EASA
European Union Aviation Safety Agency

mahepa
Modular Approach to Hybrid Electric Propulsion Architecture

MAHEPA – EASA Webinar

03 July 2020

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Aim of the webinar / panel discussion

- Inform about the MAHEPA project and its research results
- Inform about EASA's role in research and innovation in general and for the MAHEPA project in particular
- Facilitate a dialogue between webinar participants and the panellists

Some recommendations

- → Use your headset and keep your microphone muted when not speaking
- → If you would like to participate in the discussion:
  - → Use the '**raising hand**' button on the right top corner next to your name, or
  - → Use the '**chat tool**' and draft a comment or question to 'everyone'

Panellists

Fabrizio Gaspari
Lorenzo Trainelli
Tine Tomažič

Alain Leroy
Gernot Kessler

Moderator: Willy Sigl

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European Union Aviation Safety Agency

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Modular Approach to Hybrid Electric Propulsion Architecture

MAHEPA Project Presentation

MAHEPA consortium – 03 July 2020

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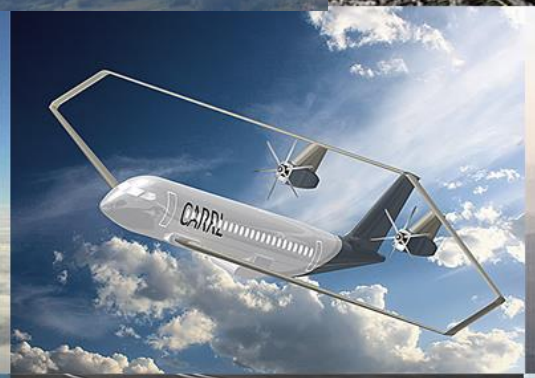
Modular Approach to Hybrid-Electric Propulsion Architecture

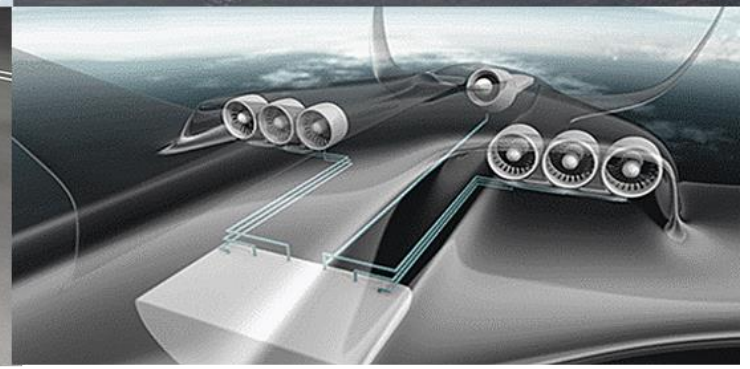
Fabrizio Gaspari

Project Coordinator

At the verge of a new era for aviation

Hybrid-electric propulsion





MAHEPA

Towards hybrid-electric flying

- **MAHEPA**: **M**odular **A**pproach to **H**ybrid-**E**lectric **P**ropulsion **A**rchitecture

- 9 M€ project entirely funded by European Union Horizon 2020 research and innovation programme

- 8 Partners:

PIPISTREL

Compact Dynamics

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

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TU Delft Delft University of Technology

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MAHEPA

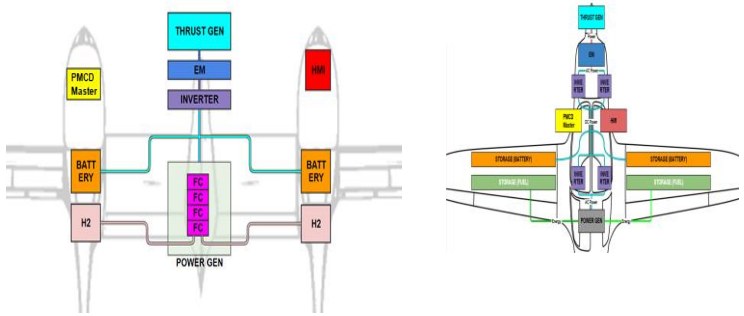
Objectives of the project

Main objectives:

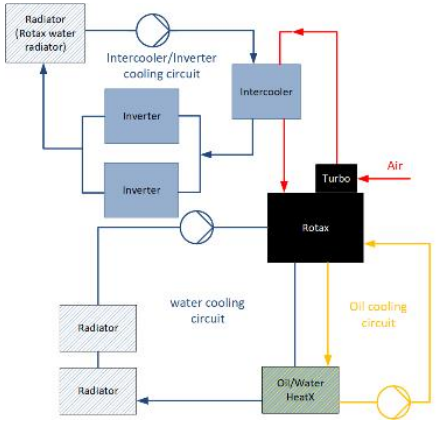
- To **advance** two variants of a low emission, highly efficient, **serial** hybrid-electric propulsion architecture to **TRL 6**
- **In-flight** demonstrations on **two different aircraft** to showcase flexibility and scalability of the powertrains
- Scalability studies towards **megawatt scale** hydrocarbon driven hybrids and zero-emission hydrogen-powered solutions

