European Commission

EUROPEAN AVIATION RESEARCH AND INNOVATION TOWARDS CLIMATE NEUTRALITY

33RD CONGRESS
OF THE INTERNATIONAL COUNCIL
OF THE AERONAUTICAL SCIENCES
STOCKHOLM, SWEDEN, 4-9 SEPTEMBER, 2022

ICAS 2022 SWEDEN

Dr. Michael Kyriakopoulos

Senior Expert - Aviation Research Policy

European Commission - DG Research & Innovation

European Commission

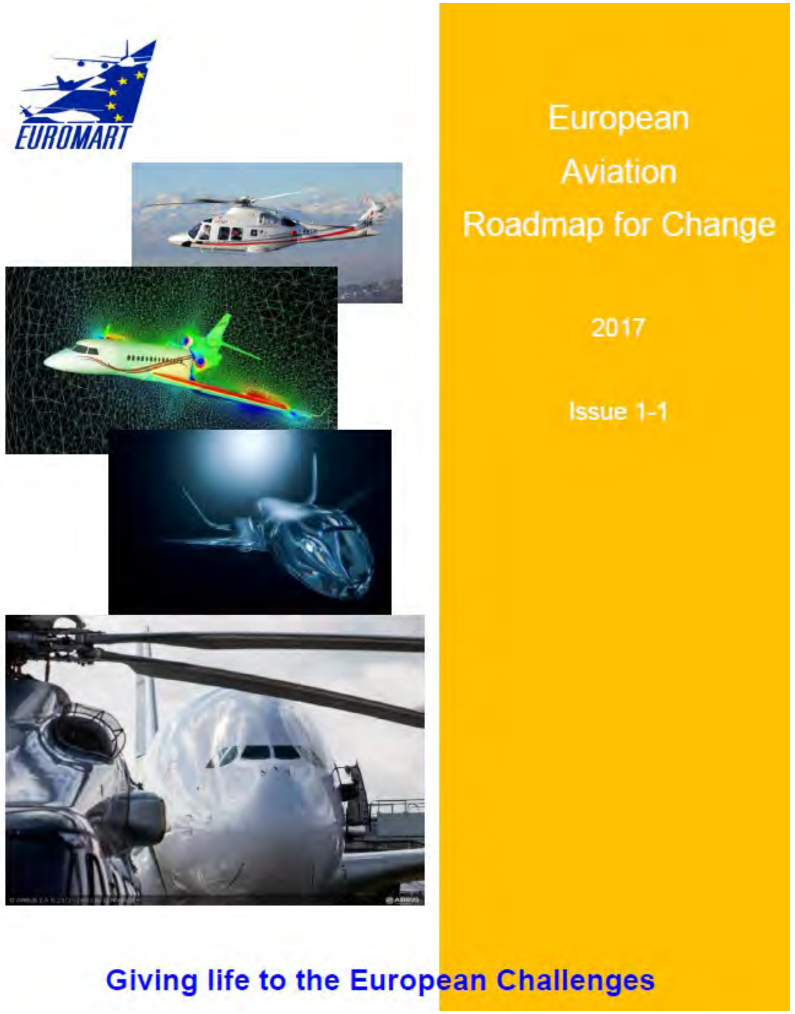
kind regards to ICAS 2022 participants from

Director Rosalinde Van Der Vlies

HoU Jane Amilhat

Introduction

European Commission

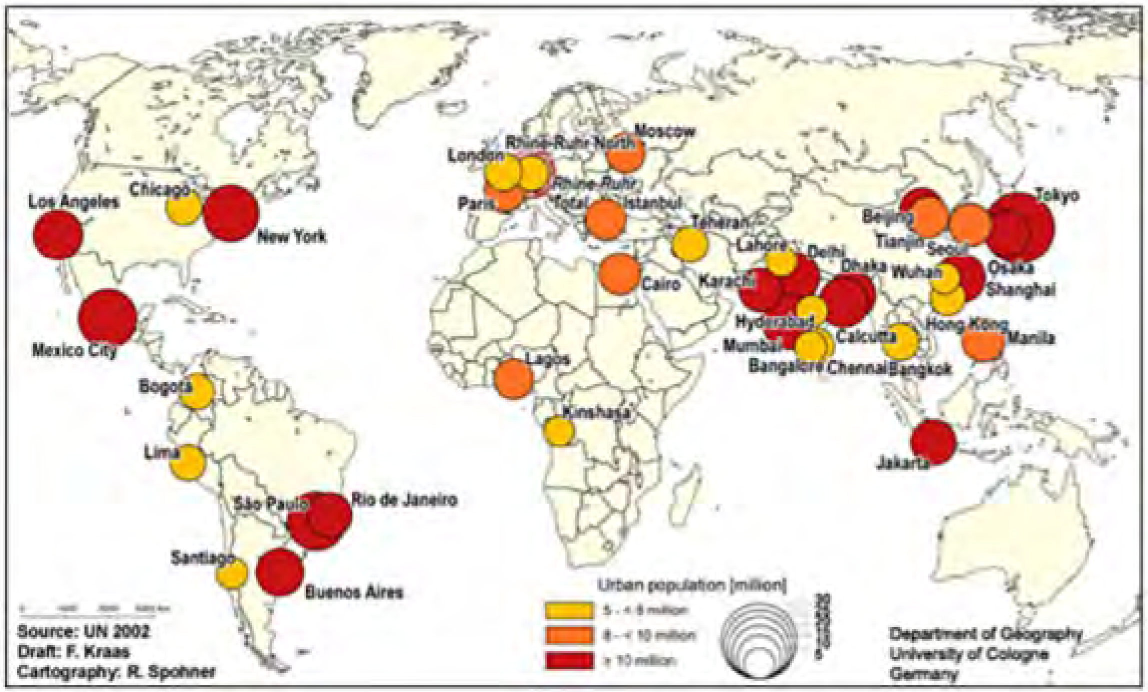


FP2 … FP5-FP6-FP7-H2020: Strategic Research Agenda & Roadmaps

Introduction

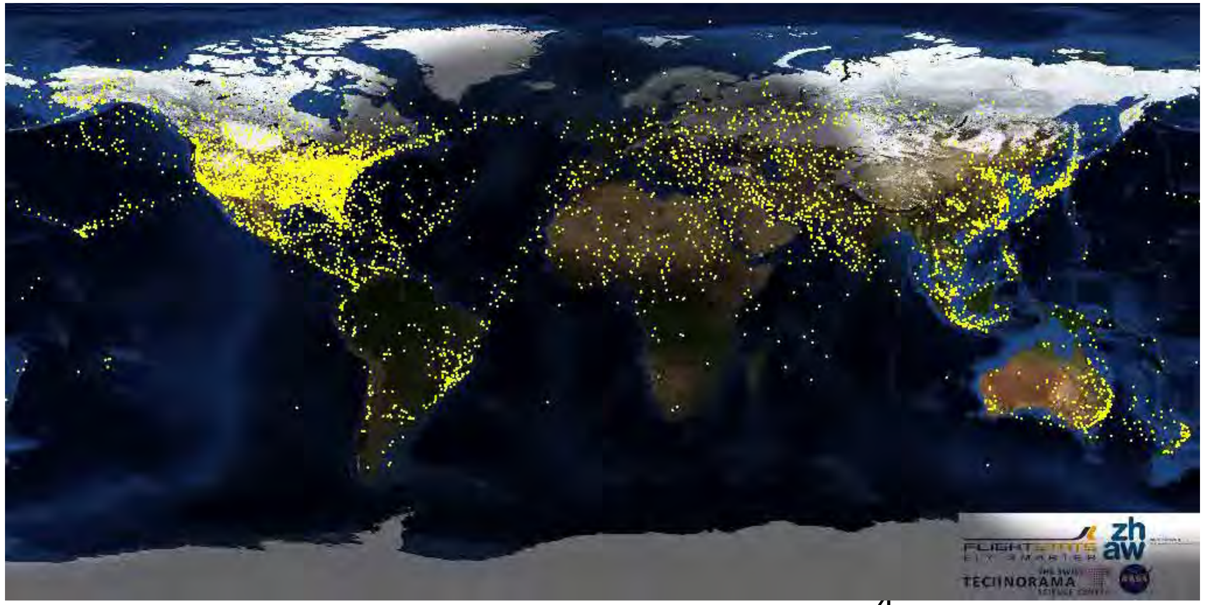
Aviation Challenges and Opportunities (2019)

- Demographic changes - emerging countries – megacities
- Air-traffic may again double in the next 15 years
- High demand - Production ramp-up and rates
- Unacceptable delays - overruns in budgets – safety & regulatory



Source: IGU MegaCity TaskForce (2012)

