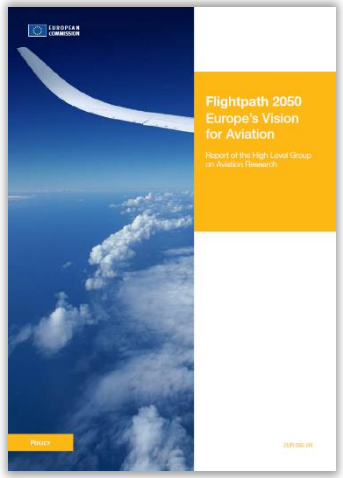
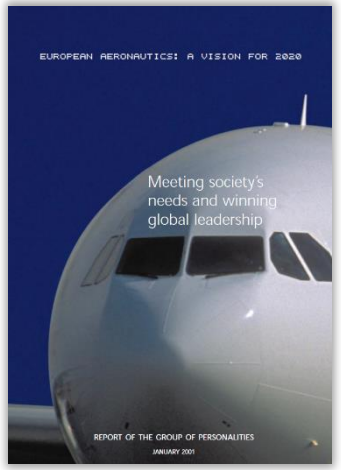


(Over) Two Decades of European Incentives for (Sustainable) Civil Aviation Research

- A Primer -



Aleksandar Joksimović
ISAE-SUPAERO (DAEP), 31 August 2022

Background

2021-(...)

2019-(...)

