CASSIO Project

CCI Belfort January 23rd 2020

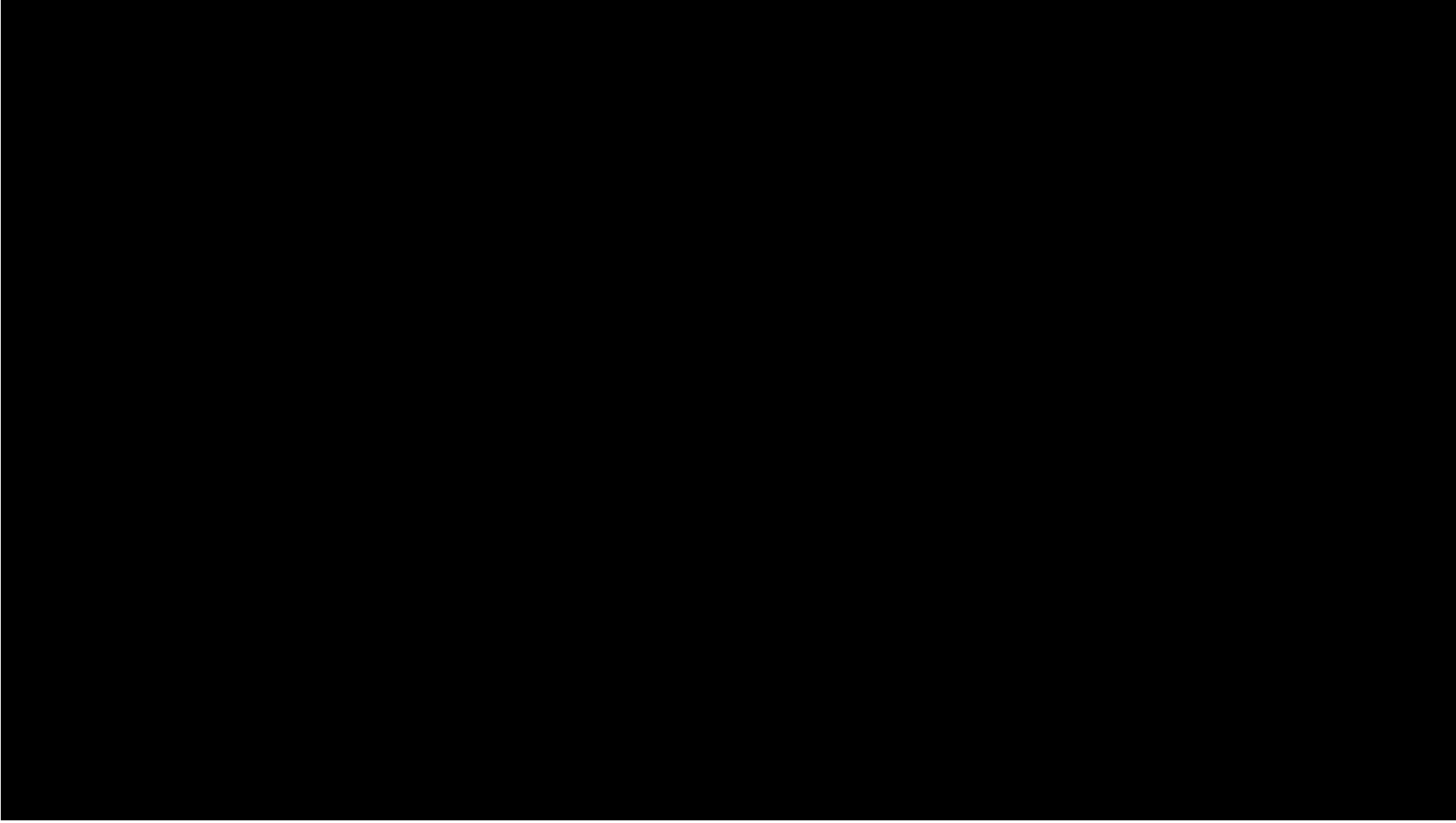
VOLTAERO

VoltAero: A unique expertise in electric aircraft

When it comes to defining and developing electric aircraft, VoltAero's founders have one statement: **"Been there, done that!" > 10 July 2015: E-Fan's all-electric flight across the English Channel, from Lydd, England to Calais, France**