4.3 billion passengers **38** million flights



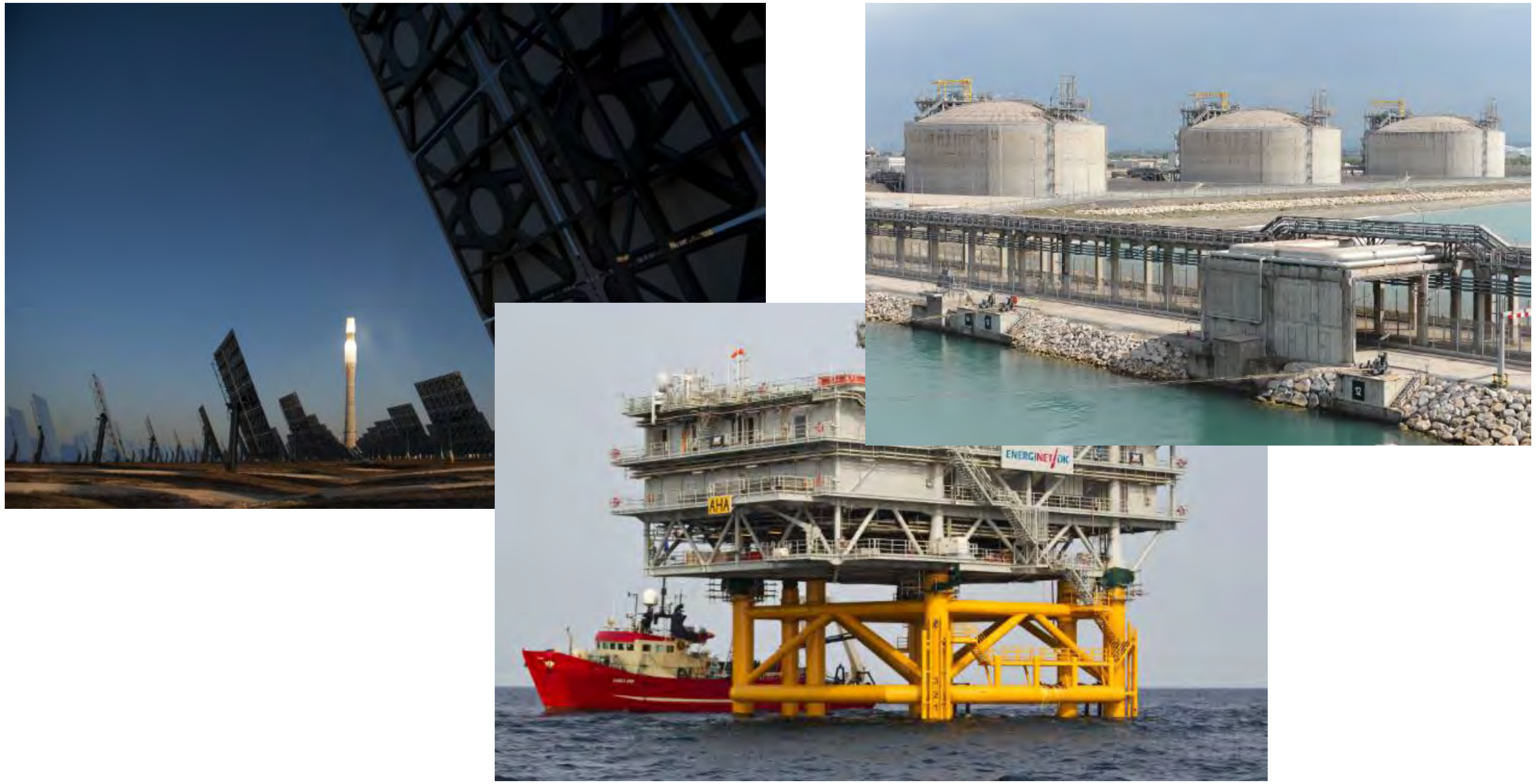
Introduction

European Aviation Research paths & roadmaps in 2022

Introduction

Aviation Challenges and Opportunities (2022)

- **Energy security – New Geopolitics – Climate Neutrality**
- **Global Economy – Uncertainties - Inflationary Pressures – Localism?**
- **Non-Fossil Fuels – SAF – Hydrogen – Electrification – non-CO2**
- **Post COVID-19 recovery – Readiness for new pandemics**



EUROPEAN AVIATION: 2021 HEADLINE DATA

EUROCONTROL

Huge financial impact for all European stakeholders:

- **€18.5 billion** net losses for **airlines**
- **€3.7 billion** in-year revenue losses for **ANSPs**

1.4-1.5 billion
fewer passengers than in 2019 (2020: 1.7 billion fewer)

106 million tonnes
fewer CO_2 emissions than in 2019

6.2 million flights 2021 vs. 11.1 million 2019 = annual loss of 4.9 million flights (2020: 5 million flights).

26,773 peak daily flights (27 Aug 2021), -28% compared to the 2019 peak of 37,228 (28 Jun 2019).

- Intra-European traffic **43%** down.
- Europe-Rest of the World **48%** down.
- Low-cost carrier flights **54%** down.
- Scheduled carrier flights **52%** down.

Aviation Challenges and Opportunities

CO_2 emissions (2017)

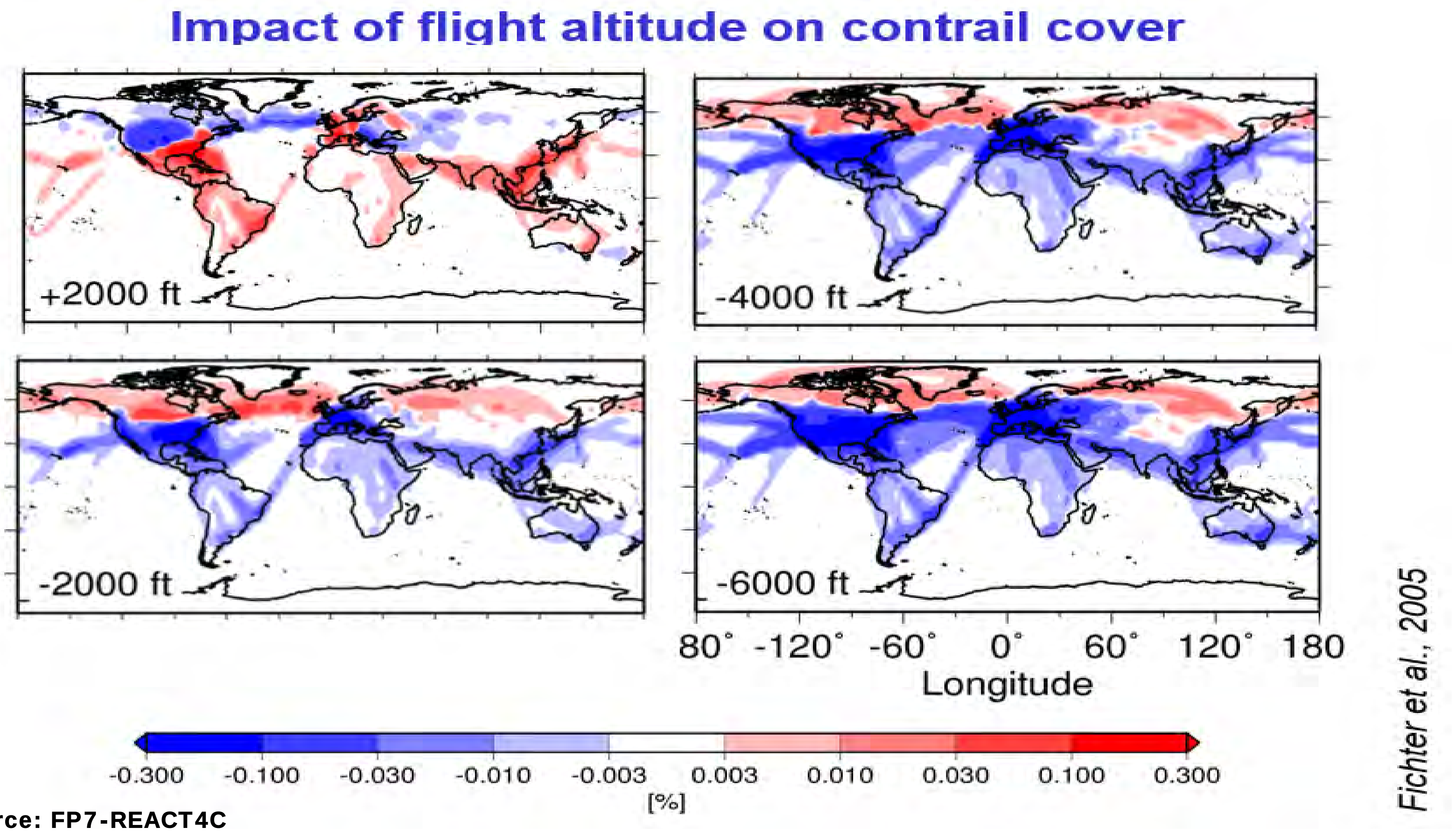
Facts & Figures

- Global Anthropogenic:	37000 Mt
- Global Aviation:	859 Mt (2.3 % of Global)
- European Aviation (incl. EU-Int):	171 Mt (0.4 % of Global)
- Global Forest Fires*:	8000 Mt

Data from IPCC, EASA and Earth Syst. Sci. Data, 9, 697-720, 2017.

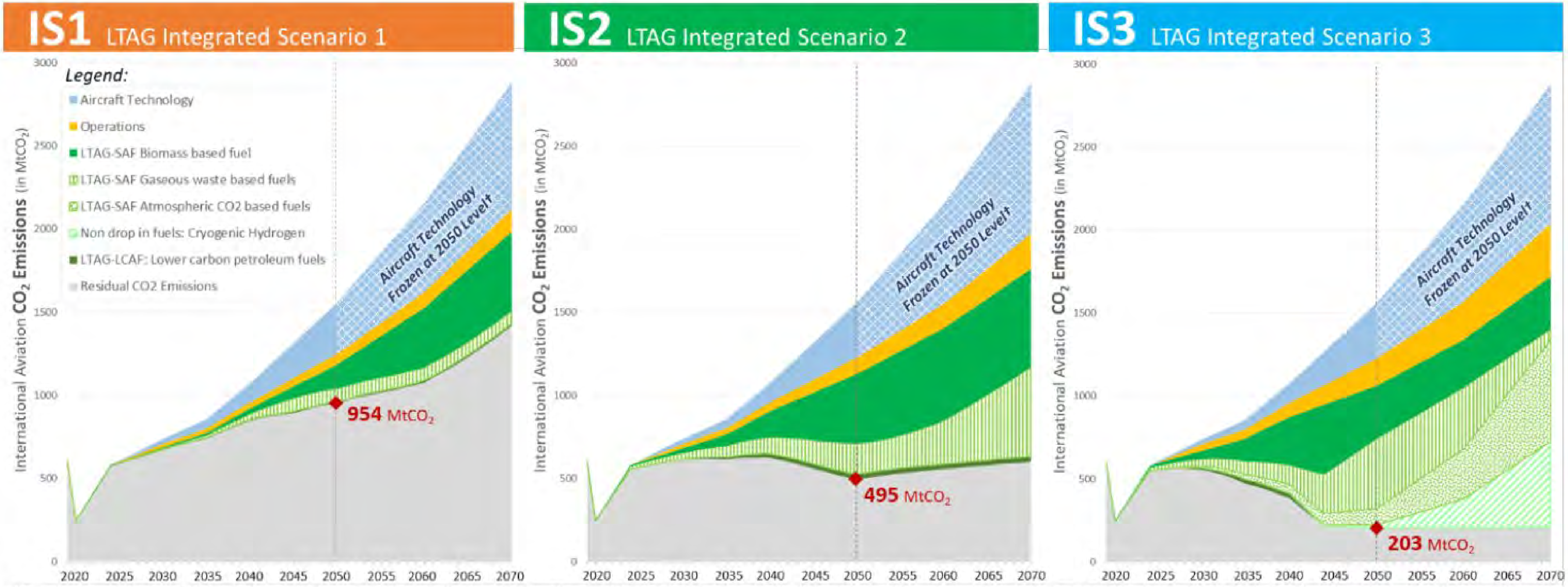
Aviation Challenges and Opportunities

- Environment / Climate / LAQ / Noise challenges
- Do we still design for Operating Cost?



