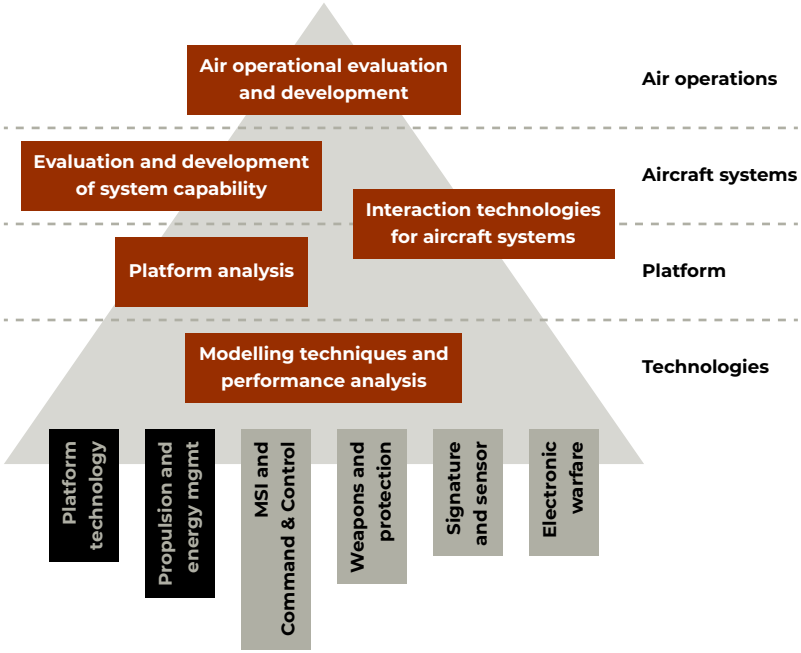


Figure 12. FoT in aeronautical systems is the Armed Forces' model of the research and technology development minimally required to maintain the governmental ability to understand the fighter technology development globally and to evaluate and direct its own long-term military capability development.

system's function developed and used by Innovair over a long period.

As the pyramid suggests, capabilities at a system level always depend on the conditions at the underlying system level. At the aircraft system level, we need to develop modelling and simulation techniques to evaluate and develop the system capability of a fighter system. This includes understanding how advanced weapons, sensor and communication systems should be integrated to best optimise the system's capability. At this system level, we also illustrate the need to develop knowledge about how an operator best interacts with the system, whether he/she is sitting aboard the aircraft or remotely controlling it. In an increasingly complex threat and work environment and with ever-greater technical possibilities, we need to understand how to relieve the pilot/operator and increase the effectiveness of the integrated human-machine system.

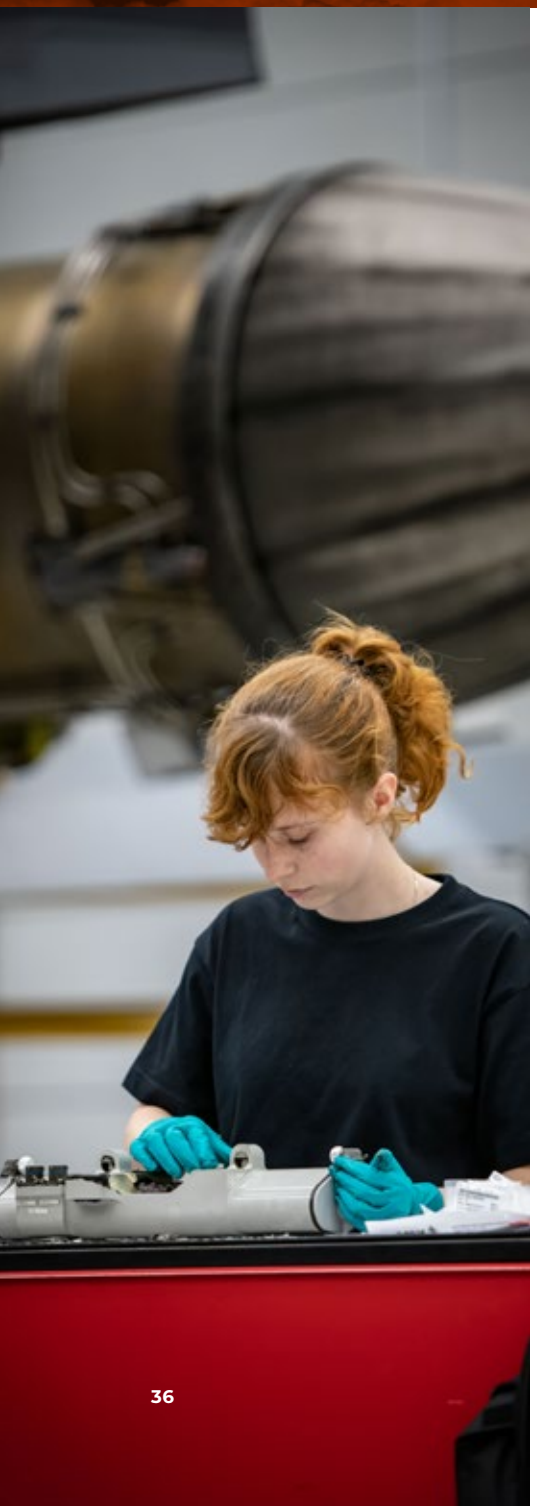
At the platform level, tools need to be developed to better understand how to balance all the flying platform's properties against the requested capabilities and cost constraints. New technologies, materials and production methods must be able to be modelled and analysed to push the boundaries for lower weight, higher speed, better manoeuvrability, more efficient propulsion, higher electric power output, better cooling capacity and better stealth features.