MAHEPA Project direct value propositions

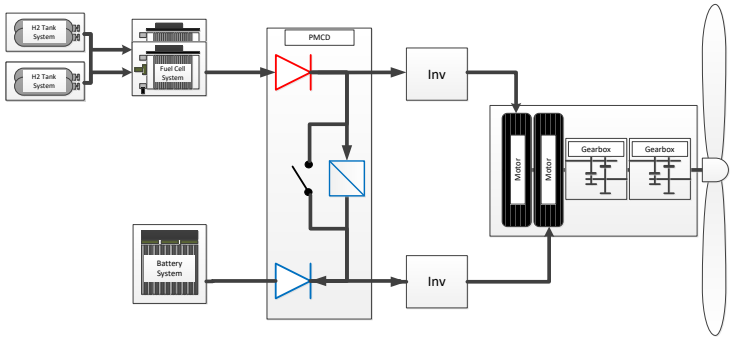
Methods



Modular Approach

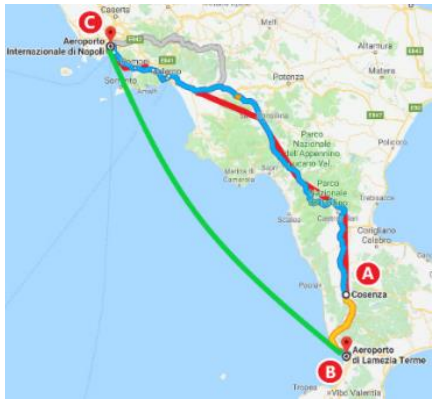


Cooling system design

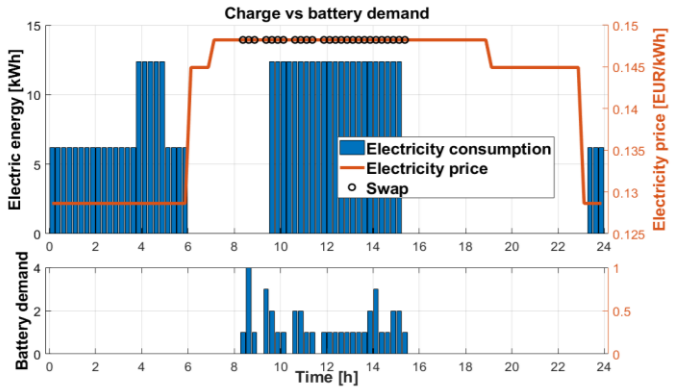


Flex FC hybrid architecture

Emission measurements



Market Demands Estimations



Ground infrastructure assessments

MAHEPA Project direct value propositions

Components

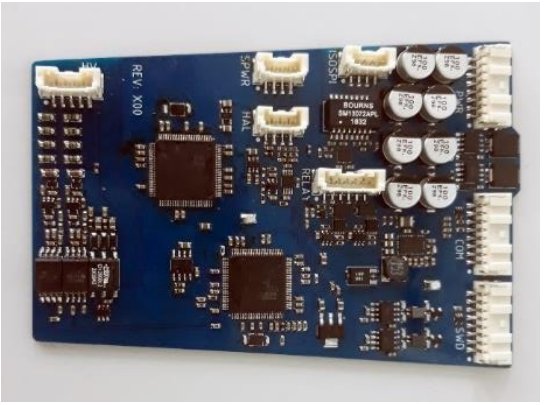
Electric Drive

Power Generation Module

Fuel Cell System

Structure adaptations

Liquid cooled battery

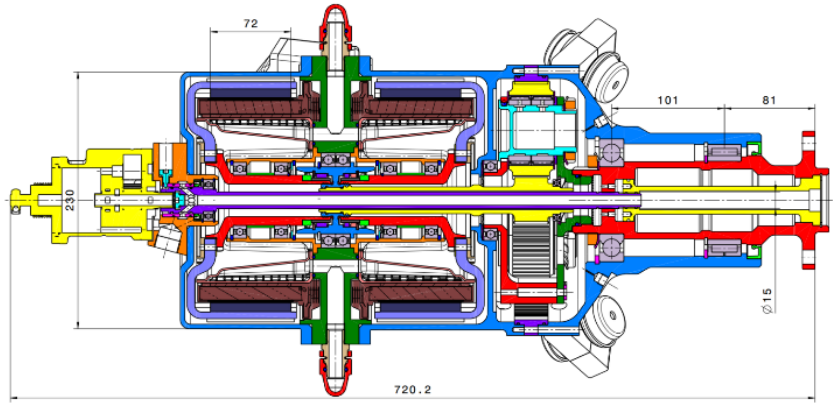


Battery Management System

MAHEPA – Electric motor

Light and powerful

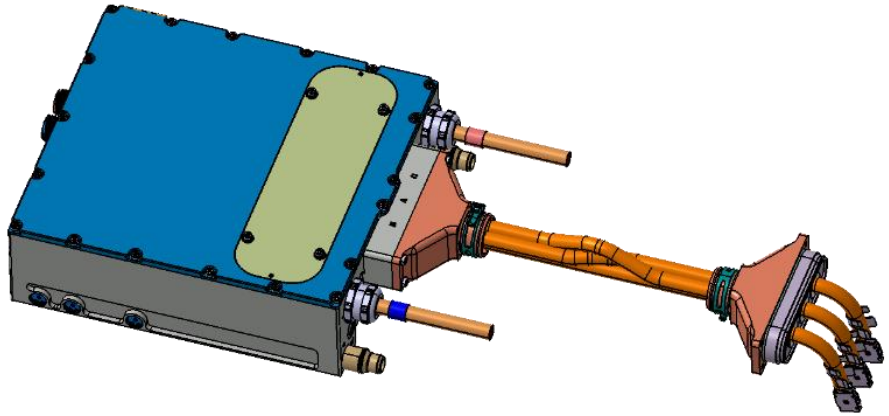
- ✓ **Dual motor** mechanically and electrically decoupled
- ✓ Free wheel to run only one motor in case of **failure**
- ✓ Peak power: **300 kW** (**50% more powerful** than previous generations)
- ✓ Weight (excl. gearbox and prop shaft): **30 kg** (**25% lighter** than previous generations)



MAHEPA – Power controller

As light as possible

- ✓ **Silicon-Carbide** technology
- ✓ Peak power: **180 kW**
- ✓ Power density: **25.7 kW/kg**
- ✓ Efficiency: **97.5 %**
- ✓ Weight: **7 kg** (each) (**29% lighter** than previous generation)



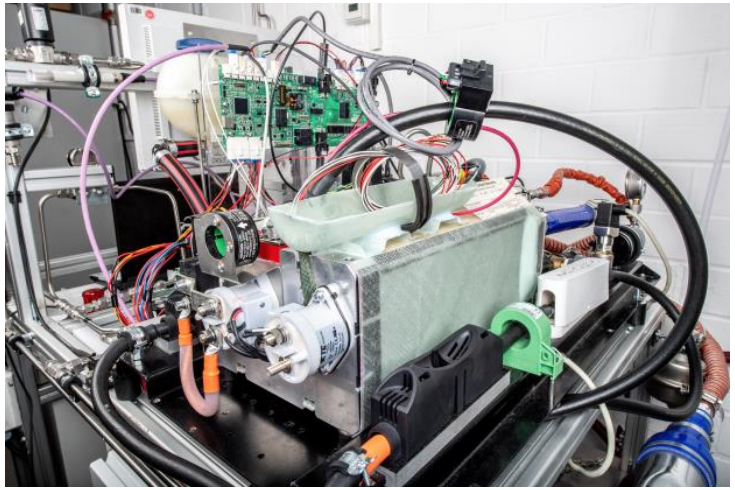
MAHEPA – Liquid cooled battery

- ✓ **Lithium-ion** technology
- ✓ Peak power: **75 kW** (each)
- ✓ Weight: **60 kg** (each)
- ✓ Fully **integrated** in the airframe
- ✓ Allowing **all-electric** take-off

