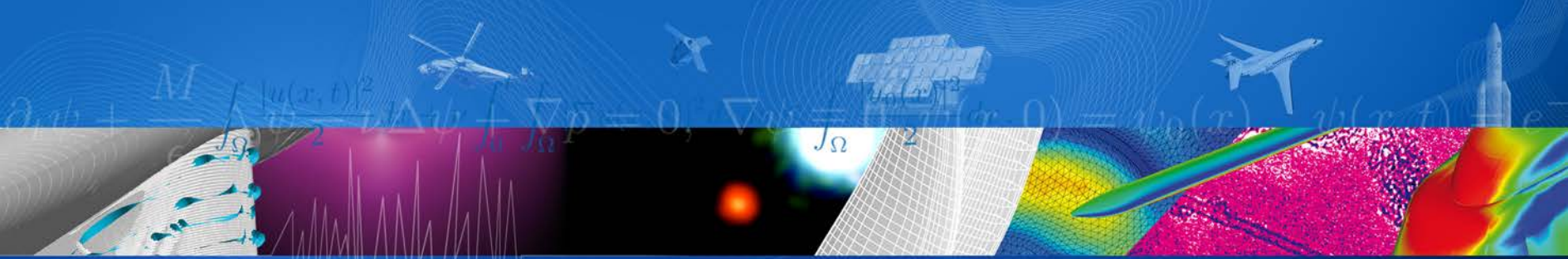

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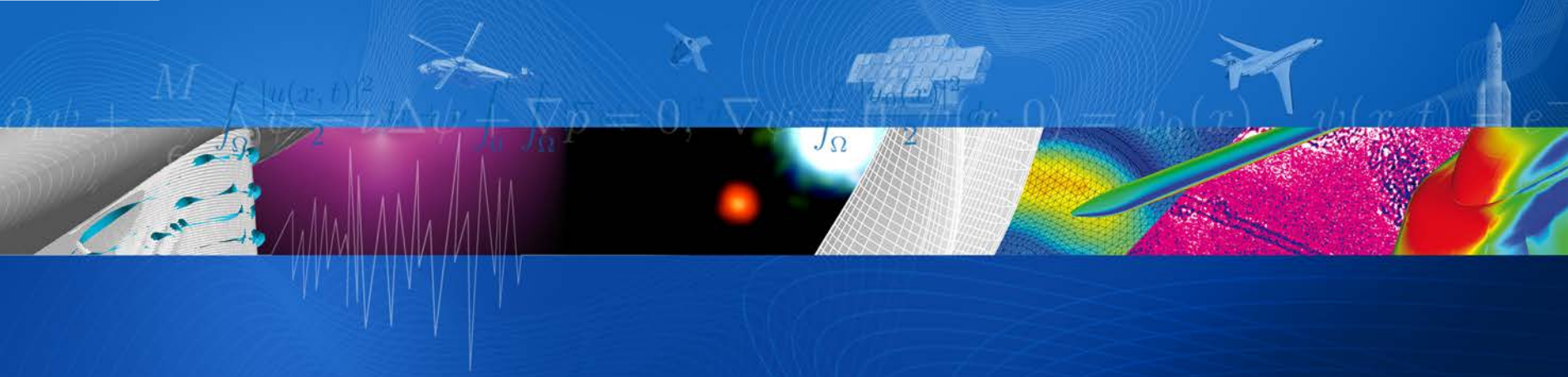

Pioneering concepts for Personal Air Transport Systems

PPlane Project

AMPERE Project

Hybrid electrical propulsion study

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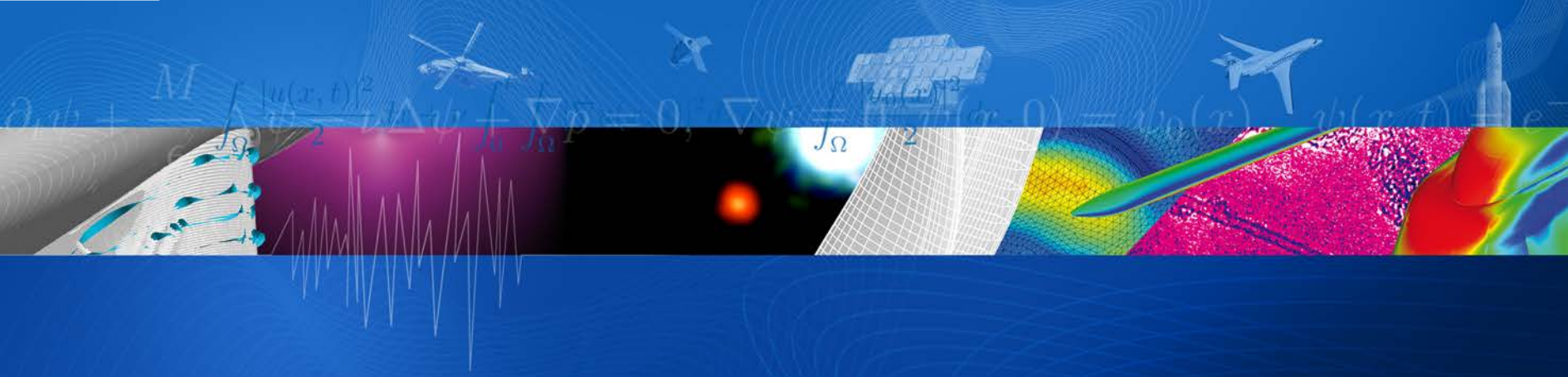

PPlane : a pioneering concept for Personal Air Transport Systems

The PPlane Project has been funded by the European Commission

Under the Seventh Framework Program (FP7)

