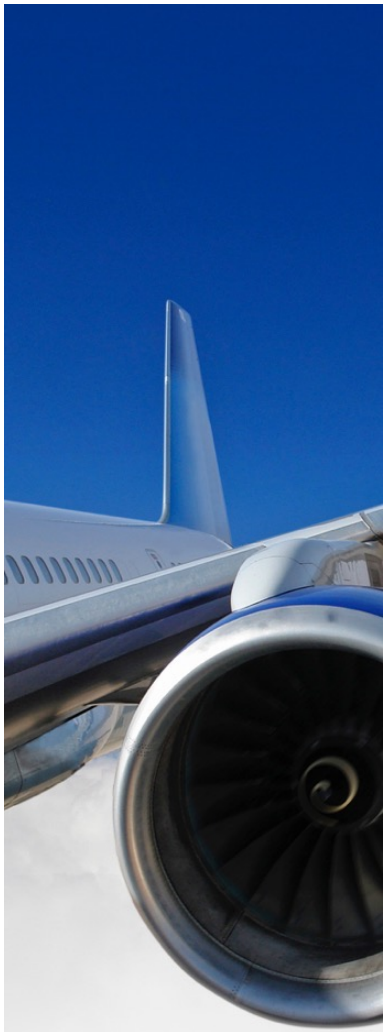
Aeronautical Innovation – Swedish and European Perspectives

Daniel & Florence Guggenheim Memorial Lecture

ICAS 2022

Anders Blom, Director Innovair



Presentation outline

- **Aeronautics in general**
- **Aeronautics in Sweden**
- **The European dimension**
- **The global dimension**

} Personal reflections

Daniel and Florence Guggenheim Award

- Named after parents of **Harry Guggenheim**
- Harry's grandfather Meyer Guggenheim emigrated to USA from Switzerland in 1847 and built an **industrial dynasty in mining, smelting, and refining**
- His **seven sons** went in different directions
- Harry loved aeronautics and **Solomon, an art collector, established the museum** with their surname

ICAS founding fathers

Harry Frank Guggenheim (1890–1971)

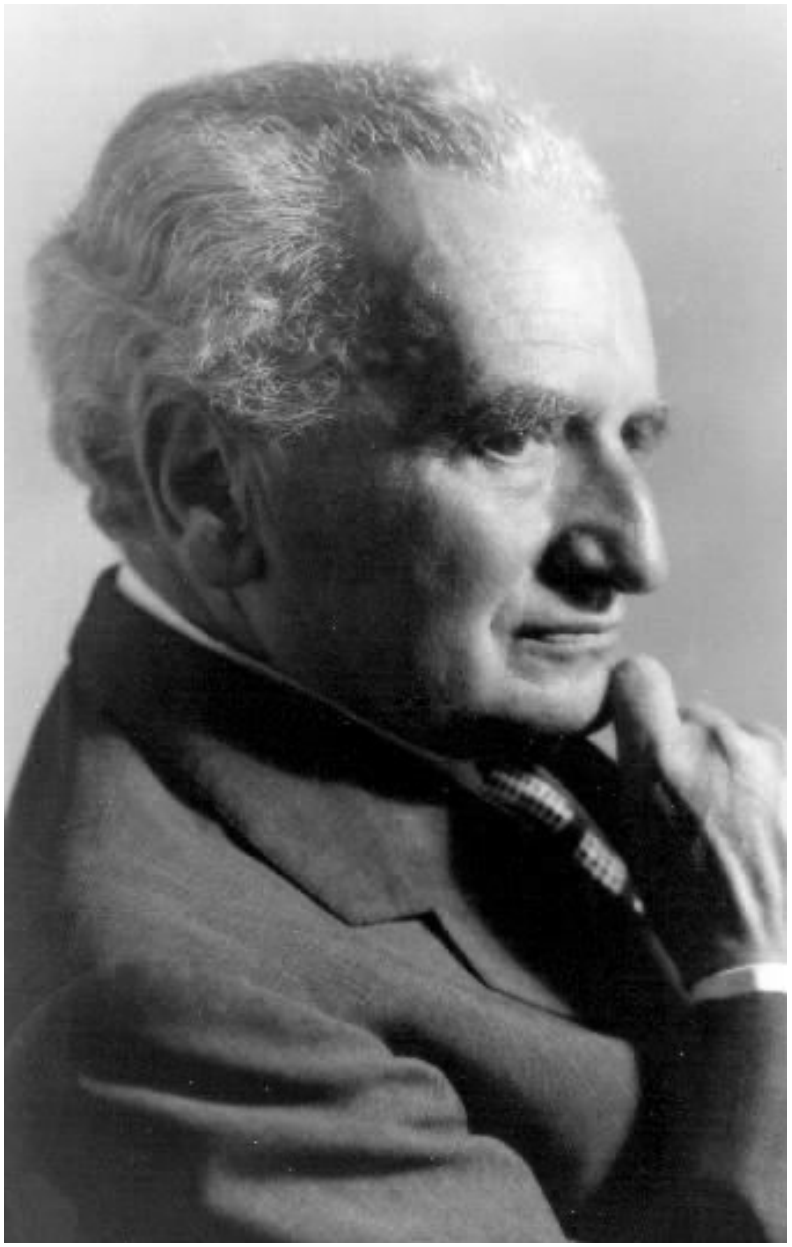
- Copper mining
- WWI seaplane pilot
- US Ambassador to Cuba 1929–33
- Served on NACA 1929–38
- Daniel Guggenheim Fund for Aeronautics

- In 1956, with von Kármán, had the idea of bringing together, at regular intervals, all the scientific bodies of the aeronautical world to discuss common problems “without regard to immediate military or political interest”.

ICAS founding fathers

Theodore von Kármán (1881–1963)

- Recruited from Europe 1930 to become Director Guggenheim Aeronautical Laboratory, Caltech
- Co-founder and director 1944 of Jet Propulsion Laboratory
- Proposer 1952 and Chairman of AGARD
- In 1958, at first ICAS congress in Madrid, presents first Daniel and Florence Guggenheim Lecture on “Some significant developments in aerodynamics since 1946”



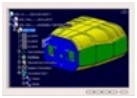
Acknowledgements

- **Innovair**
- My staff, students and collaborators over the years:
  - first in the **Aeronautical Research Institute of Sweden (FFA)**
  - then in the **Swedish Defence Research Agency (FOI)**
  - also in the **Royal Institute of Technology (KTH)**
- All the individuals I collaborated with in **AGARD, ASTM, ICAF, ACARE, EREA, GARTEUR, IFAR, EDA, ICAS,** and **CEAS**
- Funding from the **Armed Forces, Vinnova,** and the **European Union**

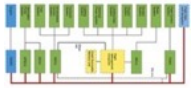

Aeronautical innovation in general

The field of aeronautics

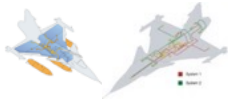
Aeronautical Engineering



Computer Systems



Vehicle Systems



Human-Machine Interaction

Autonomy & Decision Support

Maintenance Systems

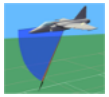
Weapons Integration

Systems Integration

- Systems of Systems Integration
- Decision support
- Operational Analysis
- Concept Design
- Overall Design and Architecture
- Survivability
- Safety & Reliability
- ILS, Availability and Maintainability

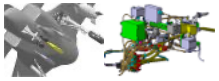
Tactical Systems

Flight Test and Verification



Structural Technology

Airframe Design



Production Systems

Support Systems and Simulators

Engine Systems

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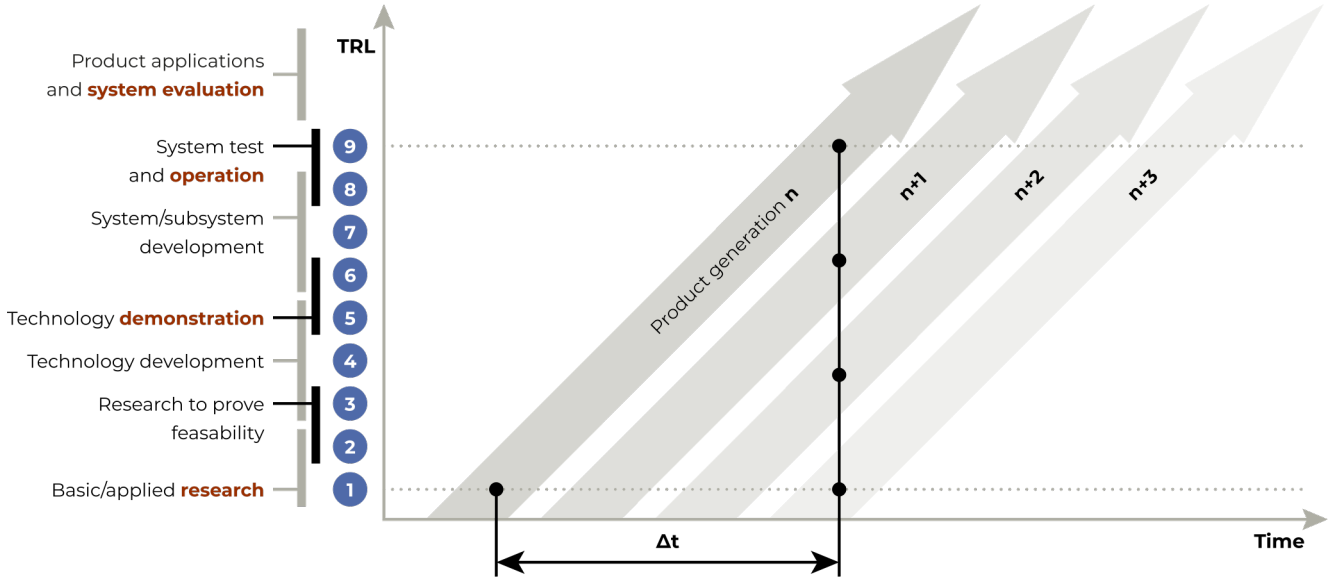
Unique R&I situation