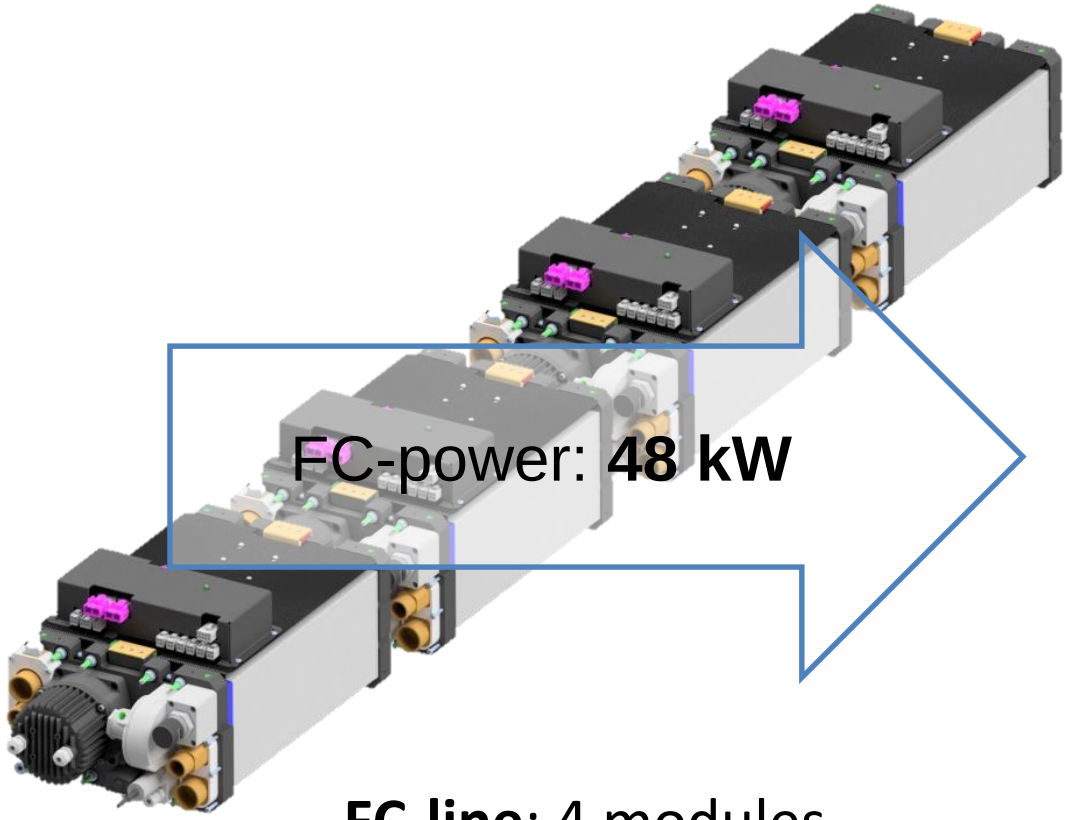
MAHEPA – Fuel Cell System

An intrinsic redundant system

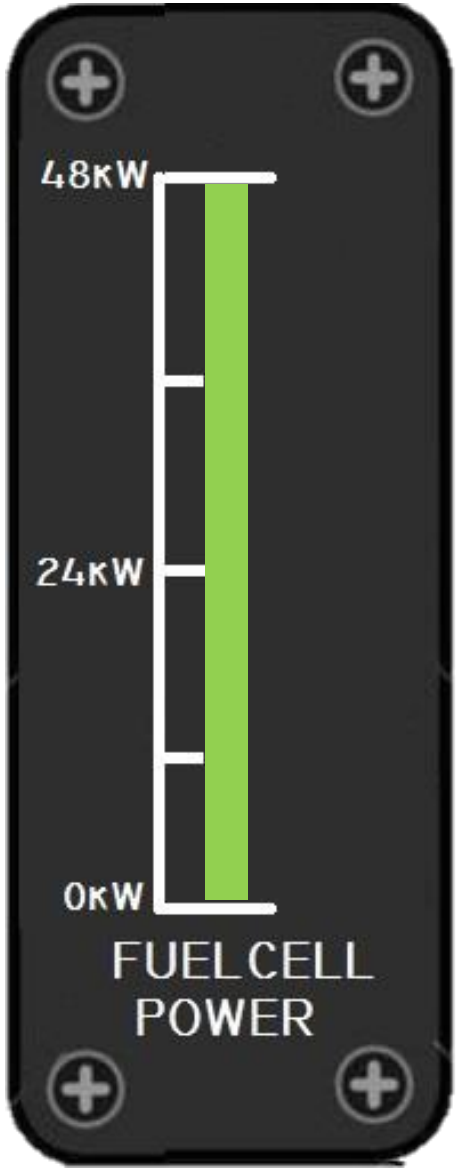
From a FC Module to FC-line



12kW **FC-Module**



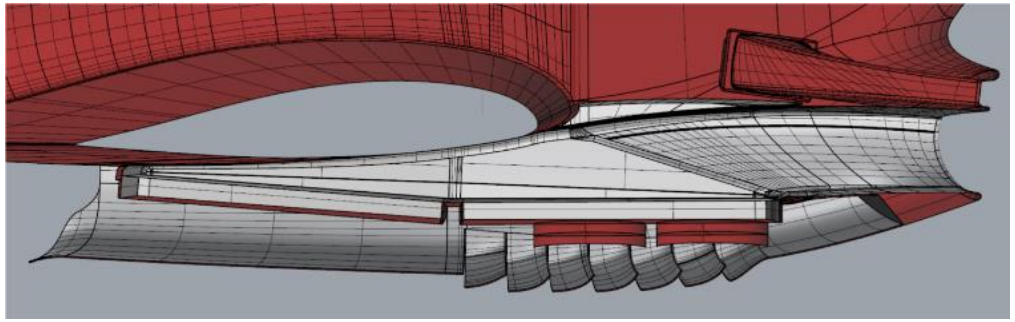
FC-line: 4 modules



MAHEPA – Fuel Cell hybrid-electric airframe

Airframe adaptations

- New structural **challenges** to integrate the fuel cell system
- **Ground tests** to toroughly understand system behaviour
- **New** Cooling System design



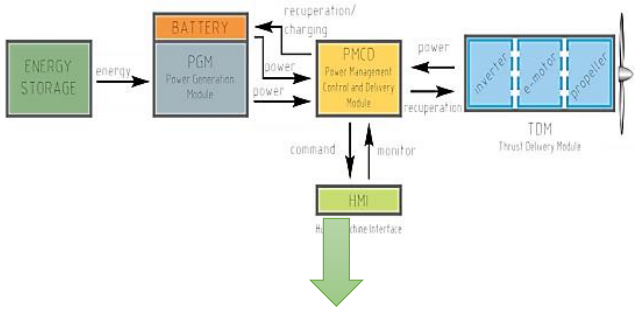
MAHEPA – Next steps

Flight tests and consolidation of results

- **Flight test** campaigns of two HE aircraft
- Advanced **power management** methods validation
- Flight data analysis and **consolidation** of results
- **Scalability studies**: design freeze of DEP and classic architectures

MAHEPA – not only about flying aircraft

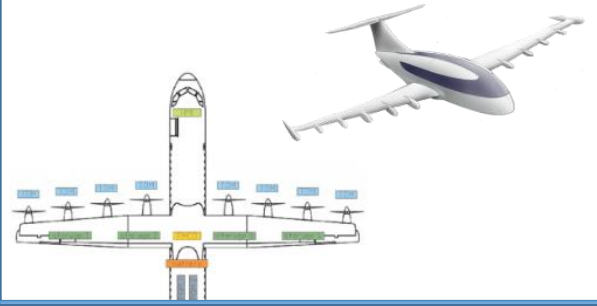
Scalability studies



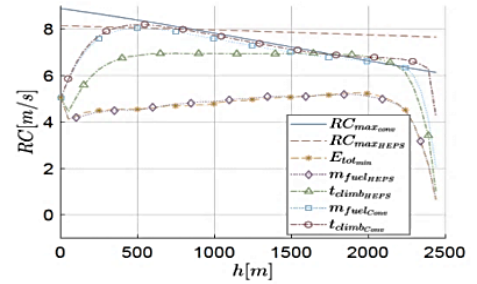
$$\begin{cases} \eta_{nom\,i} = P_{nom}, Arch, \dots \\ W_{nom\,i} = P_{nom}, Arch, \dots \end{cases}$$

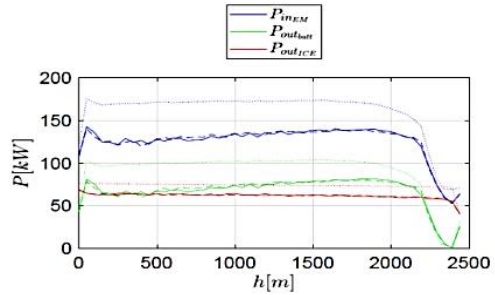
Definition of **parametric models for the powertrain components** and system performance.