ACP8-GA-2009-233805

Coordinated by Onera

Claude Le Tallec, Scientific and Technical Manager

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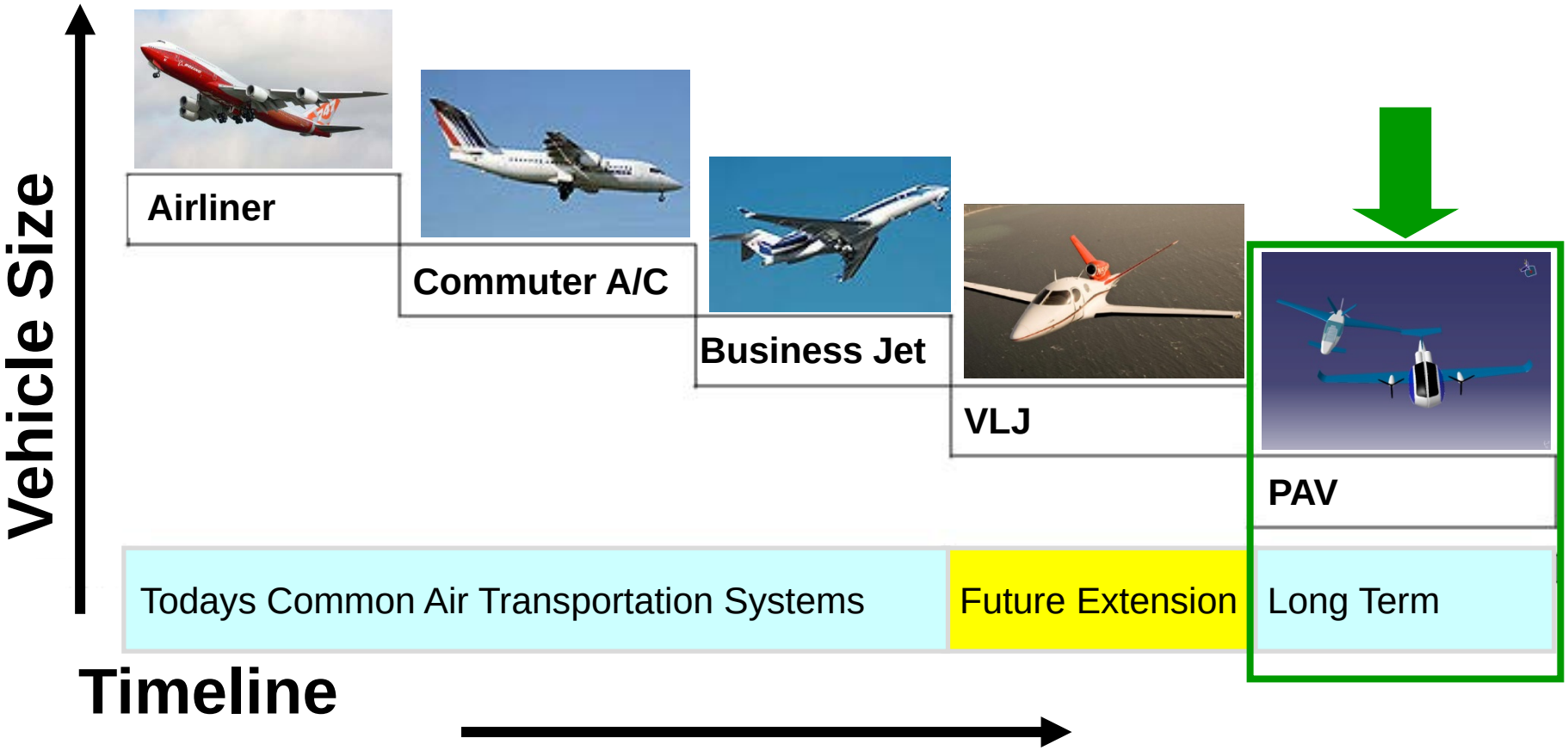
Where does PPlane fit in the Air Transport System?



What is PPlane?

- **PPlane was a research project funded by the European Commission (2009 - 2013) with the aim of defining a viable Personal Air Transport System of the future (2030 and beyond)**
- **PPlane has the following characteristics:**
  - Fully automated transport enabling a “regular Joe” to use the aircraft without any prior expertise
  - Fly in various weather conditions
  - “Push button” navigation including the integration into the airspace
- **Aircraft is part of a “system” enabling the “user” to manage his flight:**
  - Set flight destination
  - Monitor the flight from take-off to landing
  - Gets help and information from the ground, when and if needed, including emergencies
- **Aircraft operation is Safe and Secure**

Potential Concepts of PPlane Vehicles

Air vehicle: “out of the box” but realistic concept

- 6 electric engines buried in the wing, moving up (take-off and landing) or illustrated position for cruise
- Fully automated
- Versions for 2 pax or 4 to 5 pax

Concept of operation

- Only passengers on board - pilot on ground (remote pilot)
- 4D contracts to enable a smooth and safe traffic
- Ramps to take-off and land for environmental (noise), space (compactness) and energy concerns (no on-board energy used for taxiing, taking-off and landing)

