

Technical Analysis - Scaled Flight Demonstrator / Distributed Electric Propulsion

- 1:8.5 Scale Flight Demonstrator
- 6 electric propellers (3 on each side) mounted on the leading edge of the wing, powered by batteries
- Utilizes the principle of *Distributed Electric Propulsion* (with **Differential Thrust**)
 - 4-meter wingspan
 - Take Off Mass : $M = 167$ kg
 - Cruise Speed : $V = 100$ knots = 185 km/h
 - Advanced Guidance and Navigation Systems



→ Validate the **Distributed Electric Propulsion** concept = **impact on handling qualities, flight controls, and aerodynamic performance**

1. Design and Aerodynamic Study

- Sizing, CFD Simulations, Aero-Propulsive Interaction Analysis

2. Wind Tunnel Testing and Performance Assessment

- Aerodynamic Performance, CFD Validation, Differential Thrust Evaluation, Ground Testing

3. Electrical System Development and Validation

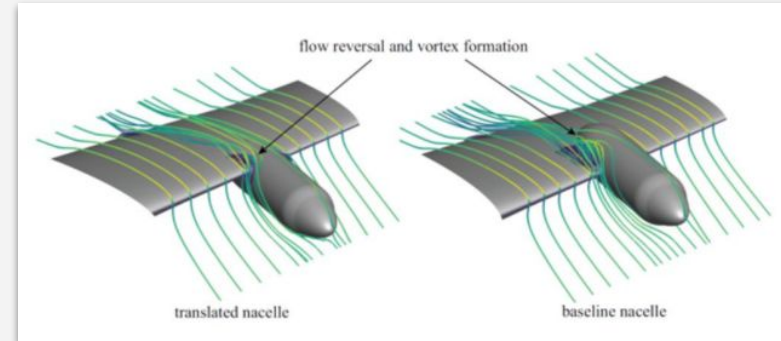
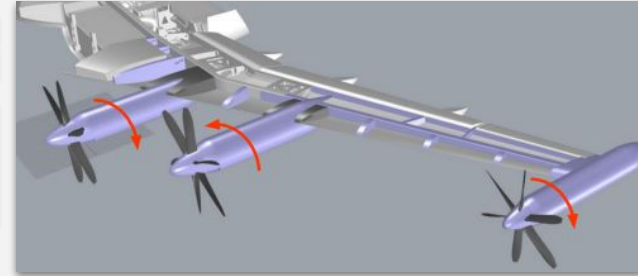
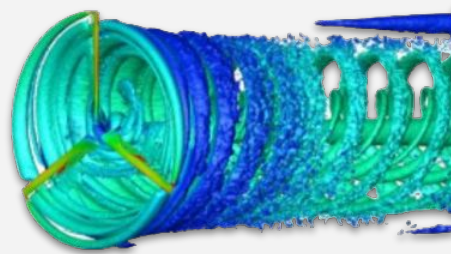
- Test Analysis, Electrical Architecture Robustness and Validation

4. Control Law Validation and Flight Testing

- Control Law Architecture, Control Mode Simulation, Flight Test Results

1. Design and Aerodynamic Study

- Propeller Configuration Choices: Positioning, Characteristics, Rotation Direction
- Airflow Zone Analysis for Optimized Nacelle and Propeller Configuration
- Validation through CFD Simulations and Empirical Data Comparison



= Achieve Optimal Aerodynamic Performance

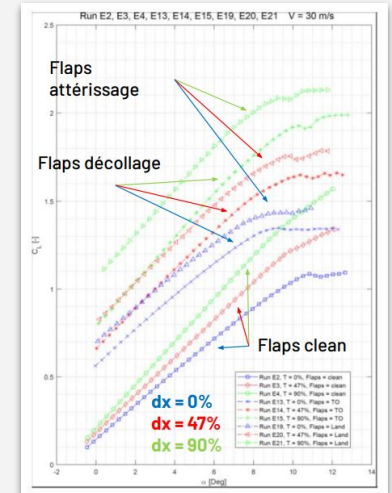
2. Wind Tunnel Testing and Performance Assessment

- Validation of Aerodynamic Performance
- Analysis of Slipstream Effect via **Differential Thrust**

→ *Lift Coefficient (Cl) as a Function of Angle of Attack α*

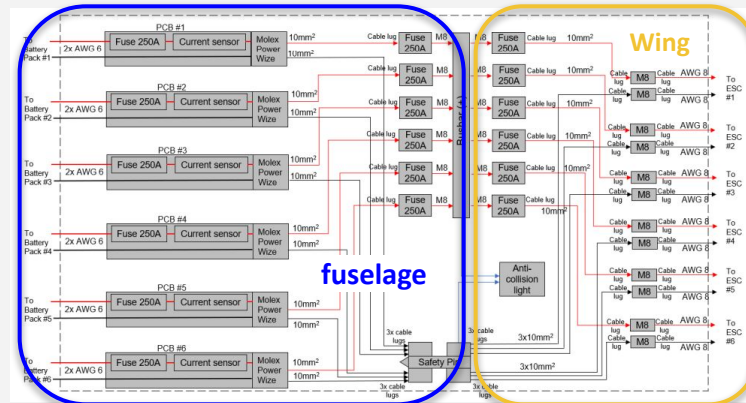
- Identification of Roll and Yaw Moments
- High speed Taxi tests (Takeoff Conditions)

