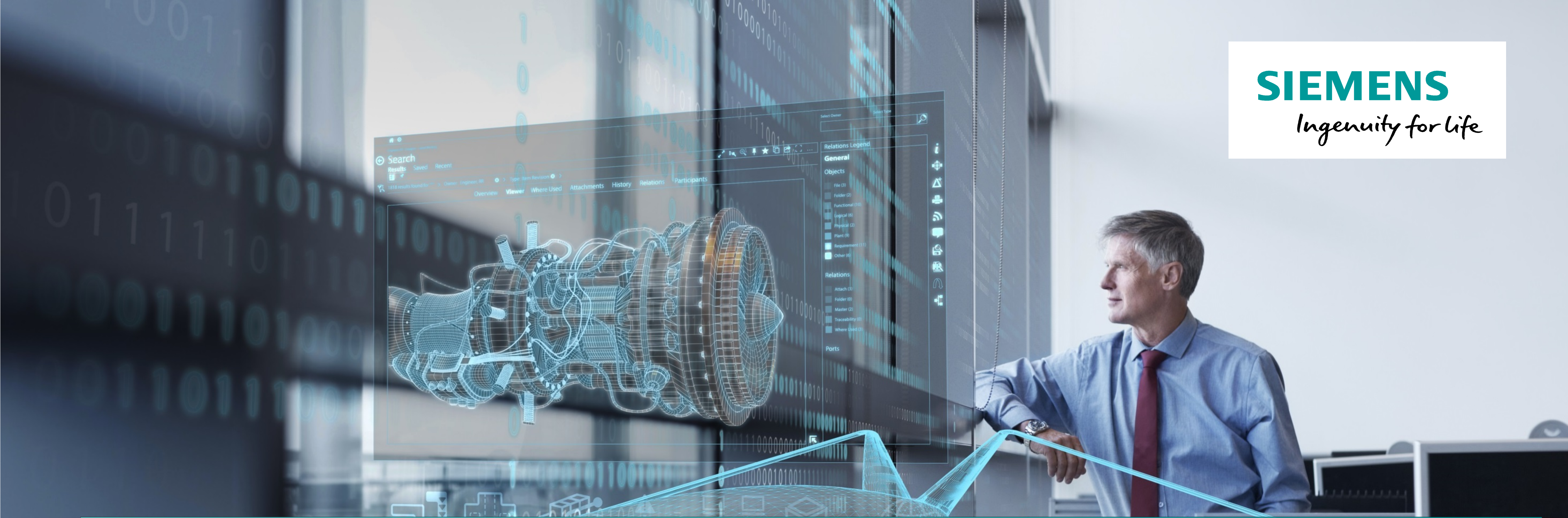

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Design and Improvement of Electric Propulsion System