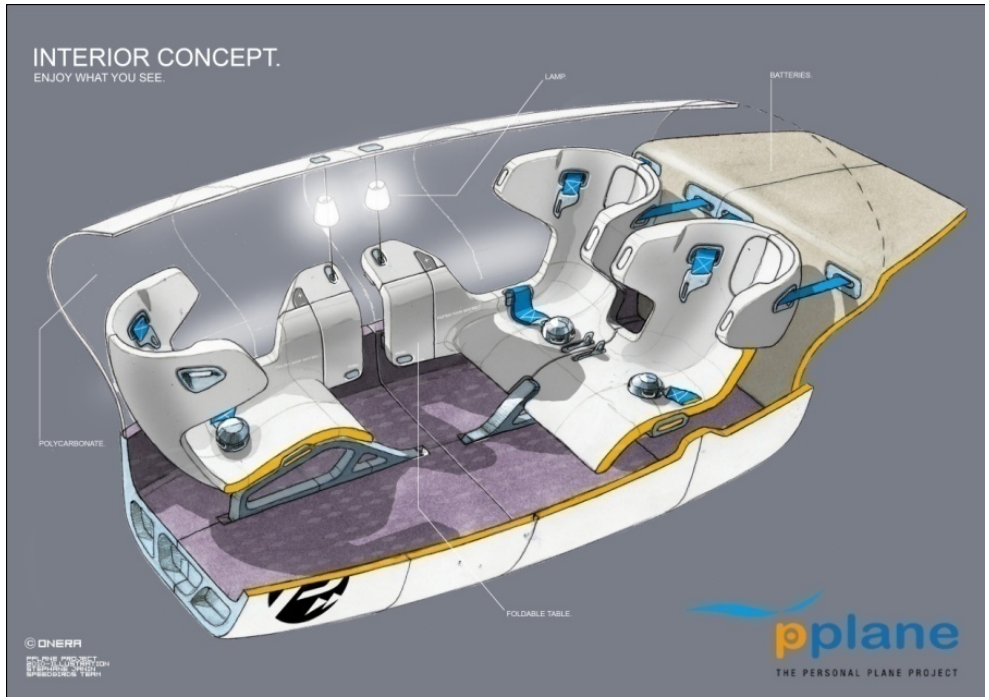
PPlane Air Vehicle Cabin/Cockpit Layout

ATC ground side:

- Remote pilots (n RP for m aircraft with n<<m)
- Interface to understand the situation and manage the flights
- High level supervision thanks to the 4D contract principle

Air side:

- Passengers in a comforting environment
- Flight information available
- Interaction with RPs to be defined



PPlane analyses

Human issues

PPlane Passenger

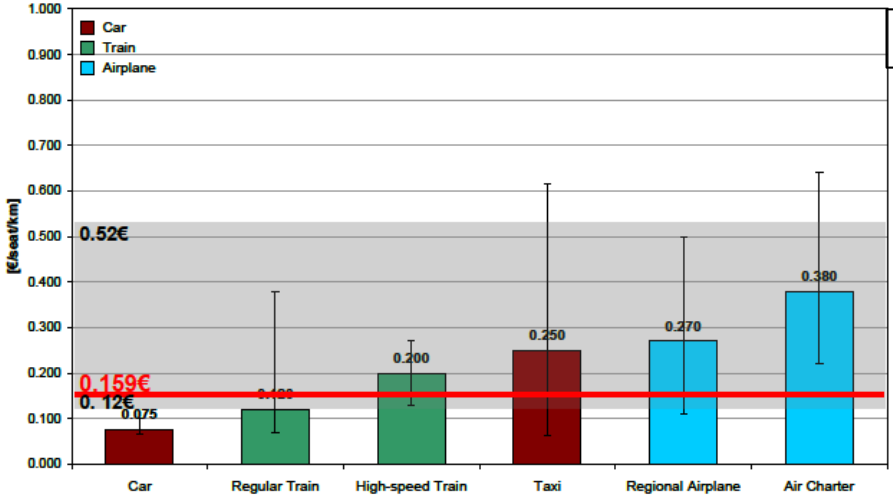
Voice & D/L

Voice com

ATCo & simulation control

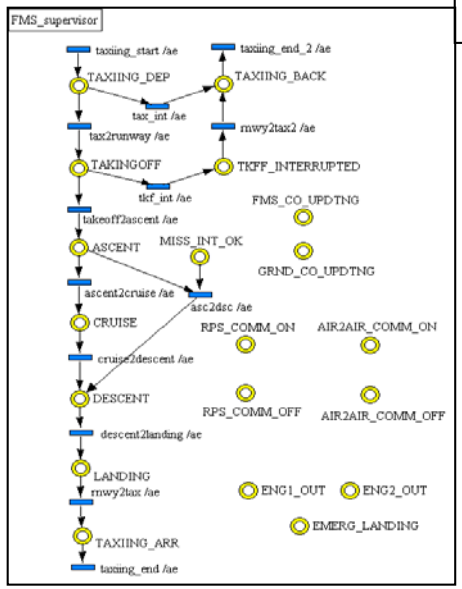
Ground Pilot

Cost

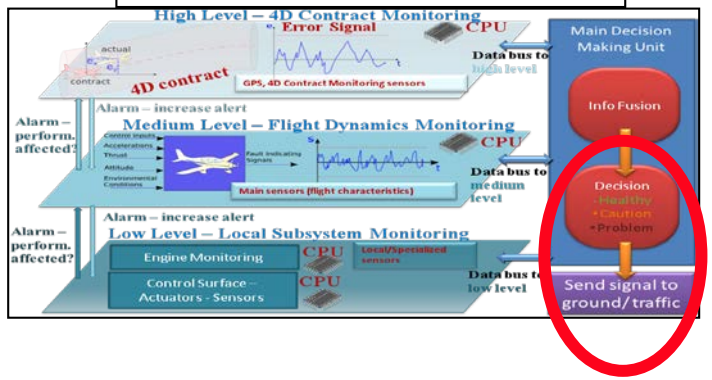


PPlane supervision system (FMS)