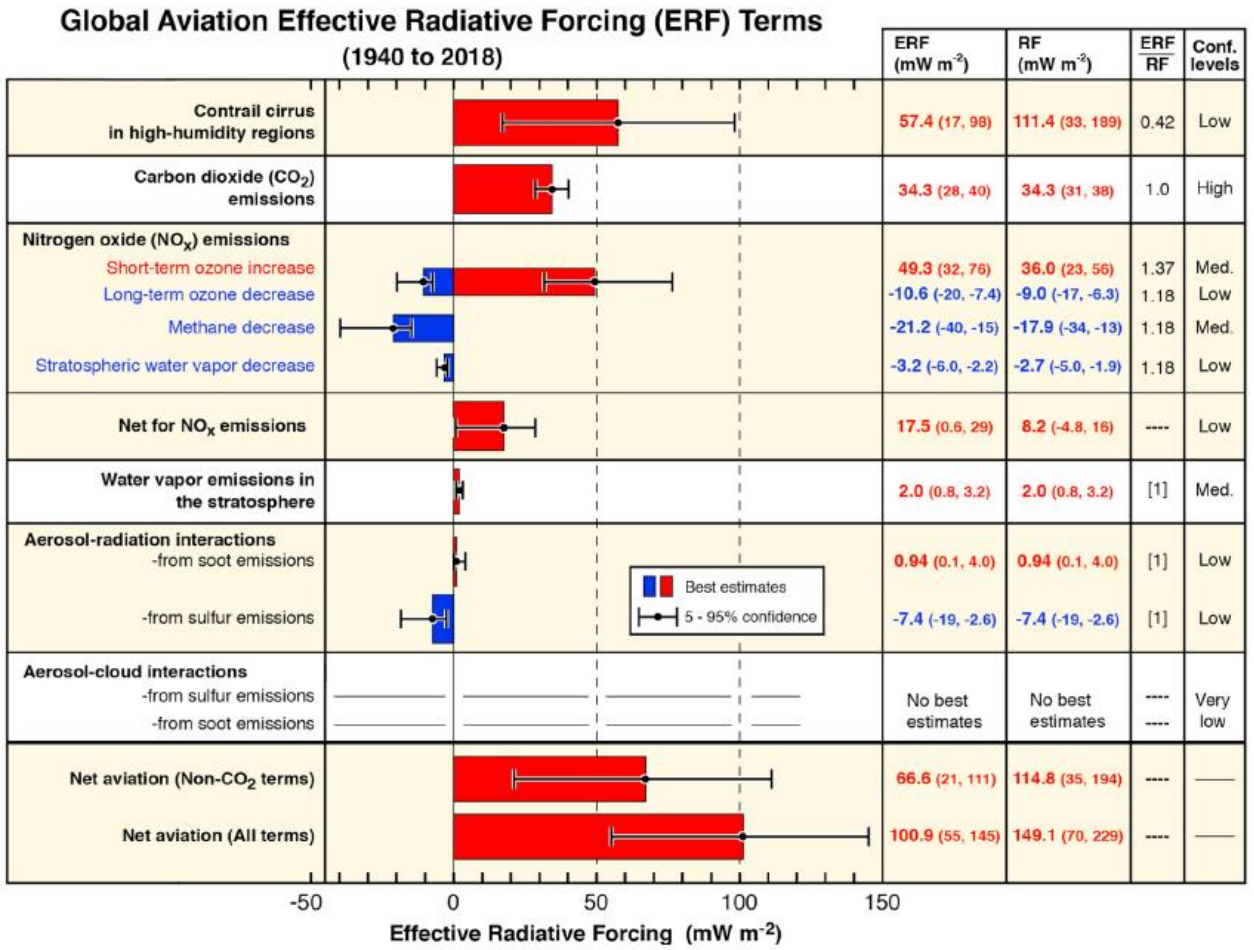
2016-21

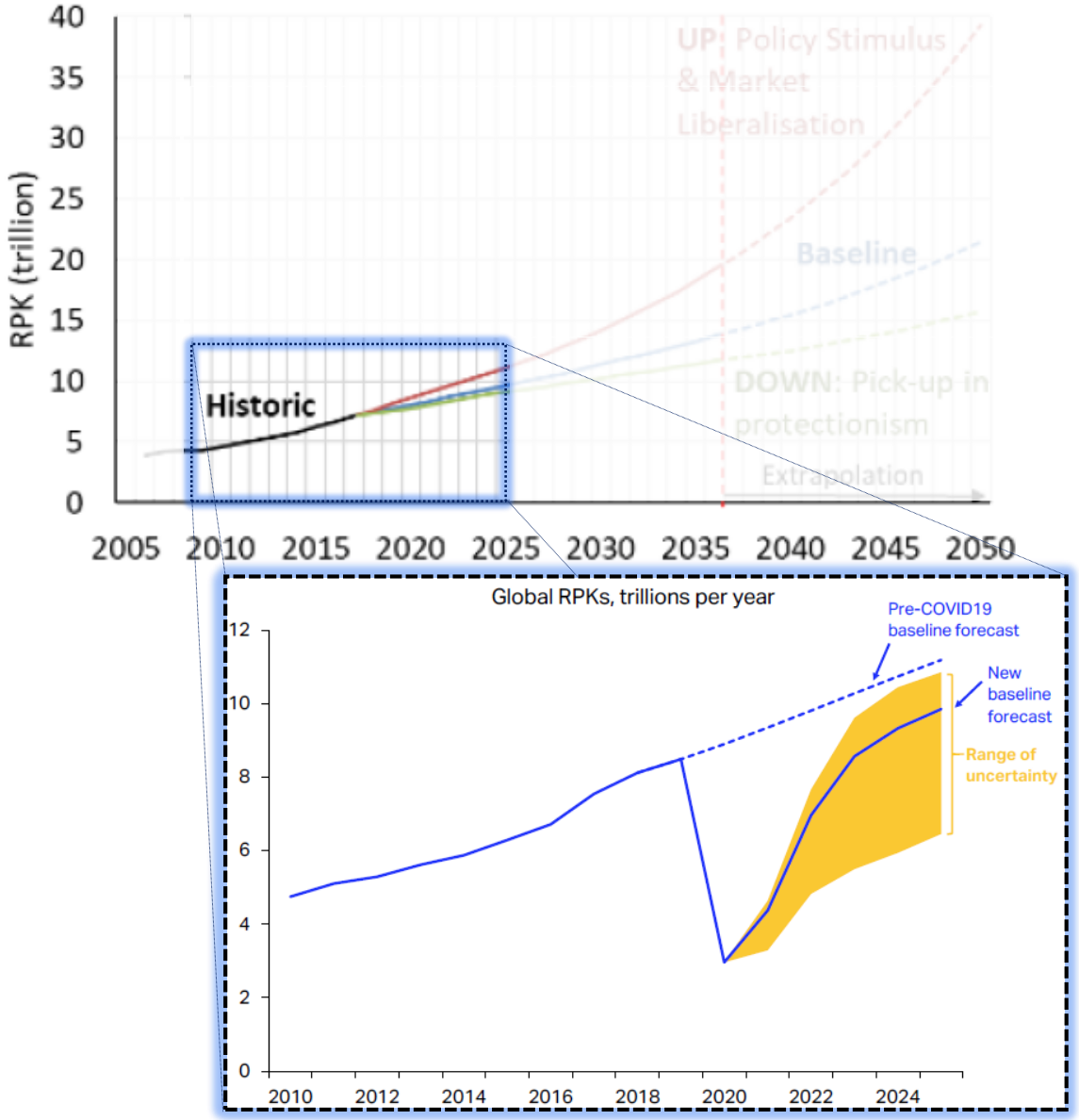
2014-16

2012-14

- **Research engineer:**
  - **Propulsive system** integration, preliminary sizing, innovative architectures;
- **PhD candidate:**
  - **Complex systems**, holistic approach to architectures and tradeoffs in early design;
- **AEGIS (SAFRAN Group):**
  - Tradeoffs in optimization (e.g.):
- **EU FP projects ENOVAL & E-BREAK:**
  - Variable turbofan engine cycles (fan, tuyère, etc.)
- **'DNM AMA' (now MAE):**
  - Aerodynamics/propulsion/advanced fluid dynamics

Tug of War





D.S. Lee, et al., The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018, Atmospheric Environment, Vol.244, 2021, https://doi.org/10.1016/j.atmosenv.2020.11783

IATA (2017, 2021)

Research Community (Europe)

1. INTRODUCTION

Aviation today represents 2% of anthropometric carbon dioxide (CO_2) emissions [1]. Objectives for Vision 2020 of the Advisory Council for Aeronautics Research in Europe (ACARE) target an 80% and 50% reduction in nitrous oxide (NO_x) and CO_2 respectively [2]. Even more ambitious goals outlined in Flightpath 2050 [3] by the European Commission (EC) for year 2050 is a 75% reduction in CO_2-emissions per passenger kilometer (PAX.km) relative to the capabilities of conventional aircraft of the year 2000. Furthermore, a 90% reduction of NO_x-emissions and a 65% perceived noise reduction is advocated. Finally, aircraft movements on the ground have to be emission-free when taxiing. The scope of the Flightpath 2050 assessment comprises total emissions between leaving the parking position at an origin airport (off-block) and the arrival at position at the final destination (on-block).