Knowledge-building regarding aeronautical engineering for the Armed Forces' needs is primarily conducted via two main tracks. One is through projects within the FoT programme, which are clearly linked to military application needs. The technology development projects within FoT are mainly ordered from the industry via FMV, while research assignments are directed to institutes (mainly FOI) and universities. The other track is via NFFP, of which over 30% is funded by the Armed Forces. As indicated in this and previous NRIA Flyg, the projects there are often at lower TRLs, with a clear connection to dual use. This track also aims to ensure a long-term national competence supply in aeronautical engineering for the defence sector's needs.

RESILIENCE – FROM A MILITARY AVIATION FUEL PERSPECTIVE

From a security-policy perspective, Sweden needs to become more self-sufficient in several areas (materials, components, spare parts, fuel, etc.). This description uses fuel as an example, but the need for resilience is much broader – both in the aviation sector and in general.

Sweden needs to reduce its dependence on fossil-based fuels, including aviation fuel, produced abroad. Therefore, we need to secure a supply chain for SAF that enables us to build the necessary supply security in accordance with the demands of the current global security situation.



This also means acquiring knowledge about SAF and understanding how propulsion systems, both existing and future, are affected by the potentially altered chemical composition of SAF compared to regular aviation fuel.

FOI has summarised assessments in a report[23] regarding what can and should be further studied about the civilian fuel transition and with the purpose to certify military aviation systems for bio-based jet fuel and various synthetic fuels. It is essential to meet conditions for field storage of fuel and to follow any standards NATO may establish as a normative "unified fuel" for military aviation.

This development should largely be driven as dual use and in international contexts (NATO, EDF, Horizon Europe and similar). There must be a clear connection to the general challenge of sustainable aviation and the fuels required to meet climate goals.

Resilience includes, among other things, having long-term access to the necessary fuels and creating conditions for domestic production. Sweden has the opportunity, provided the necessary political decisions are made, to establish such production as part of achieving climate goals while simultaneously becoming self-sufficient in fossil-free fuel.

CHALLENGE: Sweden needs to identify the scope and content regarding critical self-sufficiency and create resilient value chains for, among other things, military aviation fuel.

EUROPEAN COLLABORATIONS RELATED TO THE DEFENCE SECTOR – AN OVERVIEW

In recent years, a number of world events have significantly highlighted the sensitivity of our international cooperation and supply systems[24]. These have led the EU to develop a "strategic compass" with four sub-focuses[25] aimed at increased resilience and independence for Europe. In connection with this, the Commission has also developed a defence-industry strategy (EDIS), focusing among other things on multilateral cooperation and dual use within the EU. Additionally, the EDA has created a capability development plan to strengthen the collective defence capabilities of EU member states. Meanwhile, NATO has intensified its work on regional planning across different geographic areas within the alliance.

In military aviation technology, several concrete initiatives have been taken in recent years, which have become increasingly significant for Sweden. Below are some of the military-related programmes or activities relevant for Sweden to participate in – and where we are already involved.