- **The equivalent of nearly 50 years of combined experience in developing electric aircraft**
- **We have experienced thousands of battery charging cycles**
- **We've built and flown 2 electric aircrafts, with 1 more in flight development today**

The VoltAero Cassio aircraft



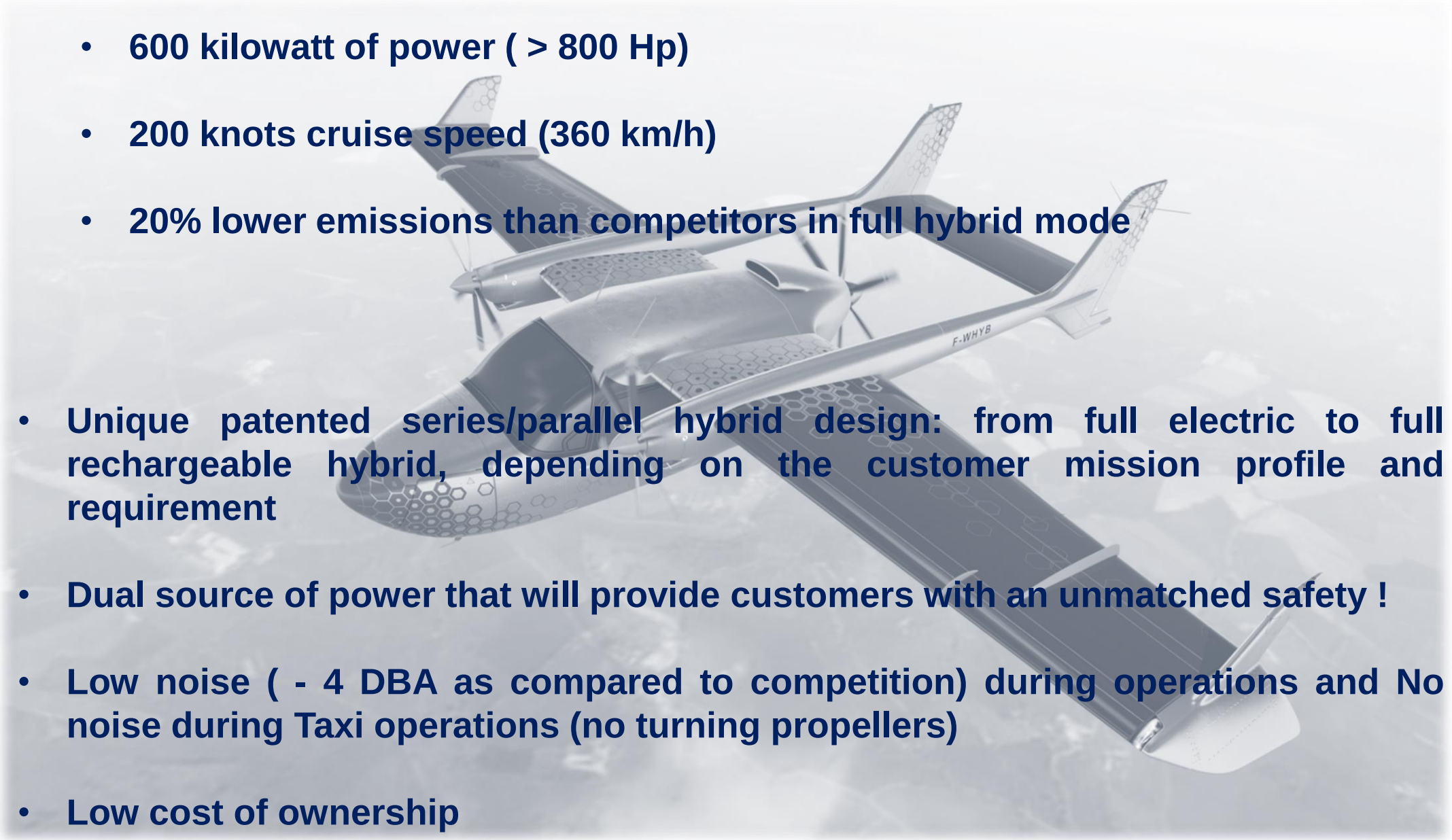
Cassio Key Product Characteristics

Safe, Affordable, Quiet, Low emissions

- Commercial aircraft of 4-6-9 seats
- MTOW of less than 2,5 tons (CS-23 certification)
- 3.5 hour of autonomy (extension possible to 5 hours)
- Range of 800 miles
- Take-off/ landing distance less than 1800 feet
- Lightweight Materials for fuselage