A/C design with "concentrated" HEPS.
POLIMI tool: ***HYPERION***



A/C design with "distributed" HEPS.
TUD tool: ***INITIATOR***

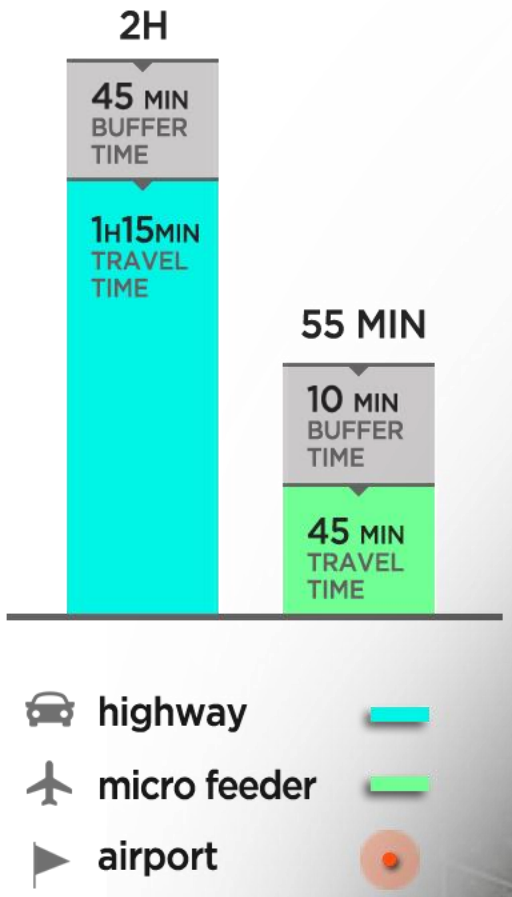




Advanced power management concept to reduce energy consumption during the mission

MAHEPA – not only about flying aircraft

19-seat microfeeder: a real business case for today's hybrid-electric technology

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 723368.

MODULAR APPROACH TO HYBRID-ELECTRIC PROPULSION ARCHITECTURE

EASA
European Union Aviation Safety Agency

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Modular Approach to Hybrid Electric Propulsion Architecture

Innovation and related activities

Alain LEROY - 03 July 2020

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Innovation and related Activities

03 July 2020 – Alain LEROY

Your safety is our mission.

Innovation & related activities

Manage & coordinate changes necessary to adapt the Agency activities and processes to innovation

Create a dynamic of innovation in the Agency and foster the sharing of innovation knowledge and information across domains

Support the Industry on innovation through partnerships.

We need to be prepared for the FUTURE

Partnership with Industry on Innovation 1

European Union Aviation Safety Agency

Memorandums of Cooperation on innovation

Establish a formal framework enabling….

upstream involvement of EASA

- Cooperation in the early stages
- Identification of key risk areas linked to innovation projects
- Evaluate possible EASA support
- Adapt our processes, organisation, procedures, rules and staff competence plans to support innovative industry projects.

Possible related tasks & actions

- Specific Innovation Partnership Contracts
- Workshops
- Research cooperation (PhD thesis, …)
- Universities networking
- Exchanges of experts (limited period)
- Training

Partnership with Industry on Innovation 2

Innovation Partnership Contracts

Cover the supply of technical knowledge and support within an innovation project to encourage the development of:

- **novel technologies**
- **new business models**
- **new services**

Focus on the exchange of expertise on a multi-disciplinary scale (certification, operation, crew qualification, ATM, etc…)

Address the concept development phase (feasibility)

do not cover any pre-certification task (this is done via Technical Advice Contracts)

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Modular Approach to Hybrid Electric Propulsion Architecture

General concept of operations

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MAHEPA-EASA Webinar
03/07/2020

Compact Dynamics

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Hybrid-electric short-haul air transportation scenarios

Lorenzo Trainelli, PhD

Hybrid-electric short-haul air transport

MAHEPA and UNIFIER19 framework

In the **MAHEPA** H2020 project, an important research effort is devoted to:

- Hybrid-electric powertrain technology and component **scalability**
- Hybrid-electric aircraft **design, performance and environmental impact analysis** methods
- Strategies for maximizing the impact of hybrid-electric aircraft in **future commercial aviation**

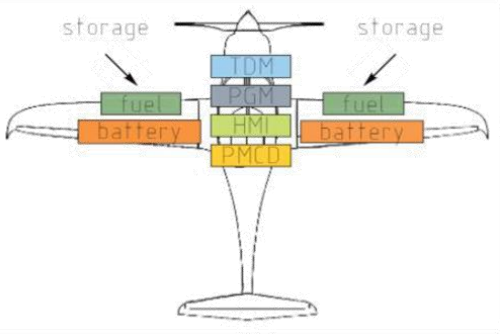
In the **UNIFIER19** Clean Sky project, a **near-zero emission 19-pax commuter** is conceptually designed

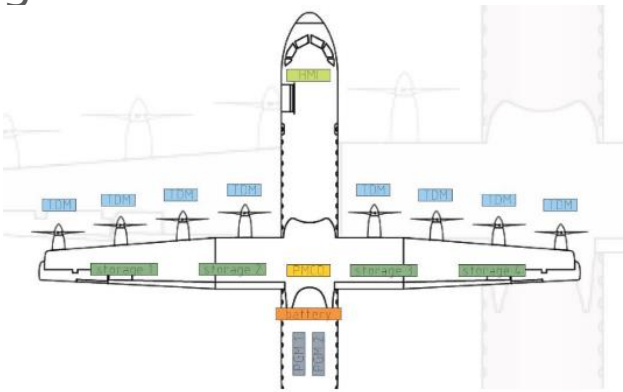
- Scenario studies are carried out to derive top-level aircraft requirements

Hybrid-electric short-haul air transport

Future European mobility

- Short-haul air transportation is a key for the enhancement of personal mobility in Europe
- **Flightpath 2050 vision**
  - **Four-hours door-to-door goal**: virtually all EU citizens shall reach any continental destination in less than four hours, door to door, by the year 2050
- Hybrid-electric aircraft are **ideal candidates** to contribute to this ambitious goal
  - Environmentally-sustainable operations
  - Technology maturity
    - Hybrid-electric propulsion shall enter the market starting with lower-weight aircraft categories
    - Scalability to commuter aircraft is **feasible**





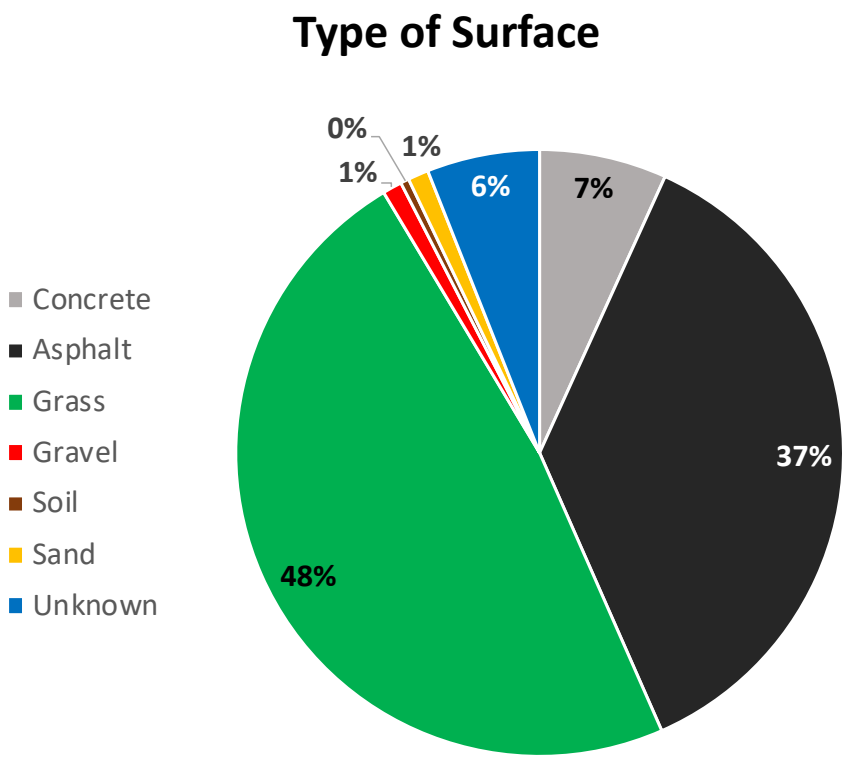
Hybrid-electric short-haul air transport