Siemens eAircraft

siemens.com

Overview

What gets me out of bed in the morning …

Aviation should be **efficient**, **individualized, quiet, emission-free,**

affordable and **easy.**

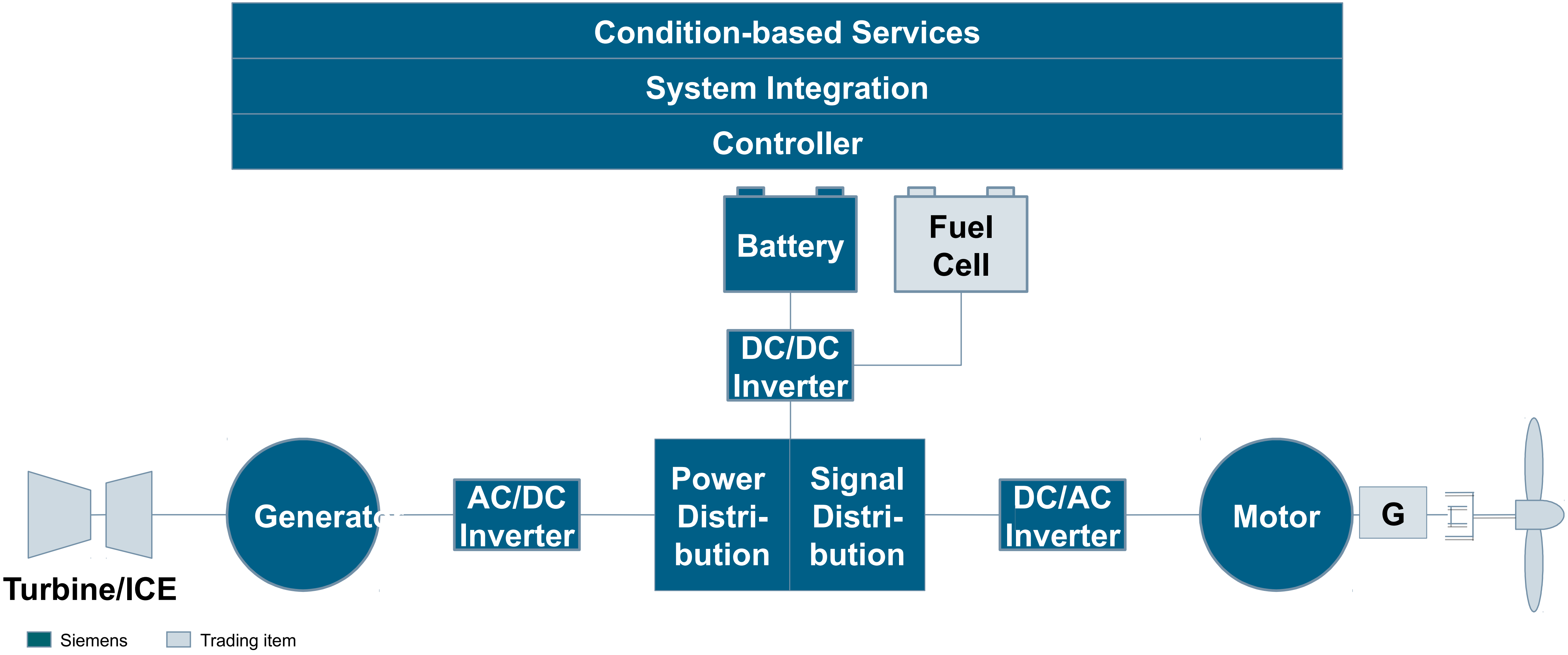
What gets me out of bed in the morning … (but please one hour later)

Aviation should be **efficient**, **individualized, quiet, emission-free,**

affordable and **easy.**

Overview

Our core portfolio – electric propulsion units (EPU) for applications with high power/weight requirements



Siemens – hybrid-electric propulsion systems and sophisticated digital twin technology

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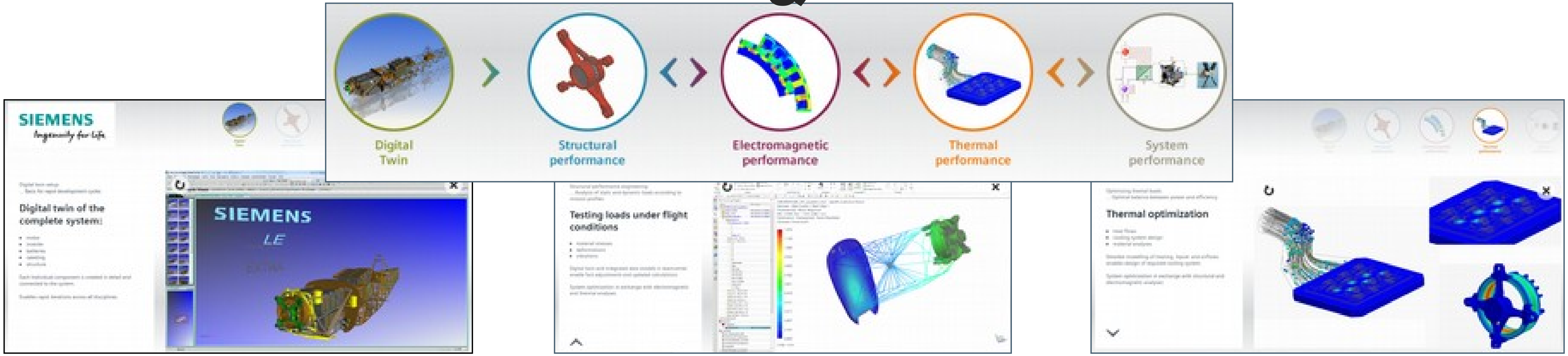

Siemens – hybrid-electric propulsion systems and sophisticated digital twin technology

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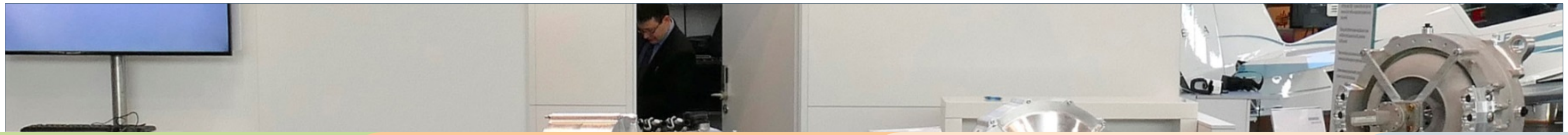


