d 1. Stand des Flugmotorenwerkes der Siemens & Halske A.-G.

Siemens Corporate Technology | October 2015

EASA – GA Workshop

Heintje Wyczisk, Siemens AG, CT NTF AIR

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1. Welcome & Introduction
2. Operational Experience
3. Electrical Propulsion Concepts & Developments
4. Technical & Regulatory Challenges
5. Questions & Answers

E-Aircraft:
Hybrid-Electric Drive System for Aircraft

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SIEMENS CT NTF AIR – „Green Propulsion“

Problems

Aircraft manufacturer (OEM) and operator

Kerosene cost | **CO_2** | **Noise** | **Life cycle cost** | **Safety**

Solutions

Siemens hybrid-electric drive system for aircraft

Propeller Aircraft | **Helicopter** | **Turbo Fan Aircraft**

Benefits

A **more efficient** combustions engine optimized for permanent operation – peak load provided by battery – **efficient piston engine** will replace turbine **reduced kerosene costs - 20 %** **lower CO_2 emission - 20 %** **More quiet** optimized integration in the fuselage	**Low Life Cycle Cost** low-wear electrical drive engineering **Improved flight dynamics** small E-drive motor actuates propeller optimally distributed hybrid components **Improved safety** redundant generators and additional battery as energy source

Concept Designs and Feasibility Studies for All Main Applications Already Started

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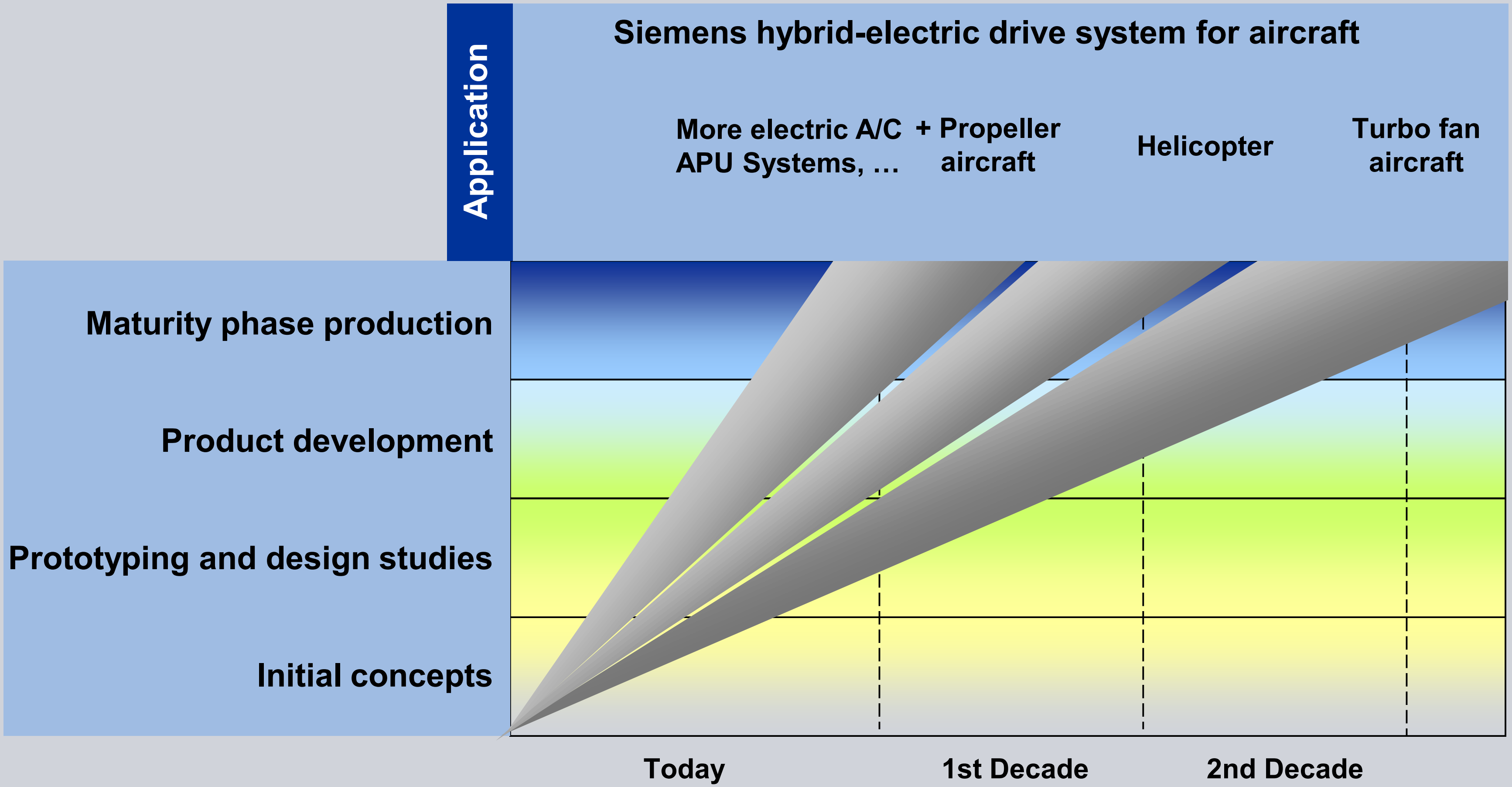

Courtesy: Airbus

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Application DA 36 e Star 1st Generation Motor Glider Propulsion System – Maiden Flight June 2011