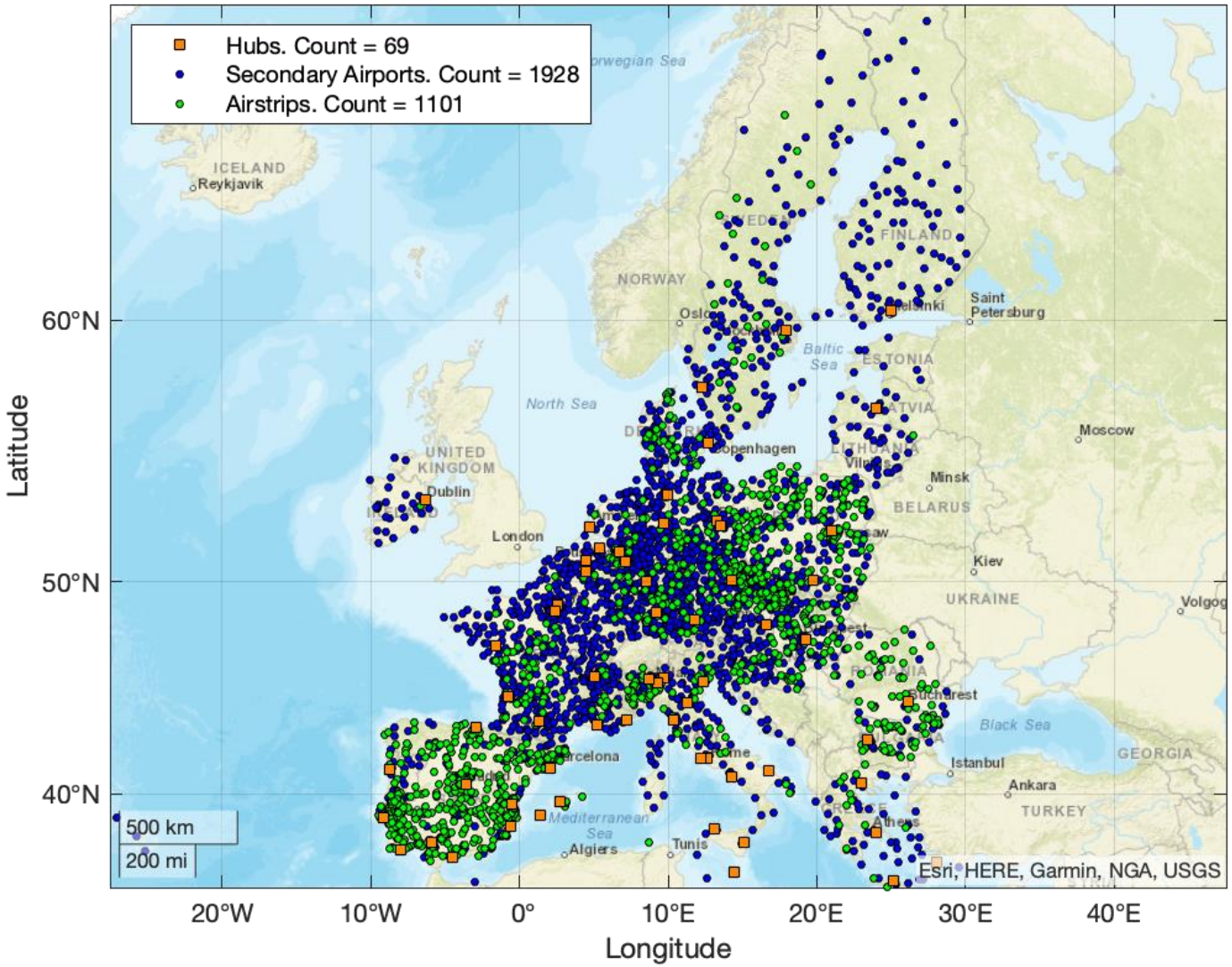
General concept

- Scenario studies specifically address the **short-haul regional** air transportation system
  - **Miniliner market** (point-to-point)
    A minliner provides a commuting service connecting small towns, substituting less-effective ground transportation means
  - **Microfeeder market** (hub-and-spoke)
    A microfeeder service brings passengers from small towns and open-country to hubs, feeding medium-range and long-range flights
- Exploiting the European **smaller airports** and even airstrips is a crucial enabler