Digital Twin of the co
system: motor, invert

→ Rapid iterations ac
disciplines

Structural optimization: k
mechanical strength, relia

→ Automated structural o
(linear / non-linear)

Optimized EM design: analysis o
magnetic field and induced stres

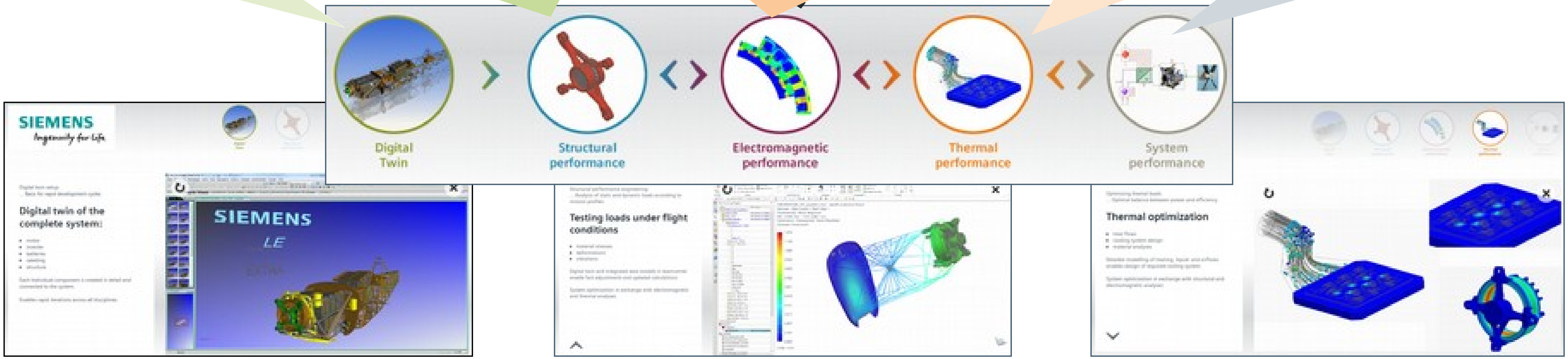
→ System optimization consider
structural and thermal analysis

Thermal optimization: simulati
of heat flow and cooling syste

→ Detailed interdisciplinary
design of required cooling sys

From simulation to real flight:
simulation and mission optimization,
data analysis