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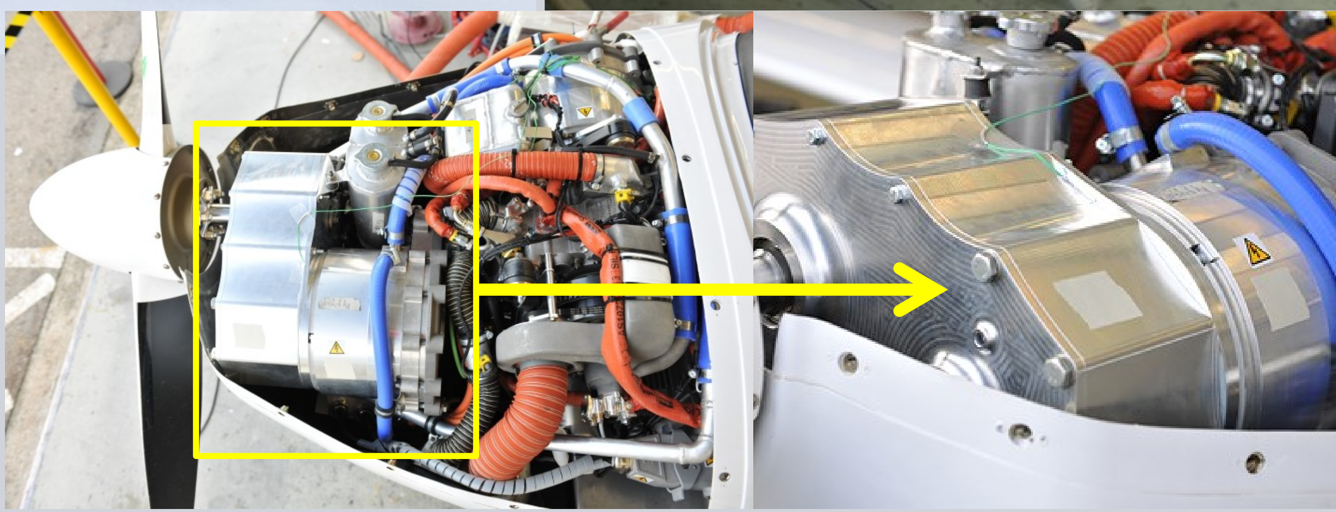
Diamond AIRCRAFT

Propulsion system w/o integrated inverter

$MTOP_{Boost\text{-}120s}$:	60 kW
MCP:	30 kW
$N_{ungeared}$:	7.100 rpm
N_{geared}:	2.500 rpm
$M_{boost\text{-}120s}$:	340 Nm
Weight:	29 kg



Application DA 36 e Star 2nd Generation Motor Glider Propulsion System – Maiden Flight 01.06.2013

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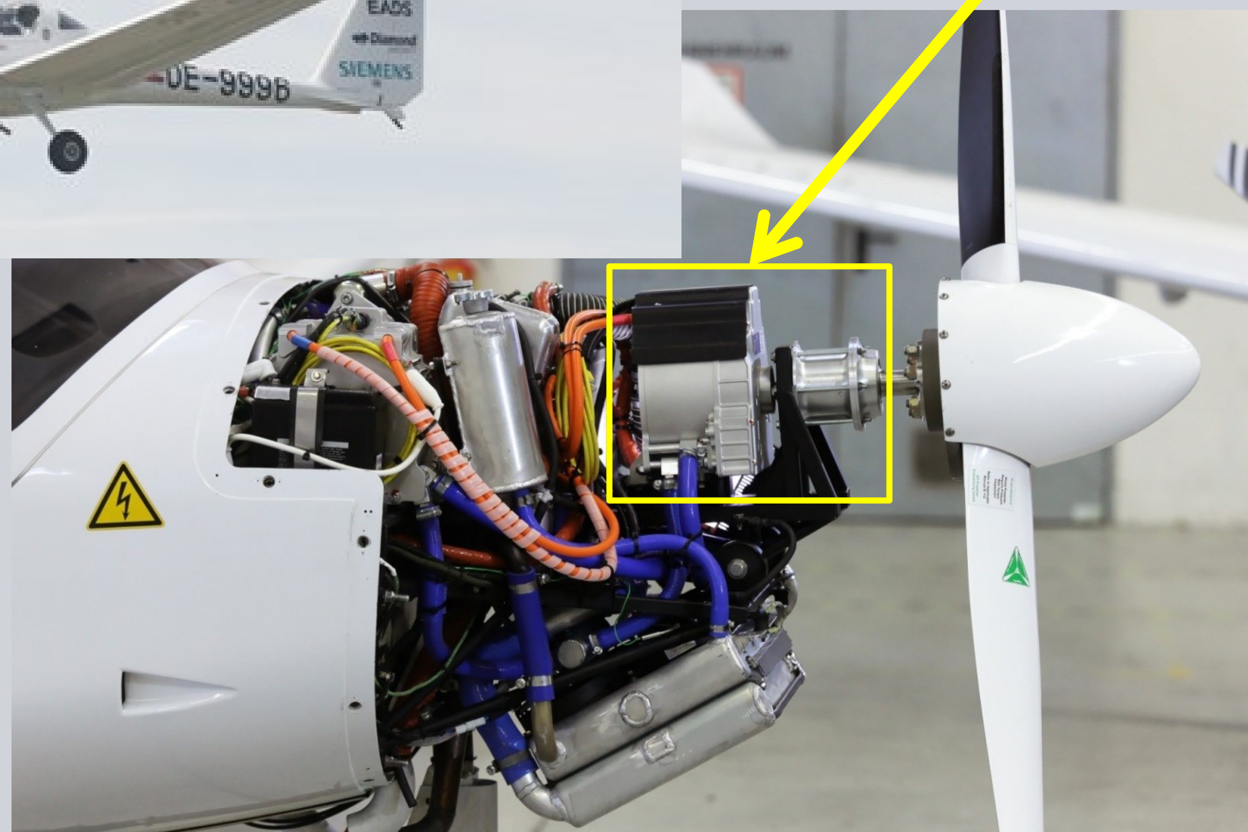
Propulsion system:
E-motor + power /
control electronic +
gearbox & propeller bearing