Hybrid-electric short-haul air transport

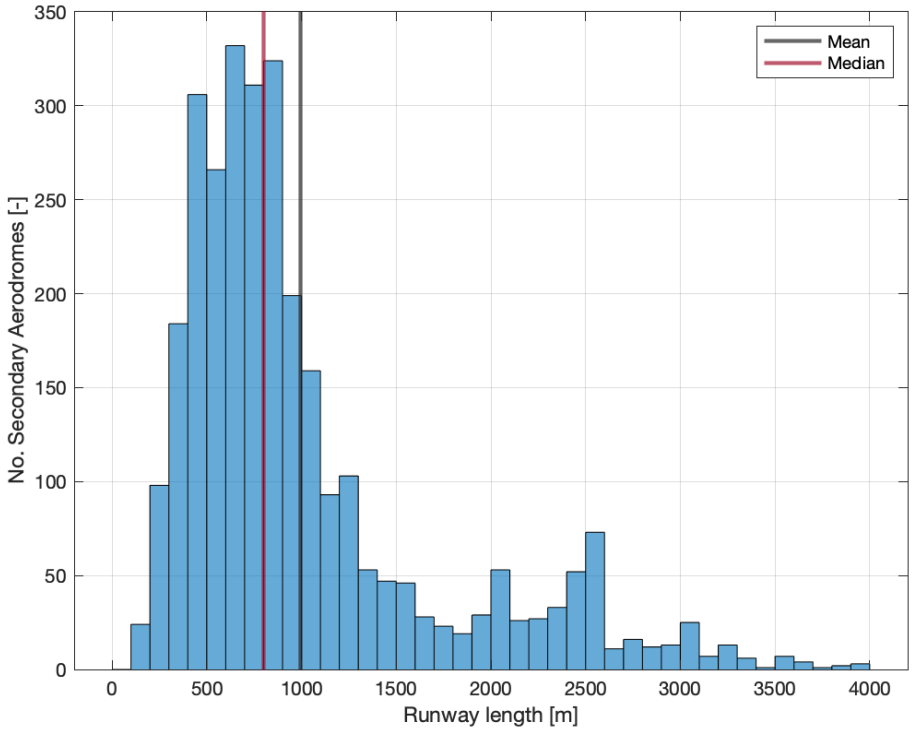
European aerodromes





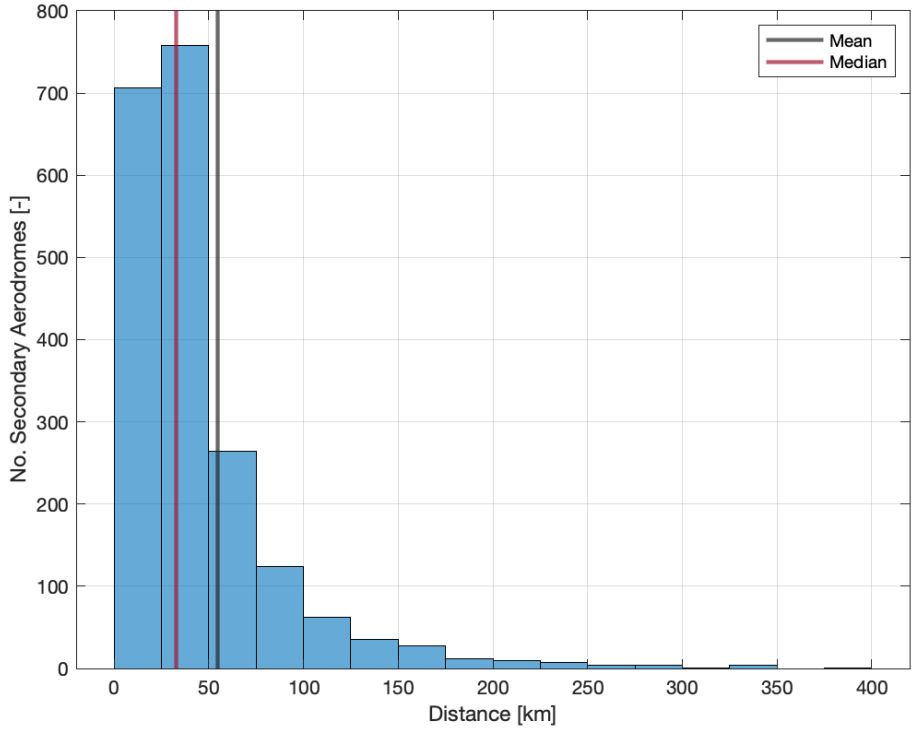
Hybrid-electric short-haul air transport

European aerodromes



Runway length distribution

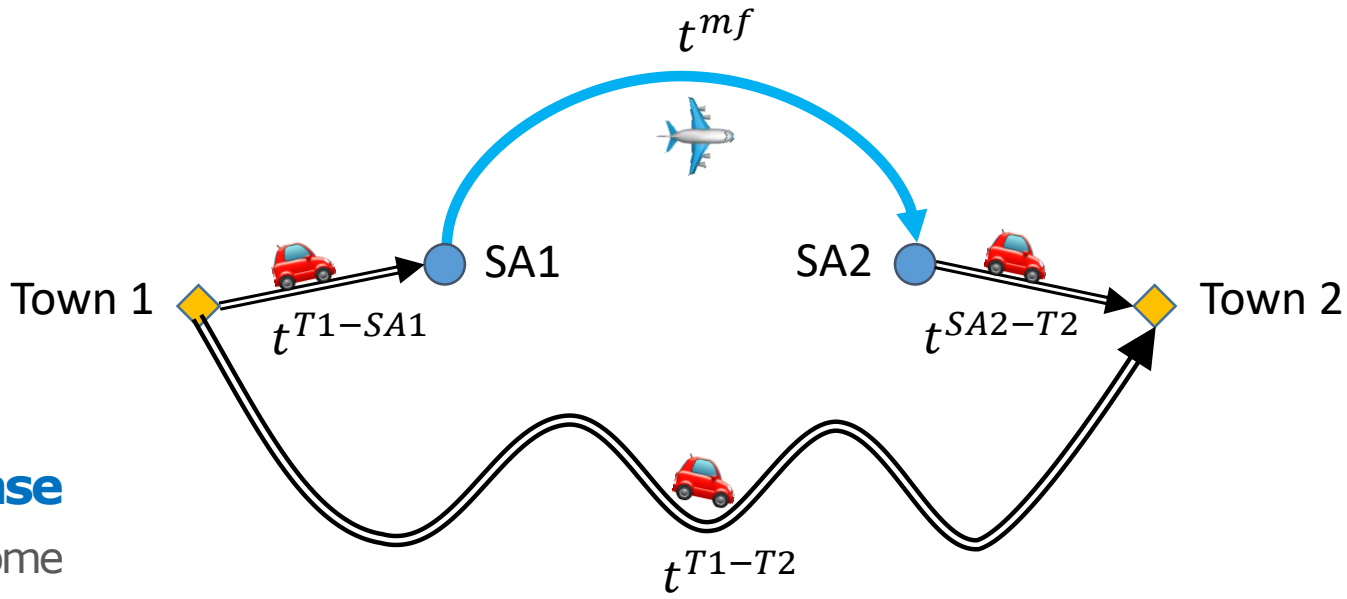
- 50% of the aerodromes feature a length over 800 m



Aerodrome mutual distance

- 88% of the aerodromes have another one closer than 100 km

- Potential demand is assessed based on the advantage of using a miniliner/microfeeder service when compared to ground transportation means
  - Multiple elements may contribute: cost, comfort, time
  - The time advantage is **crucial**



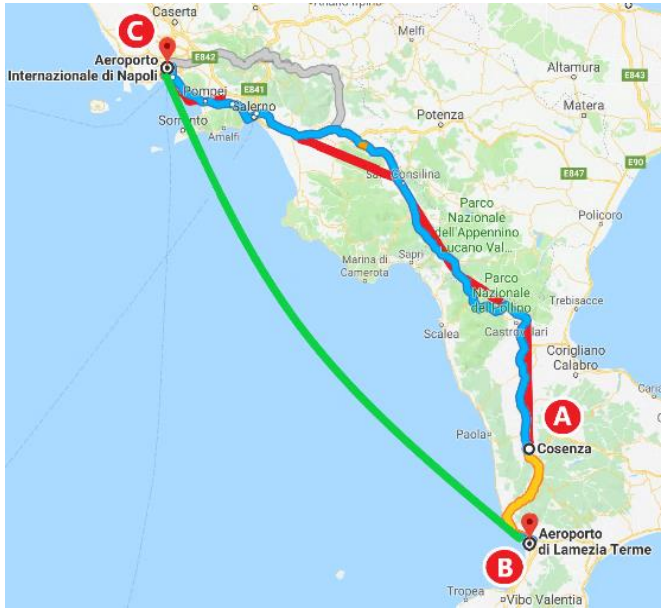
Miniliner case

SA: secondary aerodrome

Hybrid-electric short-haul air transport

Potential demand estimation

- Based on the time (possibly other parameters) advantage, a **catchment area** can be attributed to each candidate route
  - The potential traveller demand can be estimated