→ Continuous system improvements



Airbus Siemens Collaboration - SP200D

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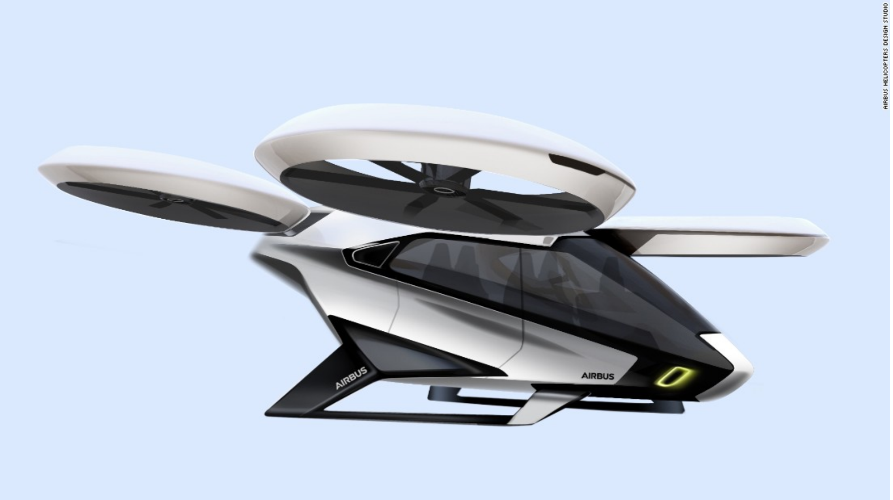
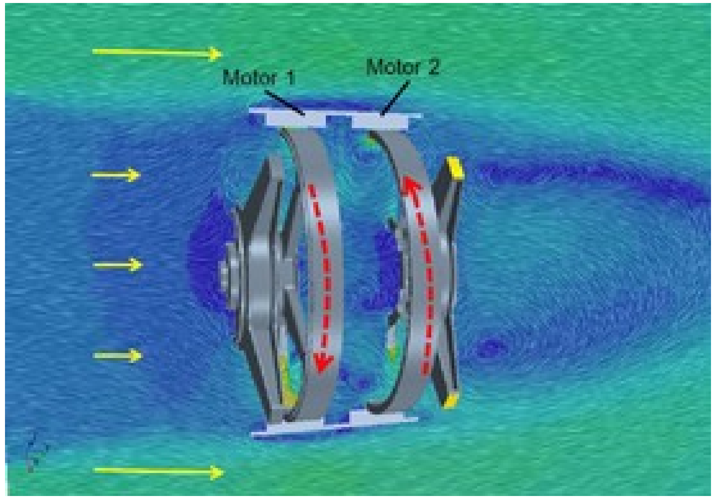
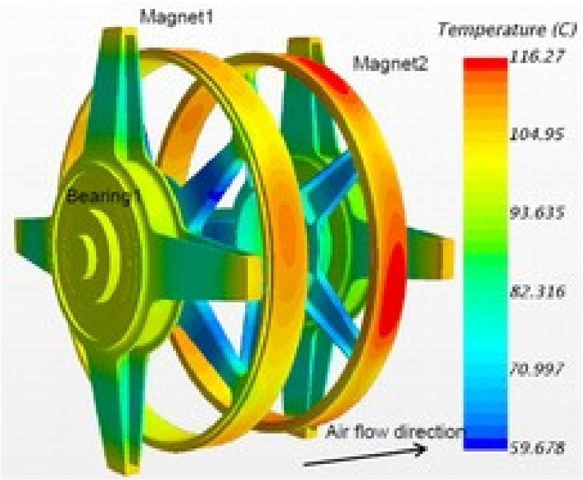
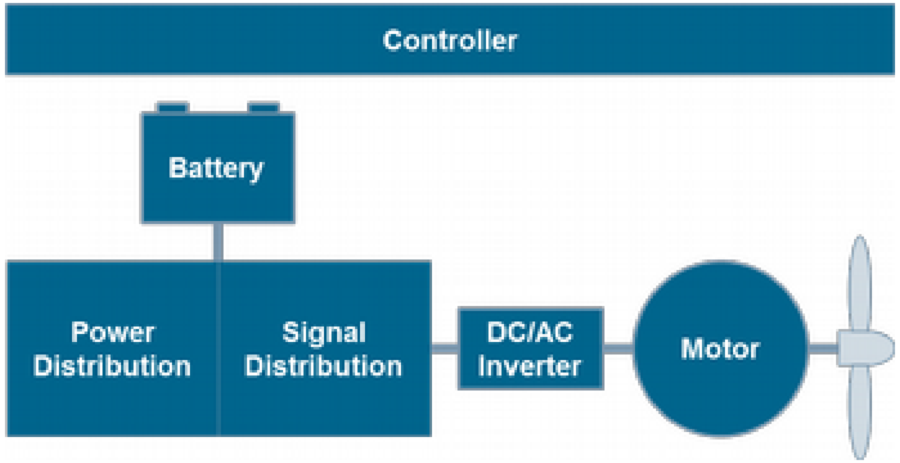
City Airbus Picture, public release June 2017