= Validate Performances and Flight Mechanics



3. Electrical System Development and Validation

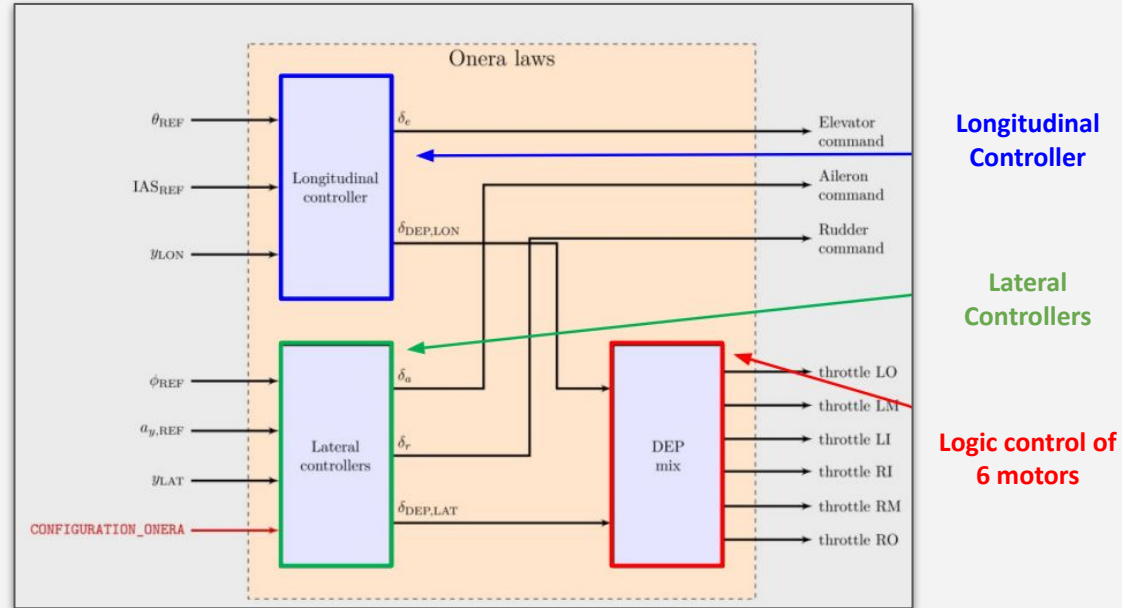
- Reconfiguration/Improvements to Electrical Architecture (after incident = total loss of the demonstrator) :
 - Component Modifications
 - Enhance Robustness against Fire Risks
 - Improve Monitoring of Electrical Architecture
- Power and Temperature Testing of Batteries on Iron-Bird



4. Control Law Validation and Flight Testing

- Definition of Nominal Control Laws through Different Combinations of Actuators and Differential Thrust

Modes	Aileron (Roll)	Rudder (Yaw)	Differential Thr.
1	Yes	Yes	No
2	No	Yes	Yes
3	Yes	No	Yes
4	No	No	Yes



Software: **MATLAB/Simulink**

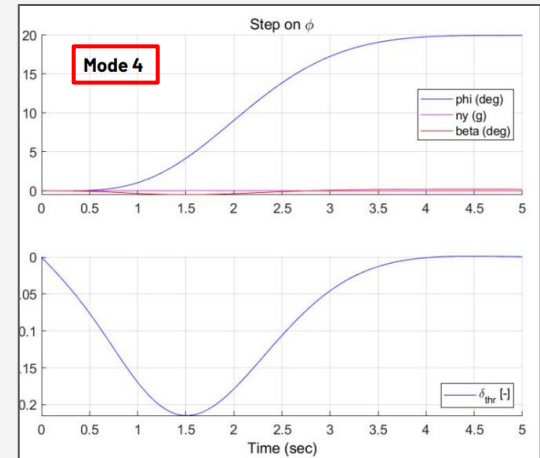
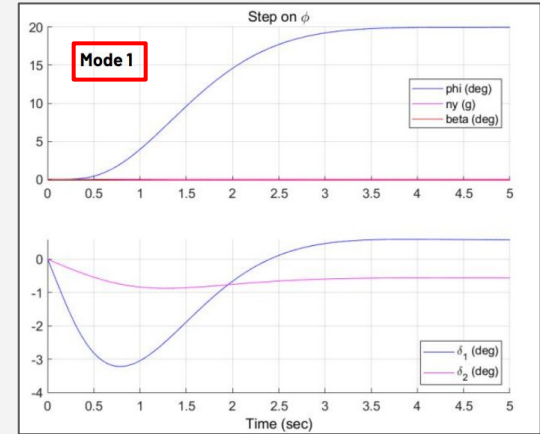
4. Control Law Validation and Flight Testing

Figures : Time responses in bank/roll angle $\phi(t)$, sideslip angle $\beta(t)$, and lateral acceleration $n_y(t)$ for a step input in desired bank angle $\phi_c = +20^\circ$ to the right during a coordinated turn with $\beta_c = 0^\circ$

with :

- δ_1 and δ_2 = Aileron and Rudder Deflections
- δ_{thr} = Differential Thrust

= Validation of **Distributed Electric Propulsion** using **Differential Thrust** for **Aircraft Control** (instead of traditional control surfaces)



Flight Testing validation ✓