- **Creating jobs/export** and developing the **transport system** is valid for all transport sectors
- **Two main reasons** for funding in aeronautics:
  - **Technology transfer** to other sectors
  - **Military aircraft** central component in **defence and security** doctrines
- **All nations want aeronautics** for these reasons
- Worldwide **competition** requires supportive **funding**
  –> problematic for **small countries**
- **80,000,000 road vehicles per year** vs
  25,000 commercial aircraft in total
- TRL 1–9 typically **15–30 years**
- Requires **long-term stability** in competence, training and funding

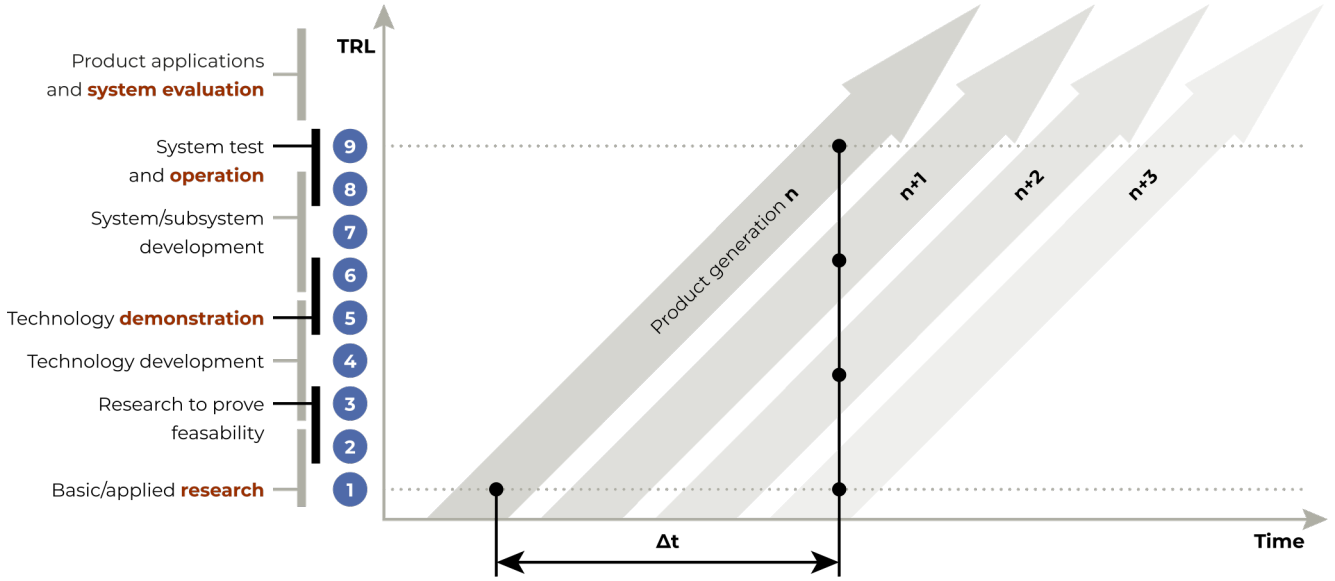
The slanted-wave principle for innovation



Short- and long-term thinking

- Activities at **all TRLs** at the same time
- Part of **forecasting** and R&T **investment decisions**
- Secure **future qualified workforce**

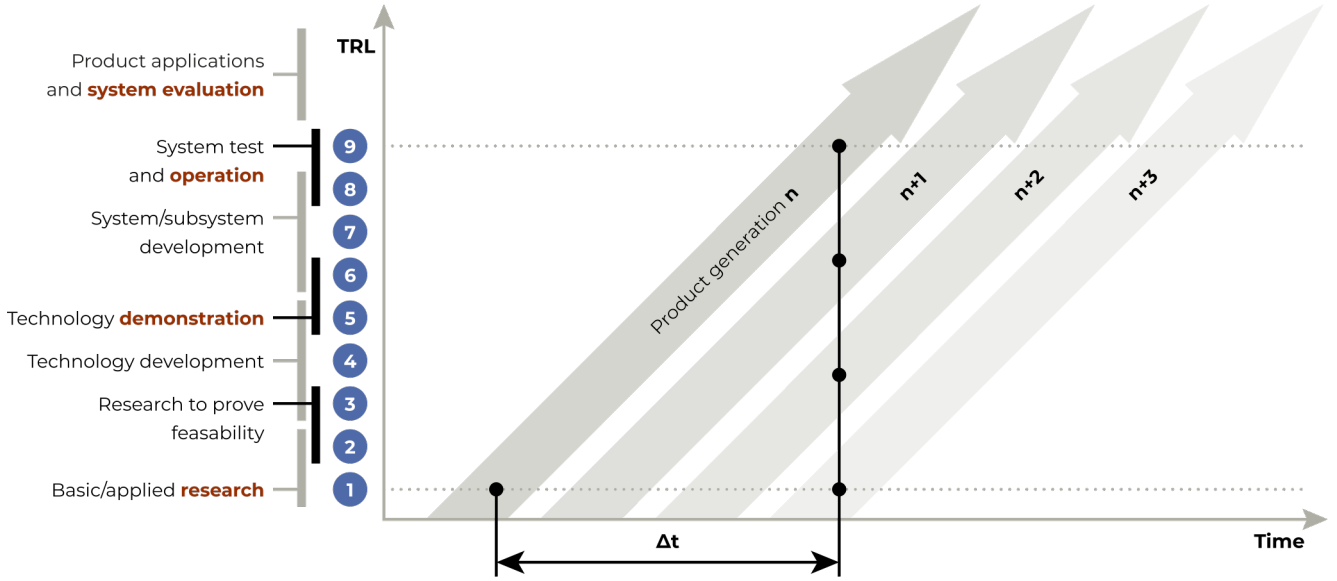
The slanted-wave principle for innovation



Use of demonstrators

- **Bridge the gap** between research and product development
- Sustain **systems-integration capability**
- Build **confidence and trust**

The slanted-wave principle for innovation



Understanding and collaboration

- When all actors **understand their position** in the innovation system, there is **no longer any conflict between basic and applied research**
- All actors are needed, but they must **collaborate in structured way,** as time for TRL 1–9 development is 15–30 years on system level


Aeronautical innovation in Sweden

Swedish Aeronautics

- **Unique strength** due to long-term political neutrality and decision for an independent military capability
- Success factors: **National Research Program in Aeronautics** (NFFP), various **demonstrator programs, Innovair**
- Challenges: to **remain competitive**

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Swedish aeronautics innovation in figures

- Industry in general:
  - **> 12,000 employees**
  - Total **turnover > 2.3 billion Euro per year** (objective 2050: 4 billion Euro per year)
  - **SME turnover > 50 million Euro per year** (objective 2050: 250 billion Euro per year)
  - **Export share ~ 70%** (objective 2050: 90%)

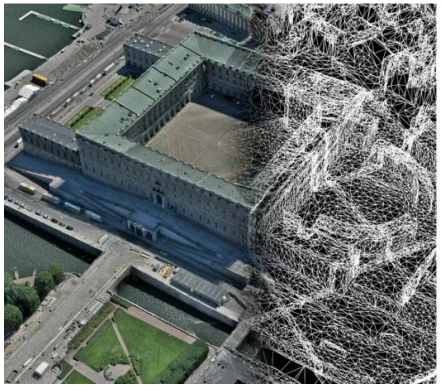
- **Swedish global position** depends on comparison base. In technical terms around **#5** to **#7**, and based on sales around **#23**
- This clarifies the challenges our actors face to **remain competitive**

Noteworthy historical accomplishments

- First **swept-wing fighter in Europe**
  – J29 Flying Barrel (1948)
- First Saab **supersonic aircraft**
  – J32 Lance (1952)
- Swedish Air Force **fourth largest in the world** (early 1950s)
- First **double-delta-wing aircraft**
  – J35 Dragon (1955)
- First **canard-wing fighter**
  – AJ37 Thunderbolt (1967)
- First **JAA/FAA jointly certified airliner**
  – Saab 340 (1984)
- First **fourth-generation fighter**
  – JAS39 Gripen (1988)

Technology transfer – examples

- **Production technologies**
- **Composites**
- **ICT**



3D mapping

Saab Tank Radar

Airbag systems

Mobile telephony

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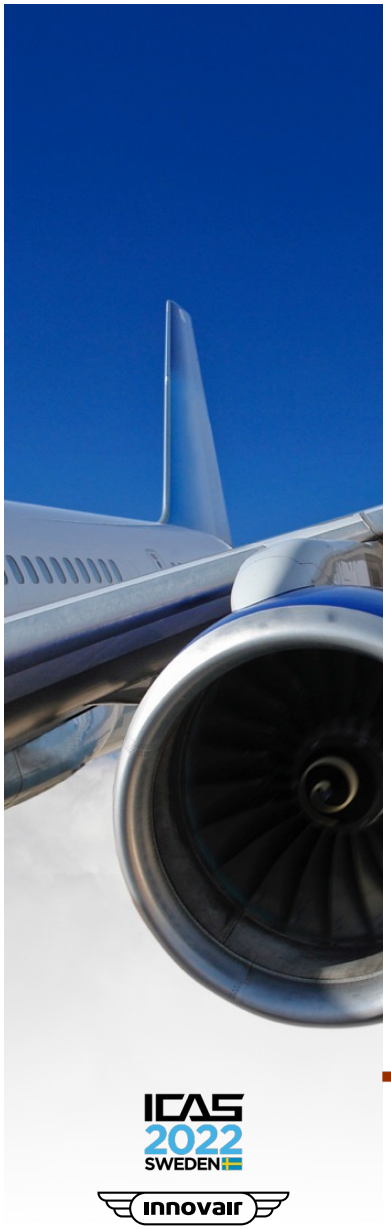
Coordination: **Innovair**