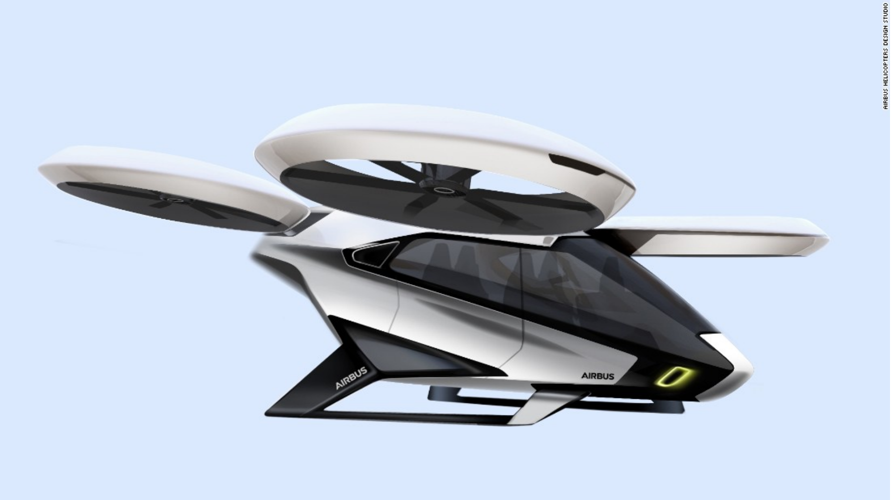


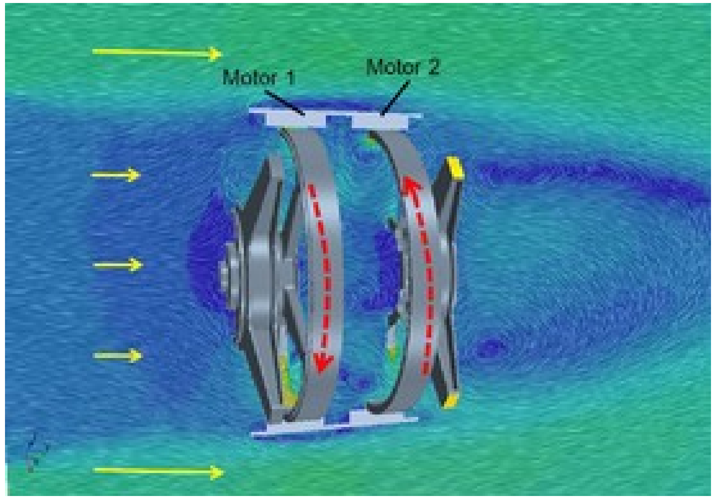


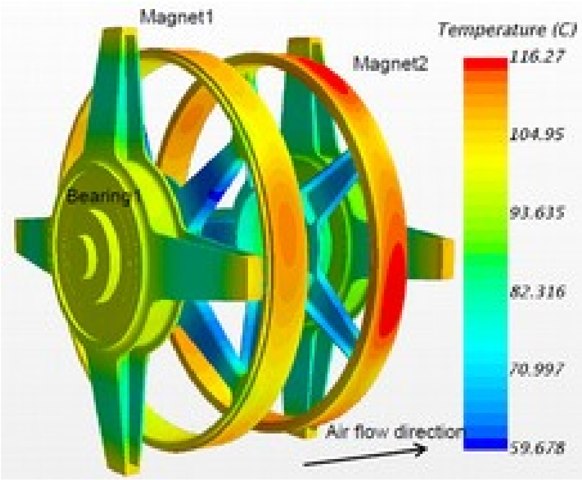
Electric Propulsion Unit EPU Data	
$P_{cont.}$	**Not released**
N_{max}	
$M_{cont.}$	
U_{zk}	
η_{Motor}	
$M_{motor,\ drive,\ propeller\ bearing}$	