Source: FP7-REACT4C

CLIMATE NEUTRALITY BY 2050

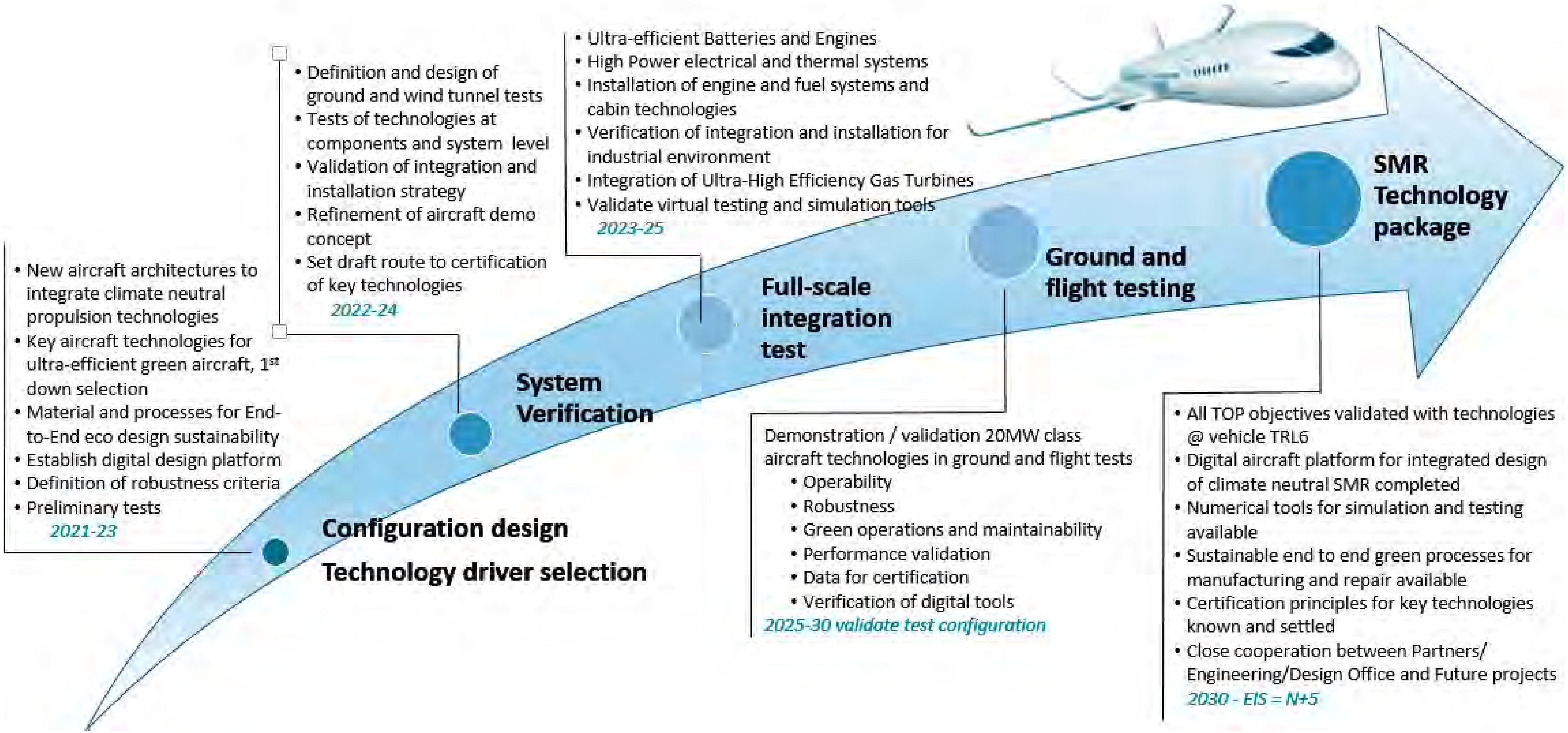


† Caution required with the interpretation of absolute CO_2 emissions levels after 2050 due to modelling assumptions e.g., frozen aircraft technology after 2050. Under these assumptions, CO_2 emissions are higher than in an alternative scenario (and modelling approach) where aircraft technology would continue to improve after 2050.

ICAO CAEP Long-Term Aspirational Goal Task Group – March 2022

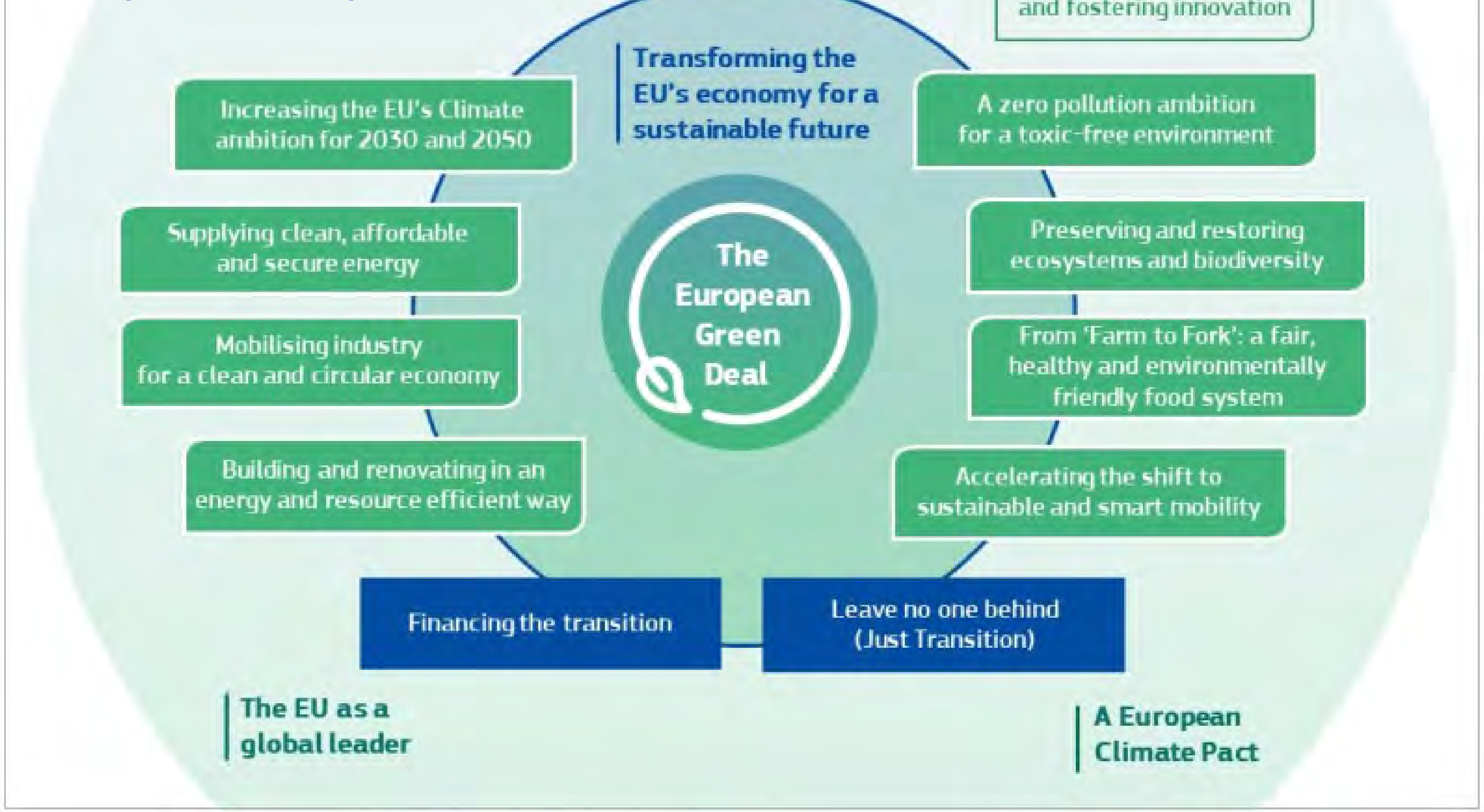
Short and Medium Range Aircraft Ambition – Roadmap