Targets for CO_2-emissions as originally defined in Vision 2020 and AGAPE 2020 [4] were categorised into Airframe, Propulsion and Power System (PPS), Air Traffic Management (ATM) and Airline Operations. As exemplified by FIG 1, the Strategic Research and Innovation Agenda (SRIA) goals [5] have been re-calibrated to reflect the achievements assessed by the AGAPE 2020 report and a new medium-term goal for Entry-into-Service (EIS) year 2035, which is a significant point for aircraft fleet renewal. A further elaboration of the chronologically assigned CO_2-emissions targets is a breakdown that recommends aircraft energy levels (for flight including all on-board systems and services).

Goals and Key contributions	2000 (Reference)	2020 (Vision)	2020 (AGAPE)	2020 (SRIA)	2035 (SRIA)	2050 (SRIA)
CO_2 objective vs 2000 ("HLG")		-50%**				-75%**
CO_2 vs 2000 (kg/pass km)*		-50%	-38%	-43%	-60%	-75%
Airframe energy need (Efficiency)	1	0.75	0.85	0.8	0.7	0.32
Propulsion & Power energy need (Efficiency)	1	0.8	0.8	0.8	0.7	
ATM and Infrastructure	1	0.88	0.95	0.93	0.88	0.88
Non Infrastructure-related Airlines Ops	1	0.96	0.96	0.96	0.93	0.88

* comparison with same transport capability aircraft and on a same mission in term on range and payload
** ACARE 2020 and ACARE 2050 High Level Goals for airframe, engine, systems and ATM/Operations

FIG 1 Chronologically defined CO_2-emissions reduction goals as recommended by ACARE in the SRIA document [5].

In order to realise a total 60% reduction in fuel burn and corresponding CO_2-emissions per PAX.km for target EIS 2035, SRIA 2035 stipulates contributions of 25% from

A. T. Isikveren and M. Schmidt, Future Transport Aircraft Ultra-Low Emissions Technology Options, GARS Workshop 2014

Challenging targets for aeronautical research and development were set by the Advisory Council for Aeronautics Research in Europe (ACARE) in the year 2001 [15]. Beside safety and economic ACARE's Strategic Research Agenda (SRA) involved ambitious environmental goals, i.e. reductions of 50% CO_2 and 80% NO_x, as well as the halving of perceived noise by 2020 relative to the state-of-the-art in the year 2000. Contributions to the aimed CO_2 goals were expected from air traffic management (5-10%), airframe technological enhancement (20-25%) and from engine technology (specific fuel consumption) improvement (15-20%) [15]. Beyond that, the environmental goals declared within the "Flightpath 2050" vision [36], published by the European Commission in 2011, include the carbon-neutral growth of air traffic beginning in 2020, and a 50% overall CO_2 emission reduction by 2050.

Seitz , A. "Advanced Methods for Propulsion System Integration in Aircraft Conceptual Design", PhD dissertation, TU Munchen, 2012.

‘Vision 2020’

European Green Deal

Net-Zero

Carbon neutral

‘Clean Sky’

‘Flightpath 2050’

Strategic Research (and Innovation) Agenda (SRIA)

ACARE

Framework Programme

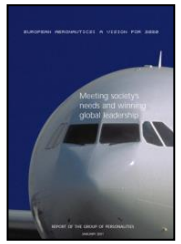
TRL

‘History’