Cassio Key Performance Characteristics

- 600 kilowatt of power (> 800 Hp)
- 200 knots cruise speed (360 km/h)
- 20% lower emissions than competitors in full hybrid mode



- Unique patented series/parallel hybrid design: from full electric to full rechargeable hybrid, depending on the customer mission profile and requirement
- Dual source of power that will provide customers with an unmatched safety !
- Low noise (- 4 DBA as compared to competition) during operations and No noise during Taxi operations (no turning propellers)
- Low cost of ownership

Objectives

Technical objectives

- Development of the hybrid electric aircraft – CASSIO - with 4-, 6- and 9-seat capacity for the general aviation market that will improve on conventional fuel-powered vehicles in operating costs, emissions, and noise; and will enhance regional mobility by providing scheduled and on-demand air services from smaller airports.
- Extension of hybrid-electric propulsion expertise of Voltaero into development of powertrains for other commercial applications (helicopters, UAVs)

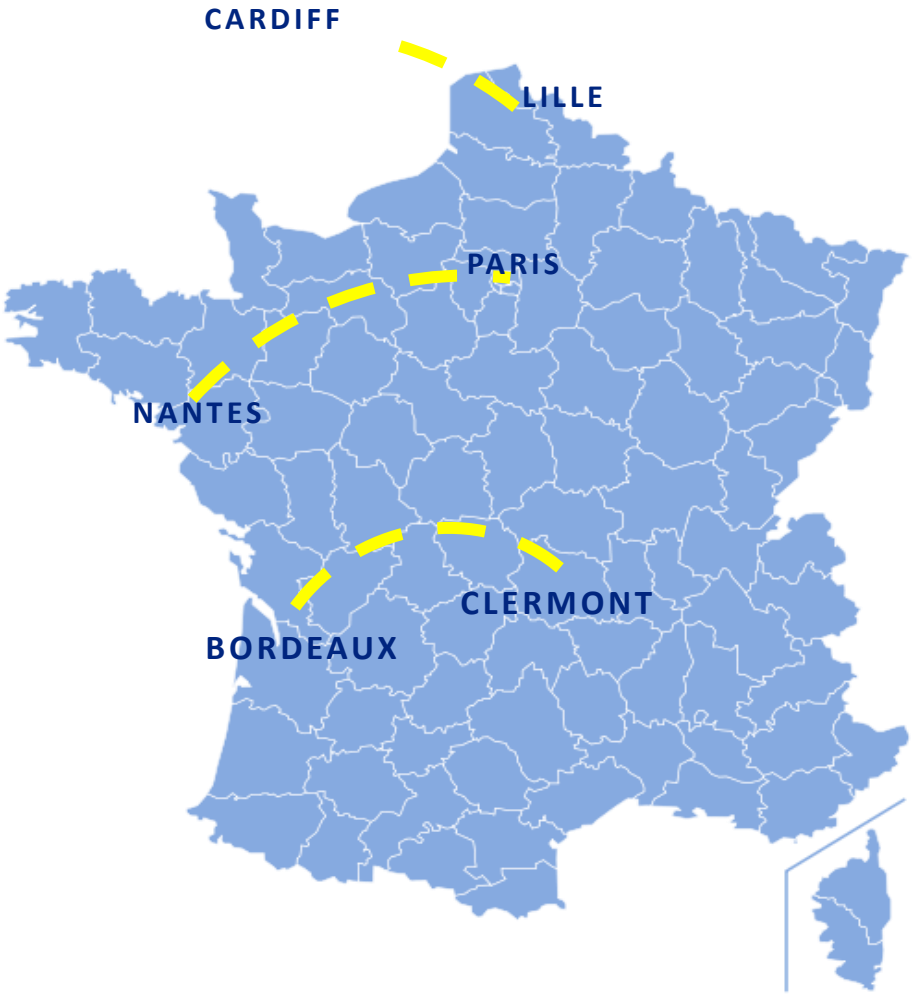
Commercial objectives

- Serial production of CASSIO aircraft by the end of 2022
- Ramp-up to steady production rate of 150 Planes/year by 2024