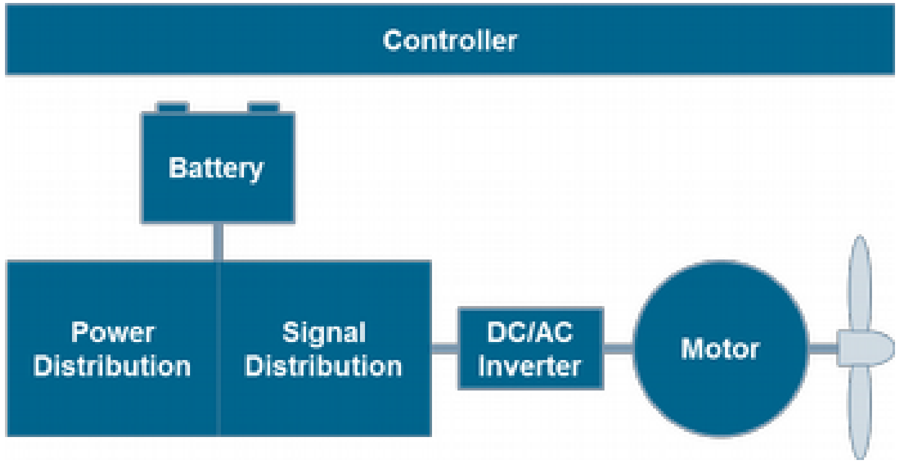
Airbus Siemens Collaboration - SP200D

City Airbus Picture, public release June 2017









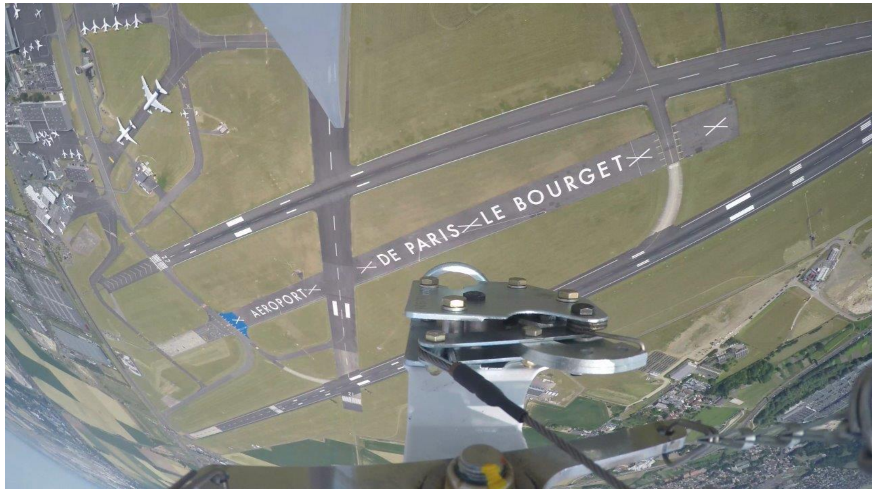
	SP260D (2015)		SP200D (2017)	
$P_{cont.}$		260 kW		204 kW
N_{max}		2500 RPM		1300 RPM
$M_{cont.}$		1000 Nm		1500 Nm
Mass		50 kg		49 kg
Torque/Mass		20 Nm/kg		30.6 Nm/kg
Inverter Type		Si		SiC

+50% !

Overview

Two active test platforms running

Sub- 100kW electric propulsion units	¼ MW and greater electric propulsion units
	



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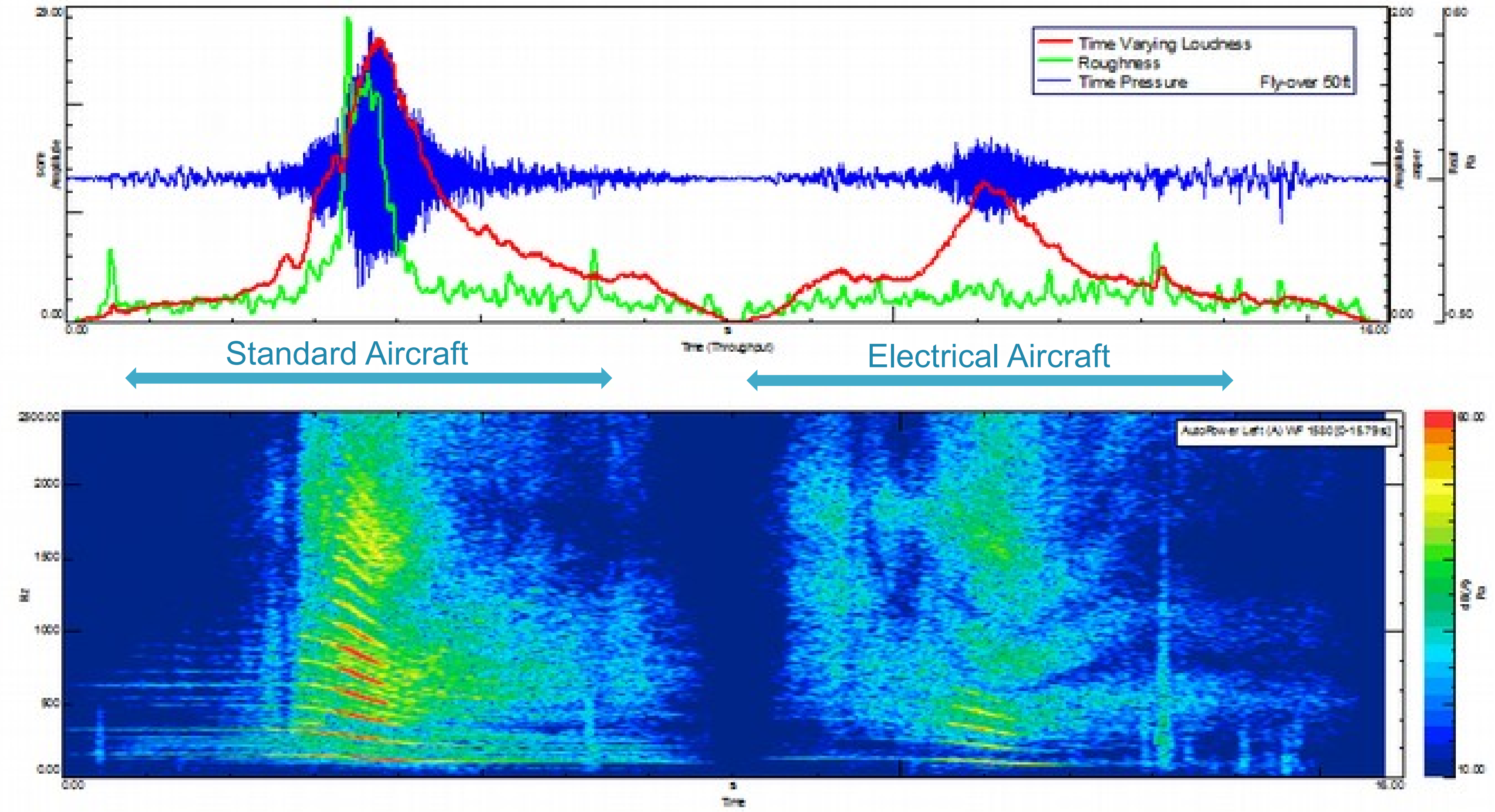
Fly-over noise measurement – Acoustic analysis Fly-over 50 ft