Propulsion system w. integrated inverter

$\text{MTOP}_{\text{Boost-180s}}$:	80 kW
MCP:	65 kW
$\text{N}_{\text{ungeared}}$:	11.000 rpm
N_{geared}:	2.400 rpm
$\text{M}_{\text{boost-180s}}$:	326 Nm
Weight:	13 kg

Application DA 36 e Star 2nd Generation Motor Glider Propulsion System – Maiden Flight 01.06.2013

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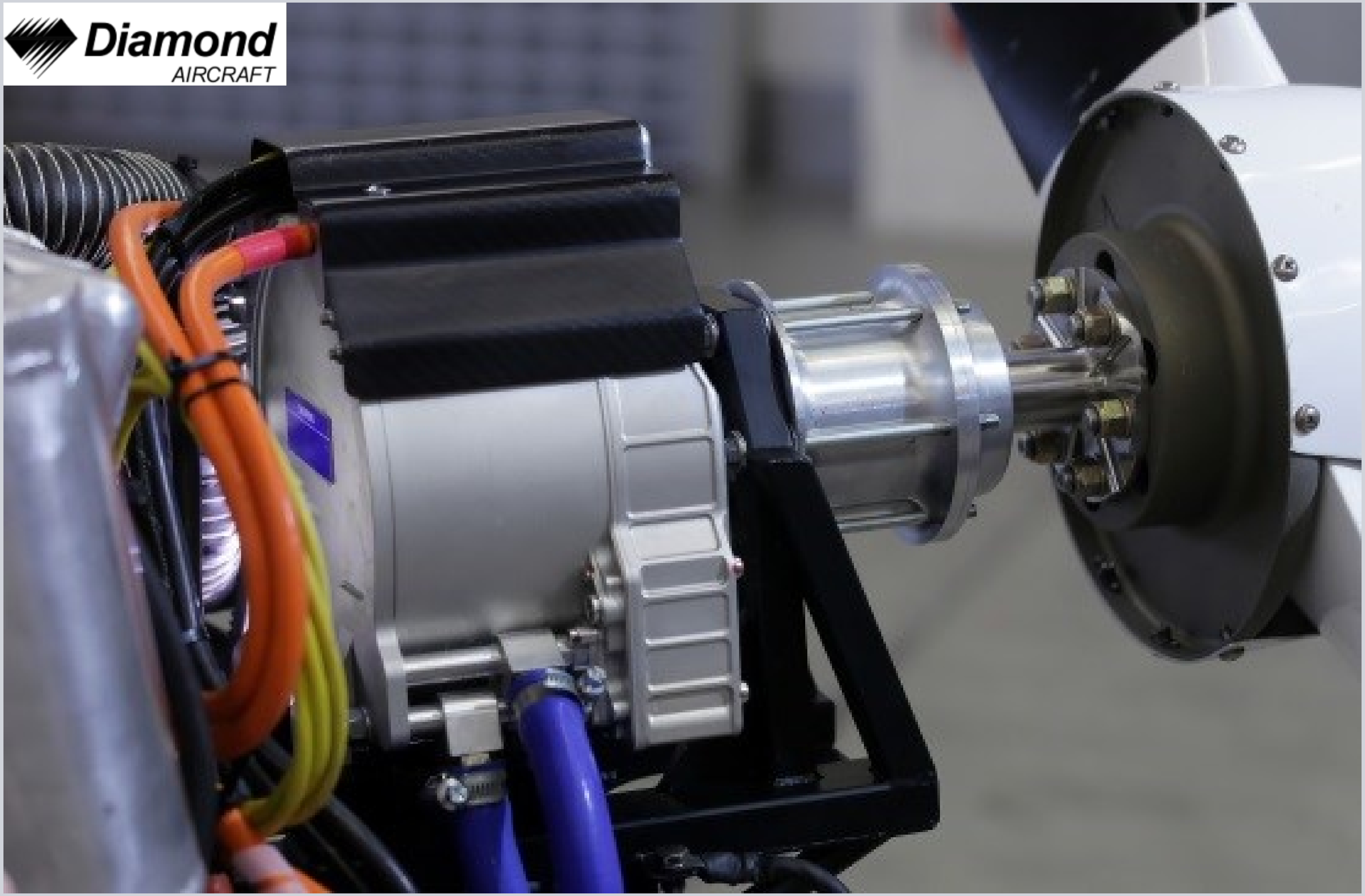

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WattsUp Prototype - 1st Flight (Aug. 22nd 2014)