- Target market: global general aviation - regional commercial, thin-haul operations, cargo, point-to-point, private and business aviation
- Very competitive aircraft**: Total Cost of Ownership and operating costs for the customer are lower than current competition**

Market Segments/ Customers

- Pilots Training / Flight schools
- Regional Commuting / Small regional operators
- Tourism / Charter and travel operators
- Cargo / Regional cargo operators
- Social Services / Medevac

Underserviced Regional Routes Samples (France)



- East-West travel links in France are not optimally covered, as compared to North-South
- CASSIO aircraft can offer significant advantages in terms of time savings and cost-per-passenger
- On these types of routes CASSIO will effectively compete with train and automotive transportation, as well as aviation.

An Airplane “à la carte!”

Cassio is a **modular concept that will offer multiple configurations for customers**, based on varying mission profiles:

Short Take off/ Landing (STOL)

RANGE:
0 – 200 km

PROPULSION:
Pure electric
330KW of available power

Regional Short Haul

RANGE:
200 – 600 km

PROPULSION:
Mild hybrid / Range extender
480 KW of available Power

Regional Medium Haul

RANGE:
600 – 1200 km

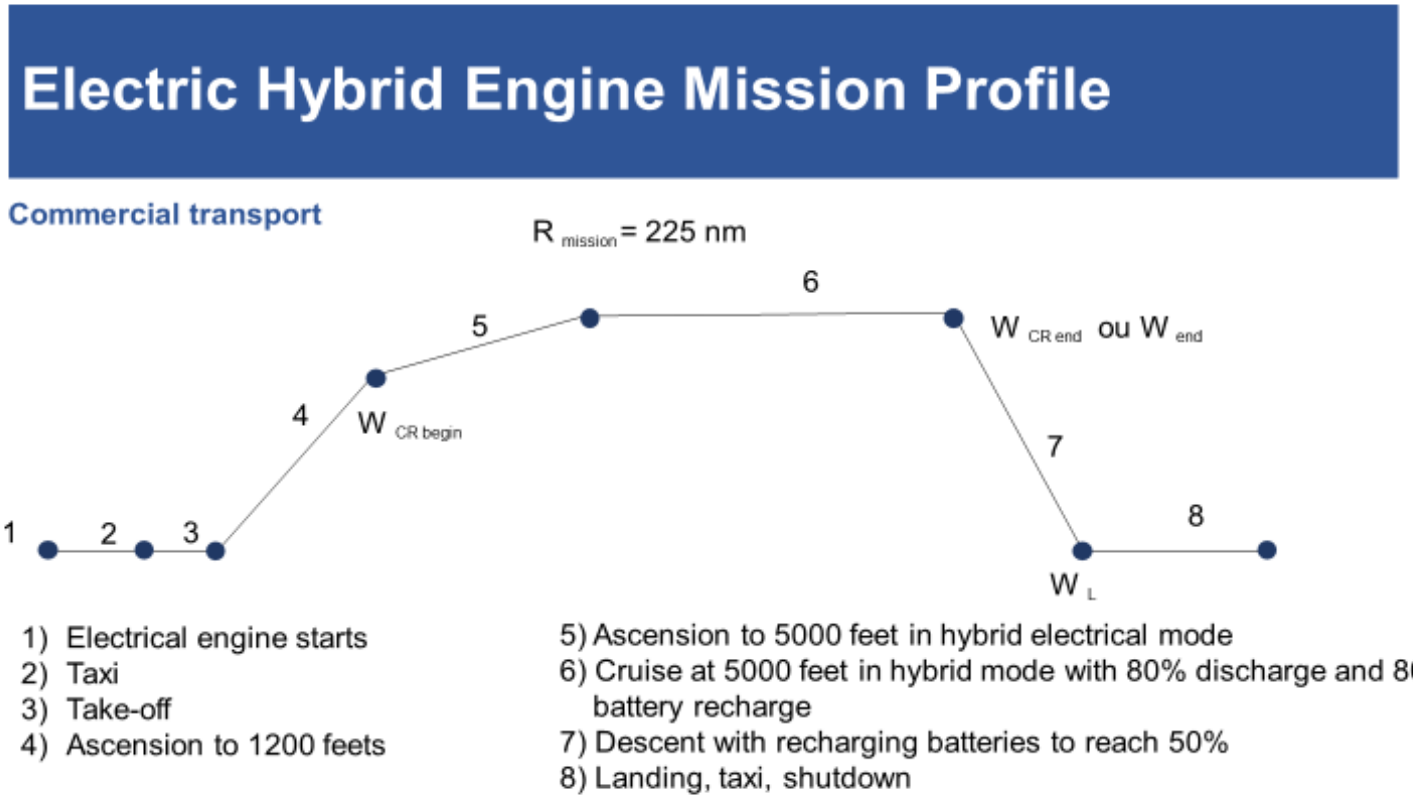
PROPULSION:
Heavy hybrid
600 KW of Available Power