- Loudness reduced from 26 to 13 Sones
- Roughness reduced from 1.9 to 0.3 Asper
- Tonal components greatly reduced

	L_{ASmax} (dBA)
Siemens e-Aircraft	69.2
Piston Aircraft	83.7
Noise Reduction	**14.5**

eFusion acoustic measurement campaign

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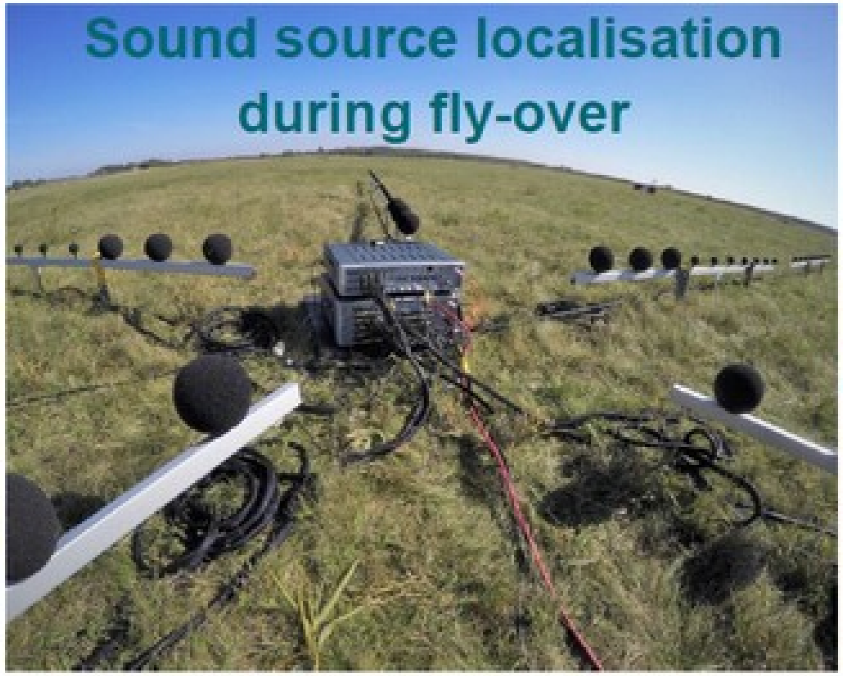

- **Goal:** Comparison between electric and piston-engine aircraft
- **Set-up:**
    - ground microphone
    - weather station

- **Goal:** Localize and quantify dominant exterior noise sources while aircraft is flying
- **Set-up:**
    - Aircraft flying at low altitude over array
    - 100-microphone array (5 arms,10 m diameter)

- **Goal:** Localize and quantify dominant exterior noise sources with aircraft on the ground and rotating propeller
- **Set-up:** Sound Camera

Source: Thierry Olbrechts
Great thanks to our HU eAircraft colleagues.