- **Strategic Innovation Programme** (one of initial six, today 17)
- Funded by **Ministry of Enterprise and Innovation** and **Ministry of Defence**
- **Small** program office**,** two full time equivalents
- **Coordinating the innovation area's stakeholders:**
  - Low–mid–high TRL (academy–institutes–industry)
  - Public sector and Armed Forces
  - Financial programmes (NFFP and demo programmes)
- Producing **National Research and Innovation Agendas** (NRIA Flyg)
- Managing international cooperation, both multilateral in **EU**, and bilateral (**Brazil, UK,** and **Germany**)
- Swedish representative in **ACARE General Assembly**
- Participating in **Team Sweden** for relevant countries



Coordination: **Innovair – history**

- 2009: **Consolidated innovation area** (strategic innovation agenda **NRA Flyg 2010**)
- 2012: **Model** for national investment in **SRIAs** followed by call for **strategic innovation programmes**
- 2013/2016/2020: **Updated Innovair strategic innovation agendas**
- **Consensus** about **strategic aeronautics innovation** in Sweden
- **Consensus** about **roles, tasks and responsibilities:**
  - academy/institutes/industry/public
  - civil/military
  - nationally/internationally
- Facilitation of **dual/triple/multi use**

Coordination: **Innovair – main goals**

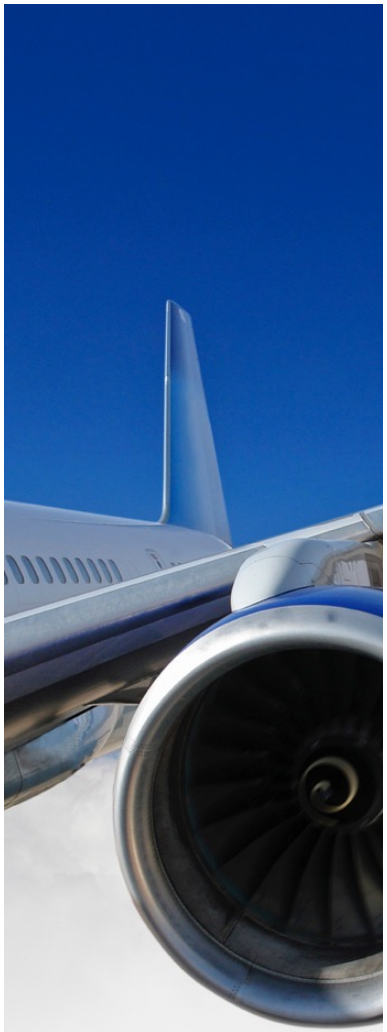
Ultimate goals for the programme:

- **National growth and export within aeronautics** and (via technology transfer) within other areas
- Fulfilment of **ACARE's Flight Path 2050 goals** with the help of aeronautics technology developed in Sweden
- Strengthened **Swedish defence capabilities**

All in conjunctions with relevant parts of the **United Nations' Sustainability Development Goals**

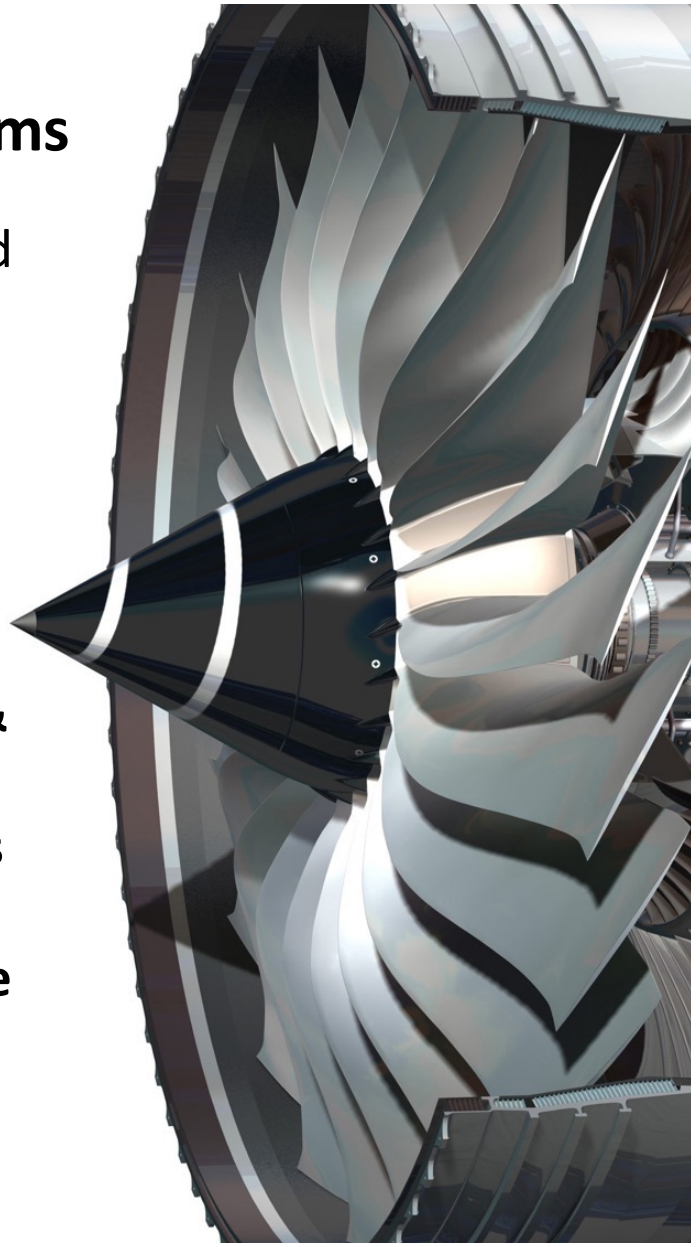
Industry: **Saab Aeronautics**

- **Radar/sensor/AEW/C4ISR** systems
- **ATM** and **remote-tower** solutions
- **Advanced airborne systems/subsystems, UAS, aerostructures,** and **services**
- **Gripen fighter aircraft**
- **340/2000** civil commuter aircraft
- Boeing-Saab **T7 Red Hawk** – new trainer for the US Air Force
- **Tier-1 supplier of aerostructures** to both Airbus and Boeing
- Main partner in the European **Clean Sky** programme
- Lead company **EDA MIDCAS**



Industry: **GKN Aerospace Engine Systems**

- Components for **aircraft/rocket engines** and **gas turbines**
- Independent **tier-1 supplier** to the global aviation industry
- Product support to **RM12** engine for Gripen
- Delivery of turbo pumps and nozzle exhaust to **Ariane 5 and 6**
- Deliveries for **General Electric Genx, Pratt & Whitney PW1000G, Rolls-Royce Trent XWB**
- GKN parts in **90% of all civil aircraft engines**
- Focus on **design, lightweight structures, advanced manufacturing,** and **maintenance**



Industry: **Aerospace Cluster Sweden (ACS)**

- National **industrial cluster to increase business** in the aviation and space arena
- Focus on **small and medium-sized enterprises (SMEs)** in collaboration with larger companies
- Some **50 companies**
- Three nodes:
  - **Western node** (around GKN Aerospace)
  - **Eastern node** (around Saab Aeronautics)
  - **Northern node** (around Swedish Space Corporation)
- Financed by **industry, public actors, governmental actors** (with upscaling of **EU funding**)

AEROSPACE
CLUSTER
SWEDEN

Industry: **Prioritised technology clusters**

Saab Aeronautics

- Conceptual and SoS methods
- Cooperating systems
- Aeronautical Engineering
- Avionic platform technology
- HMI and decision support
- Sensors – system and functions
- Operation and maintenance
- Structures and manufacturing technology

GKN Aerospace

- Propulsion Systems
- Turbomachinery
- Lifing methods
- Value-driven development
- Metallic materials
- Manufacturing systems and processes
- Composites in aeroengines

- All coordinated by **industrial cluster leaders**

Academy: **Swedish Aerospace Research Centre (SARC)**

- Created and financed by **Innovair**
- **Structuring academic research and education** and tying it to **industry's needs** in collaboration with **cluster leaders**
- Four main players:
  - **Linköping University** (Linköping, current management)
  - **Chalmers** (Gothenburg)
  - **Royal Institute of Technology** (Stockholm)
  - **Luleå Technical University** (Luleå)