FHA



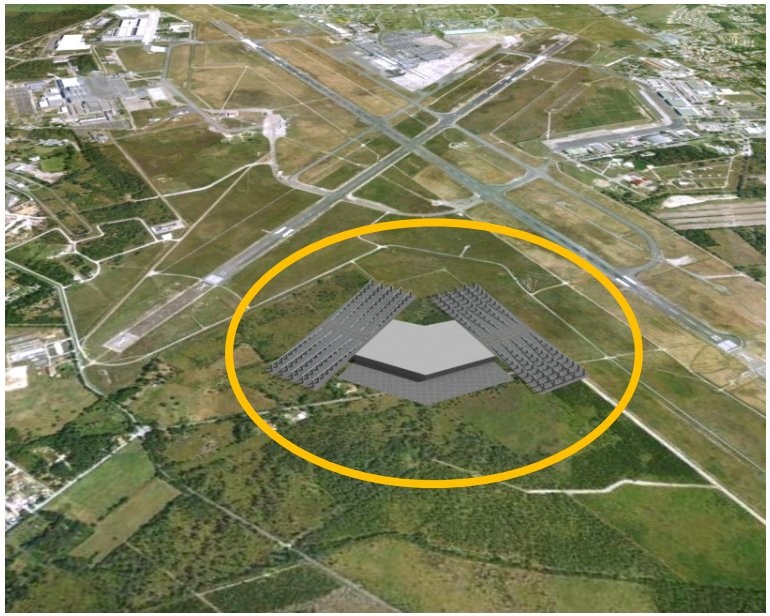
Fault detection and identification

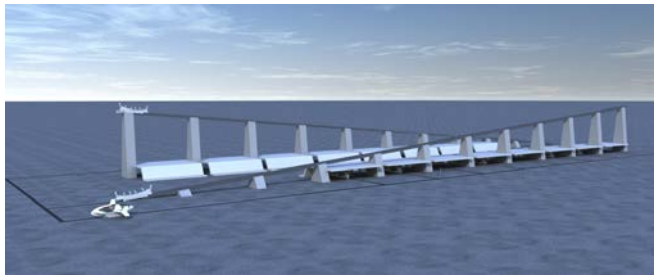


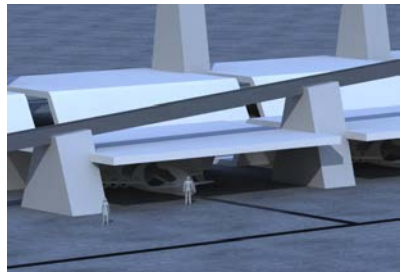
PPlane ground side

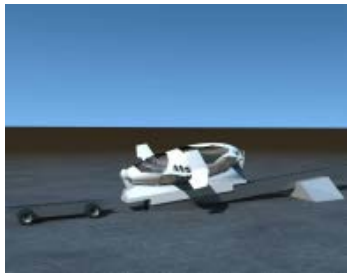
PPort concept:

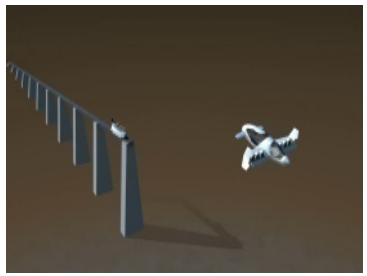
- PPort specifically designed for PPlane aircraft
- Integrated to current airport + other remote locations
- Ramps to take-off and land
- Automatic taxiing provided by a trolley