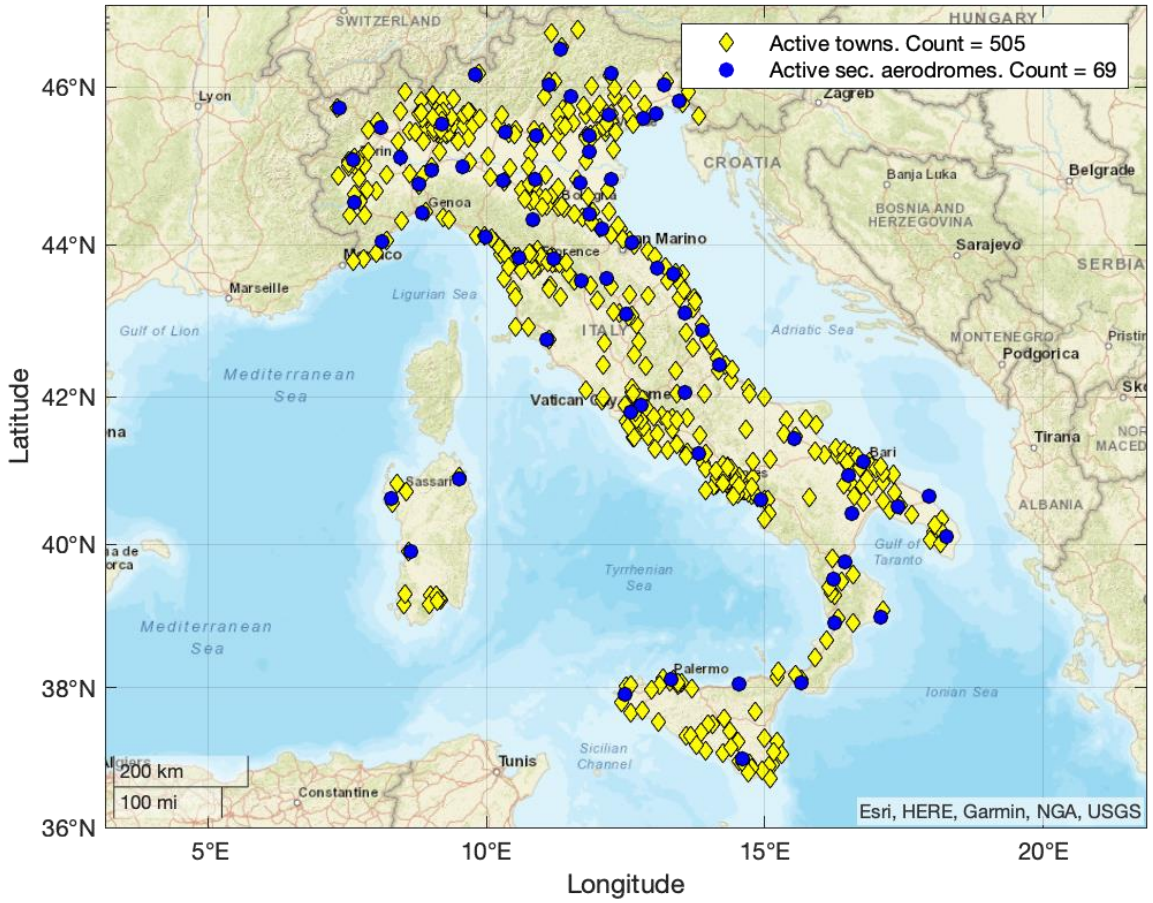


Microfeeder case

Catchment are a for the Lamezia Terrme -Naples International Airport route

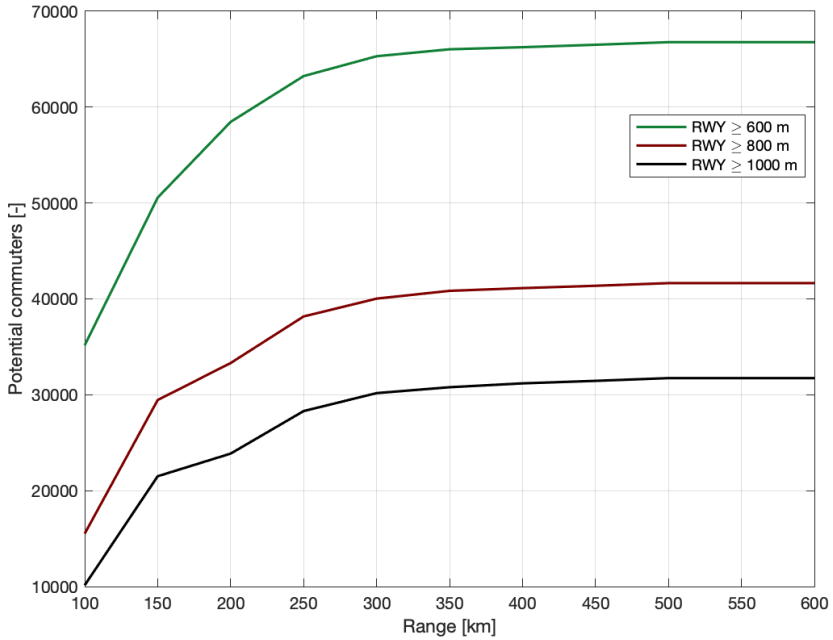
Hybrid-electric short-haul air transport

Miniliner scenario studies



Italian scenario example

- Trip distance 200 km
- Cruising speed 200 KTAS
- Runway length 800 m or longer



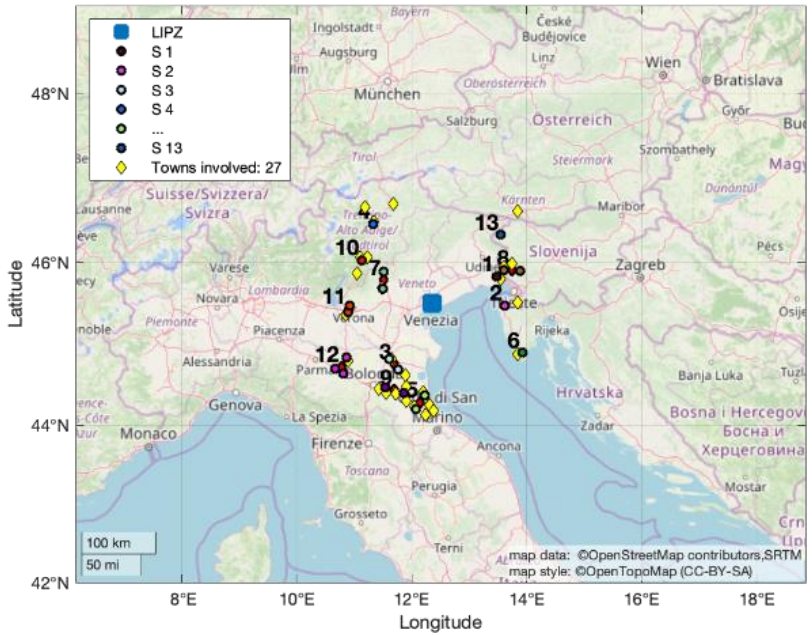
Potential demand estimation

Hybrid-electric short-haul air transport

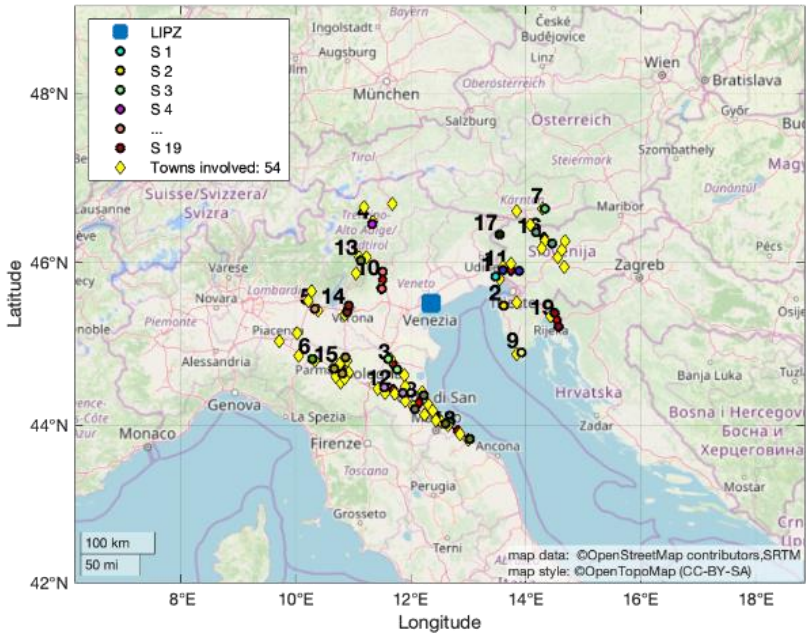
Microfeeder scenario studies

Venice International Airport example: distribution of towns and secondary aerodromes involved