  But open for all
- Technology areas **in sync with strategy** and industry

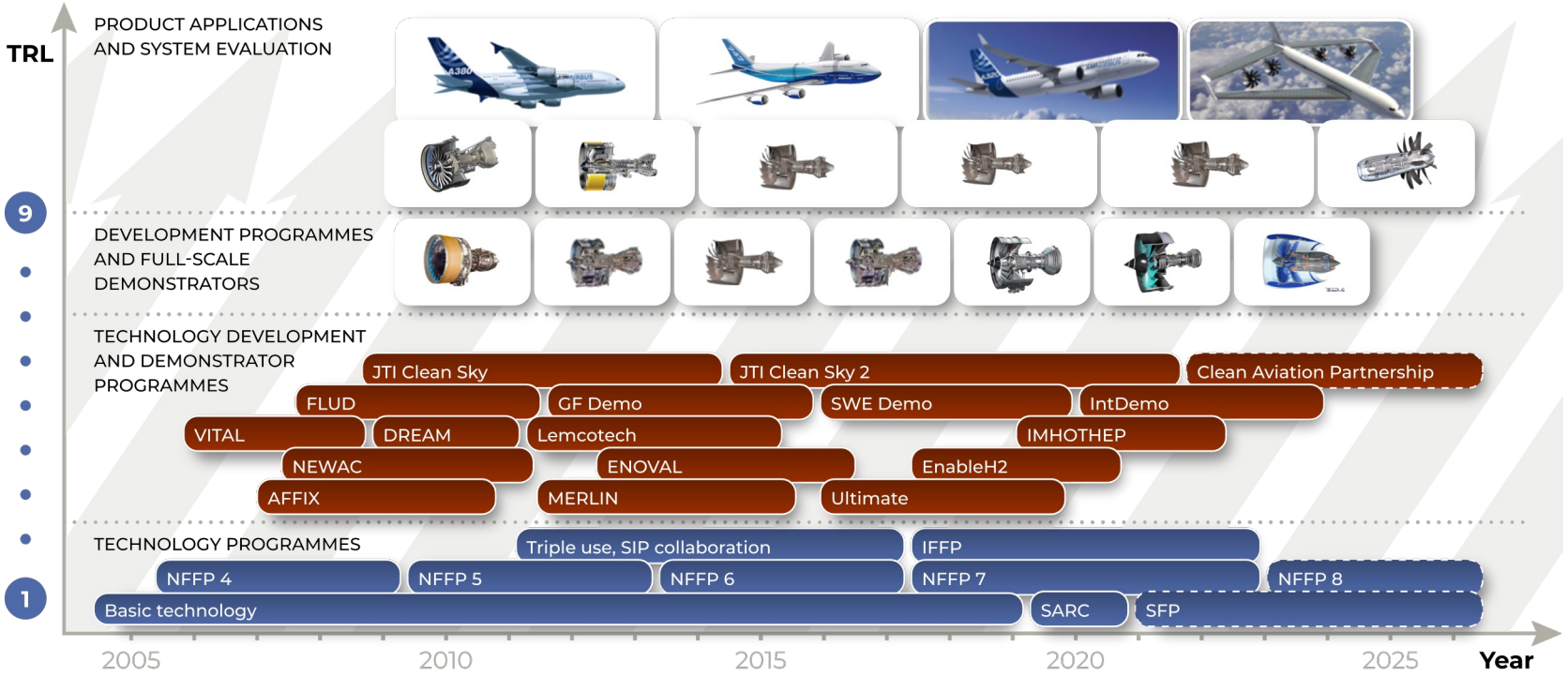
Institutes: **RISE, FOI, VTI**

- **RISE** – Research Institutes of Sweden
  - Main civil institute with broad activities in aeronautics
  - Main funding from Innovair in advanced materials and production
  - Remains to focus activities to obtain critical mass in competence and infrastructure for industrial cooperation

- **FOI** – Swedish Defence Research Agency
  - Main military institute
  - New focus on systems evaluation rather than independent technical research
  - Requires strong cooperation with academia for technical input

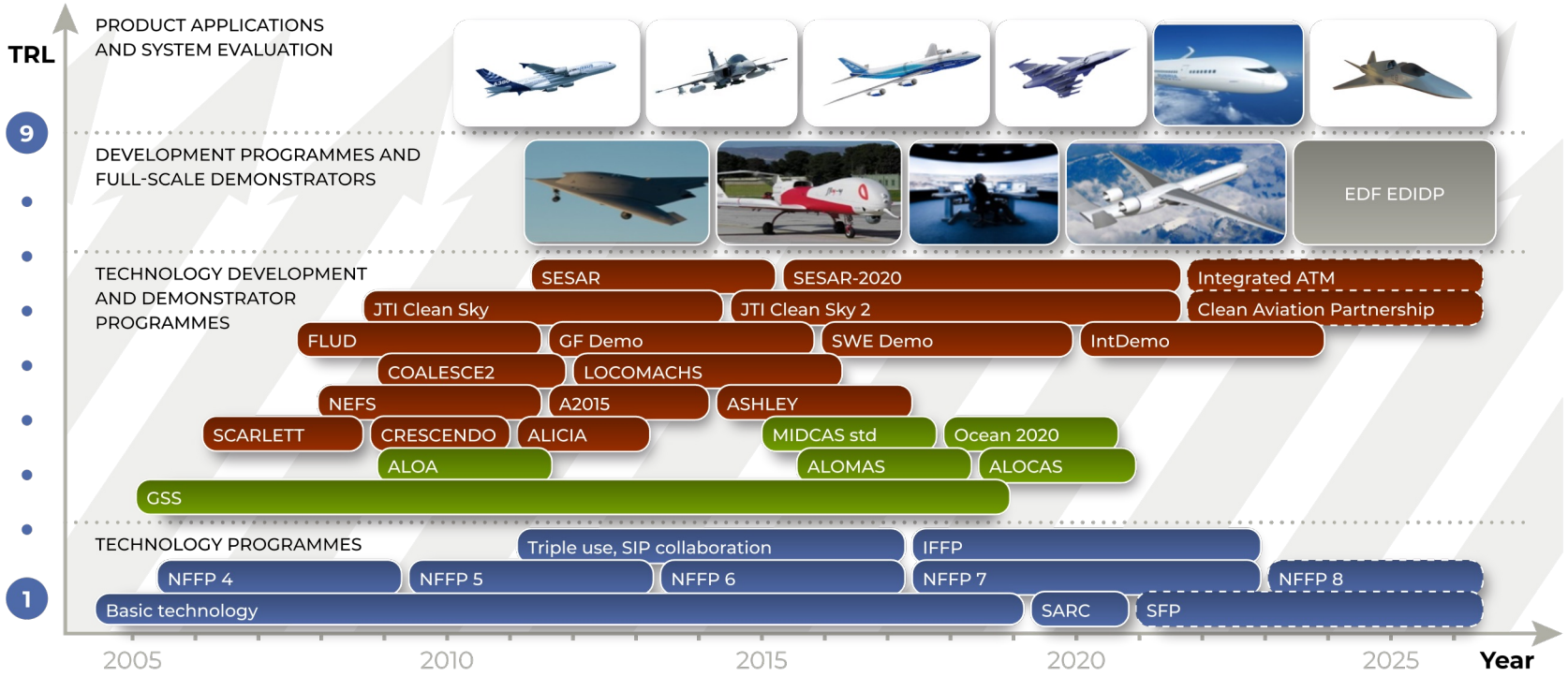
- **VTI** – Swedish National Road and Transport Research Institute
  - Recently increasing activities in aviation

The slanted-wave principle – GKN Aerospace



- NFFP (TRL 1–3) followed by FP (TRL 2–4) and national demo programmes (TRL 5) and Clean Sky/Aviation (TRL 6) due to costs involved
- Partnership foundation with OEMs for future industrial programmes

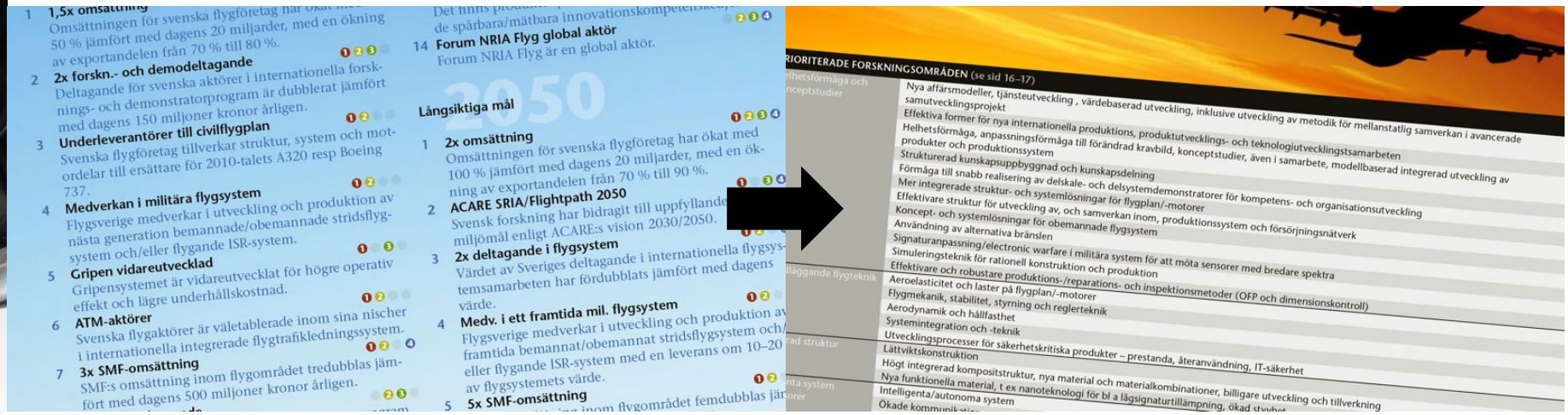
The slanted-wave principle – Saab Aeronautics



- Same baseline logic as for GKN
- However, higher system level requires different supply chain