Technology and concept validation & verification



CLIMATE NEUTRALITY BY 2050

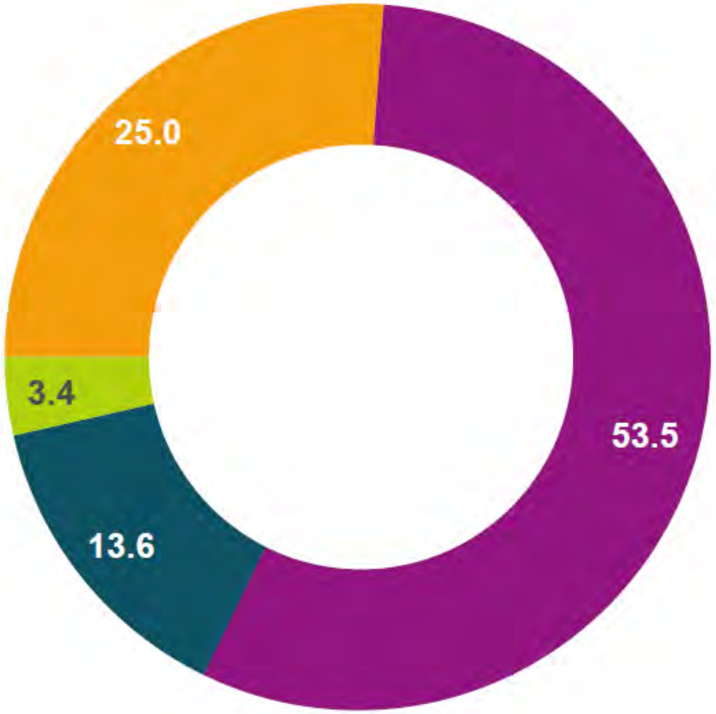
- no net emissions of greenhouse gases by 2050
- economic growth decoupled from resource use
- no person and no place left behind



One third of the 1.8 trillion euro investments from the NextGenerationEU Recovery Plan, and the EU's seven-year budget will finance the European Green Deal.

Horizon Europe Budget: €95.5 billion (2021-2027)

(including €5.4 billion from NGEU – Next Generation Europe – programme of EU for Recovery from COVID-19 crisis)



Political agreement December 2020

€ billion in current prices

- Excellent Science
- Global challenges and European ind. comp.
- Innovative Europe
- Widening Part and ERA

HORIZON EUROPE

SPECIFIC PROGRAMME: EUROPEAN DEFENCE FUND

Exclusive focus on defence research & development

- Research actions
- Development actions

SPECIFIC PROGRAMME IMPLEMENTING HORIZON EUROPE & EIT*

Exclusive focus on civil applications

Pillar I
EXCELLENT SCIENCE

- European Research Council
- Marie Skłodowska-Curie
- Research Infrastructures

Pillar II
GLOBAL CHALLENGES & EUROPEAN INDUSTRIAL COMPETITIVENESS

Clusters

- Health
- Culture, Creativity & Inclusive Society
- Civil Security for Society
- Digital, Industry & Space
- Climate, Energy & Mobility
- Food, Bioeconomy, Natural Resources, Agriculture & Environment

Joint Research Centre

Pillar III
INNOVATIVE EUROPE

- European Innovation Council
- European Innovation Ecosystems
- European Institute of Innovation & Technology*

WIDENING PARTICIPATION AND STRENGTHENING THE EUROPEAN RESEARCH AREA

- Widening participation & spreading excellence
- Reforming & Enhancing the European R&I system

EURATOM

- Fusion
- Fission
- Joint Research Center

* The European Institute of Innovation & Technology (EIT) is not part of the Specific Programme

Pillar II - Clusters

GLOBAL CHALLENGES & EUROPEAN INDUSTRIAL COMPETITIVENESS:

€53.5 billion

Cluster 1	Health	€8.246 billion (including €1.35 billion from NGEU)
Cluster 2	Culture, Creativity & Inclusive Societies	€2.280 billion
Cluster 3	Civil Security for Society	€1.596 billion
Cluster 4	Digital, Industry & Space	€15.349 billion (including €1.35 billion from NGEU)
Cluster 5	Climate, Energy & Mobility	€15.123 billion (including €1.35 billion from NGEU)
Cluster 6	Food, Bioeconomy, Natural Resources, Agriculture & Environment	€8.952 billion
	JRC (non-nuclear direct actions)	€1.970 billion

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Overview of 49 candidate European Partnerships

HORIZON EUROPE PILLAR II - Global challenges & European industrial competitiveness

CLUSTER 1: Health

- Innovative Health Initiative
- Global Health Partnership
- Transformation of health systems
- Chemicals risk assessment
- ERA for Health
- Rare diseases*
- One-Health Anti Microbial Resistance*
- Personalised Medicine*
- Pandemic Preparedness* *Co-funded or co-programmed*

CLUSTER 4: Digital, Industry & Space

- Key Digital Technologies
- Smart Networks & Services
- High Performance Computing
- European Metrology (Art. 185)
- AI-Data-Robotics
- Photonics
- Made in Europe
- Clean steel – low-carbon steelmaking
- Processes4Planet
- Global competitive space systems**

CLUSTER 5: Climate, Energy & Mobility

- Clean Hydrogen
- Clean Aviation
- Single European Sky ATM Research 3
- Europe's Rail
- Connected and Automated Mobility (CCAM)
- Batteries
- Zero-emission waterborne transport
- Zero-emission road transport
- Built4People
- Clean Energy Transition
- Driving Urban Transitions

CLUSTER 6: Food, Bioeconomy, Agriculture, …

- Circular Bio-based Europe
- Rescuing Biodiversity to Safeguard Life on Earth
- Climate Neutral, Sustainable & Productive Blue Economy
- Water4All
- Animal Health & Welfare*
- Accelerating Farming Systems Transitions*
- Agriculture of Data*
- Safe & Sustainable Food System*

PILLAR III - Innovative Europe

EIT (KNOWLEDGE & INNOVATION COMMUNITIES)

- InnoEnergy
- Climate
- Digital
- Food
- Health
- Raw Materials
- Manufacturing
- Urban Mobility
- Cultural and Creative Industries

SUPPORT TO INNOVATION ECOSYSTEMS

- Innovative SMEs

CROSS-PILLARS II & III

- European Open Science Cloud

Legend:
- Institutionalised Partnerships (Art 185/7)
- Institutionalised Partnerships / EIT KICs
- Co-Programmed
- Co-Funded

* *Calls with opening dates in 2023-24*
** *Calls with opening dates not before 2022*

European Commission

Horizon Europe – Partnerships - SRIA

Annex to GB decision no. CleanHydrogen-GB-2022-02

CLEAN HYDROGEN JOINT UNDERTAKING

Strategic Research and Innovation Agenda 2021 – 2027

Clean Hydrogen Partnership

Horizon Europe Partnerships: Strategic Research & Innovation Agenda

Clean Aviation Partnership – 1st call

European Commission

Hybrid electric and full electric architectures

Ultra-efficient aircraft architectures

Disruptive technologies to enable hydrogen-powered aircraft

Disruptive Low Emission Hybrid Electric Regional / Short Range Aircraft

Disruptive Low Emission Short and Medium Range Commercial Aircraft

Zero Climate Impact Short Range Disruptive Concept (e.g. hydrogen powered)

Zero Climate Impact Long Range Disruptive Concept

Flight demonstration in Clean Aviation and impact by 2035

Development of disruptive technology options

Budget: 1.7 billion € by Horizon Europe

- **First Call: launched 23 March 2022 – deadline 23 June 2022**
  14 topics – 736 million €

Clean Aviation Partnership – 1st call

HORIZON-JU-CLEAN-AVIATION2022-01-	Title	Max Number of projects	Ind. Topic Value (Funding in M€)
Hydrogen-powered aircraft topics			
HPA-01	Direct Combustion of Hydrogen in Aero-engines	2	115
HPA-02	Multi-MW Fuel Cell Propulsion System for Hydrogen-Powered Aircraft	2	50
HPA-03	Large Scale Lightweight Liquid Hydrogen Integral Storage Solutions	1	10
HPA-04	Near Term Disruptive Technologies for Hydrogen-Powered Aircraft	2	7
Hybrid-electric powered regional aircraft topics			
HER-01	Multi-MW Hybrid-Electric Propulsion System for Regional Aircraft	2	75
HER-02	Thermal Management Solutions for Hybrid-Electric Regional Aircraft	1	40
HER-03	Electrical Distribution Solutions for Hybrid-Electric Regional Aircraft	1	40
HER-04	Innovative Wing Design for Hybrid-Electric Regional Aircraft	1	20
Short/short-medium range aircraft topics			
SMR-01	Ultra Efficient Propulsion Systems for Short and Short-Medium Range Aircraft	3	175
SMR-02	Ultra Performance Wing for Short and Short-medium Range Aircraft	2	55
SMR-03	Advanced Low Weight Integrated Fuselage and Empennage for Short Range and Short-Medium Range Aircraft	1	40
Transversal activity topics			
TRA-01	Aircraft concepts for regional, short and short-medium range aircraft enabling 30 to 50% reduction in emissions	3	90
TRA-02	Novel Certification Methods and Means of Compliance for Disruptive Technologies	1	18
Coordination and Support Actions			
CSA-01	Developing a European Clean Aviation Regional Ecosystem (ECARE)	1	0.72
TOTAL	**14 topics**	**up to 23 projects**	**735.72M€**

Clean Hydrogen Partnership – 1st call

Clean Hydrogen Partnership

Annual Work Plan 2022

Call for proposals 2022

The Call for Proposals will have two deadlines, with a **total budget of EUR 300.5 million**