Selected Documents

2000
Aeron. for Europe

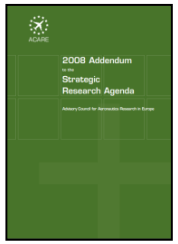
2001
Vision 2020



2002
SRA-1

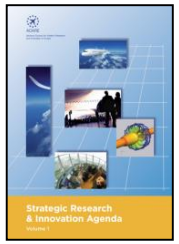
2004
SRA-2

2008
SRA Addendum



2011
Flightpath 2050

2012
SRIA



2017
SRIA Update

2020
Time for Change

2020
CA SRIA

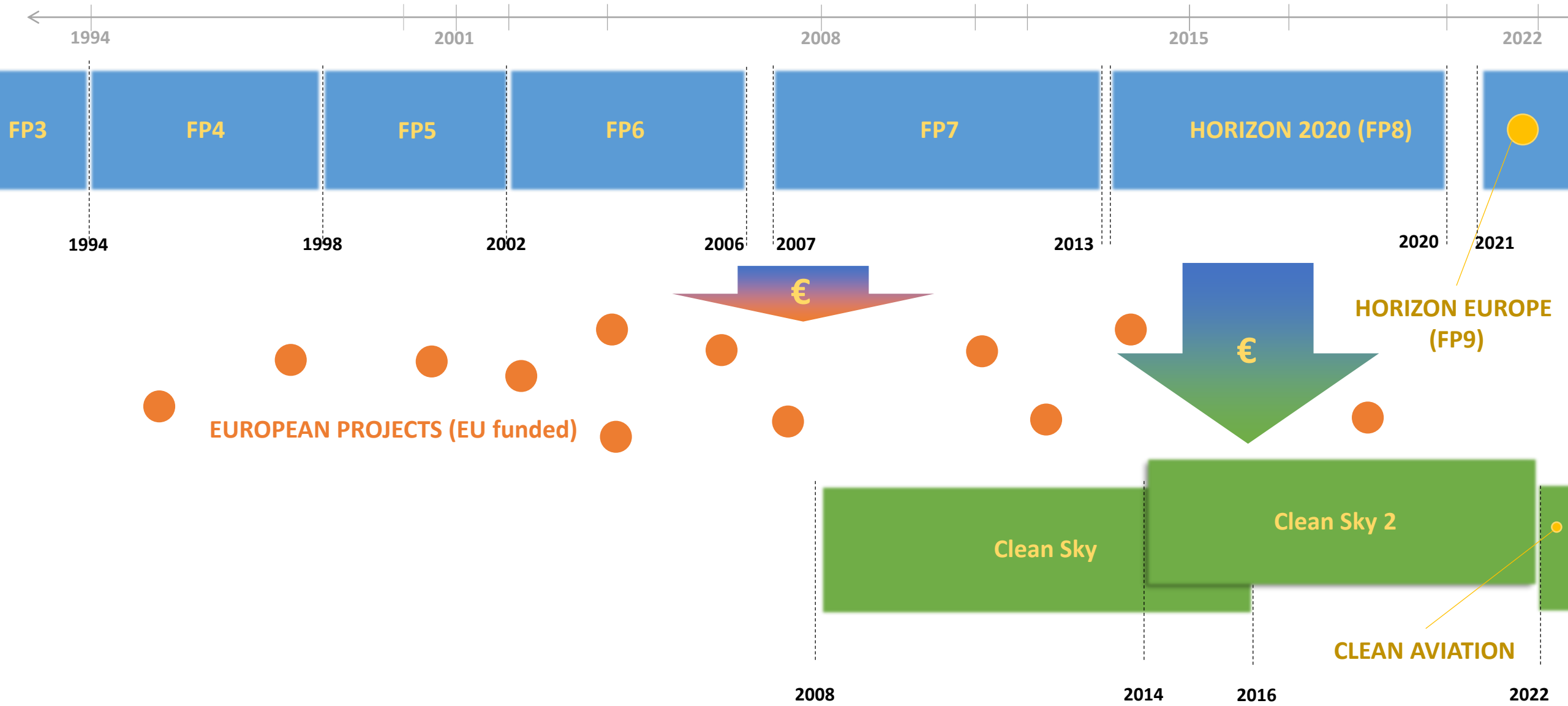
2022
Fly the Green Deal

(…)

Glossary

- **ACARE (Advisory Council for Aeronautical Research in Europe):**
  - High-level group of experts, advisory body commissioned by EC.
- **'Vision' Documents (2020, 2050, Green Deal):**
  - Projected scenarios by high-level group of experts that imagine (mid- and long-term) future scenarios for EU airline industry, to enable/guarantee European status as the global actor.
- **SRIA (Strategic Research and Innovation Agenda):**
  - Technical roadmap(s) enabling to evolve towards achievement of the *Visions (cf. above)*.
- **Framework Programme:**
  - Funding programmes by EU/EC to support and foster research in European Research Area.
- **Joint Technology Initiative/Joint Undertaking:**
  - Public-private partnerships at the European level, in the framework of the FP's.
- **TRL (Technology Readiness Level):**
  - Technology maturity metric (concept-EIS).

