Antares DLR-H2 - Flying Test Bed for Development of Aircraft Fuel Cell Systems

Fuel Cell Seminar 2013

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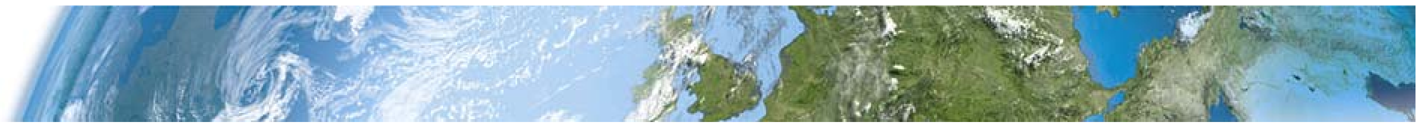
Short Presentation DLR

DLR is the Aerospace Research Center as well as the Space Agency of the Federal Republic of Germany

Research Areas

- Space Flight
- German Space Agency
- Aeronautics
- Transport Research
- Energy Technology



DLR - Sites and employees

7.000 employees working
in 31 research institutes and
facilities
- at 8 sites
- in 7 field offices.

Offices in Brussels,
Paris and Washington.

Fuel cell research in Hamburg
and Stuttgart

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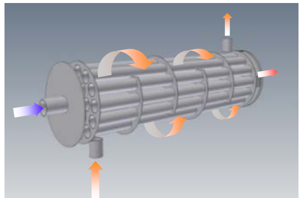
DLR - Institute of Technical Thermodynamics
Electrochemical Systems

Fuel cells systems



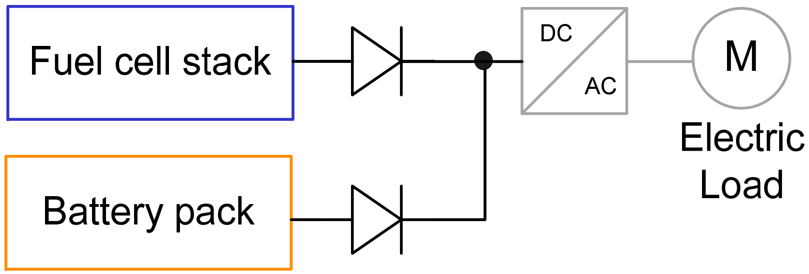

Reformer and stacks

Battery systems

Battery packs

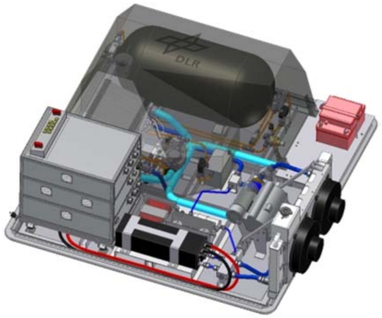
Electrolysis

Hybrid systems



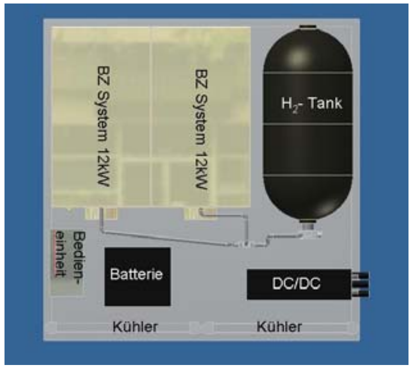
Fuel Cell Aircraft and Airport Applications at the DLR

Airworthy technology development platform for A320



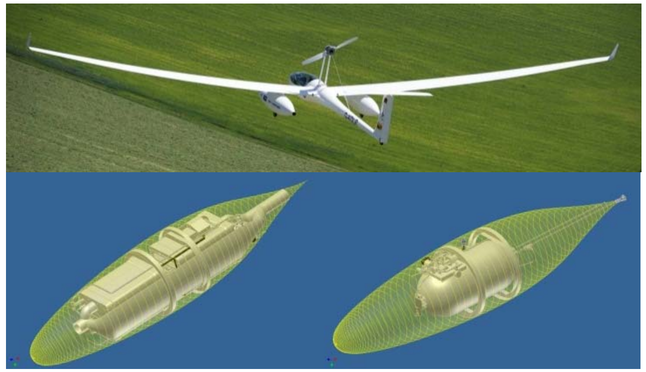
- for emergengy power
- for multifunctional use
  → APU
- energy source for nose wheel drive

Modular architecture development platform



- for GPU applications
- for high torque airport applications (transport)

Modular airworthy propulsion platform Antares DLR H2



- for UAV applications
- for general aviation (up to 6 Pax or utility)