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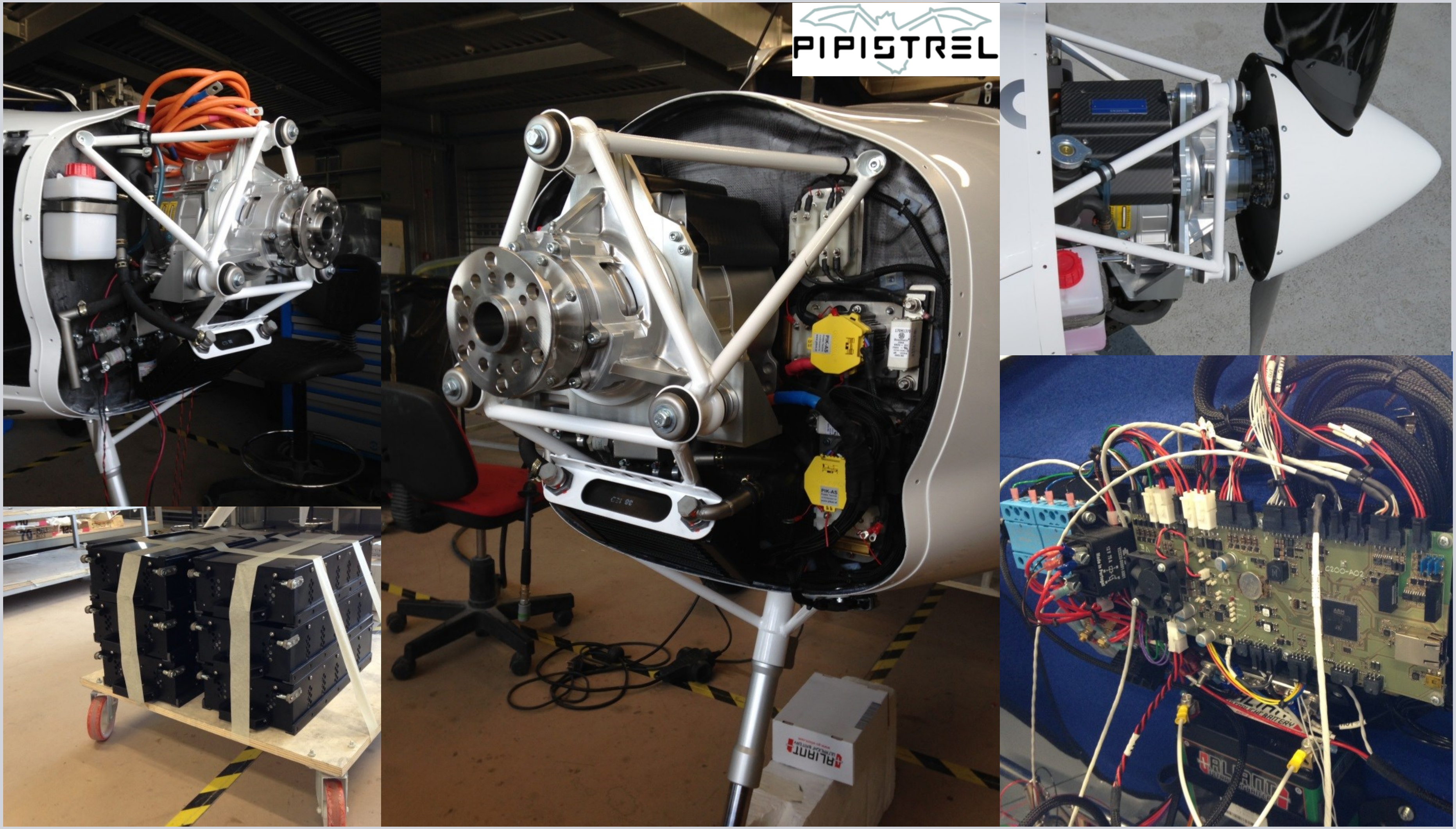
WattsUp Prototype - Airframe Integration



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¼ MW E-Motor - SP260D

Supported by:

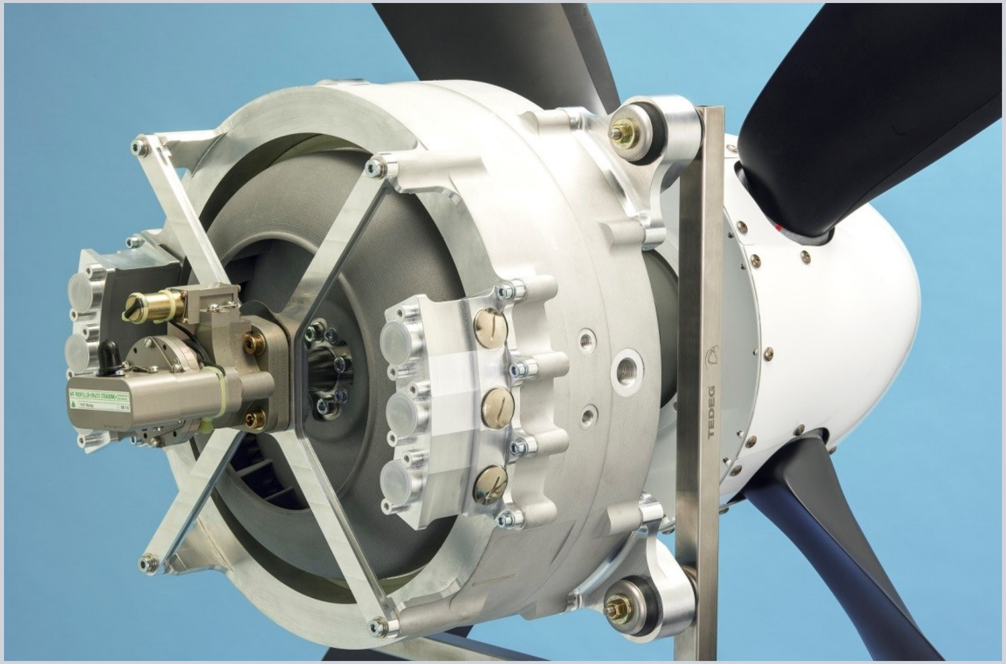
Federal Ministry of Economics and Technology