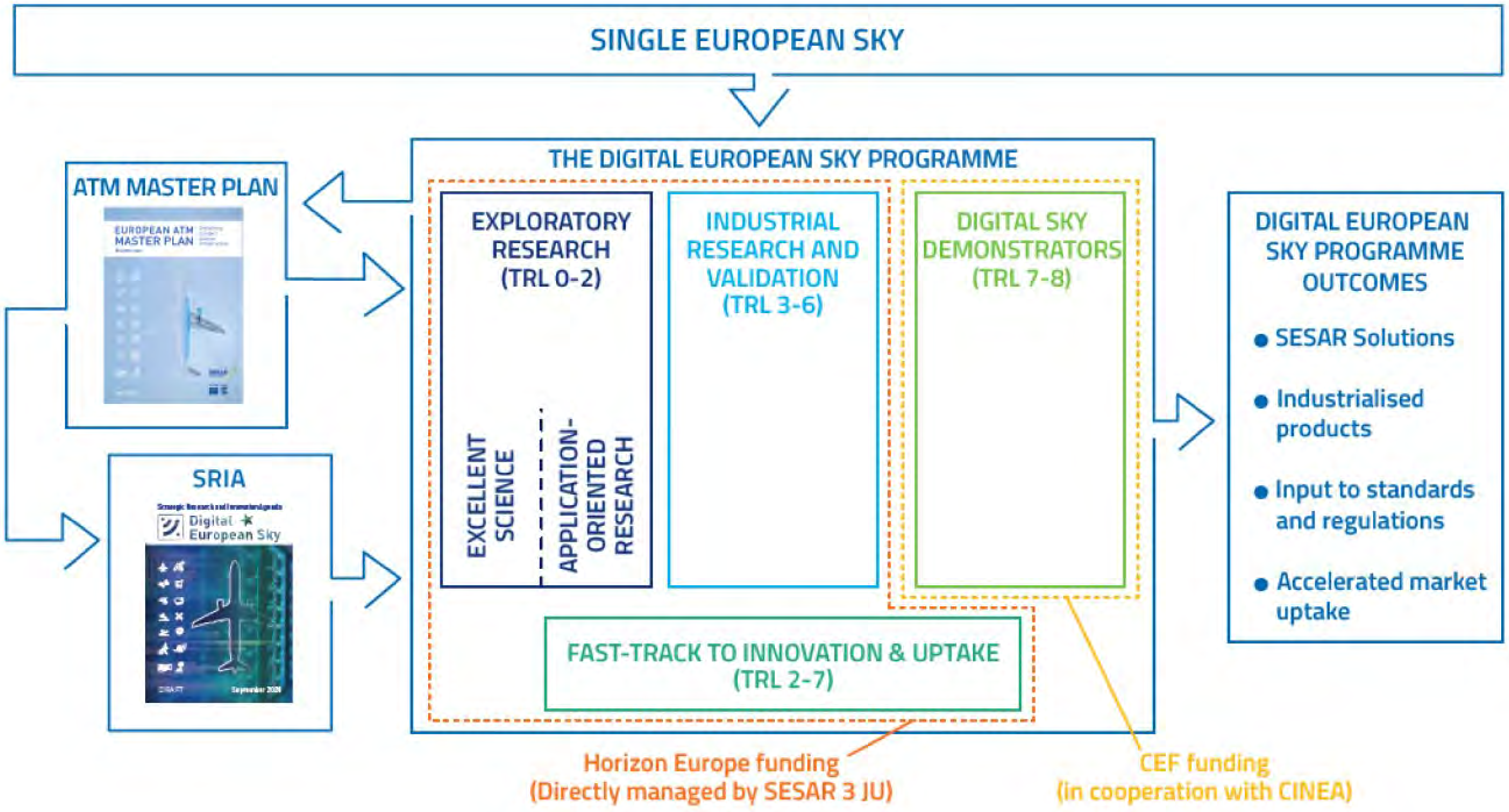
	Budget (EUR million)	Publication	Deadline
First deadline	179.5	1st of March 2022	31st of May 2022
Second deadline	121.0	1st of March 2022	20th of September 2022

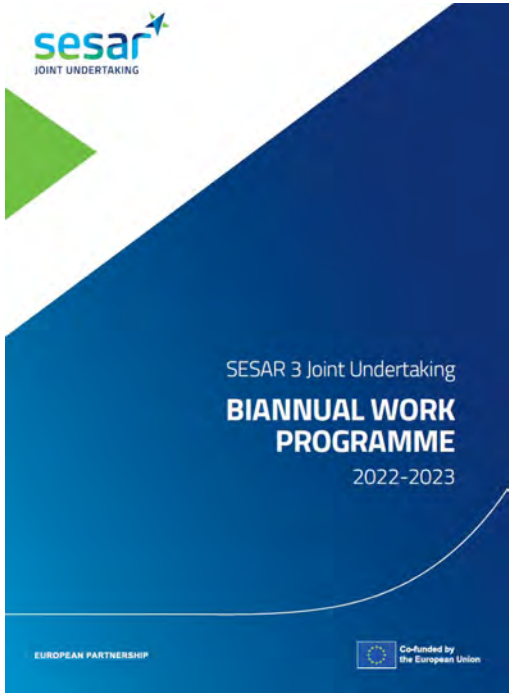
Co-funded by the European Union

Clean Hydrogen Partnership – 1st call

European Commission

SESAR3 ATM Partnership – 1st call





Cluster 5 – low TRL – WP2021-2022

European Commission

169.5 million

(Destination 3 on SAF)
- Demonstration of cost-effective advanced biofuel technologies utilizing existing industrial plants – 20
- Development of algal and renewable fuels of non-biological origin – 15

(Destination 5 on technologies & policy)
- Greenhouse gas aviation emissions reduction technologies towards climate neutrality by 2050 – 25
- Next generation digital aircraft transformation in design, manufacturing, integration and maintenance – 29
- Towards a silent and ultra-low local air pollution aircraft – 20
- Digital aviation technologies for new aviation business models, industrial competitiveness – 20
- European Aviation Research Policy in support to EU policies and initiatives – 5

(Destination 6 on safety)
- Safe automation and human factors in aviation – intelligent integration and assistance – 12
- More resilient aircraft and increased survivability – 9

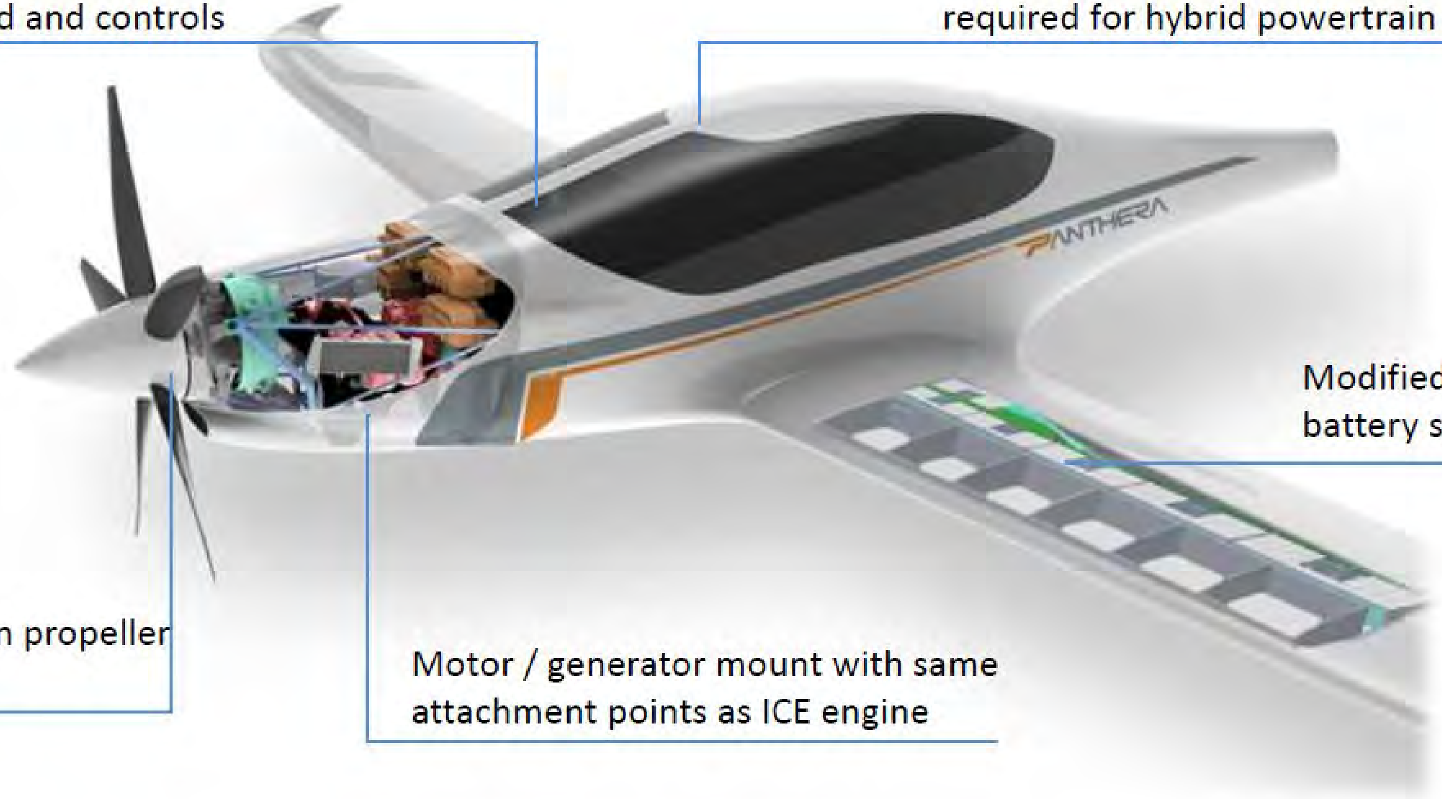
(Studies-Indirect Actions)
- Study on using pre-commercial procurements for drop-in advanced biofuel – 0.3
- Response to lessons-learnt from recent accidents / incidents in air transport – 2022 - (EASA) – 3.4
- Safety standards for the introduction of key concepts and technologies – 2022 – (EASA) – 3.4
- Solutions for runway safety (2022) – EASA – 2.1
- Standards supporting the digital transformation of aviation – (2022) – EASA – 2.1
- Development of new aviation health safety standards (for flight crews) – (2022) – EASA – 1.7
- Impact of security measures on safety (2022) – EASA – 1.5