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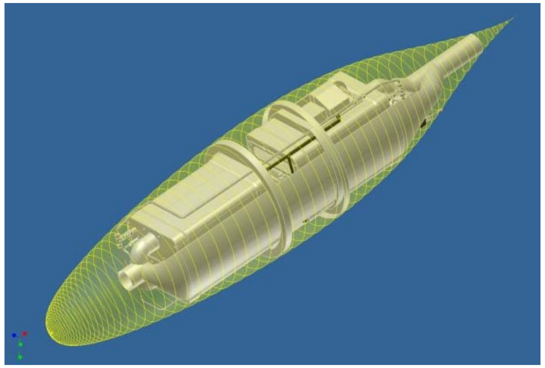
Antares DLR-H2 – overview, build-up

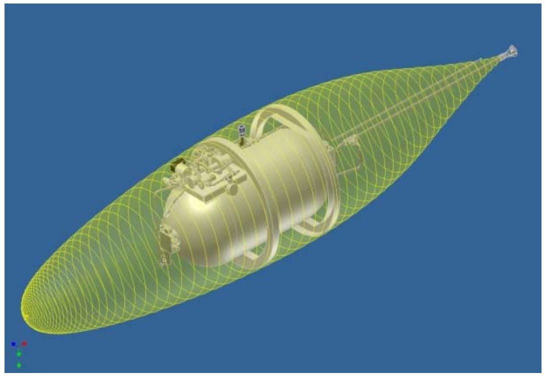
High efficient airplane

Technical Challenges:

- High efficient fuel cell system
- Minimized air drag
- Optimized aeroelastics



Fuel cell system



Hydrogen storage

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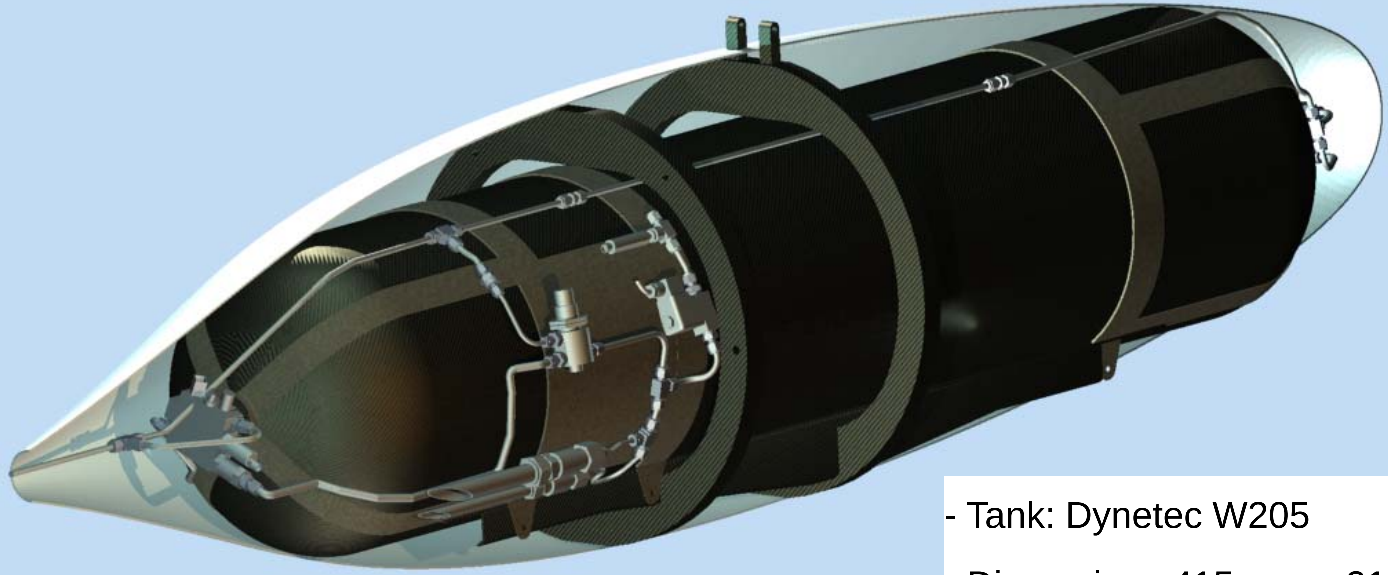
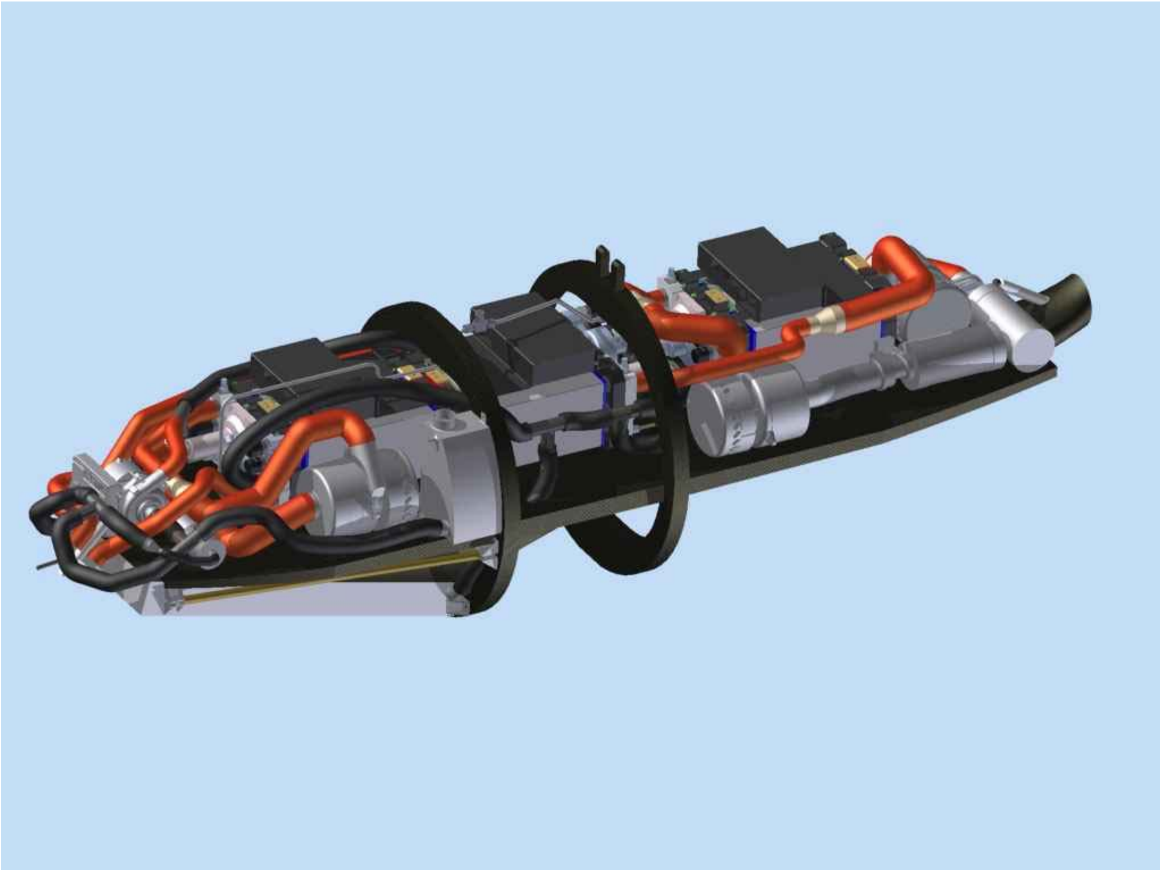
Hydrogen storage system