on the basis of a decision by the German Bundestag

Permanent excited synchronous machine

→ direct drive

MTOP/MCP:	260 kW
N_{max}:	2.500 rpm
M_{Cont}:	1.000 Nm
Weight:	50 kg
Diameter:	420 mm



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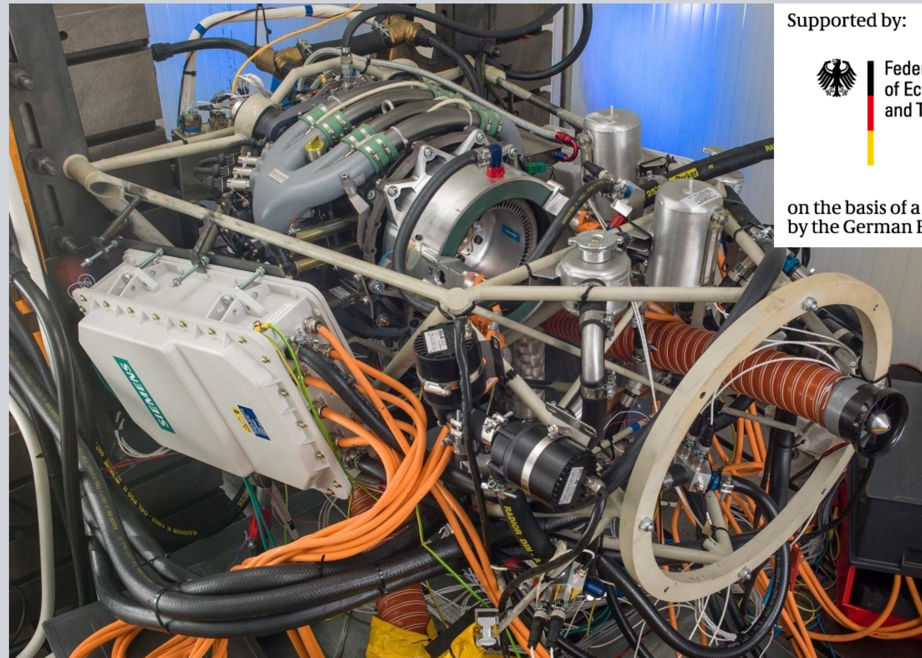
Test Lab Setup MAF Project @ University Kassel



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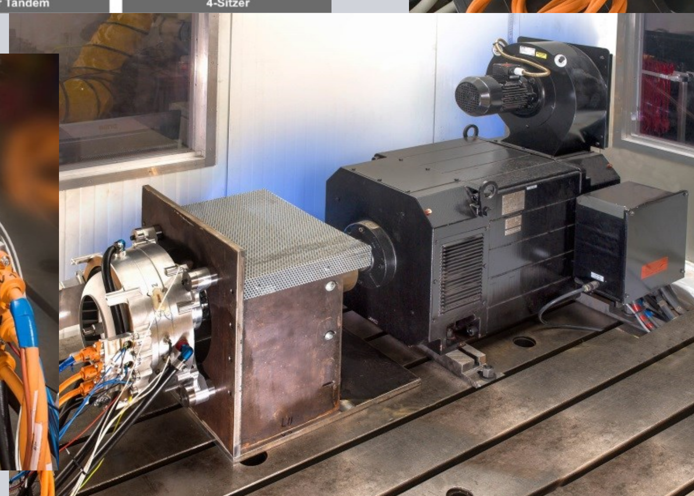

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Hybrid Electrical Twin Engine Plane

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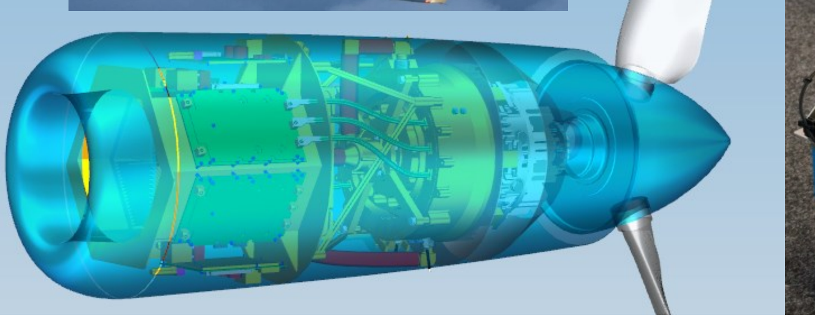