- **EDA** (European Defence Agency);
- EDA's **CDP** (Capability Development Plan);
- **EDF** (European Defence Fund);
- **CARD** (Coordinated Annual Review on Defence);
- **PESCO** (Permanent Structured Cooperation);
- **NATO,** including
- **DIANA** (Defence Innovation Accelerator for the North Atlantic);
- **STO** (Science and Technology Organization);
- **NIF** (NATO Innovation Fund);
- **NIAG** (NATO Industrial Advisory Group);
- Dual-use parts of upcoming civilian research programmes like EU FP10[26].

Central initiatives are currently being carried out within the EU, particularly related to the changing security situa-

tion in the vicinity. This rapid increase in ambition is expressed, among other ways, through the European Defence Fund (EDF) which aims to strengthen and consolidate the European defence industry to reduce dependency on non-European resources and to ensure the military capability growth needed within the EU.

CHALLENGE: A successful Swedish exchange from the EDF is strongly dependent on how well national synchronisation can occur among the defence department, relevant authorities, academia and industry, as well as internationally with other member states. Additionally, active participation in the EU's programme committees is required.

Another important actor is the European Defence Agency (EDA), which is an intergovernmental authority within Europe aimed at promoting collaboration and initiating new initiatives to enhance Europe's defence capacity. Within the EDA, there are several capability technology groups (CapTech groups) composed of experts from agencies, industry, SMEs and academia. These groups design strategic research agendas for their respective areas of responsibility, having significant influence on plans within the EDF.

CHALLENGE: To achieve the best possible return from European R&D funding, Swedish agencies and companies (including SMEs) need to be engaged in EDA CapTech groups relevant to aviation technology, which requires both financial and personnel resources.

Within the NATO sphere, there is the STO (Science and Technology Organization), whose various committees provide another forum for increased insights into and influence on relevant collaborative projects. Through the NATO membership, Sweden gains a more significant role in STO activities, with opportunities for new business prospects.

CHALLENGE: Sweden needs to leverage its NATO membership to become part of a larger European framework, thereby gaining access to a larger market and greater opportunities for co-financing Swedish fighter development.

The driving forces behind the rapid development of European defence-industrial investments and collaborations are a desire to make EU member states more independent from external influences (read: the USA) for their defence. There is talk of strategic autonomy, which will lead to a strategic European defence capability over time.

This context highlights the current situation where overall investments in defence material in Europe are directed only 20–30% towards European suppliers[27], while the remaining 70–80% primarily go to the USA. The Commission has expressed a clear intention to reverse these figures.

CHALLENGE: Currently, about 70% of all European investments in defence material go to suppliers outside of Europe. The EU's ambition is for the proportions to be reversed, meaning 70% within the EU.

In Europe, a relatively large number of countries primarily operate American fighter systems (predominantly older F-16 and F-18 models and the new F-35). If the EU's ambition to procure European systems continues, there is significant potential for the Swedish aviation industry to grow within Europe as several countries will be upgrading to modern systems.

In **supplement F** – link on page 3 – more extensive documentation is provided regarding defence-related international collaborations linked to the aviation technology sector.

23 Klimatneutral Försvarsmakt – Analys av fossilfria vägval för försvarsgrenarna. Möjliga åtgärder på kort sikt, FOI report FOI-R--5201--SE, 2021-12-31 (in Swedish).
24 The COVID pandemic, Russia's war of aggression in Ukraine, events in the Suez Canal, individual countries' obstructions in both EU and NATO contexts, etc.
25 ACT: The ability to act rapidly and robustly within the EU framework, SECURE: Enhanced ability to anticipate threats, INVEST: Reduce technological and industrial dependencies outside the EU, PARTNER: EU security and defence partnership forum.
26 FP10: The EU next Framework Programme for research and innovation.
27 EDA: Report 2021: 18%, EDA Annual Conference 30 Nov 2023: 20–30%.

Now that we have … three megatrends, it is time to look a… re required for effective and inte… ive innovation.

EXCERPT FROM NRIA FLYG 2024
This is an excerpt from NRIA Flyg 2024, the startegic agenda for Swedish research and innovation in aeronautics. The aim is to strengthen the conditions for international competitiveness within the field of aeronautical innovation. The document has been compiled by key individuals from universities, institutes, companies, interest organizations and authorities (ACS · Chalmers · Swedish Armed Forces · Swedish Defence Materiel Administration, Swedish Defence Research Agency · GKN Aerospace · KTH Royal Institute of Technology, Linköping University · NFFP · Saab · SARC · Swedish Air Transport Society as well as SMEs and arenas) under the process management of Innovair, who together hold all rights to the document. The content may be freely quoted provided the source is clearly acknowledged.

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