

# Siemens eAircraft Disrupting the way you will fly!

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Realize innovation.

#### **Presentation** on behalf of Siemens eAircraft





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Siemens eAircraft Siemens Next47



Siemens Digital Factory PLM Software Simulation & Testing Solutions

### **Electrification, automation and digitalization** Are the core of the Siemens strategy



Leveraging key technology enablers along our entire portfolio to create next level of customers benefits.



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#### Digitalization has an impact on the entire value chain ... ... and Siemens





#### Siemens Digital Factory (DF) Division – Integrating Automation and Product Lifecycle Management under one roof





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#### Disrupting the way you will fly!





## **Challenges and Needs**

# The Electric Propulsion Unit (EPU)

Siemens Solutions, Collaborations & Achievements

**Engineering EPUs using Digital Twins** 

#### Disrupting the way you will fly!





## **Challenges and Needs**

# The Electric Propulsion Unit (EPU)

Siemens Solutions, Collaborations & Achievements

Engineering EPUs using Digital Twins

#### In the meantime in aviation industry... ... compete each other to boredom!







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# The aviation industry is on the verge of a major shift towards electrified propulsion





1) IATA technology roadmap, June 2013 © Siemens AG 2018

#### **Innovation happens Bottom-Up**





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#### **Innovation happens Bottom-Up**







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#### Aircraft "Powerplant" Thrust & Energy Needs



#### Engine Power Output for typical Wide-Body Aircraft Engine



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#### **Disrupting the way you will fly!**





## **Challenges and Needs**

# The Electric Propulsion Unit (EPU)

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**Engineering EPUs using Digital Twins** 

# Conventional propulsion relies on piston engines, turboprop or turbofan



Types of aircraft propulsion: conventional



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#### Three different types of electric propulsion allowing to substitute or support conventional technology



Types of aircraft propulsion: electric



© Siemens AG 2018

### Our core portfolio – electric propulsion units (EPU) for applications **SIEMENS** with high power/weight requirements Ingenuity for Life



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#### Siemens eAircraft Our motivation for electrifying aircraft propulsion



- Electric drive systems are one of the main business domains of Siemens
- The application to aerospace is attractive, technologically challenging, and requires safety and certification
- We are committed to the development and production of hybrid electric aircraft propulsion systems as a future area of business
- Technology spill over for other Siemens businesses





#### We expect e-propulsion to be the standard solution by 2050







#### **Disrupting the way you will fly!**





## **Challenges and Needs**

The Electric Propulsion Unit (EPU)

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Engineering EPUs using Digital Twins

#### SP70D & SP55D NextGen Si inverter





Direct Drive permanent-magnet electric motors Hollow shaft Design derived from SP45D which has >300 flight hours on eFusion Motor and Inverter Water-Glycol cooled



#### eFusion - Magnus Aircraft Corp. (Hungary)

Two-seat side-by-side low-wing monoplane with **aerobatic capability** for **upset recovery training**.

#### Safe and Robust battery propulsion system

designed, developed and verified by Siemens Target cost-sensitive segments of Very Light, Light Sport and Ultra Light Aircraft.



### Magnus eFusion Full electric aircraft propulsion system installed firewall-forward



#### Magnus eFusion – maiden flight Summer 2016

Battery system Auxiliary 	Aircraft Data	
	Empty weight including batteries and parachute	410 kg
	MTOW	600 kg
	Wingspan	8.4 m
Electric Motor with	Length	6.6 m
Bearing	Height	2.4 m
	Propulsion System Data	
<b>SIEMENS</b>	Power	45 kW MCP 60 kW MTOP 85 kW max.
	N <sub>max</sub>	2500 rpm
	DC-link voltage (nominal)	350 VDC (300 …450 V)
2525252 525252525	Torque M <sub>Boost</sub>	324 Nm
	Battery	10.1 kWh
	Max. airspeed	97 KIAS

#### Magnus eFusion High Power Density Inverter SD104





#### SD104 Inverter

Silicium Carbide Micro-Channel cooling plate

Dimensions: 47 mm x 94 mm x 141 mm Weight: 900 g Propulsive Power: 57 kW



#### Magnus eFusion Hybrid-Electric configuration First Flight April 11th, 2018







#### SP260D & SP260D-A Record breaking Power Density





#### **SP260D-A**

Direct Drive Permanent Magnet MTOP 260 kW @ 2500 RPM Torque 977 Nm UDC 580 V Oil cooled @ 90 °C Efficiency 95% 50 kg Weight 44kg 5.2 kW/kg Power Density 5.9 kW/kg

Developed for maximal Power Density Redundant 3 Phase Windings

#### Implemented in Extra 330LE

Achievements:

- Electric Aircraft Speed Records
- Electric Aircraft Climbing Records
- First All-Electric Glider Towing



### Extra 330LE Flying Testbed for ¼-MW class electric propulsion systems





\* As rated in the Extra 330LE

### Extra 330LE Maiden Flight on July 4, 2016 at Dinslaken airfield





https://m.youtube.com/watch?v=fiu8TFnXYFY

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#### Achievements, Record Flights and Opportunities Fly-Over Noise Reduction



https://www.youtube.com/watch?v=WyILWeDtPy0&index=7&t=0s&list=PLw7ILwXw4H53YUddJ99vzOVFgn-o4f17U

#### Achievements and Opportunities Electric Glider Towing



https://www.youtube.com/watch?v=R4T7LZaMxI8&index=2&t=0s&list=PLw7ILwXw4H53YUddJ99vzOVFgn-o4f17U

#### World's <u>Strongest Electric</u> aircraft delivers the <u>Most Silent</u> flight demo Paris Air Show 2017





#### eAircraft Airbus-Siemens Collaboration – joint development agreement signed April 2016



# SIEMENS

"Siemens is determined to establish hybrid-electric propulsion systems for aircraft as a future business."