MOET
www.moetproject.eu
More-Electric Technology
for Next-Generation Aircraft
Electro-mechanical actuators
Power electronics (liquid-cooled)
Electric wing ice protection
AIRBUS
All-electric APU
±270V DC power system
All-electric air conditioning
Electric engine start

HYPSTAIR Installation Platform Concept

HMI integration with modified dashboard and controls

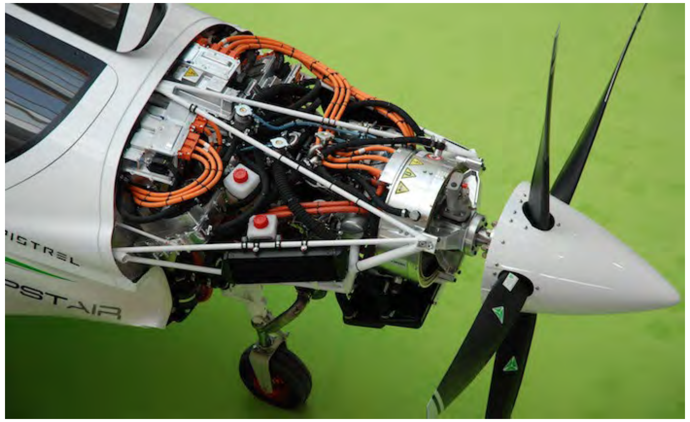
Fuselage with few modifications required for hybrid powertrain



Modified wing structure for battery system integration

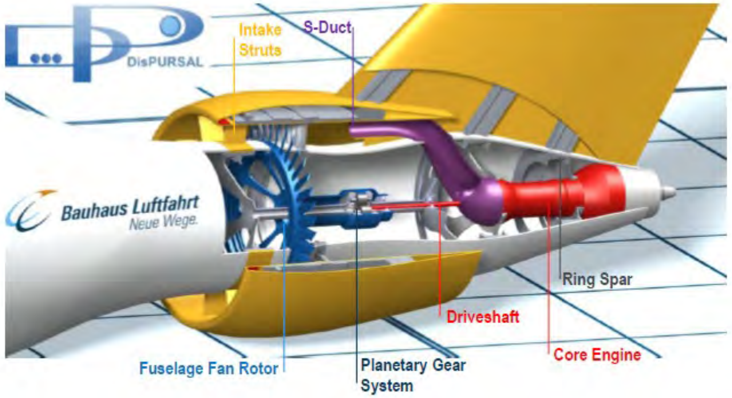
Low rpm propeller design

Motor / generator mount with same attachment points as ICE engine

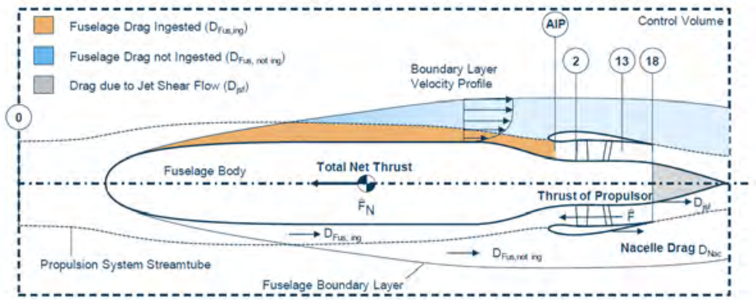


Selected Propulsive Fuselage Concept: Concept 1

DisPURSAL



>> Mapping of power plant integration effects



>> Thrust / Drag Book-keeping:

$$\bar{F}_N = \bar{F} - \bar{D}$$

where $\bar{D}$ includes all drag shares occurring for the configuration

>> Integration Factor:

$$f_{int} = \frac{F_{N,calc}}{\bar{F}_N}$$

cf. Bijewitz et al. (2014)

>> Fuselage Fan (FF) + Underwing-Podded UHBPR Turbofans Concept

Wing Concept

- Low Drag Design
- Natural/hybrid laminar flow technology
- Option: Integration of Cross Flow Fan (CFF) at trailing edge (not to be rated)

Fuselage Fan

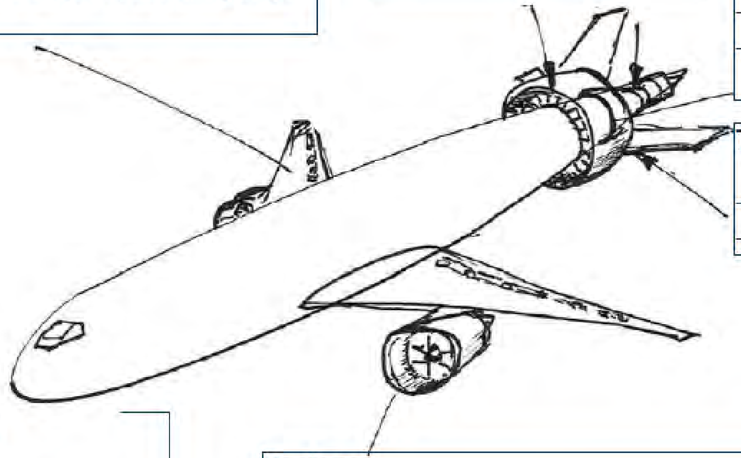
- Single or counter rotating
- Ducted or unducted

Gas Turbine for Fuselage Fan Drive

- Position most aftward
- Air intake behind Fuselage Fan
- Maintainability: Easy access at fuselage aft tip
- Blade-Off scenario: Burst corridor independent between FF and wing-mounted engines

Redundancy Concept

- *Thrust production of fuselage only to compensate for viscous fuselage drag*
- *Required excess thrust produced by installed UHBPR engines*



Tail Configuration

- Classical or T-Tail, V-Tail
- Mounted on fuselage aft cone

Preferable configuration

- Fuselage Fan + two under-wing mounted UHBPR turbofans
- Approximately equal thrust/power split of the three installed power plants
- Laminar wing technology, augmented by trailing-edge mounted Cross Flow Fan devices (not to be rated)

Power Transmission for Fuselage

- Mechanical via reduction gear system, or
- Electro-magnetic induction
- Drive of optional CFF (not to be rated): mechanical or hydro-mechanical (bleed air from UHBPR turbofans)

Engines

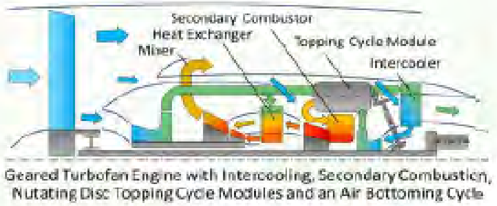
- Two underwing mounted UHBPR turbofan engines, or
- Two aft-fuselage pylon mounted UHBPR turbofan engines (not to be rated)

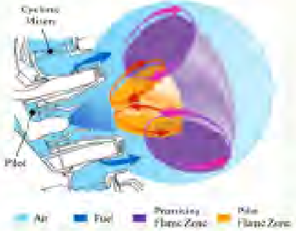
European Commission

Cranfield University

ENABLEH2 Strategic Importance

ENABLE·H2





ENABLE·H2

Disruptive propulsion, aircraft and electrical technologies to improve propulsive efficiency and overall airframe and engine integration

Disruptive propulsion core technologies for enhancing thermal efficiency and reducing NOx

\+

LH_2 is a key ENABLER for many of these advanced aircraft, propulsion system and more electrical disruptive technologies

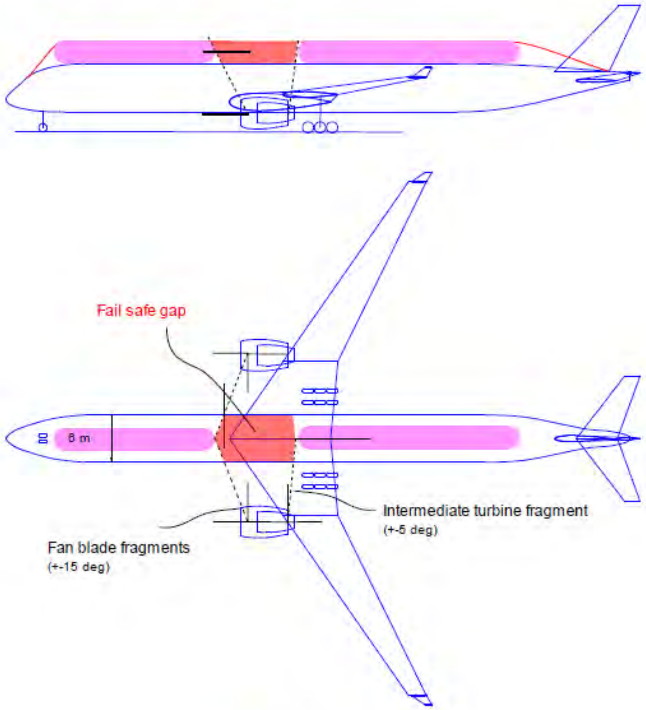
CO_2↓,CO ↓, UHC ↓, Soot ↓ NOx↓,
Environmental Impact ↓

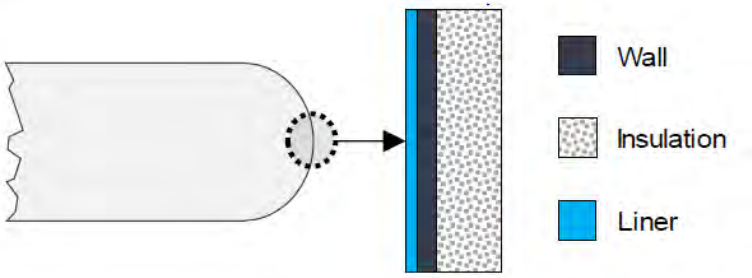
~~CO_2, CO, UHC, Soot,~~ NOx↓ ↓ ↓,
Mission Fuel Burn ↓↓↓
Environmental Impact ↓↓↓
(with appropriate mission management and LH_2 production methods)