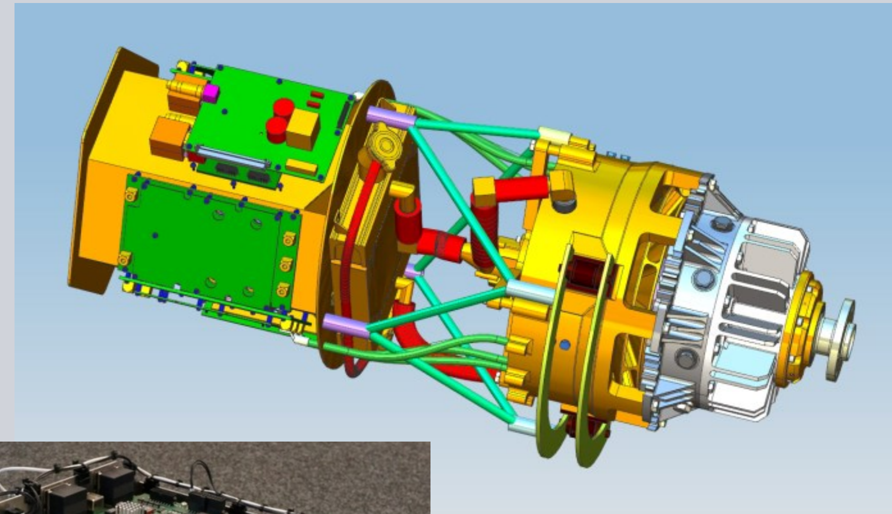

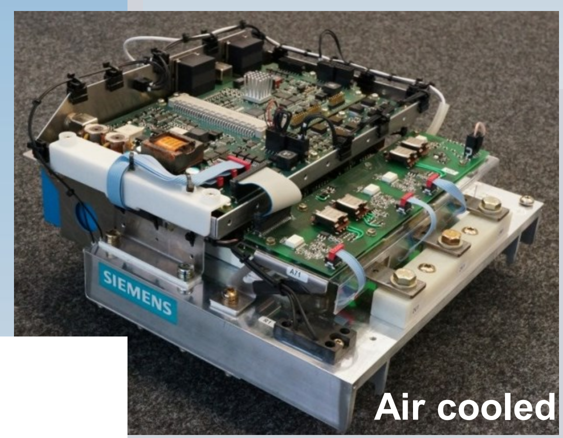

Permanent excited synchronous machine
→ Geared drive:

MTOP/MCP:	120 kW
N_{max} (w/o gearbox):	6.500 rpm
M_{cont} (w/o gearbox):	176 Nm
Weight:	28 kg
Diameter:	334 mm

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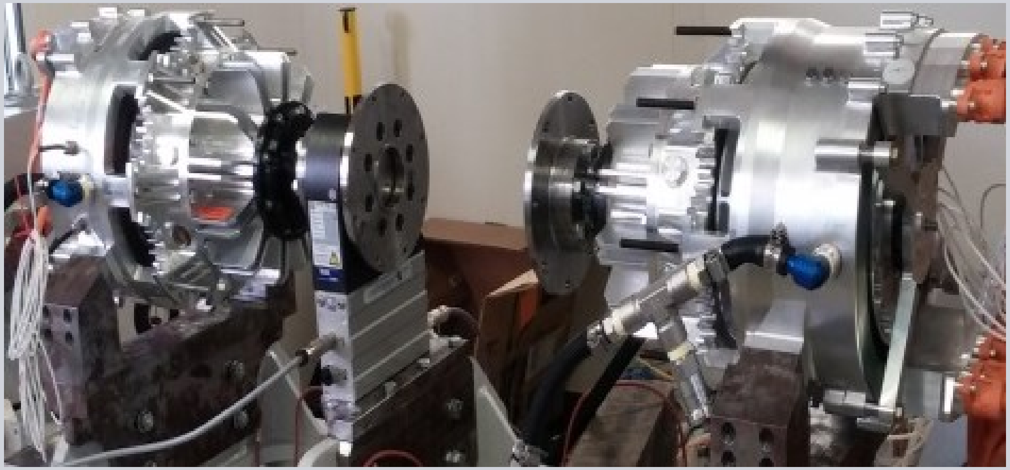
HETEP Tests Lab Setup



Diamond AIRCRAFT

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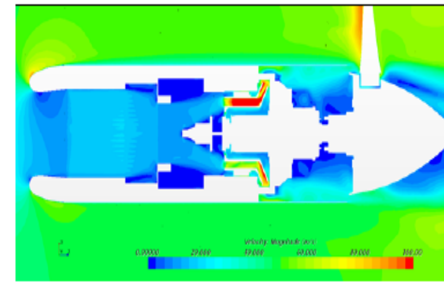
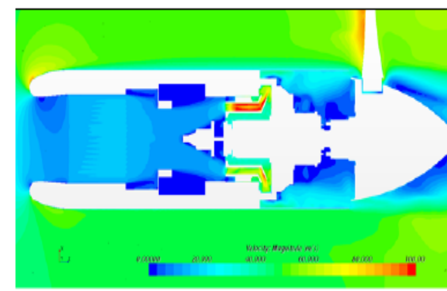
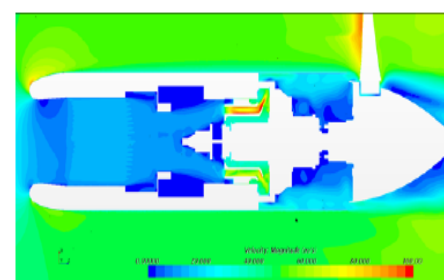
Lüfter-Variante A