EU Research Structure



EU Research Structure

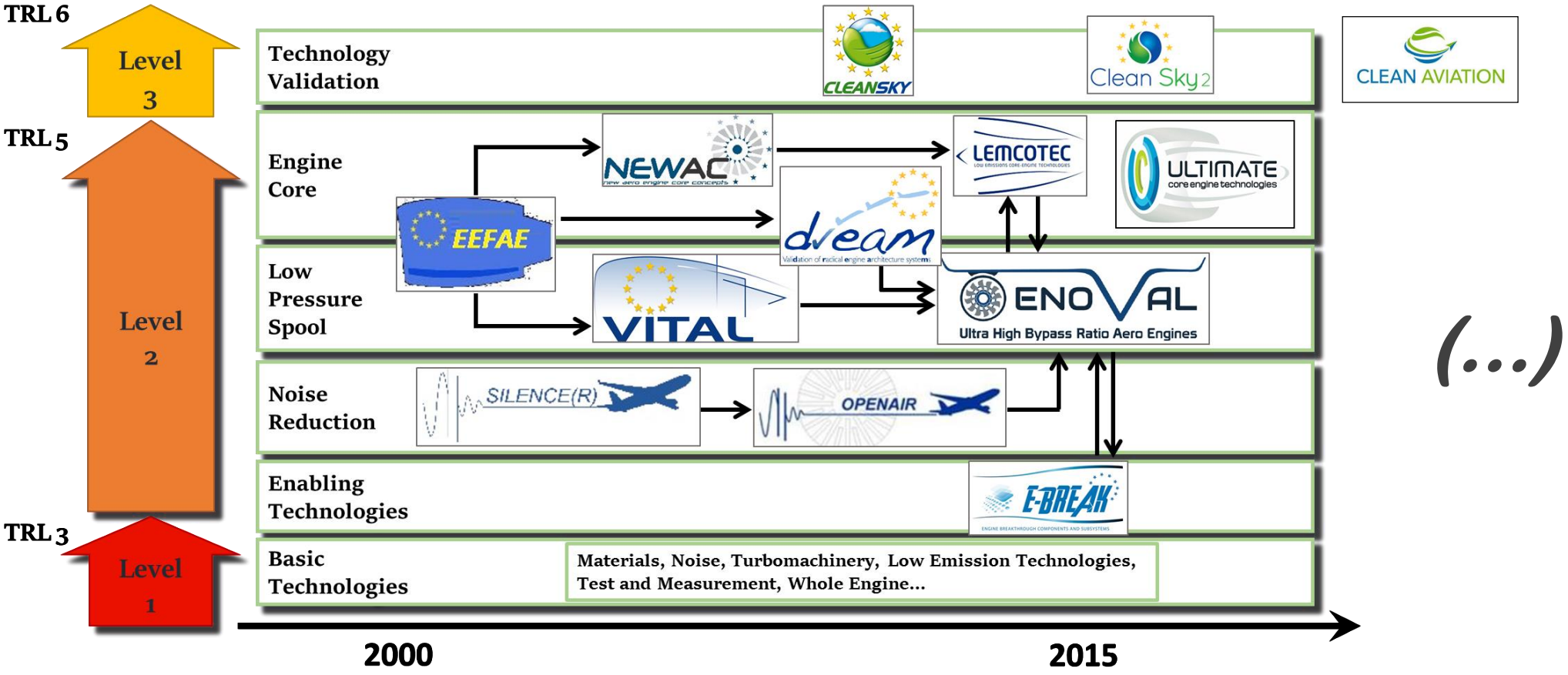
images: https://www.rolls-royce.com/media/our-stories/discover/2020/how-to-test-a-jet-engine-power-of-trent.aspx

TRL 9	**Actual system proven in operation**
TRL 8	**System complete and qualified**
TRL 7	**Prototype demonstration in operation environment**
TRL 6	**Demonstrated in relevant environment**
TRL 5	**Validated in relevant environment**
TRL 4	**Technology validated in lab**
TRL 3	**Experimental proof of concept**
TRL 2	**Technology concept formulated**
TRL 1	**Basic principles observed**

2000 **2015**

adapted from: Sieber (2015)

EU Research Structure

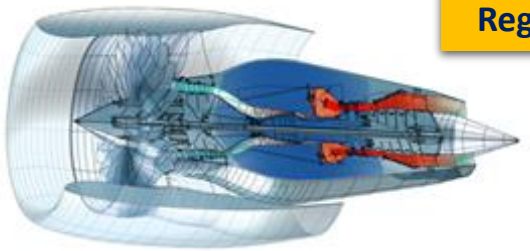


(...)

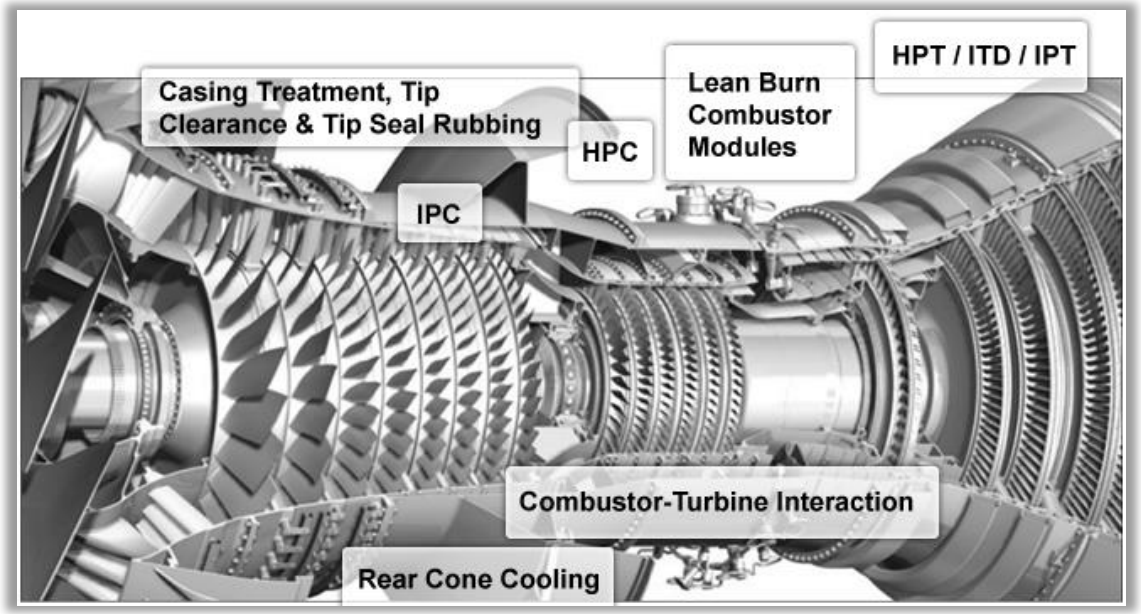
adapted from: Sieber (2015)