Strategic innovation agendas – NRIA Flyg

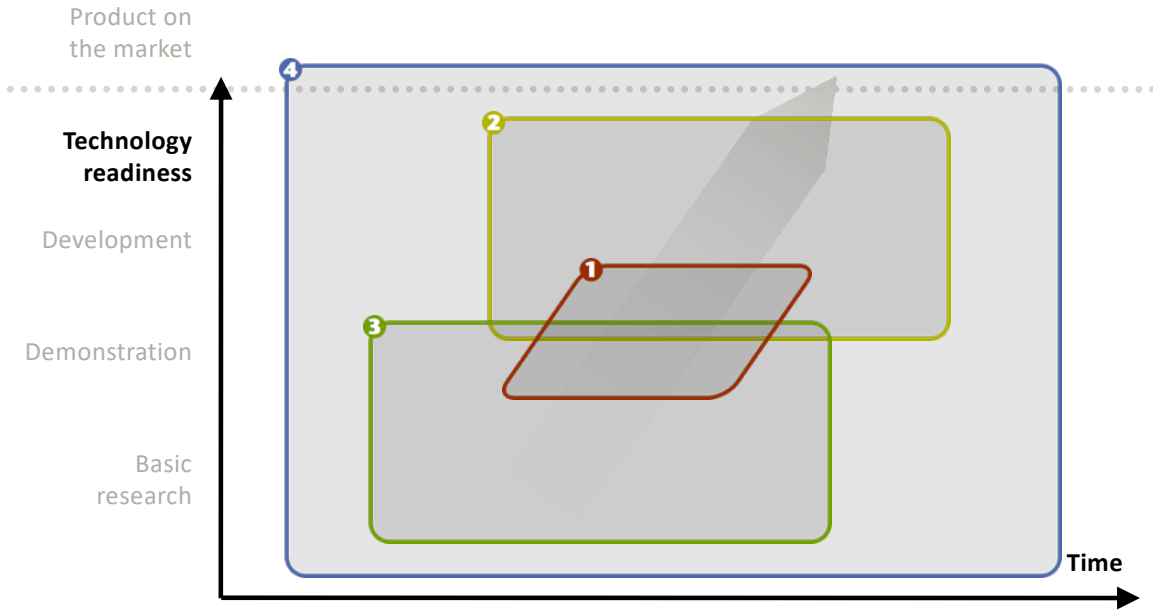
- Directing Innovair's activities – **produced by Innovair's actors in collaboration**
- Published every three/four years since 2010
- Formulating **long-term strategic goals with** high permanence …
- … and **short-term goals** that are continously updated …
- … **prioritising technologies** to fit the strategy



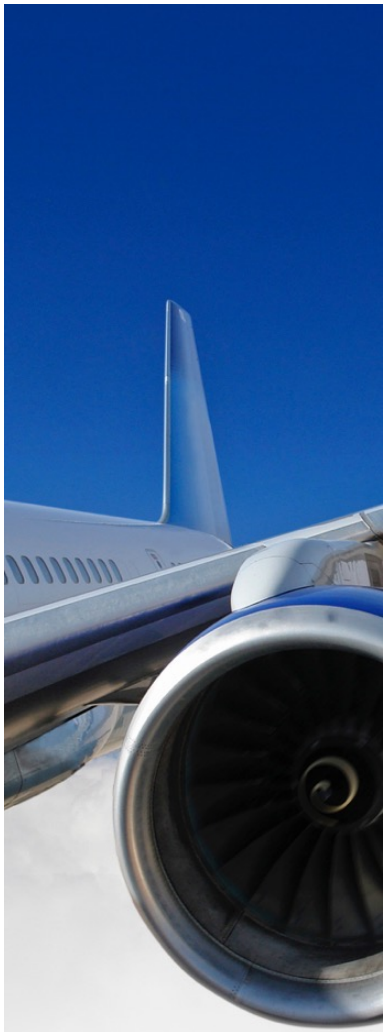
Summary of strategic innovation agendas

- **NRA Flyg 2010** focussed on **what** we wanted to do
- **NRIA Flyg 2013** described **how** we would achieve this
- **NRIA Flyg 2016** focussed on a **delta analysis** of what both we and others had done since 2010 and how this influenced our **tactics** to reach **strategic** goals
- **NRIA Flyg 2020** was a summary of **activities and results** for half-time evaluation and also remaining **challenges and recommendations** as input to the R&I bill

Example of strategic modelling (NRIA Flyg 2013)



- Focus on demonstrators to create continuity across “Valley of Death”
- Secure the best possible conditions for domestic production
- Integrate academia through strengthened networks
- Obtain consensus and governance (by what became Innovair)



Cooperation – different dimensions

1. **Within the innovation system** for aeronautics:
   - Academy
   - Institutes
   - Industry
   - Public sector
   - Finance
2. **Between civil and military** (including space)
3. **With other innovation areas** (transport, industrial development, …) and **other strategic innovation programmes**
4. **Internationally**

Internationalisation

Multinational:

- EU (Clean Sky, SESAR)
- Framework Programmes
- EDA (MIDCAS)
- European Defence Fund
- nEUROn
- ACARE (EREA, ASD, EASN, …)
- GARTEUR
- IFAR

Bilateral:

- Brazil
- UK
- Germany

Internationalisation: Brazil

- Prioritised country for the **Government export strategy**
- **Swedish export since 1890s** with continuous presence in Brazil
- Present industries have some **70.000 employees** in 220 companies
- 2014 – Saab wins **Gripen contract**
- 2015 – **Minister Damberg delegation to Brazil.** Innovair tasked in setting up first **High Level Group (HLG)** meeting during President Rouseffs visit to Sweden
- The 30 year+ use of Gripen is used as **catalyst to enhance innovation cooperation** also in other technical areas. Swedish-Brazilian Research and Innovation Centre (**CISB**)
- 2015 – Swedish endowed **professors from present SARC at ITA** established. **BARInet** later established with SARC as model
- 2015 until now – **HLG held annually** rotating between the countries, **joint bilateral technical calls, air-domain studies, workshops** etc

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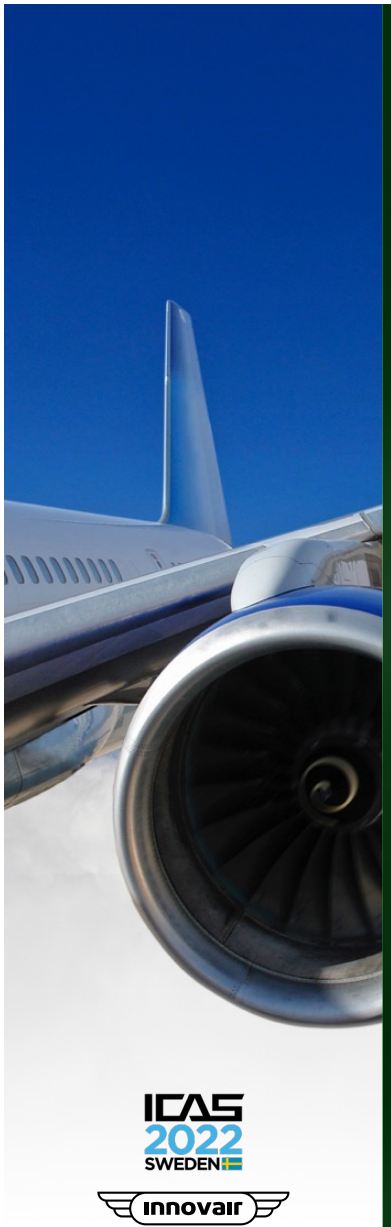

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Examples of joint projects with Brazil

- Hardware and Software Dependencies in Multi-Core Avionic Systems
- Early analysis of performance for future avionics platform
- PILOT – Platform-Independent Level of Testing
- Conceptual Aircraft Design LABoratory
- Efficient Performance Based Air Vehicle Maintenance
- Investigation and modelling of time variable aerodynamic effects on aircraft controllability (UMTAPS)
- Methods for sub-scaled demonstrator and control law testing
- Human Factors Lab for Future Air Systems
- Pre Laminar Flow Design
- Digital Hydraulic Actuator for Flight Control
- Flexible Automation for Cost Effective Aircraft Manufacturing
- Air Domain Study
- Planning virtual UAS IRS joint demonstrator

… and many more

Some achieved results: Brazil

Saab contract

- Plant in Gavião Peixoto for **manufacturing of Gripen**
- **Training** of hundreds of **engineers** in Linköping
- **Technology transfer** as per contract
- **Flight training** of all Gripen pilots in FOI/Air Force simulators

Innovair and SARC

- Over **400 applications** for joint research projects
- Some **70 projects** approved and funded jointly
- At least **26 universities** involved
- At least **25 sandwich doctorates** achieved
- Some **30 postdocs** involved

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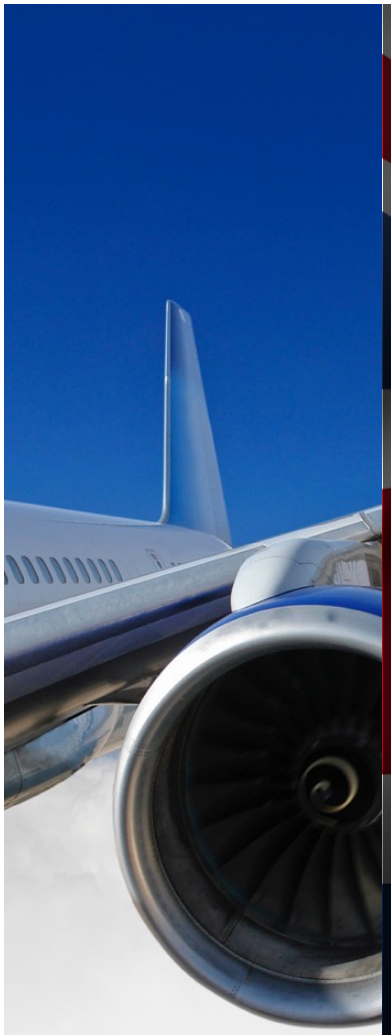

Internationalisation: UK

- **Leading country in aeronautics,** OEMs in both aircraft and engines
- **Long tradition of bilateral cooperation** (Airbus–Saab, Rolls-Royce–GKN)
- GKN mother company for GKN Aerospace Sweden (previously Volvo Aero)
- **ATI** (civil aeronautics only) **established** with some **3.9 B£** for 13 years
- **Bilateral delegation visits,** both regarding academia, institutes, and industries
- 2018 – **joint bilateral call** for civil aviation technologies within the **Eureka** mechanism
- 2019 – **MoU signed** for joint technology development for **FCAS**
- **Strong trade** between the countries