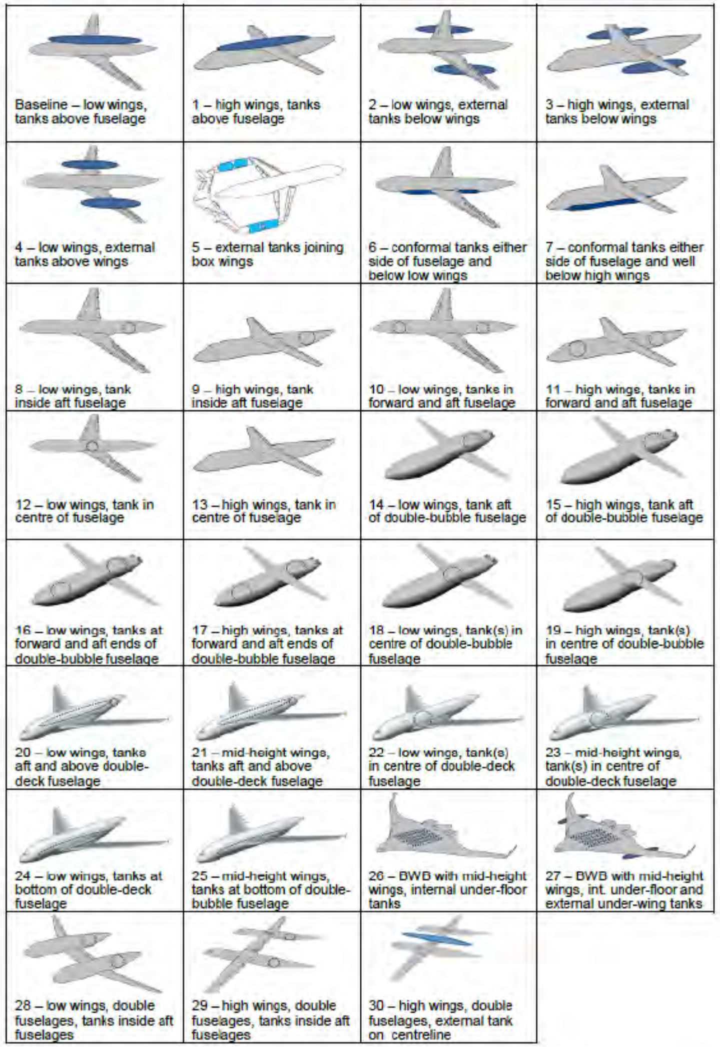
Images courtesy of GE, NASA and EU H2020 ULTIMATE Project

Cryogenic hydrogen tanks

- ENABLEH2 study.
- Chalmers concept follows simple existing idea
- Focus innovation on propulsion system / fuel heat system
- Insulated foam tanks are low TRL
- Double walled vacuum tanks are heavy (difficult with longer ranges)
- Polyvinylchloride rigid closed cell







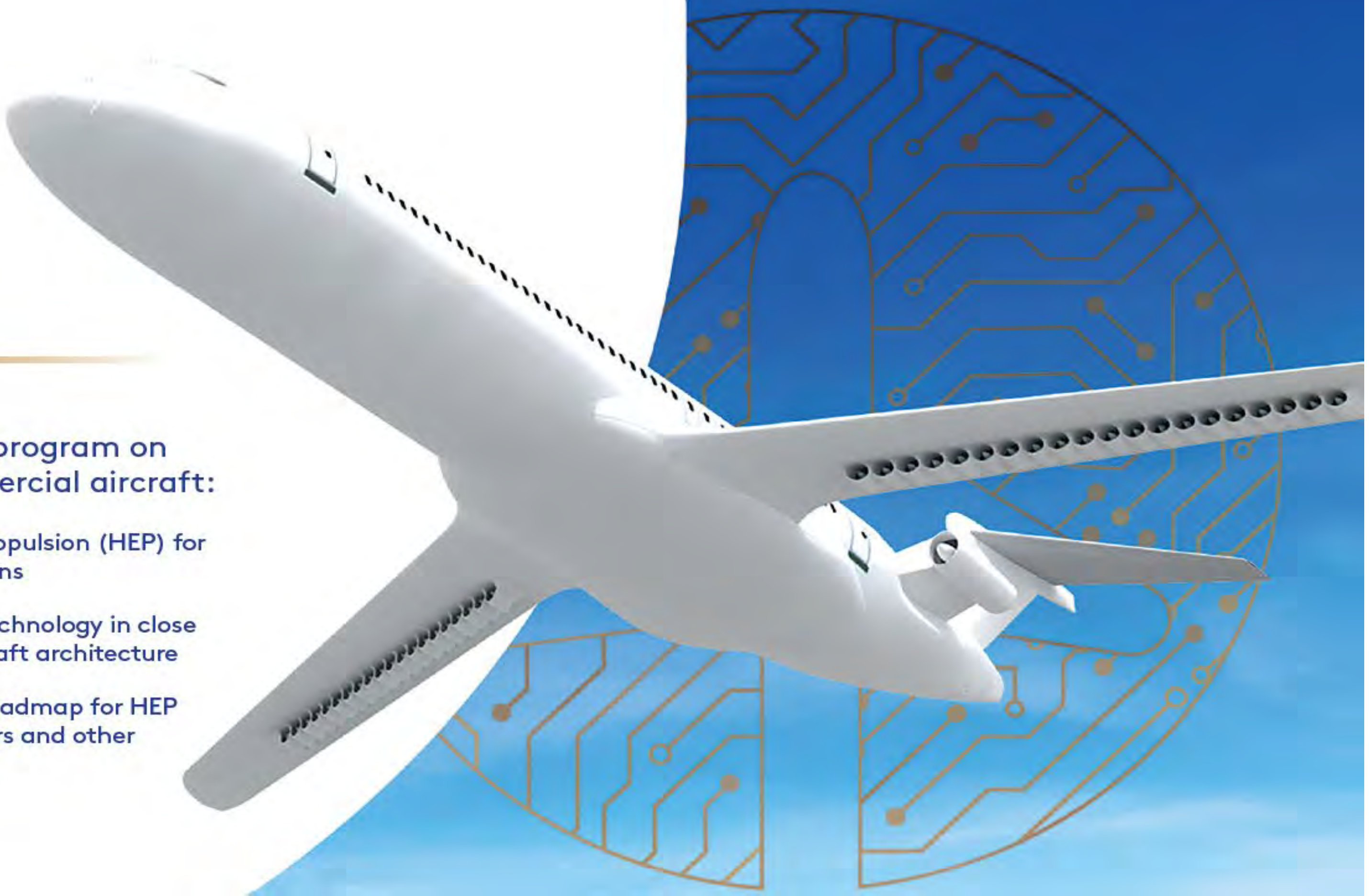
Rompokos, P, Rolt A, Nalianda D, Isekveren A T, Senné C, Grönstedt T., Hamidreza A., Synergistic technology combinations for future commercial aircraft using liquid hydrogen", Journal of Engineering for Gas Turbines and Power, Volume143, Issue, 7, 2021

IMOTHEP

GETTING HYBRID ELECTRIC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875006

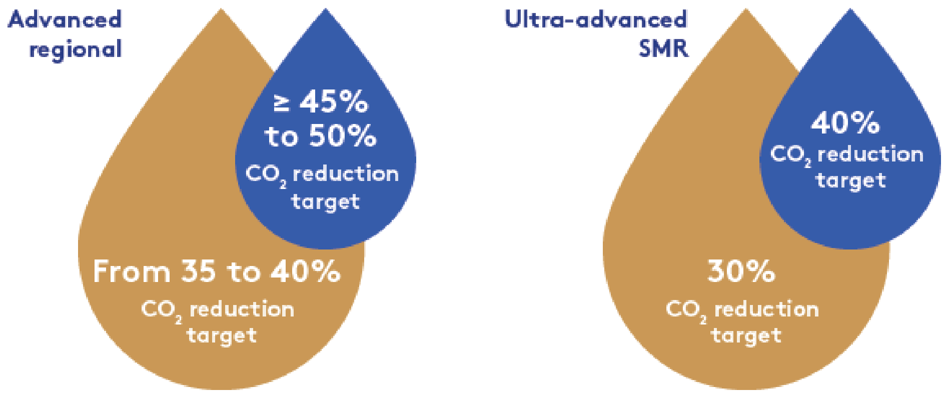
GETTING HYBRID ELECTRIC



An ambitious 4-year technological program on hybrid electric propulsion for commercial aircraft:

- A holistic approach toward hybrid electric propulsion (HEP) for the reduction of commercial aircraft emissions
- An in-depth analysis of hybrid power train technology in close connection with propulsion system and aircraft architecture
- The ultimate goal to elaborate a European roadmap for HEP development, in connection with stakeholders and other on-going projects
- A powerful multidisciplinary consortium

IMOTHEP vs CS2 reduction target

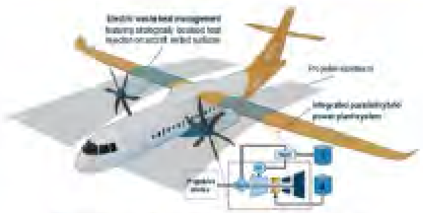
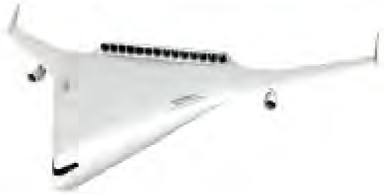


Reference for emissions reduction: 2014 technology

2 reference missions

Mission	Pax	Speed	Targeted range
Regional	50	[0.4 - 0.48]	600 nm
SMR	150 - 180	[0.6 - 0.8]	≥ 800 nm 1200 nm best option