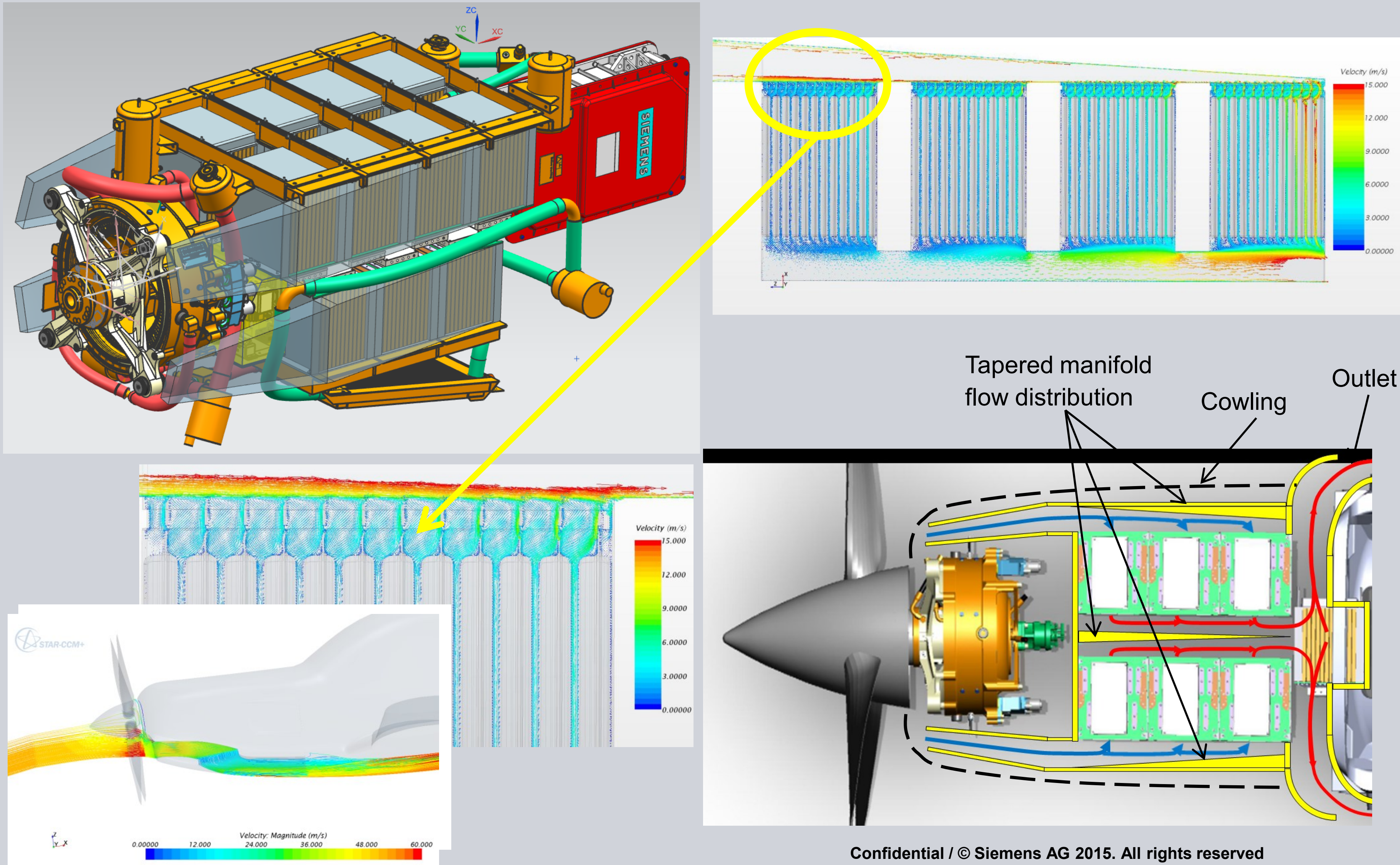
Lüfter-Variante B



Lüfter-Variante C



Single Engine Propulsion Unit Design Concept



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Courtesy: Airbus

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Single Hybrid Engine Concept with Twin Engine ELOS approach