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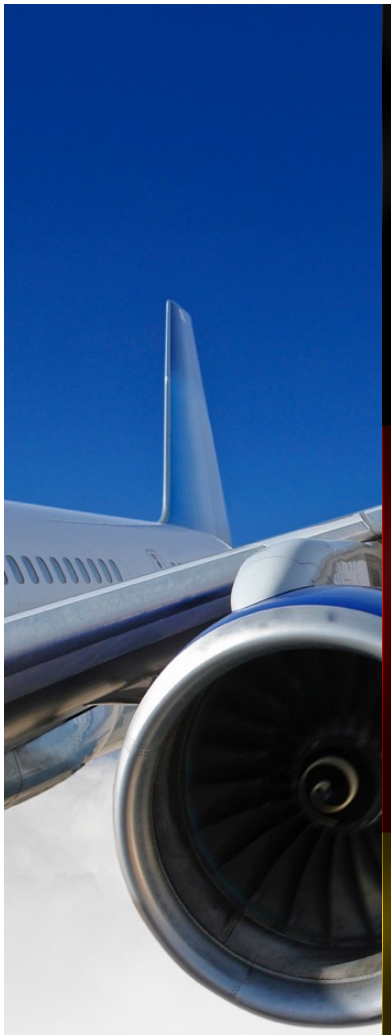

Internationalisation: Germany

- 2017 – **Innovair visit to BMWI** (Bundesministerium für Wirtschaft und Energie)
- **BMWI participants,** including head of aviation and responsibles for LuFo (Luftfahrtforschungsprogramm) which is Europe's largest national programme for aviation research
- **Agreement** for need for **bilateral cooperation** as addition to European programmes
- **Joint bilateral projects** with Innovair – LuFo funding
- **Good contacts with industries** and DLR on both management and research levels

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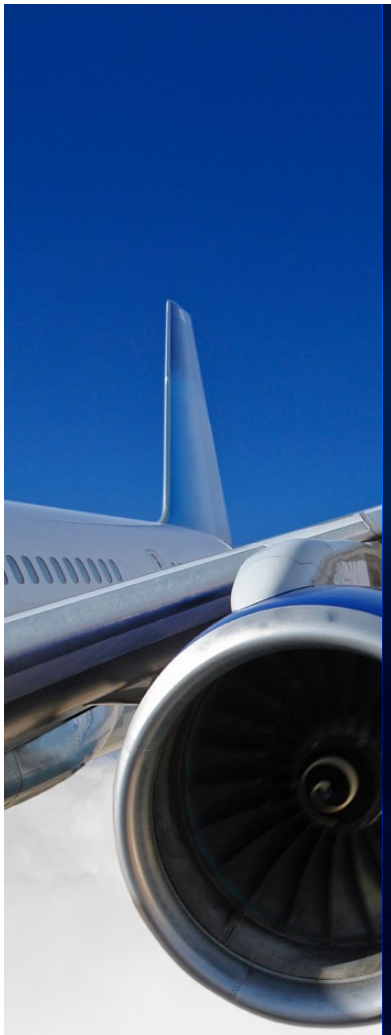

Internationalisation: EU and global

- Swedish aeronautics well positioned in the **Framework Programmes, Clean Sky/Aviation, SESAR,** and **Horizon Europe**
- Saab and GKN develop **sustainable technology** for next generation aircraft and engines
- Sweden has led work on **remote ATM technology** and **green landings**
- We also work on **noise issues** and **alternative jet fuels**
- **Regional agreements** between two regions and Clean Sky/Aviation
- Active participation in **EDA** and **EDF, NATO STO (**and **AGARD & RTO** since early ‘80s)
- With increased funding we want to **expand existing contacts with France and USA** into structured bilateral cooperation

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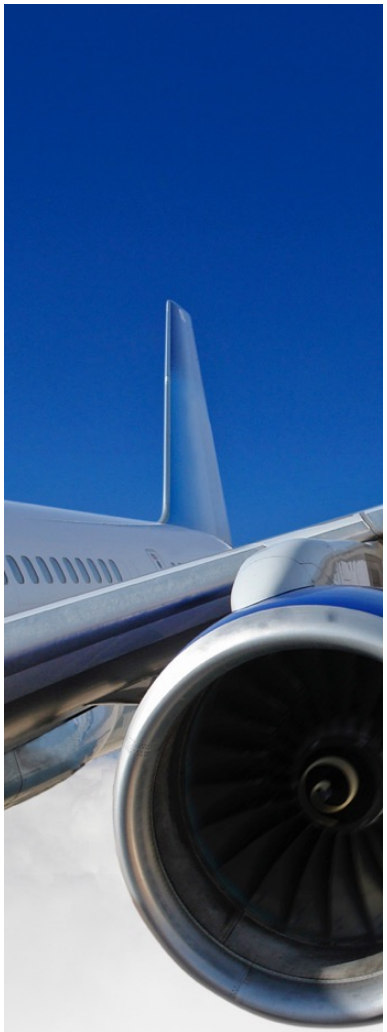

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Innovair: main results 2010–2022

- Strategic agenda (**NRIA Flyg**)
- Prioritised **technology areas and clusters**
- **Funding programmes** in place (research and demonstration)
- Academic network (**SARC**)
- Aerospace Cluster Sweden (**ACS**) with three nodes
- **SME Aeronautics** network
- Two **arenas for advanced manufacturing**
- Conditions for **triple/multi use**
- Conditions for **international collaboration**
- Official **bilateral collaboration**
- **MoU** between Swedish regions and Clean Sky
- **Coherent innovation system** in place

- **–> National growth and export, environmental gains, defence**

Communication and influence

- **Strategic innovation agenda** every 3–4 years
- **Newsletter** 3–4 times annually
- **Showcases** with important results and functions within Innovair
  - Product/service/system
  - Process/method
  - Actor/organisation/infrastructure
  - Instrumentation/finance
  - Science
- **Social Media**

Apart from specific results – show well-structured and proven **innovation** mechanisms (including technology transfer)

Challenges

- Divided and unclear **funding** (Science Council and Vinnova)
- Lack of national funding for **research, tests and demonstration** compared to competing nations
- Lack of **aeronautics funding** to match EU calls. Particular problem for institutes with large indirect costs for infrastructure
- **Military capability** effects on system level needs academic input to FOI models and simulations
- **Military demonstrator** programmes needed
- Need for **civil system-evaluation capability** similar to FOI work for Air Force
- Need for **interdepartmental collaboration** in government, in order to achieve best overall decisions for the country


Aeronautical innovation in Europe

European aeronautics innovation in figures

- **EU**
  - Over 400,000 employees
  - **130 B€ revenue**
  - **109 B€ export**
- **Horizon Europe** (2021–2027) collaborative **aviation research 330 M€**
- **Clean Aviation –** total public/private around **4 B€**
- **SESAR –** total public/private around **1,8 B€**
- **European Defence Fund (EDF)** aeronautical related call 2022 **80 M€**

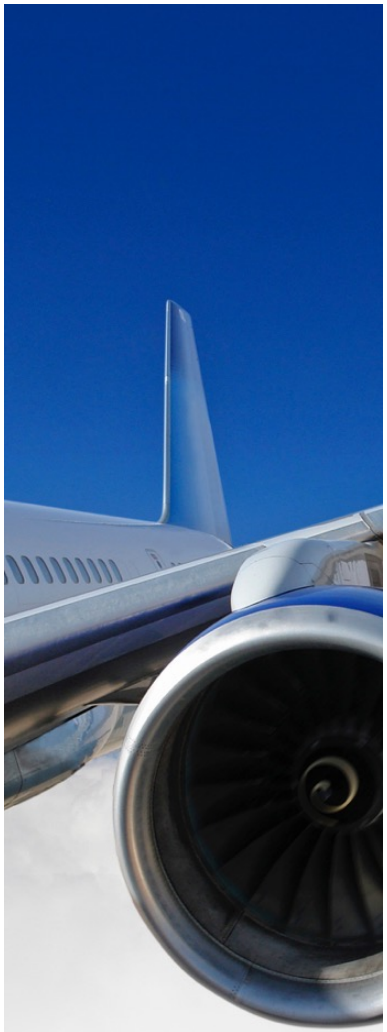
- **UK**
  - 85,000 employees

- Also **Turkey** and **Russia** partly European

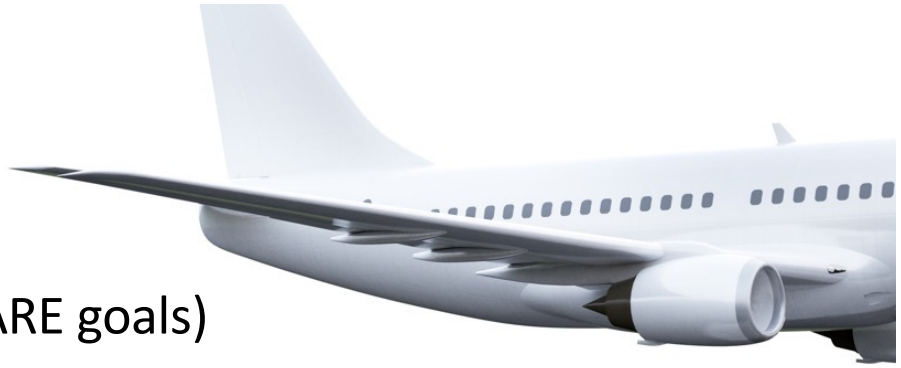
ACARE

- Some **350 individual members** and **50 organisations**
- Industry: aeronautics, space, defence, and security industries (**ASD**)
  - Leonardo (IT)
  - Airbus (FR, DE, UK, ES)
  - Safran (FR)
  - Thales (FR)
  - Rolls-Royce (UK)
  - Dassault (FR)
- Academy/research: **15,000 researchers** in 28 European countries
- **Strategic research-and-innovation agenda** (SRIA)
- **European Aeronautics Science Network** (EASN)
- **Association of European Research Establishments in Aeronautics** (EREA) – 14 countries
- Also includes airports, airlines, maintenance/services, member states