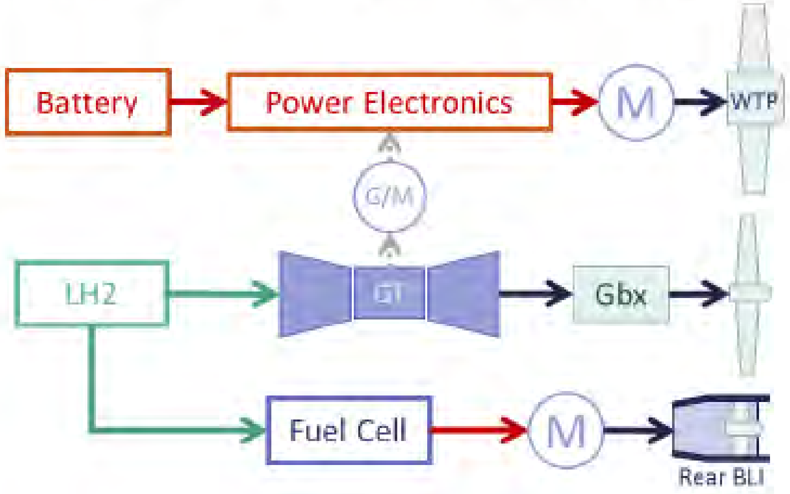
4 supporting configurations

	Conservative	Radical
Regional	 Credits: Bauhaus-Luftfahrt Electrically assisted turboshaft	 Credits: Safran Turboelectric + DEP + wing-tip propeller
SMR	 Credits: ONERA Tube & wing, turboelec, DEP (from CS2)	 Credits: ONERA BWB, turboelectric, DEP, BLI

FUTPRINT50

Future propulsion & integration:
towards a hybrid-electric 50-seat regional aircraft

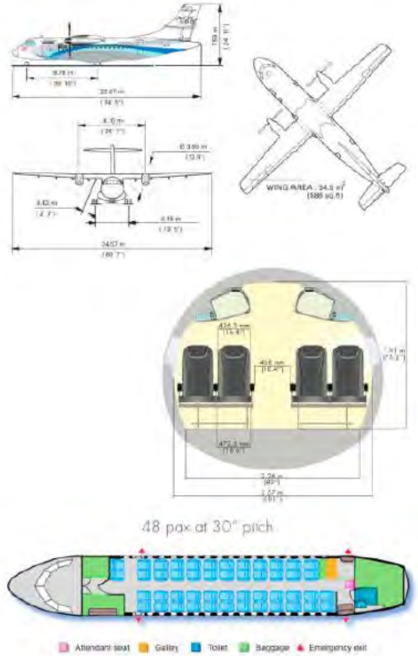
Architectures 4 - Figure 19 offers the potential for zero carbon tail pipe emissions and in some special cases even zero tail-pipe emissions throughout the mission profile.



FUTPRINT50

Future propulsion & integration:
towards a hybrid-electric 50-seat regional aircraft

It is important to highlight that data presented in **Figure 23** and **Figure 24** have distinct assumptions for fuel reserves and OEW.



Standard configuration	48 seats
Engines Pratt & Whitney Canada	PW127M
Take-off power	2,160 SHP
Take-off power - One engine	2,400 SHP
Max continuous	2,400 SHP
Max climb	2,160 SHP
Max cruise	2,132 SHP
Propellers Hamilton Standard	568F
Blades, diameter	6, 3.93 m - 12.9 ft
Weights	
Max take-off weight (basic)	18,600 kg - 41,005 lb
Max landing weight (basic)	18,300 kg - 40,344 lb
Max zero fuel weight (basic)	16,700 kg - 36,817 lb
Max zero fuel weight (Option)	17,000 kg - 37,478 lb
Operational empty weight (Tech. Spec.)	11,550 kg - 25,463 lb
Operational empty weight (Typical in-service)	11,700 kg - 25,794 lb
Max payload (at typical in-service OEW)	5,300 kg - 11,684 lb
Max fuel load	4,500 kg - 9,921 lb
Airfield performance	
Take-off distance	
- Basic - MTOW - ISA - SL	1,165 m - 3,822 ft
- TOW for 300 Nm - Max pax - SL - ISA	1,025 m - 3,363 ft
- TOW for 300 Nm - Max pax - 3,000 ft - ISA +10	1,215 m - 3,986 ft
Take-off speed (V2 min @ MTOW)	112 KCAS
Landing field length (FAR25)	
- Basic MLW - SL	1,126 m - 3,694 ft
- LW (max pax + reserves) - SL	1,055 m - 3,461 ft
- Reference speed at landing	104 KIAS
En-route performance	
Optimum climb speed	160 KCAS
Rate of climb (ISA, SL, MTOW)	1,851 ft/min
Time to climb to FL170	12.7 min
One engine net ceiling (95% MTOW, ISA +10)	13,010 ft
Max Cruise speed (95% MTOW - ISA - Optimum FL)	300 KTAS - 556 km/h
Fuel flow at cruise speed	811 kg/hr - 1,788 lb/h
Range with max pax	716 Nm
200 Nm Block Fuel	565 kg - 1,246 lb
200 Nm Block Time	54.1 min
300 Nm Block Fuel	783 kg - 1,727 lb
300 Nm Block Time	75.0 min

Assumptions for en-route performance:
- Max optional TOW & LW
- Payload: max pax
- OEW: typical in-service
- Pax weight: 95 kg (including baggage)
- Reserves: 5% trip fuel + 30 min hold + 100 Nm diversion
- Taxi: 4 min

H3PS

HIGH POWER HIGH SCALABILITY AIRCRAFT HYBRID POWERTRAIN

The H3PS project is developing the first parallel hybrid powertrain for General Aviation, in a 4-seater aircraft. H3PS will power the Tecnam P2010 in order to demonstrate the benefits and high scalability of the hybrid powertrain for up to 11-seater airplanes. The project will introduce a marketable solution, that will allow superior performance, fuel savings and greener operations, at comparable installation weights.

H3PS completed the design phase of the hybrid powertrain and physically manufactured all the key components. This includes the dedicated Rotax 915iS combustion engine, Genset (electric motor/generator), batteries, battery container, wiring looms, and control boxes. The consortium weighted all aforementioned components and validated that, for the first time in aviation, the global installation weight of a hybrid solution is equivalent to the weight of the standard configuration.

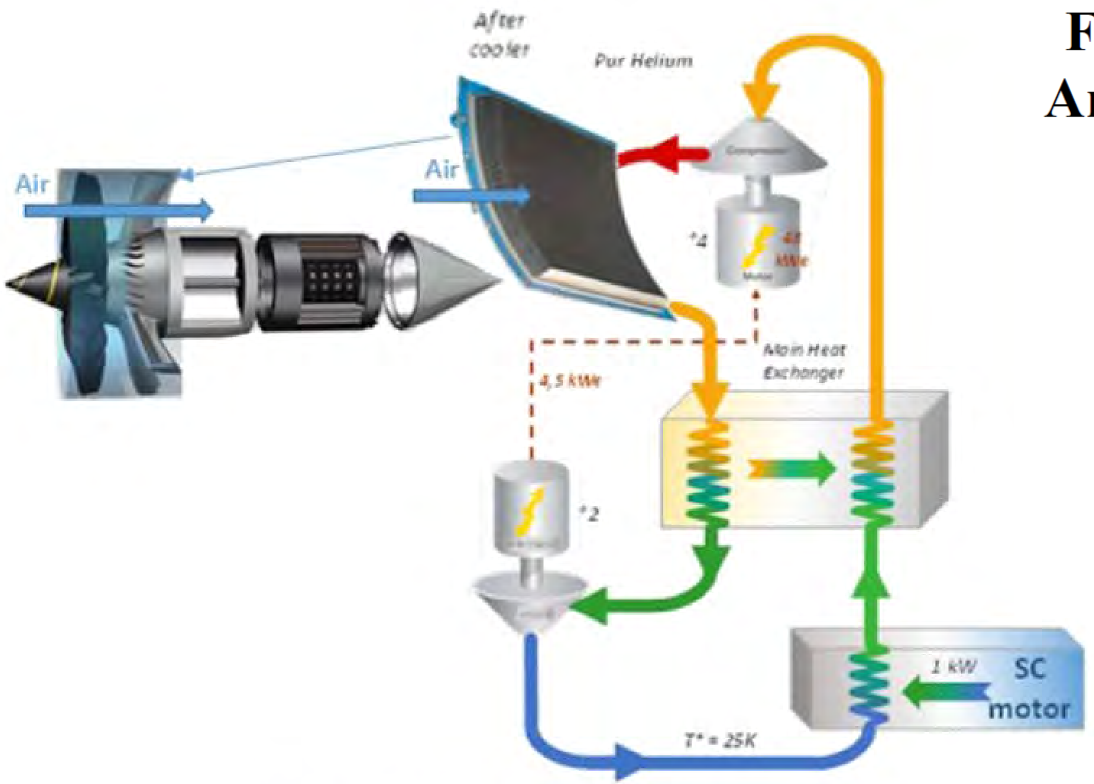


Figure 1: cryocooler cycle with air as hot sink

Field Cooling Magnetization and Losses of an Improved Architecture of Trapped-Field Superconducting Rotor for Aircraft Applications

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ASuMED

Advanced Superconducting Motor Experimental Demonstrator

Takeaways

1. **Horizon Europe – Pillar II**
Global Challenges – Industrial Competitiveness

€53.5 billion

2. **Opportunities for Collaboration – incl. International**

3. **Airbus and CFM International to pioneer hydrogen combustion technology**

@Airbus @CFM_engines @GEAviation @SAFRAN #A380 #Sustainability #ZEROe

Toulouse/Washington, 22 February 2022 – Airbus has signed a partnership agreement with CFM International, a 50/50 joint company between GE and Safran Aircraft Engines, to collaborate on a hydrogen demonstration programme that will take flight around the middle of this decade.

Thank you for your attention

https://ec.europa.eu/research/transport/index.cfm