Cassio Modes of Operation

The hybrid-electric propulsion system is used for the different phases of flight

- For taxi, an electric-powered landing gear wheel
- Power from the electric motor-driven propellers for takeoff and landing
  - Low-noise operations at airports
  - High energy efficiency
- Thermal engine turns the rear “pusher” propeller at cruise and also drives the associated electric motor as a generator to recharge the aircraft’s batteries

Sample Mission Profile



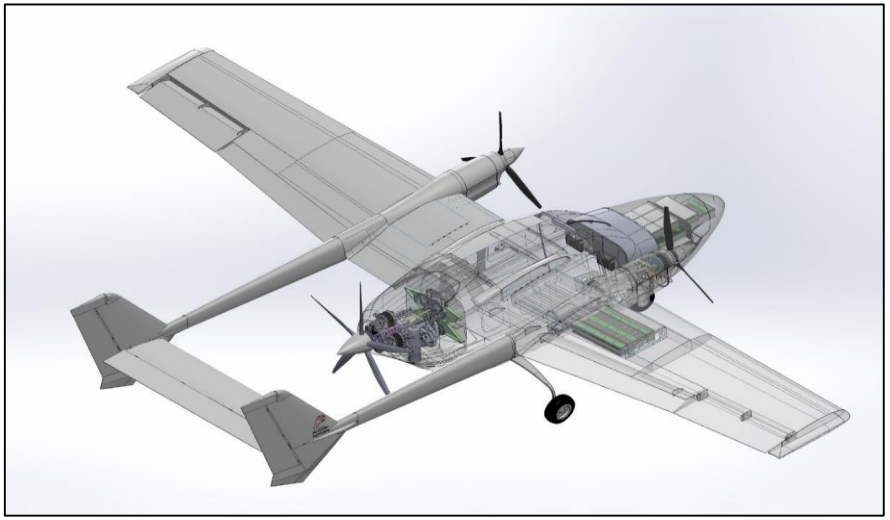
- Hybrid flight allows to save up to 20% fossil fuel with a battery SOC remaining 82%, allowing new electrical takeoffs in the same configurations.

- This is in spite of an additional weight of around 400 kilos related to the battery packs and electric motors and distribution

The “POWER TO FLY SAFELY!”

The VoltAero Cassio aircraft will be highly efficient and safe to operate

- Two electric motors that drive propellers in the tractor (“puller”) position, installed on the wings
- A combined “power module” installed in the aft fuselage
    - Electric motor and thermal engine, which share the same shaft to a pusher propeller (series and parallel hybrid)
    - This will allow independent modes of operations: in case one source of energy fails, the other can bring the passengers safely to ground



Future Cassio cognitive Glass cockpit.

- Development of a cognitive cockpit in order to facilitate the pilot workload.