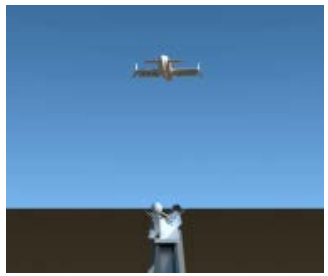


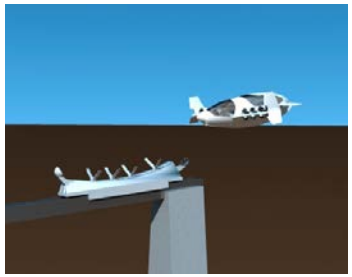


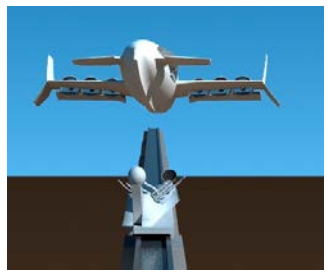








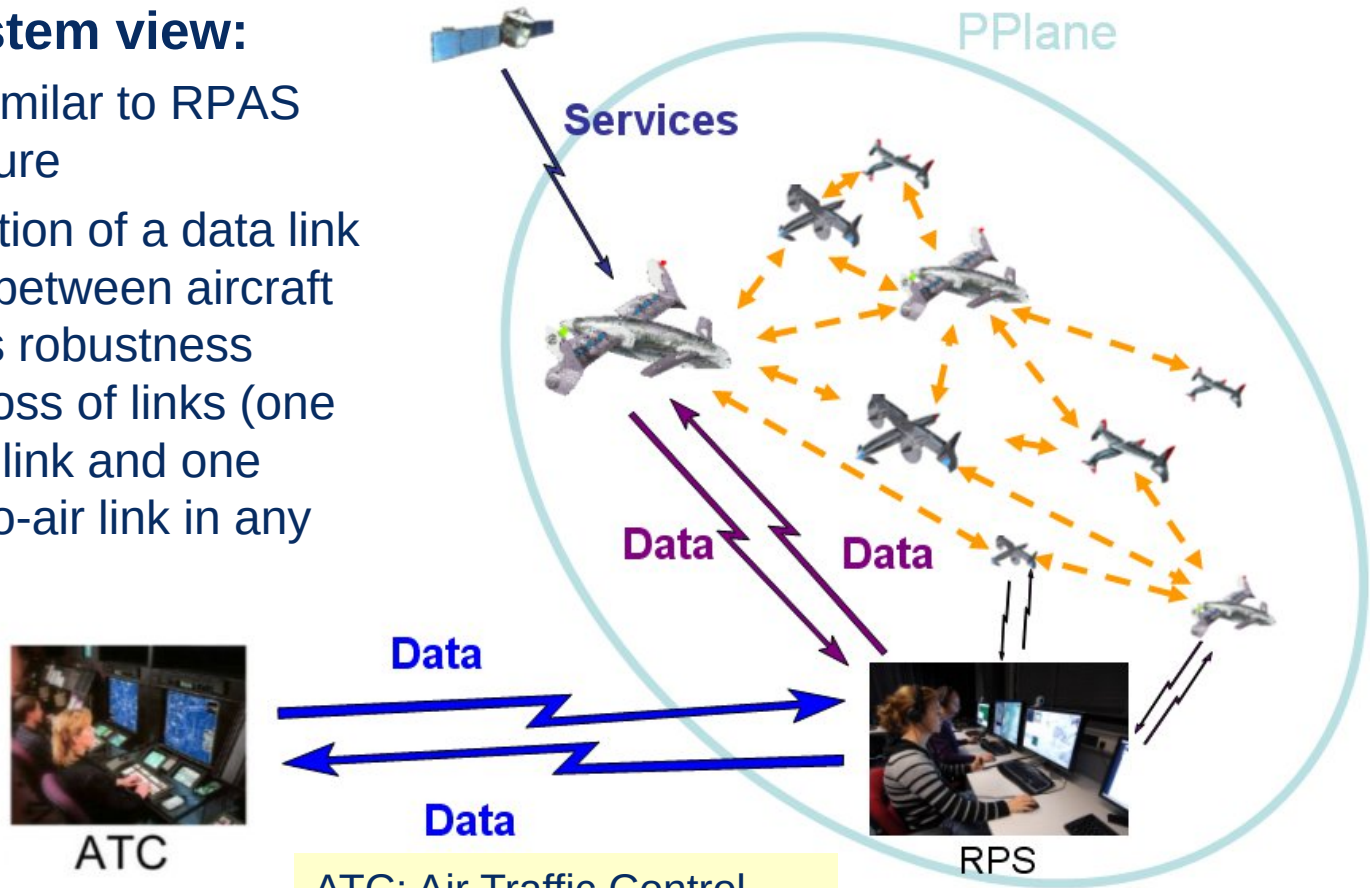




PPlane System Architecture

PPlane system view:

- Is very similar to RPAS architecture
- The addition of a data link network between aircraft improves robustness against loss of links (one air-to-air link and one ground-to-air link in any Pplane)

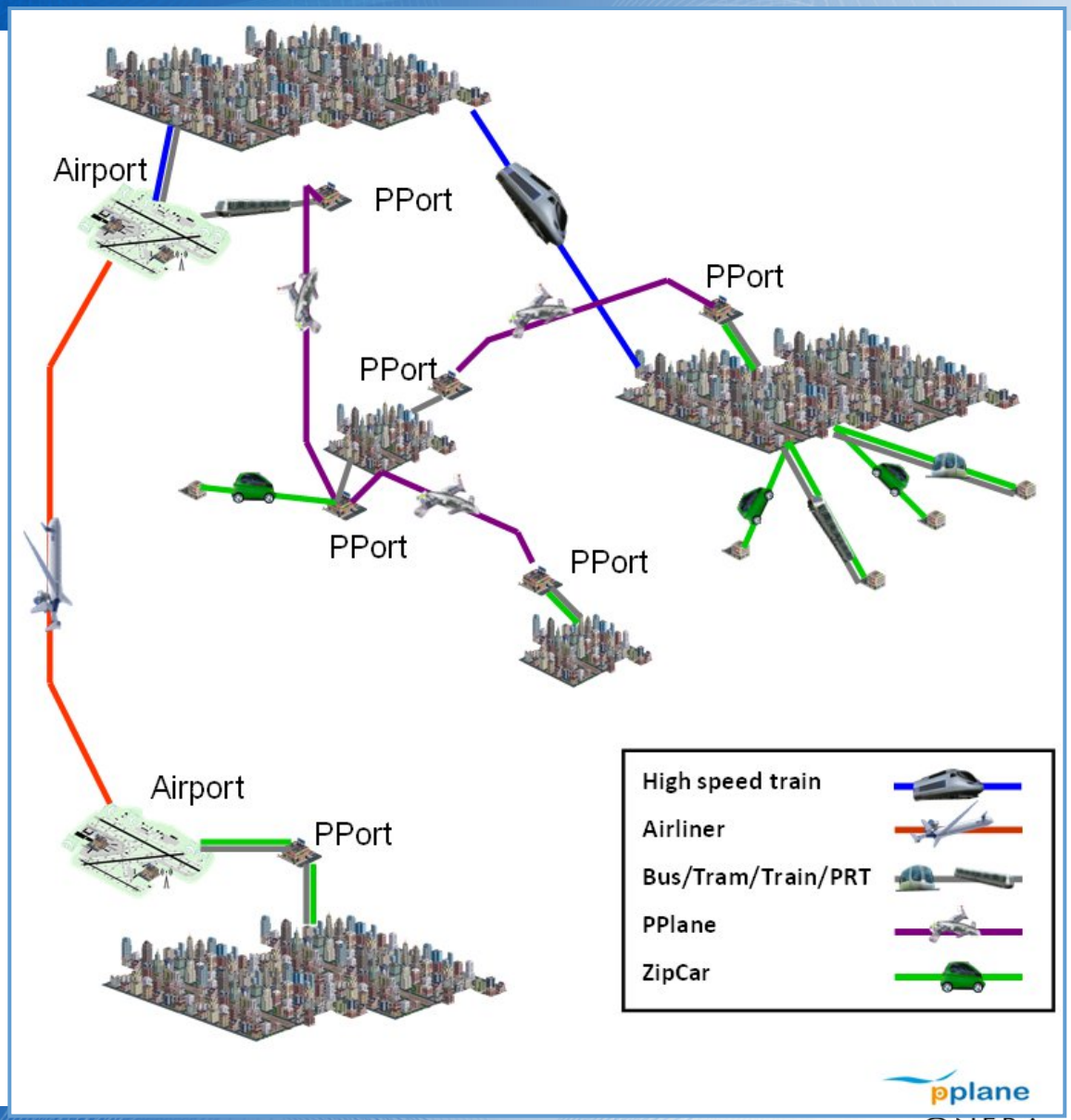


ATC: Air Traffic Control
RPS: Remote Pilot Station

PPlane as an Element of a Multimodal Transport System

PPlane is not a substitution to any current transport means, it is one segment of a multi modal transport system

Personal Rapid Transport (PRT)