Overview

Current limiting factors and potential immediate applications

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Limiting factor / constraint

- Storage energy density

- Certifiability of technology

- Noise in urban area

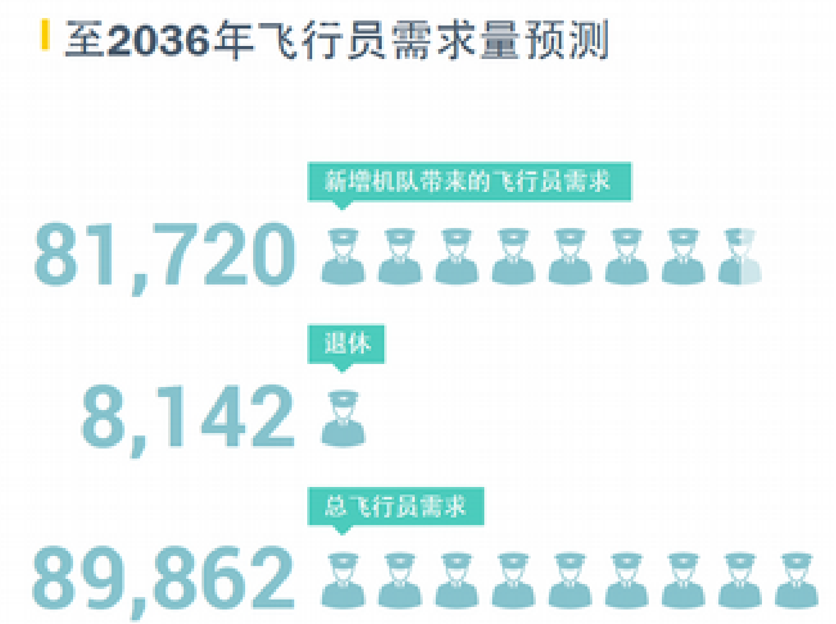
Potential application in spite of constraints

Short duration or high-cycle missions:

- Flight training
- Glider towing

- Immediate: UL, VLA/LSA
- Short-term: CS23/FAR23

Market perspectives for e-aircrafts



[1] 亚翔航空 2017 年中国通航报告 / China GA Report 2017

- Airbus market forecast for China:
  - Number of passengers will be tripled in the next 20 years
- Number of pilots in China:
  - Current annual increase 4~5% (2012 – 2016)
  - Future annual increase of 11% till 2036

→ **High market potential for pilot training missions in China with electric LSA**

Contact

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Backup: Overview

New Agenda

Three basic topologies substitute or support conventional technology – Siemens already tests, or is developing systems in each

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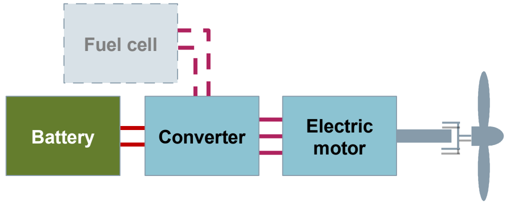
Topologies for hybrid-electric propulsion

Battery electric

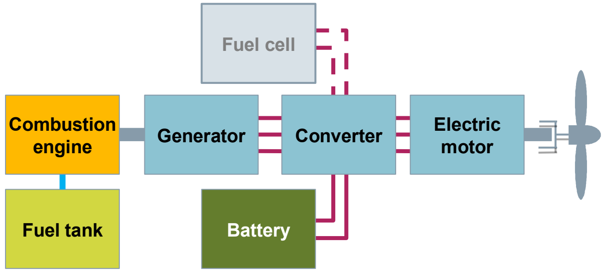


Energy from battery is used in **electric motor** to turn **electric into mechanical energy** for **propeller** rotation

Advantage
- Highest flexibility for spatial arrangements
- Minimizes noise, thermal and other emissions

Disadvantage
- Battery endurance still low

Serial hybrid electric

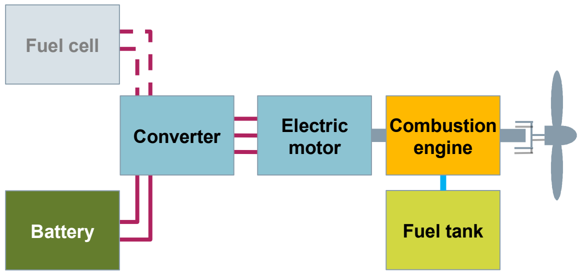


Combustion engine used to **generate electrical energy** to **charge a battery** or run the electric motor

Advantage
- Enables separation of power and thrust generation
- Potential for situation-dependent flight modes

Disadvantage
- Additional weight of generator
- Higher complexity than conventional

Parallel hybrid electric



Electric motor provides **rotation** and **supports** the **combustion engine** for **peak performance**

Advantage
- Conventional engine able to run at optimal power point with peak power by electric motor

Disadvantage
- Higher complexity than conventional

Connections: Electrical Mechanical Fluid