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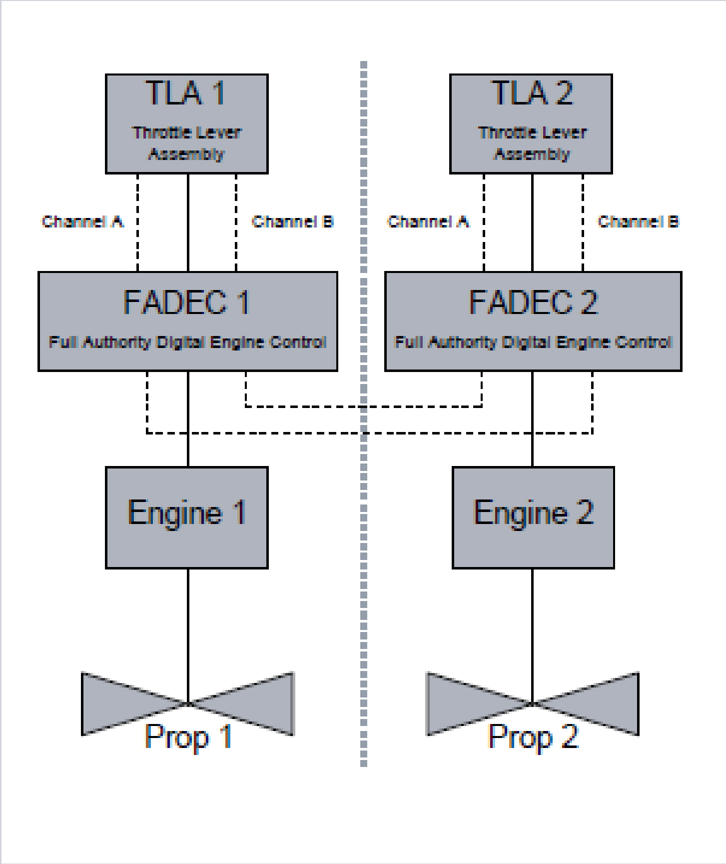
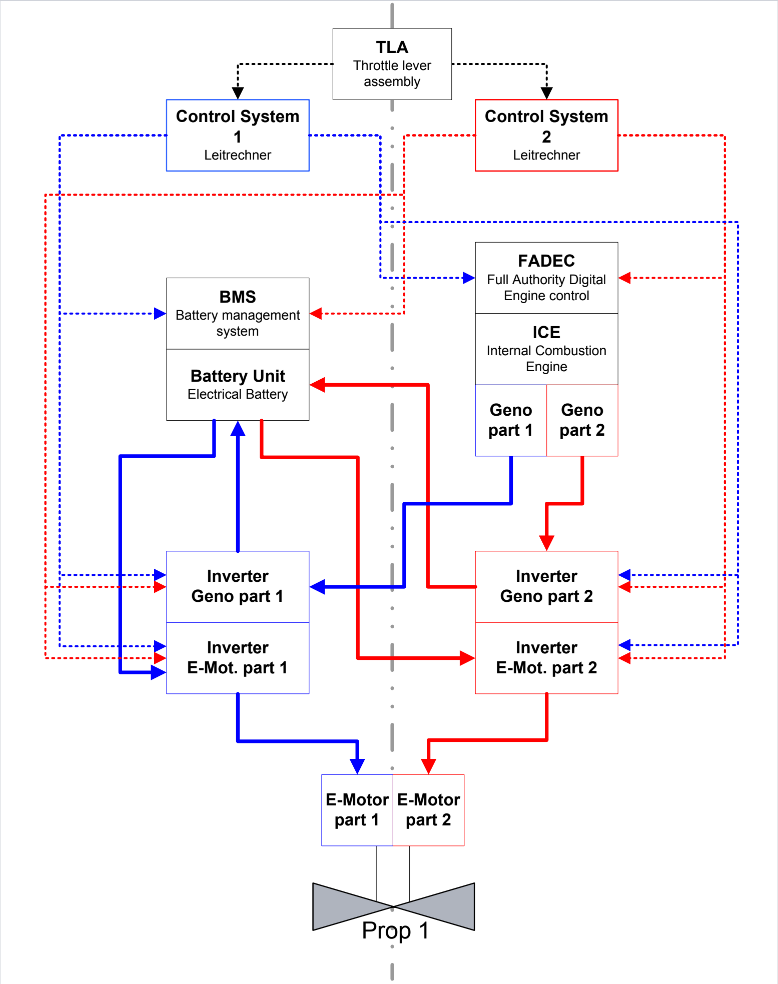
Classical Twin Engine Setup



Serial Hybrid Propulsion Setup



Technical Challenges of EPU/HEPU Designs

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Principle design aspects:

- ✓ Development of sustainable airborne application concepts for electrical machines & power electronics
- ✓ Availability of high power dense energy sources >500 Wh/kg
- ✓ Application optimized ICE concepts
- ✓ Reduction of overall system complexity
- ✓ Higher EPU/HEPU integration level to airframe designs
- ✓ Structural weight optimization of passive parts e.g. usage of alternative materials

Reliable safety concepts to:

- ✓ Avoid thermal runaway conditions of high voltage batteries
- ✓ Operate „safe & redundant“ control system architectures (HW / SW)
- ✓ Realize electrical security using high voltage in aircraft >1.000 V (AC/DC)
- ✓ Enable the usage of power electronics at high altitudes considering cosmic radiation effects, etc …

Efficient cooling system concepts for:

- ✓ Operational temperature and air density range
- ✓ High voltage batteries get max power output / time
- ✓ Electrical machines & power electronics to realize high power density

Regulatory Challenges of EPU/HEPU Designs

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- **Design & Airframe integration aspects: Basic regulations / proposals are available:**
  - ✓ ASTM F2840-14
  - ✓ CS-22H
  - ✓ SC's / CRI's
  - ✓ A-NPA's
  - ✓ Guidance material …

  … but don't cover yet the full range of required regulatory frame for sustainable product development & certification

- **Adaptation/inclusion of existing regulatory frame (CS-x) to new technology need to be simplified and easy traceable (e.g. same CS-x numbering vs. trace matrix for more transparency & less complexity, especially important for aviation novices)**

- **Standard (ELOS) interpretation of conventional airworthiness requirements are only partly usable/reasonable, because of new technology aspects (→ new AMC's / guidance material required)**

- **Current initiatives like ASTM with initially transparent process for re-writing FAR-23 making slow progress, because of low willingness to invest significant effort, but political interest very high**

Courtesy: Airbus

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… we have the competence to contribute to the next aircraft generation …

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… let’s take-off for a green future!

Thank you for your attention!

Siemens Corporate Technology
Contact and further information

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Corporate Technology
New Technology Fields
CT NTF AIR

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