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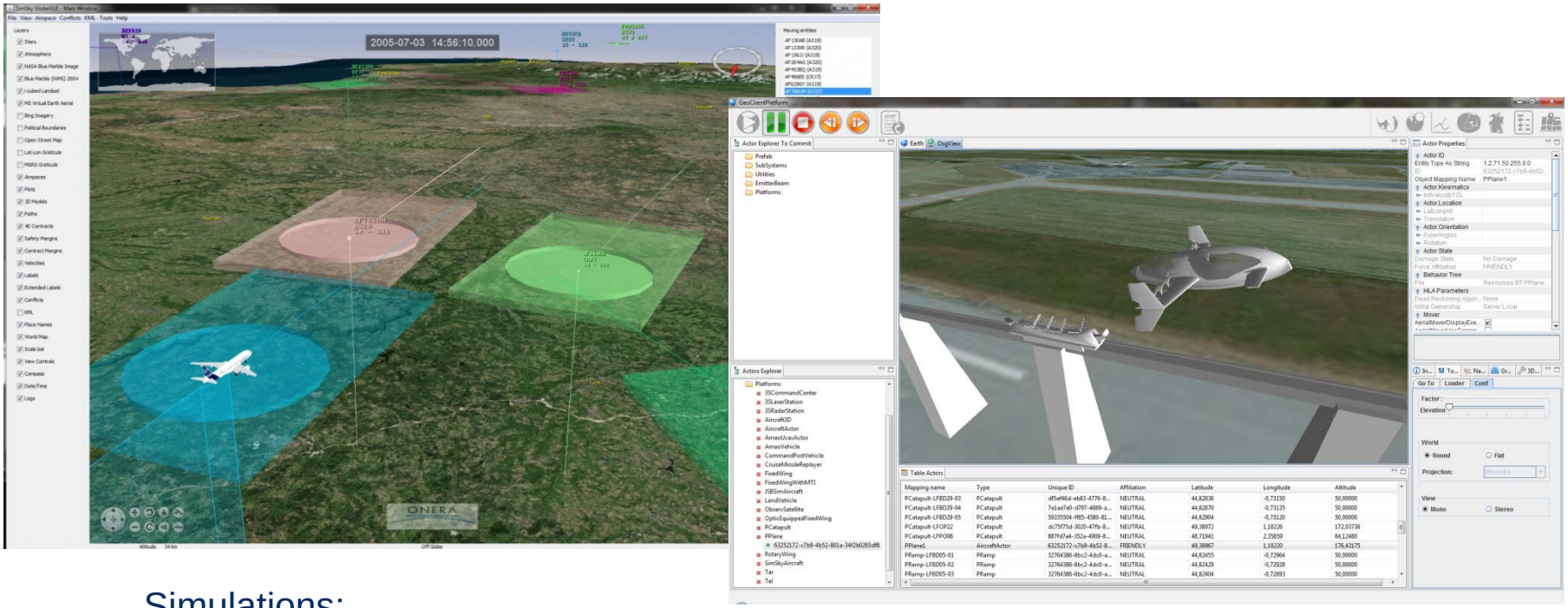
4D contract concept validation

- Validation / Demonstration of the 4D contract concept for PPlane traffic:
  - PPlanes flights
  - Other traffic flights



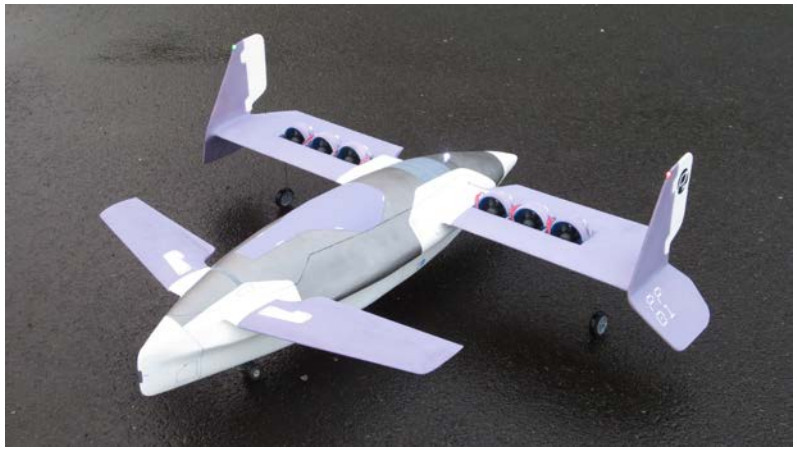
Simulations:

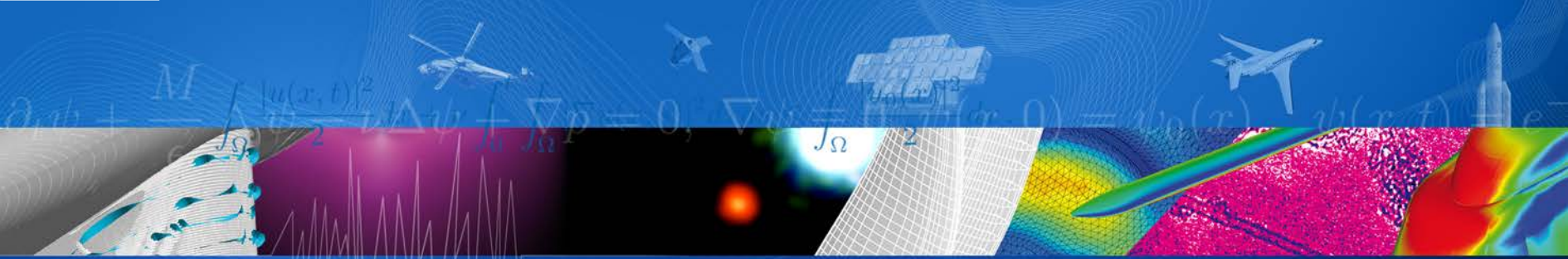
⇒ Global traffic management + 4D-Contract planning

⇒ « Gate-to-gate » traffic of the PPlanes + 3D Visualization

PPlane vehicle

Six electric ducted fans engine model for very preliminary qualitative « test fights »





Highly Automated, clean, quiet & safe business transport aircraft

AMPERE project

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Motivations

The PPlane concept cannot be implemented in the short term:

- Need for a novel 4D contract based ATM system
  - Technically not mature
  - Social acceptance to be gained (pilots & controllers)
- Fully automated aircraft for passenger transport are not mature
  - Technically not mature
  - Social acceptance to be gained (passengers)
  - Experience feedback needed (from UAS operations)

A highly automated aircraft concept could help bridge the gap:

- Light business and GA aircraft safety has to be improved
- Environment has to be preserved
- Automation capabilities are growing exponentially
  - Electrically powered business aircraft (5 pax)
  - Pilot on board with a novel training and licensing process
  - Highly automated aircraft to lower the need for highly proficient pilots