- The right information at the right time!

- The pilot is in full control

Test Aircraft Flight progress

Phase 1: Cassio 1 Demonstrator

Up-to-date: Configuration V2 integration in progress

- Objective: to test in flight the whole electrical circuits of the wings from the battery packs to the electrical motors and the propellers
- Test flights: test of electric circuits in flight (cruise, climbing and take-off phases) benefiting from 2 original thermal engines for safety,flights scheduled for the end of November (one month flight tests planned depending on weather conditions)

Demonstrator F-WOLT V2.Integration in progress

Phase 1: Cassio 1 Demonstrator

Configurations already tested in flight:

-Cassio 1 behaviour and performances with structural modifications (wing pylons and aerodynamic fairing), new digital cockpit

Aerodynamic characterization of wing pylon careenage

Wing Pylon Integration

New digital cockpit

Number of flights performed:	**22**
Total flight duration:	**12h55**

Phase 1: Cassio 1 Demonstrator

Battery Pack validated:

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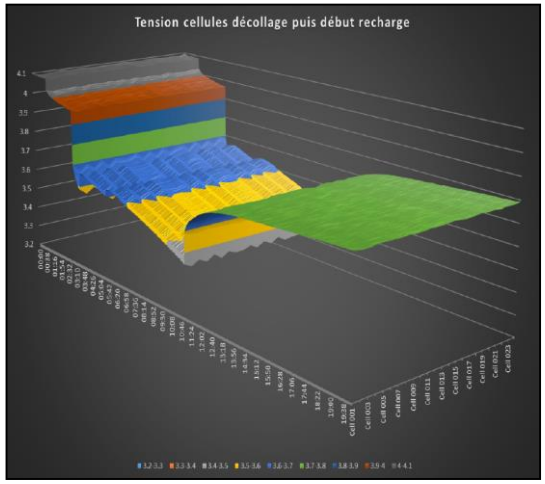
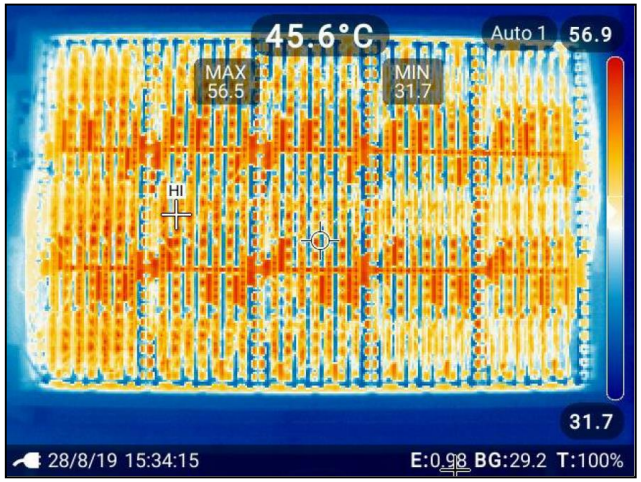
Battery Module & Battery Packs (x5)

- Complete in House design
- Prototype built based on our past experiences . Safety is key !