ACARE



Civil aeronautics



- Joint Technology Initiatives (JTIs)
  - **Clean Sky/Clean Aviation** (ACARE goals)
  - **SESAR**
- **Decreased FP funding** at **low TRL** (slanted wave)
- Political aim: **"all" countries take part**
- Yet, **only a few needed** for technical reasons
- However, **letting other countries into the supply chain** lays the foundation for **future political and member countries support**
- **Technology transfer** will also aid such countries to build up competitive technology **in other sectors**

- Present strong **European focus** on emission reductions clearly leaning to **hydrogen**
- This contrasts present **US focus** on **SAF**

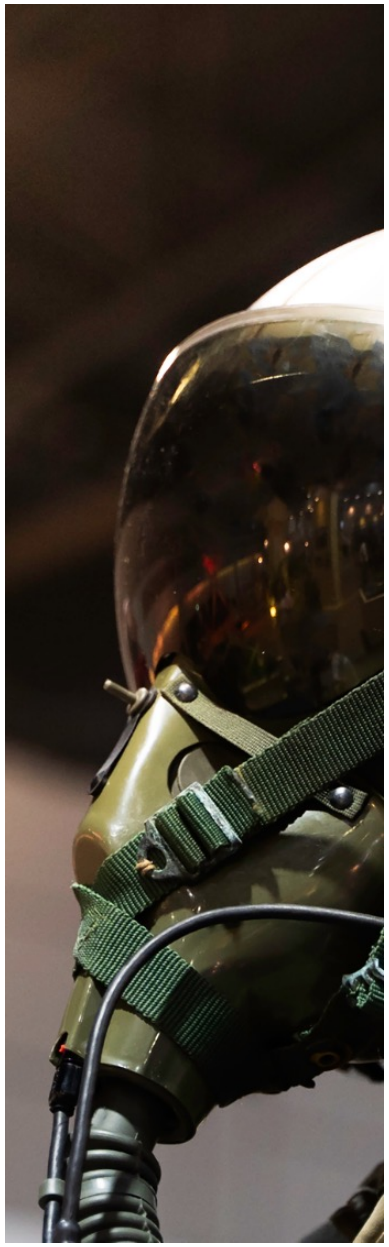
Military aeronautics

- **EDA, ETAP** long time existing, but only with **new EDF** will Europe get an **important joint funding** for **military** activities including **aeronautics**
- **Dual use** critical to keep competitiveness in a competitive world
- Also, **hard to find funding** for all current research and innovation **unless both civil and military aspects** are considered
- Renewed **industrial structure** needed, in terms of mergers or otherwise
- However, **European defence industry is strong** but European defence is not
- Need for European defence both for **future procurement** and for defining **future capability requirements**

Current war and security considerations

- With current **Ukraine war** Europe has changed its directions:
  - **Germany** will radically build up its **defence sector**
  - **Sweden** and **Finland** want to join **NATO**
  - Current **US** administration focuses on **Russian aggression**
  - More **NATO troops** to eastern Europe

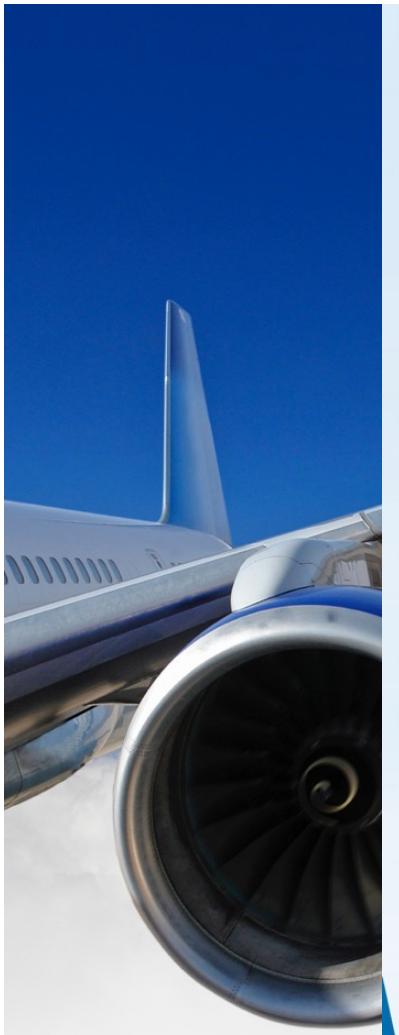
- After this war, or with another US administration, **US focus will be on Asia**
- Population in **sub-Saharan Africa will multiply** in next decades
- These aspects motivate **much stronger European defence** and **stronger FRONTEX** for border control




Global aeronautical innovation

Globalisation

- **Globalisation** has a central role
- Positive side: **less poverty**
- Negative side: **delicate supply chains** …
  - … means **western reindustrialisation** …
  - … leaving Asia in **fossil dependence**
  - Also **nationalism** has resulted
- Current world situation **very difficult,** similar to that in 1956–58 when ICAS was founded
- **Globalisation may slow down** but will eventually grow again
- The world wide web and the **physical equivalence, aeronautics,** have made the **world smaller**
- Travelling will **continue to expand** as more people can afford this
- The West needs to **export innovative solutions**