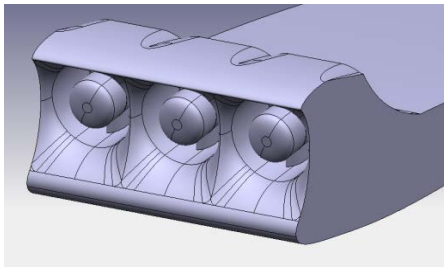
AMPERE project overview

Initial Onera's Long-term investigation pointed out key-technologies or topics for future AEA:

1. Distributed propulsion
2. Command and control through the association of multi-motors and control surfaces
3. Electric Ducted Fan (EDF)
4. Energy supply, storage and hybrid capabilities
5. Modular architecture and in-flight reconfiguration capabilities of the overall electric propulsion system
6. Improved Multidisciplinary Design and Optimization (MDO) capabilities

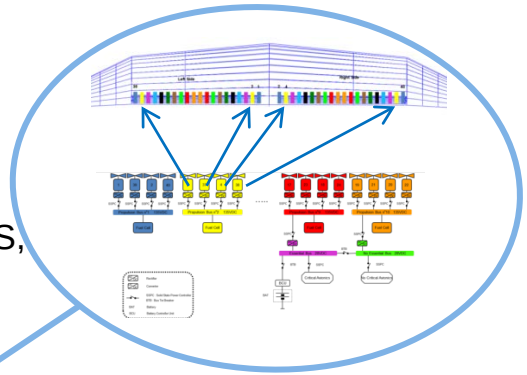
Onera started in 2015 a 3 years internal project dedicated mainly to the two first topics, based on numerical and experimental investigations

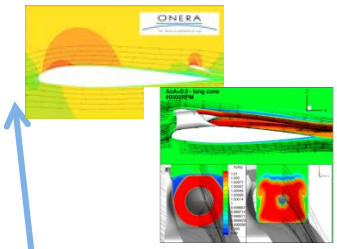
AMPERE Project – Onera's Concept-plane using DEP (Distributed Electric Propulsion)



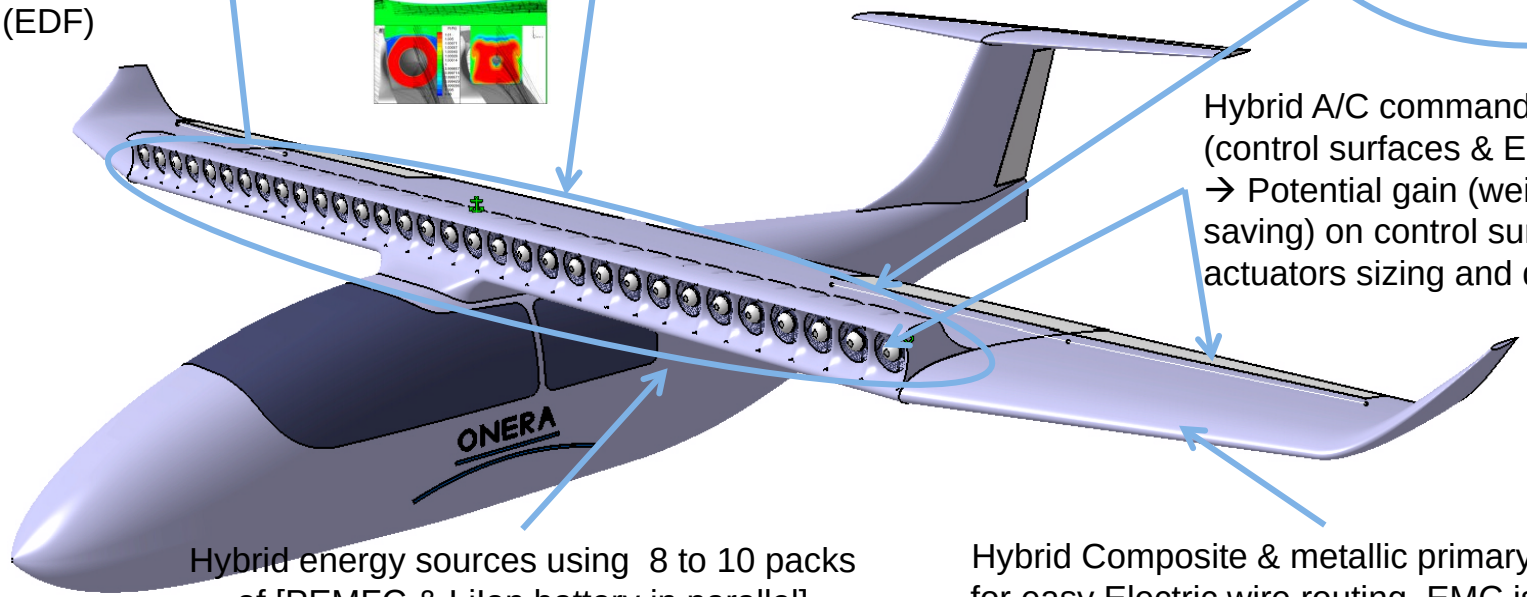
Hyper distributed propulsion using 32 to 40 EDF
→ High lift capabilities, intrinsic redundancy for safety issues

Distributed Electrical Architecture
→Power sources redundancy (safety)
→Lower level of current/voltage in ECS, EWIS etc.