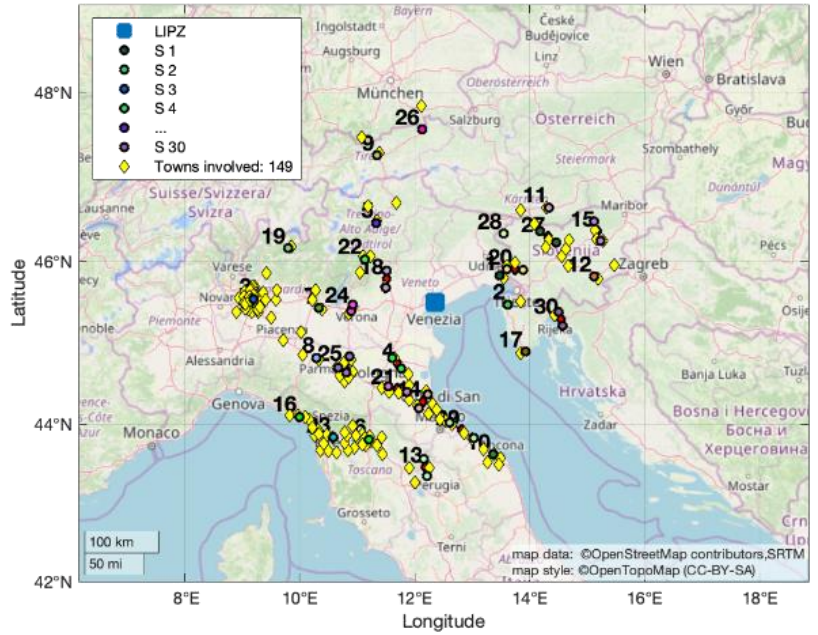
- Case of 800 m or longer runways and a cruising speed of 200 KTAS



Maximum trip distance: 150 km



Maximum trip distance: 200 km

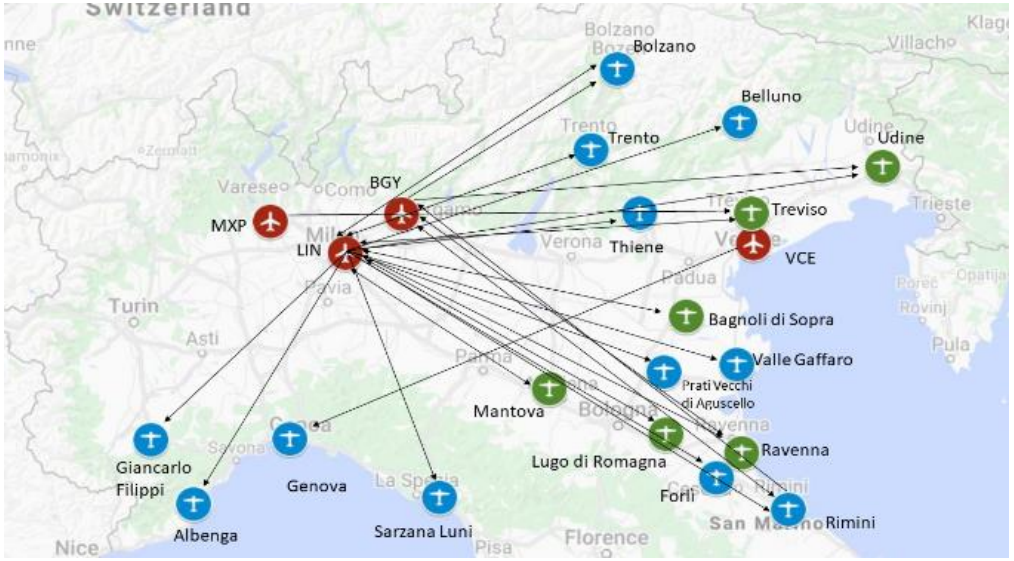


Maximum trip distance: 250 km

Hybrid-electric short-haul air transport

Optimal transportation network

- Potential demand assessment allows to derive effective top-level **aircraft design requirements**
  - These drive the **conceptual design** of innovative, near-zero emission commuter aircraft
- It also provides the input for a **location and routing algorithm** that defines the **optimal route network**
  - Maximizes the total demand satisfied while minimizing the number of active secondary airports
  - Provides the complete time-scheduling of flights operated with the miniliner/microfeeder



Multi-hub microfeeder case

Optimal network between 8-9 a.m., using a fleet of 80 aircraft

Thank you for your attention!

FMSlab
Flight Mechanics & Flight Systems Laboratory

Lorenzo Trainelli, PhD
Department of Aerospace Science and Technology
Politecnico di Milano

- MAHEPA WP10 leader
- UNIFIER19 WP1 leader

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 723368.

Check out www.mahepa.eu

UNIFIER19
COMMUNITY FRIENDLY MINILINER

This project has received funding from the Clean Sky 2 Joint Undertaking (JU) under grant agreement No 864901. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Clean Sky 2 JU members other than the Union

Check out www.unifier19.eu

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Modular Approach to Hybrid Electric Propulsion Architecture

Innovation integration into the regulatory framework

Gernot KESSLER - 03 July 2020

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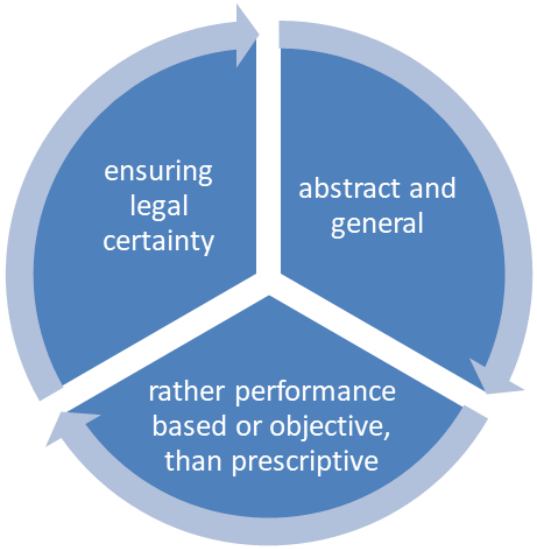
Regulatory Concept:
How to best accommodate New Technologies

The rules we need will be:

- → Timely available
- → Clear and robust
- → Easy to adjust
- → Outlooking
- → Technologically neutral
- → Enforcable



The art of regulation is to combine these aspects!

Regulatory Concept:
How to best accommodate New Technologies

To master challenges:

- Find proper balance
- Do NOT 'All New'
- Subsidiarity
  - What for EU?
  - What for local bodies?
  - Formal borders?
- Mind recognition: ICAO, FAA, …
- Involve upfront:
  - Closest involvement by all
  - Research
  - EASA TACs, IPCs, …

HARD law vs. SOFT law
All New vs. Patches
Harmonisation vs. Local Solutions

- Clear and robust
- Easy to adjust
- Outlooking
- Technologically neutral
- Enforcable