First battery back integrated



Cell Voltage Evolution



Thermal distribution visualized with thermal camera

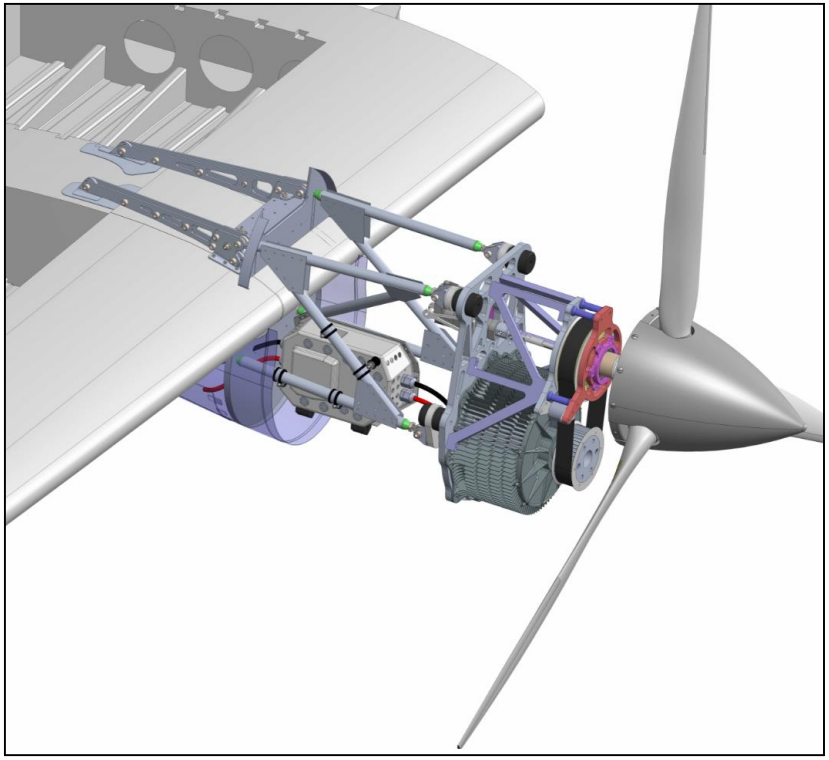
Phase 1: Cassio 1 Demonstrator

New front electric motors integration design:

- Front electric motors integration design reviewed since SAFRAN Smart Motor are ready to be tested in flight.

- **SAFRAN Smart Motor** integrates its own power electronics and inverter

- Proven performances

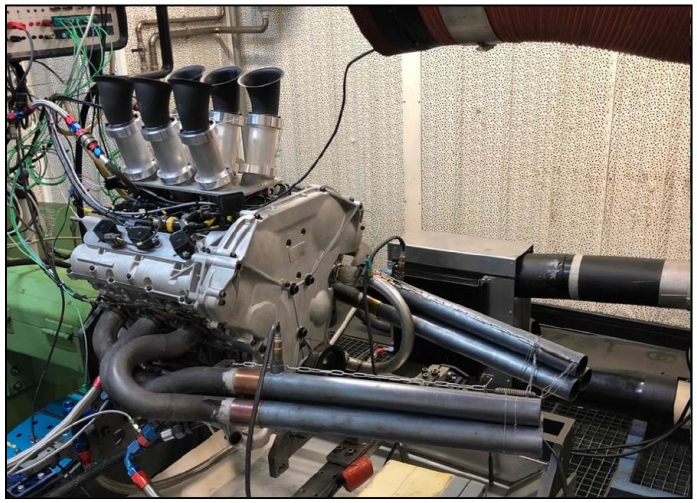


SAFRAN Smart Motor Integration design

Phase 1: Cassio 1 Demonstrator

Thermal Engine tested:

- V6 3.5L specifically prepared for Cassio1 application



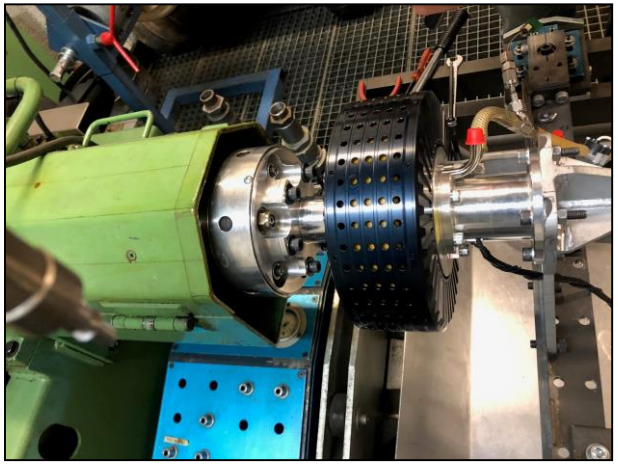
Nissan VQ35 V6 mounted on Solution F test bench

Power and Torque delivered at Sea Level: 345hp@5,500rpm

Phase 1: Cassio 1 Demonstrator

Hybrid modulus integrated in a first version:

- **Validation of the assembly of “ Gun Barrel” mounting**

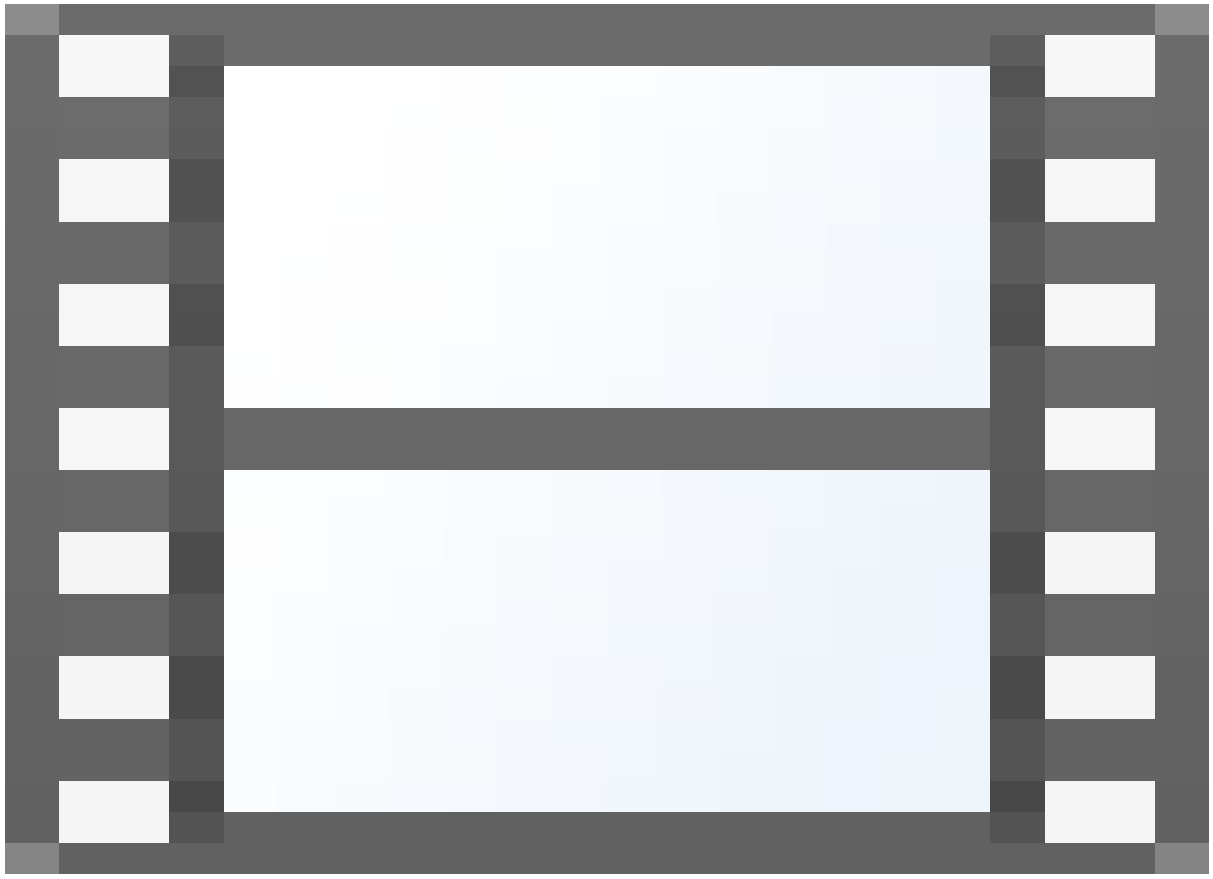


New electric motors being characterized

First version of the hybrid modulus system

Movie on Cassio preparation

Module Hybride en Test



Phase 1: Cassio 1 Demonstrator

Coming up next:

- **Cassio 1 Flying Configuration (No rear power module but front electric motors) :**
  - **Integration of all components in progress : front electric motors, batteries, cockpit, wiring…**
  - **Flight test campaign expected for w 04 2020**

- **Cassio 1 FINAL Configuration (new rear module power included with new aerodynamics) :**
  - **First Hybrid official flight planned March 2020 !**
  - **Final Integration phase scheduled for April 2020**
  - **Pre-industrialization phase has already started**

Thank you for your attention !

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