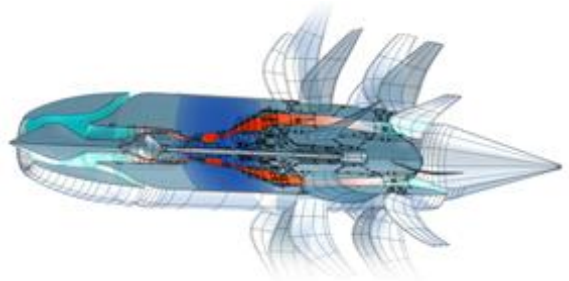
EU Research Structure

European Project Example (Extract)

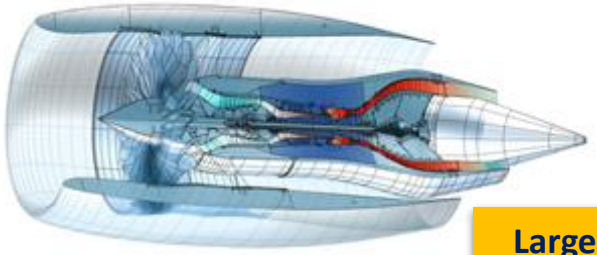


Regional Turbofan





Mid-size Open Rotor

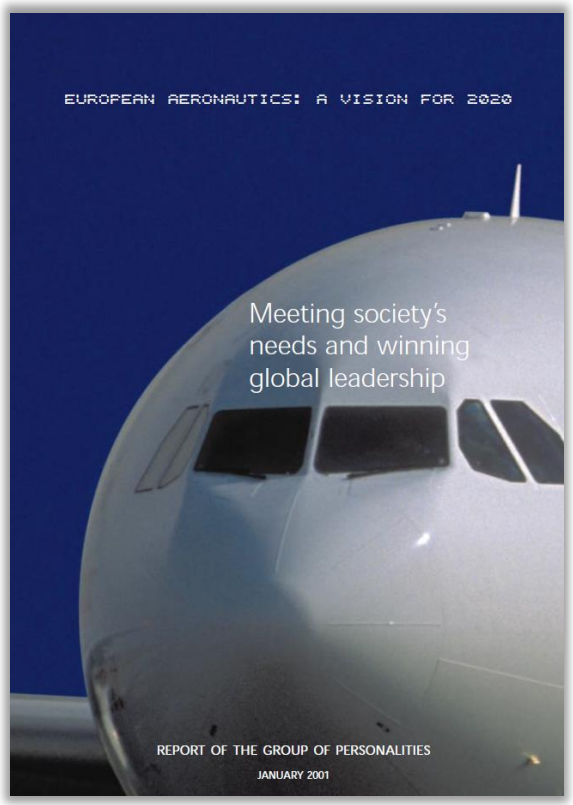


Large Turbofan

image: EU FP7 project *LEMCOTEC (2011-2017)*

Vision Illustration

'Vision 2020' (2001)



Vision:

Aircraft and air transport system

*that are responding to **society's needs**,*

despite a three-fold increase in air transport [in 2020].

Strategy/Market (extract):

- Global leadership by Europe;
- World-class airline system.

Environment/emissions (extract):

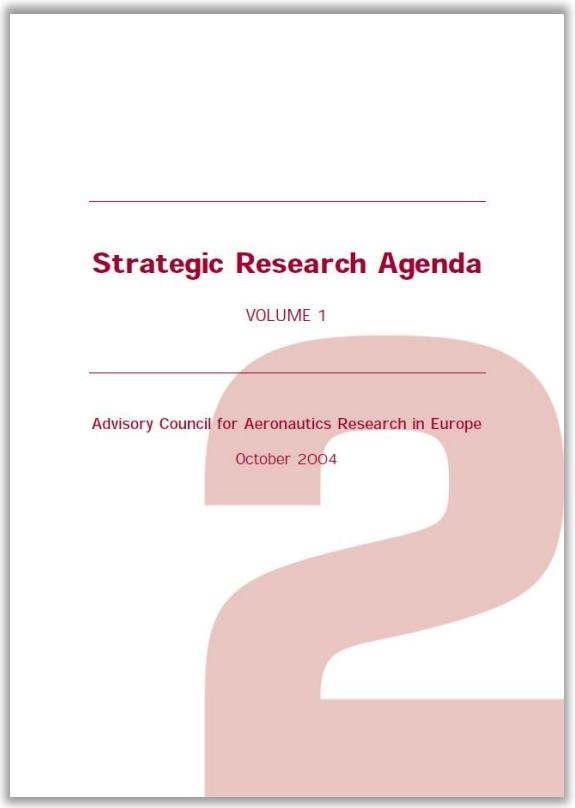
- -50% CO2;
- -80% NOx;

(year 2000 baseline)

- Noise abatement goals
- Full understanding of the sector's contribution to the impacts.