CLEAN AVIATION'S JOURNEY TO CLIMATE NEUTRALITY BY 2050

TODAY, THE AVIATION INDUSTRY GENERATES

87.7M JOBS

2.8% OF GLOBAL CO_2

BY 2050:
DEMAND FOR FLIGHTS x3

IF NO ACTION IS TAKEN:
EMISSIONS x2

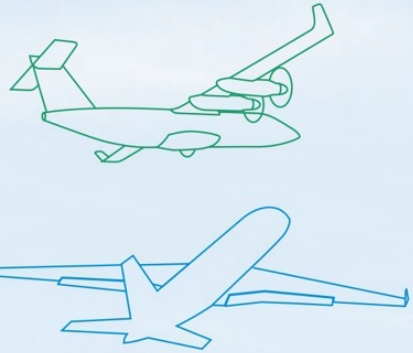
CONTEXT

TARGETS

SOLUTIONS

OPPORTUNITY

INVESTMENT



30-50% IMPROVED ENERGY EFFICIENCY THROUGH TECHNOLOGY

100% NET GREENHOUSE GAS EMISSION REDUCTION THROUGH TECHNOLOGY, H2, SAF & OPERATIONAL MEASURES

€1.7B PLEDGED THROUGH HORIZON EUROPE

€2.4B VIA EUROPE'S AERO INDUSTRY

= €4.1B TOTAL INVESTMENT

KEY IMPACTFUL TECHNOLOGIES

FOR FLIGHTS OF LESS THAN 4000 KM

1. (HYBRID) ELECTRIC REGIONAL AIRCRAFT
2. ULTRA EFFICIENT SHORT/MEDIUM RANGE AIRCRAFT
3. HYDROGEN-POWERED AIRCRAFT

REPLACING OVER 40,000 AEROPLANES BETWEEN 2035-2050

= €5 TRILLION IN ECONOMIC VALUE

BRINGING TOGETHER THE WHOLE EU AERONAUTICS SECTOR

CLEAN AVIATION

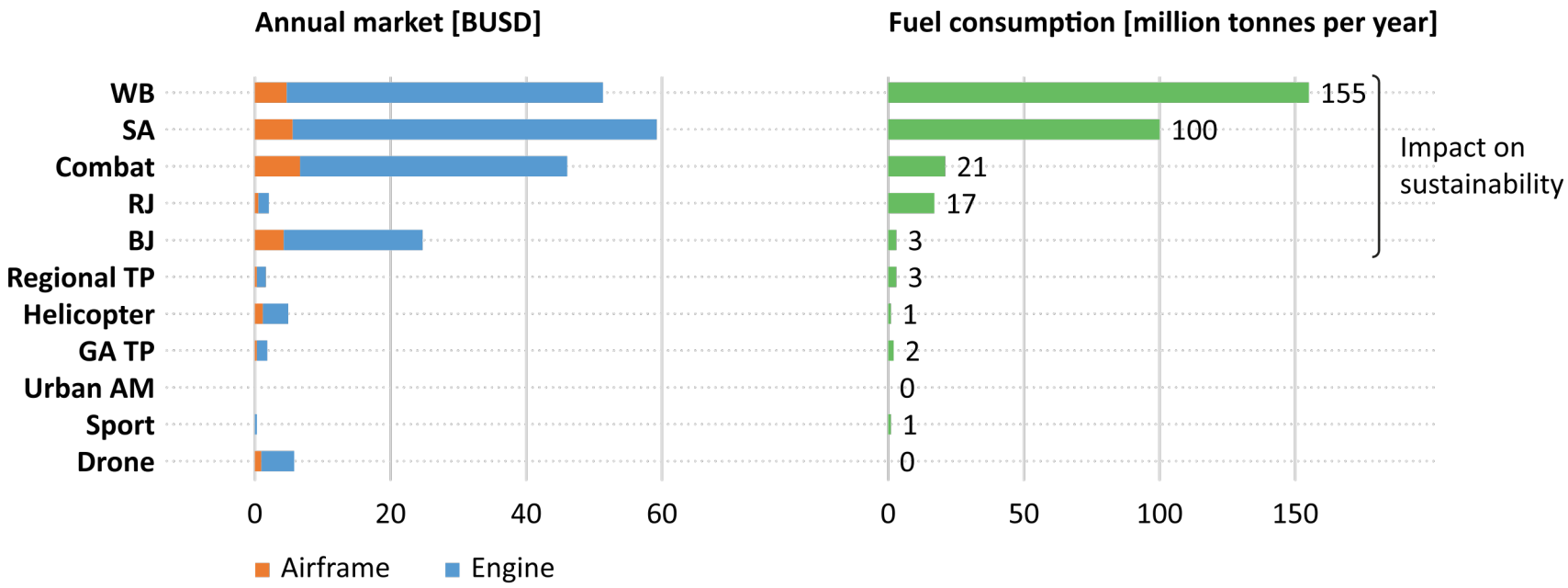
www.clean-aviation.eu

EUROPEAN PARTNERSHIP Co-funded by the European Union

ICAS 2022 SWEDEN

innovair

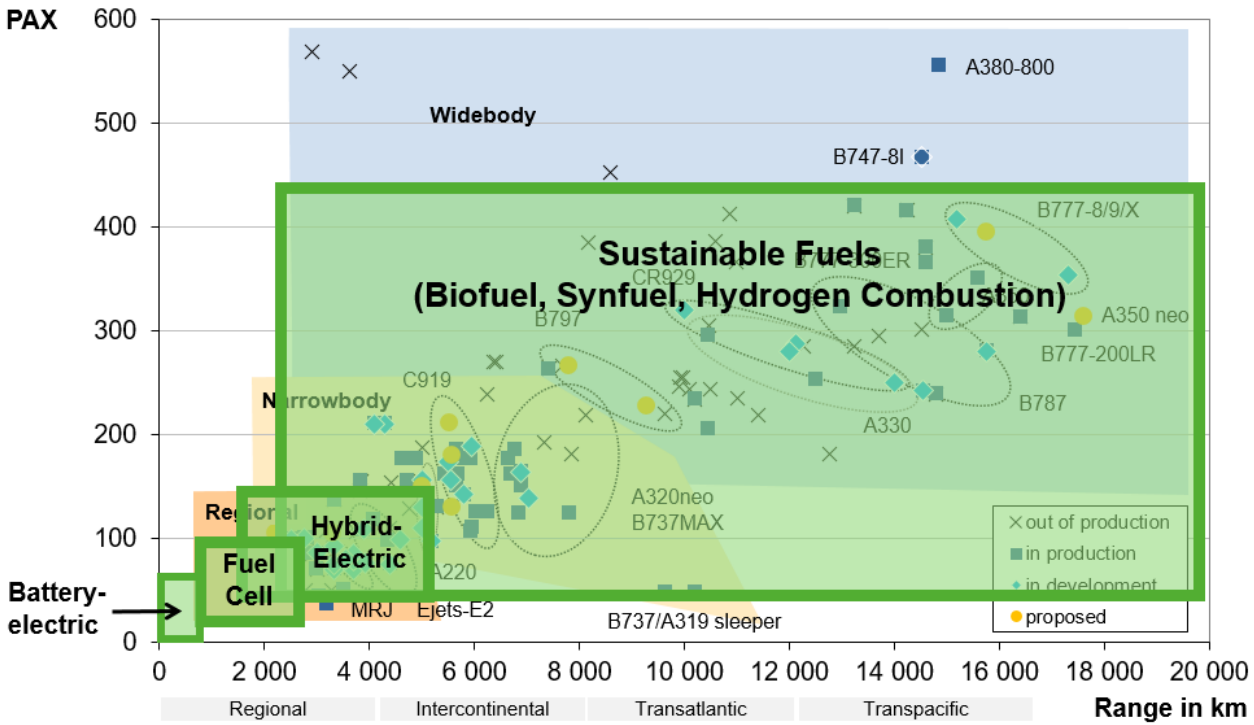
Aviation market and its emissions



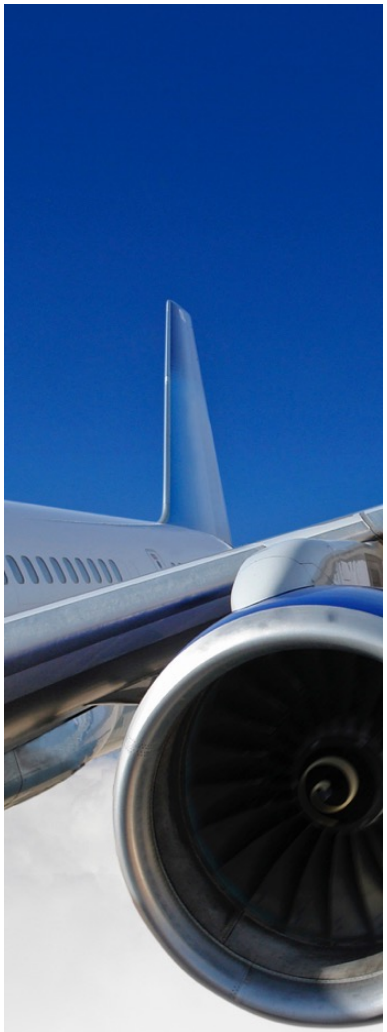
WB Wide-body (200–600 seats)
SA Single aisle (100–250 seats)
RJ Regional jet (30–120 seats)
BJ Business jet (4–30 seats)

TP Turboprop (10–80 seats)
GA TP General aviation turboprop (1–10 seats)
Urban AM Urban air mobility (1–8 seats)
Sport Piston engine (1–8 seats)
Drone Unmanned aircraft (0 seats)

Solutions supporting sustainable aviation (by 2050)



Gas turbine technology remains dominant for long-term sustainable WB and SA solutions



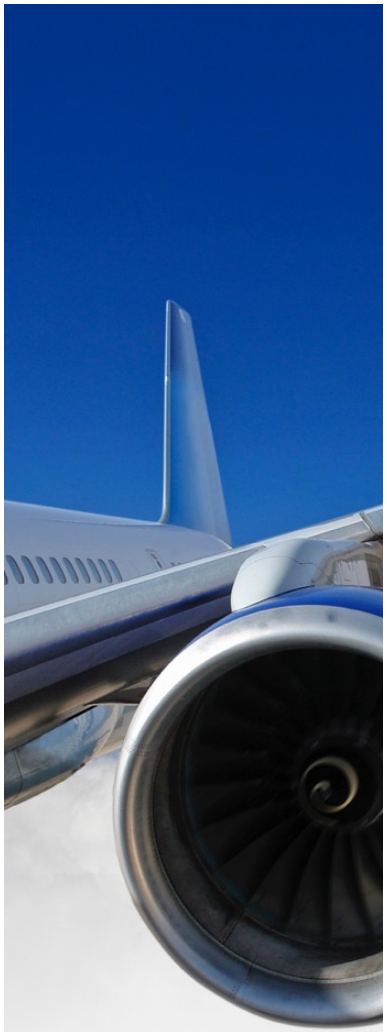
Global civil aeronautics in the future

- Solution: **efficient innovation** – especially at **system levels**
- Focus on spending innovation on **most promising technologies** (hydrogen and sustainable aviation fuel)
- Exported environmental problem needs **exported solutions.** Problem **not in Sweden nor in Europe.** Example: if all 11 million Swedes disappear, with over 80 million people added to world population annually, the positive effect lasts only a few months.
- **New technology trends**
  - Decreased emissions
  - Urban air mobility

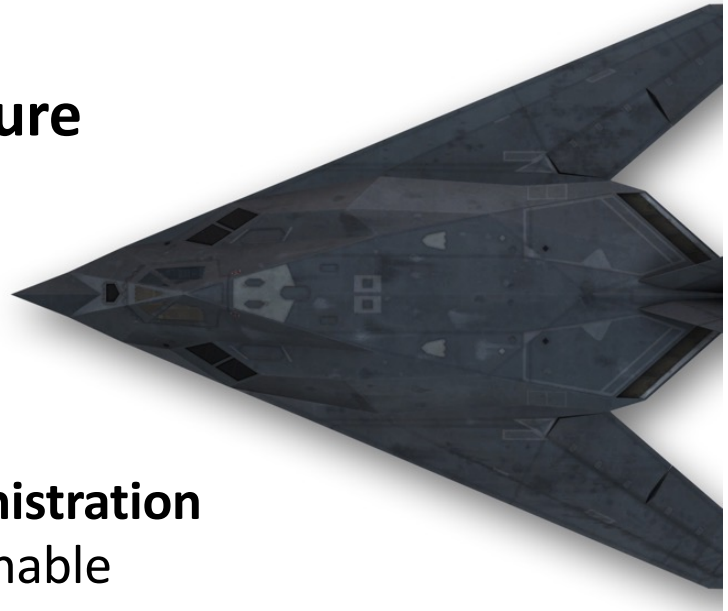
Dual-use challenges in the future

- **Cyber security, AI, autonomy, new manufacturing, reduced costs**
- **Experimental activities** need to be strengthened at universities and institutes
- Two different innovation systems
  - **Platforms**
  - **Digital systems**
- This puts strong requirements on **very stable platform technology** for long life times, otherwise update of digital systems useless
- MDO and virtual design develop fast. Yet, many involved **lack design and certification experience**

- Focus on new technologies might **drain resources from traditional technologies**
- **Few** new **projects** make **competence transfer** from one generation to next **difficult**



Global military aeronautics in the future



- **USA will dominate** for decades
- **Europe**
  - Renew **industrial structure**
  - Increase **armed forces**
  - Anticipate effects of another **US administration**
- **Russia** – present war not financially sustainable
- **New military players** – **China** most obvious contender. **South Korea, Turkey, Japan** aiming for national FCAS activities

- Need for **competence** and **critical mass**
- Need for **dual use**
- Need for **broken cost curves**
- **Loyal wingmen** and **swarms of micro-UAVs** to **block air-defence and radar systems**

Challenges for our community

Political influence

- Secure **strategic activities and funding**
- Help politicians understand how **supply chains can build welfare** through technology transfer
- Explain where **funding is best used** to achieve effects on environment
- Explain complex issues like **effects on global environment** if supply chains are withdrawn more close to ”home”

New defence and security global situation

Competition for competence

- New fields are ”trendy” and well paid – **other motivation** needed

Gender issue

- **Role models** needed
- All actors need to show that careers in our field are **not gender specific**


Thank you for listening.