Electric Ducted Fan (EDF)



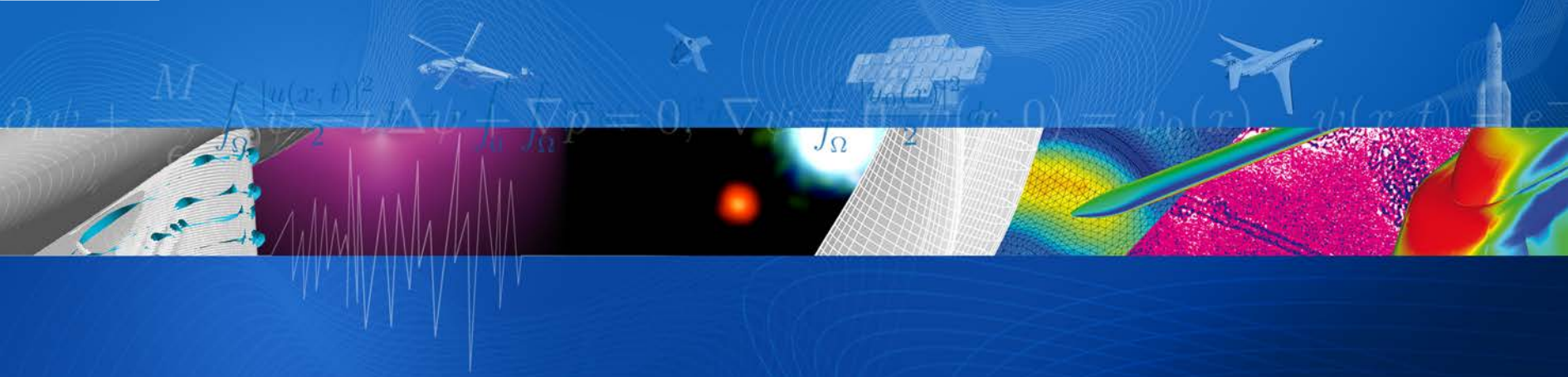
Hybrid A/C command& Control (control surfaces & EDF)
→ Potential gain (weight and energy saving) on control surfaces, actuators sizing and distribution

Hybrid energy sources using 8 to 10 packs of [PEMFC & LiIon battery in parallel]
→ Zero emissions during operations

Hybrid Composite & metallic primary structure for easy Electric wire routing, EMC issues and thermal management

AMPERE – Project status and on-going activities

- Overall A/C configuration defined, including local EDF integration by 3D CFD computations
- First investigations on hybrid control/command, with focus on EDF dynamic behavior
- Wind tunnel mock-up (scale 1:5) designed (CAD), using COTS components for propulsion system
- Mock-up manufacturing in progress
- Wind-tunnel experiments expected in last 2016 quarter



Hybrid electrical propulsion study

PTEROSAUR vehicle

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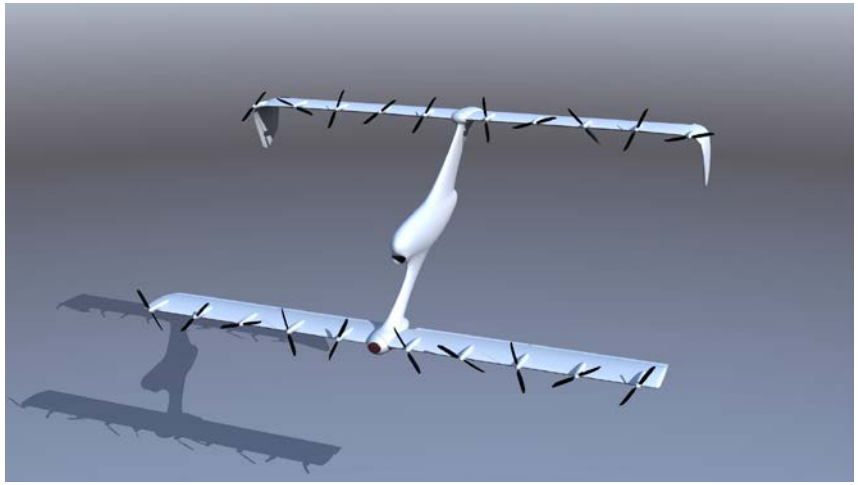
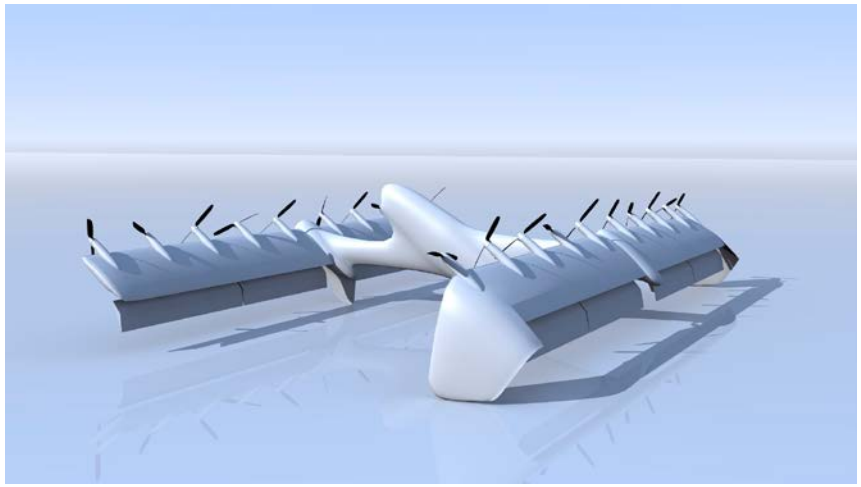
Motivations





Research study about:

- Hybrid electrical propulsion and powered lift
- Hybridization battery/ turbo-generator for various types of mission
- High agility aircraft (high/low speed, VTOL/STOL capabilities)

The PTEROSAUR:

- Is an hybrid electrically powered unmanned aircraft
- Has V/STOL capabilities and efficient cruise performance
- Benefits from powered lift:
  - Multiple engines
  - Flaps and ailerons
- Is not a convertible: no mobile wing and/or engines
- Is designed with redundancy requirements and needs in mind to allow operations without restrictions

Current status

Preliminary studies and analyses

1. Parametric analysis to define the energy requirements
   - Take-off and landing, Cruise
   - Low speed & stationary flights
2. Contingency robustness analysis
   - Battery, Engine, Turbo-generator failures
   - Emergency landing
3. Definition of the architecture of the vehicle from 1 and 2
   - Aerodynamic
   - Propulsion

Type A: Energy mainly stored in batteries, turbogenerator used for cruise (low stationary flight capabilities, higher cruise range)
Type B: Lower part of energy stored in batteries, more powerful turbo-generator (higher stationary, capabilities, lower cruise range)