SR(I)A Illustration

'SRA-2' (2004)



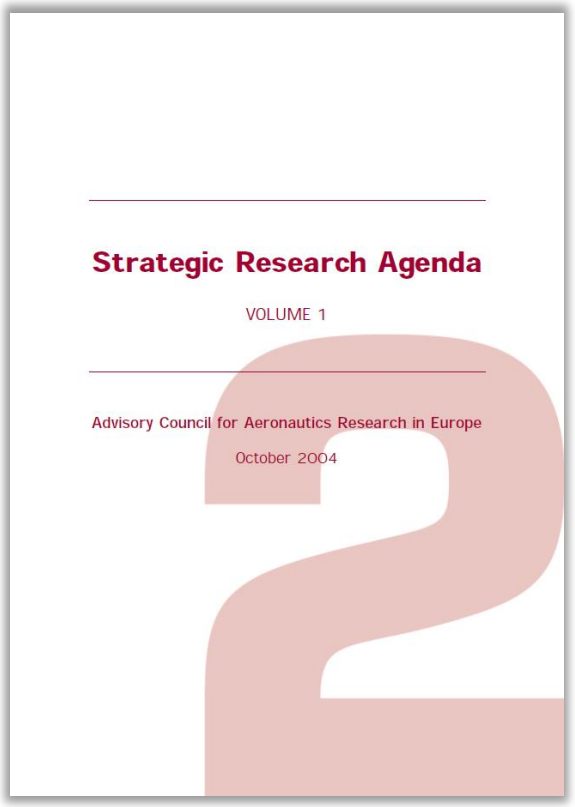
Scenarios:

1. Segmented Business Models,
2. Constrained Air Traffic Growth,
3. Bloc Building.

Economy,
Politics,
Society,
Ecology & Energy,
General Air Traffic,
Infrastructure,
Airlines.

SR(I)A Illustration

'SRA-2' (2004)



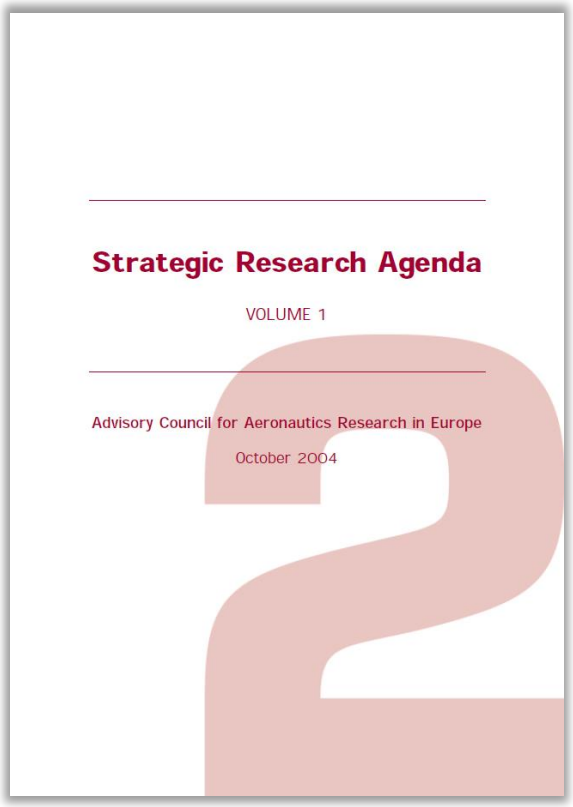
Challenges:

1. Quality and affordability;
   a) Reducing cost, increasing choice, flying office, freight…
2. Environment;
   a) (CO2, NOx…subsystems contributions)
3. Safety;
4. Efficiency of the air transport system;
   a) Punctuality, airport time, 3x volume…
5. Security.

→ **High Level Target Concepts**

SR(I)A Illustration

'SRA-2' (2004)



High Level Target Concepts for the Air Transport System (ATS):

1. Highly Customer Oriented ATS,
2. Highly Time Efficient ATS,
3. Highly Cost Efficient ATS,
4. Ultra Green ATS,
5. Ultra Secure ATS.

Ultra Secure ATS

Ultra Green ATS

Challenge: Quality and affordability

Goals

- Reducing travel charges
- Increasing passenger choice
- Transforming air freight services
- Creating a competitive supply chain able to halve time-to-market

Challenge: Environment

Goals

- To reduce fuel consumption and CO_2 emissions by 50%
- To reduce perceived external noise by 50%
- To reduce NOx by 80%
- To make substantial progress in reducing the environmental impact of the manufacture, maintenance and disposal of aircraft and related products

Challenge: Safety

Goals

- Reduction of the accident rate by 80%.
- Reduction in human error and its consequences

Challenge: Air Transport System efficiency

Goals

- To enable the Air Transport System to accommodate 3 times more aircraft movements by 2020 compared with 2000
- To reduce the time spent by passengers in airports to under 15 minutes for short-haul flights and to under 30 minutes for long-haul
- To enable 99% of flights to arrive and depart within 15 minutes of their advertised scheduled departure time, in all weather conditions

Challenge: Security

Goal

- Zero successful hijack.