- Both companies take a significant joint development decision
- Demonstrate the technical feasibility of various
  hybrid-electric propulsion systems by 2020
- Assemble joint development team of some 200 employees

GROUP "We believe that by 2030 passenger aircraft below 100 seats

could be propelled by hybrid propulsion systems..."

Airbus Group CEO Tom Enders

AIRBUS

- Prototype propulsion systems ranging from a few 100 kW up to 10 MW and more
- for short, local trips with aircraft below 100 seats, helicopters or UAVs up to classic short and mediumrange journeys.
- Target: breakthrough innovation in aerospace emobility

#### Airbus & colleagues ... feel the pressure





Source: http://airbus-xo.com/innovation-age-third-aerospace-revolution/

### Siemens – Airbus Roadmap towards Hybrid-Electric Flight





Source: http://airbus-xo.com/innovation-age-third-aerospace-revolution/

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#### SP200D Record breaking Torque Density





#### **SP200D**

Direct Drive Permanent Magnet  $P_{max,cont} = P_{max,5min} = 204 \text{ kW}$   $N_{cont} = N_{max} = 1300 \text{ RPM}$   $M_{cont} = M_{max} = 1500 \text{ Nm}$ UDC 450 - 850 V

> Oil cooled Syltherm 800 Weight 49 kg

Record Torque Density 30 Nm/kg

Designed for high-torque low-speed requirements.

Allows for slow rotating propellers, hence low noise.

Currently under Test





#### SP200D Powering the CityAirbus





# Airbus communication on CityAirbus





Source: http://www.airbus.com/newsroom/press-releases

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#### CityAirbus "Iron Bird" Integration testing





### Target Piloted First Flight eo. 2018

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#### Airbus, Rolls-Royce & Siemens



#### **28** November 2017

EN FR DE ES

**Commercial Aircraft** 

Airbus, Rolls-Royce, and Siemens team up for electric future Partnership launches E-Fan X hybrid-electric flight demonstrator



Source: <u>http://www.airbus.com/newsroom/press-releases</u>

#### High Power Class Flying testbed E-Fan X





#### Source: http://www.airbus.com/newsroom/press-releases

#### **Disrupting the way you will fly!**





## **Challenges and Needs**

# The Electric Propulsion Unit (EPU)

Siemens Solutions, Collaborations & Achievements

## **Engineering EPUs using Digital Twins**

#### EPUs with Record Power Density are Complex & Highly Integrated Products







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#### **Digitalization's value fully realized** Digital threads connect the twins





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#### Simcenter Portfolio Engineer innovation for aircraft performance





#### Simcenter Portfolio Engineer innovation for aircraft performance





## The Siemens SP200D - record breaking torque/weight ratio Fly it before you build it, with Siemens PLM integrated solutions

SIEMENS

Ingenuity for life

## CityAirbus uses Siemens SP200D EPU Direct Drive: SIEMENS Based on SP260 technology - 50% increase in Torque to Mass Ratio







	SP260D 2015		<b>SP200D</b> 2017
Continuous Power	260 kW		204 kW
Rotational Speed	2500 RPM non-geared		1300 RPM non-geared
Continuous Torque	1000 Nm		1500 Nm
Mass	50 kg		49 kg
Torque to Mass Ratio	20 Nm/kg	Increase by 50%	30.6 Nm/kg
Inverter Type	Si		SiC

#### **Generative design**







- Set the conditions
- Run the simulation
- Iterate, iterate and iterate again
- Get your optimized design

# Discover Better Designs, Faster!

#### Simulation-driven generative design



#### Computational fluid dynamics



#### **Design space exploration**



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#### Automated flying and new mobility concepts Next level of systems of systems simulation



#### Controlled airspace



#### "Un-controlled" airspace



#### Hitting-the-road - roadspace



#### **Driver in control**



#### Car in control



Verification and validation autonomous operations



#### **Continued investment in the Digital Enterprise**





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## In the meantime in aviation industry... ... compete each other to boredom!







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#### Innovation is happening today - New Concepts are in reach! The near future will be Cleaner, Less Noisy, ... Fun!





#### Follow on Youtube! Siemens eAircraft



Aircraft Performance Engineering - Validating Aircraft in-cabin Noise & Vibration Performance

Reduce noise with electric propulsion - technical comparison

Source: Youtube, Search for *Siemens eAircraft* Channel <a href="https://www.youtube.com/playlist?list=PLw7lLwXw4H53YUddJ99vzOVFgn-o4f17U">https://www.youtube.com/playlist?list=PLw7lLwXw4H53YUddJ99vzOVFgn-o4f17U</a>

# Simcenter helps optimize design and deliver innovations faster, with greater confidence







Siemens eAircraft - Fly it before you build it

Source: <a href="https://www.youtube.com/watch?v=T\_X\_9VQ03b0">https://www.youtube.com/watch?v=T\_X\_9VQ03b0</a>

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#### Follow on Twitter! Siemens eAircraft



Philipp Schildt @PhilippSchildt · Aug 18



Measurement of atmospheric turbulence with Taifun motorglider equipped with SIEMENS LMS Scadas XS at the #idaflieg #sotre



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# Explore how Simcenter helps optimize design and deliver innovations faster, with greater confidence





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