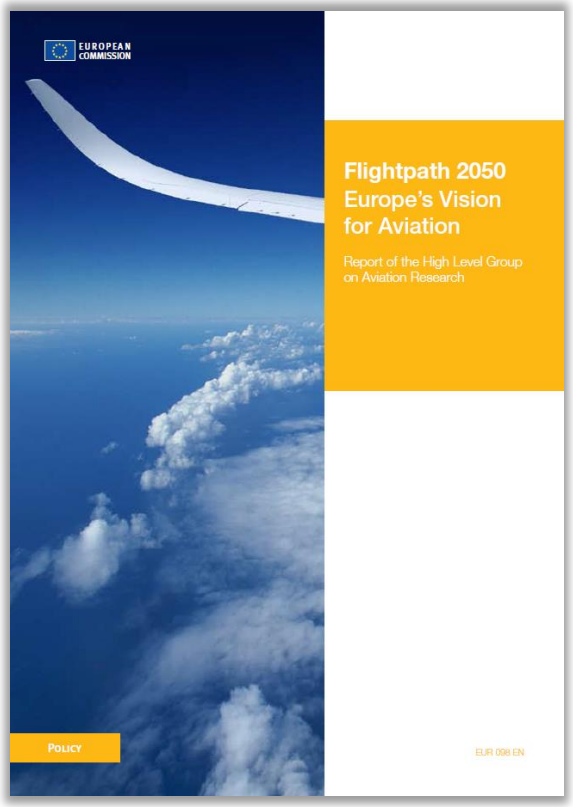
Highly Customer Oriented ATS

Highly Time Efficient ATS

Highly Cost Efficient ATS

Figure 1

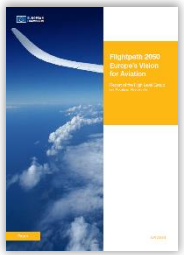
Evolution



Environmental/emissions goals (extract):

- ~~-50% CO2~~ -75% CO2;
- ~~-80% NOx~~ -90% NOx;
- Emission-free taxiing;
- Noise objectives;
- EU centre of excellence on alternative fuels (HC still in use);
- Full understanding of the sector's contribution to the impacts.

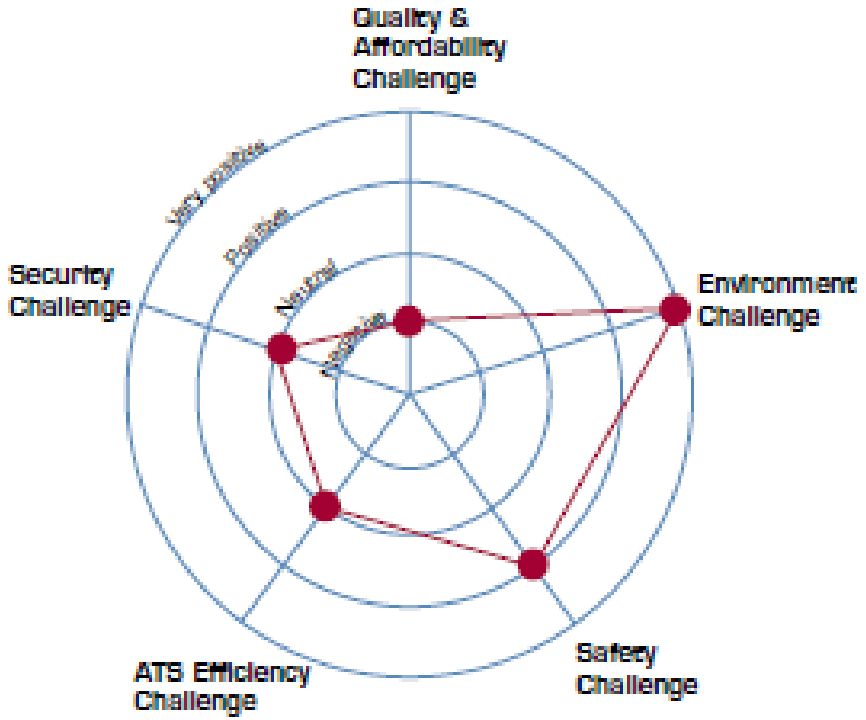
Evolution



Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• By 2030, net CO_2 emissions from all intra-EU flights and those departing the EU are reduced by 55% compared to the 1990 baseline[11]; • By 2030, non-CO_2 climate effects are fully understood, managed, monitored and reduction targets are set in-line with the latest scientific understanding and available mitigation solutions.	• By 2035 new technologies, fuels and operational procedures in service result in a 30% reduction in non-CO_2 climate effects of all intra-EU flights and those departing the EU relative to the 1990 baseline.	• By 2050, net-zero CO_2 emissions has been achieved for all intra-EU flights and those departing the EU; • By 2050 new technologies and operational procedures in service result in a 90% reduction in NOx emissions from all intra-EU flights and those departing the EU relative to the year 2000[12]; • By 2050 new technologies and operational procedures in service result in a 90% reduction in non-volatile particulate matter (nvPM) emissions from all intra-EU flights and those departing the EU relative to the year 2000; • By 2050 new technologies and operational procedures in service result in a 90% reduction in warming contrail cirrus relative to the 2000 baseline; • By 2050 new technologies, fuels and operational procedures reduce the climate impact of CO_2 and non-CO_2 effects of all intra-EU flights and those departing the EU by 90% relative to the year 2000.

Summary

- It's a **complicated (complex?)** system and optimisation problem;
- Market-based incentives and strategies;
- Ever-stronger ambitions w.r.t. objective functions, (but…)
- …complicated (complex?) tradeoffs (see illustration):



Thanks