- Tank: Dynetec W205
- Dimensions 415mm x 2110 mm
- Weight 99,5 kg
- Volume 74 Liter, H_2 capacity 4,89 kg
  at 350 bar → max. 5 h flight time

Fuel cell technology Antares DLR H2



Modular fuel cell system with cooling booster

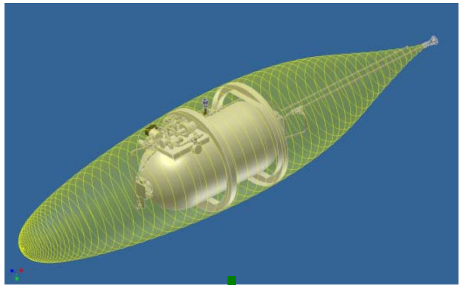
Fuel cell system power
up to 33kWnet

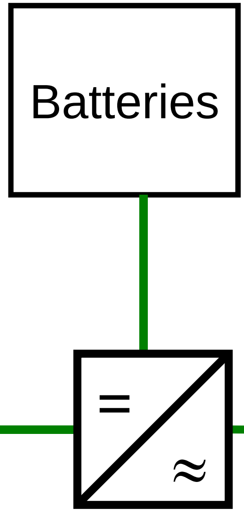
→ modular system 3 x 11kW
→ liquid cooled

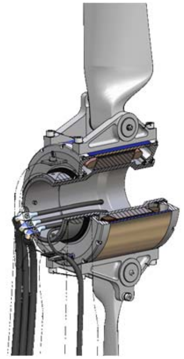
Antares DLR H2 – LT PEM Fuel Cell Technology Gen 2
Optimized electrical network - direct hybrid

> 40% overall efficiency (from chemical energy to movement)

Storage System





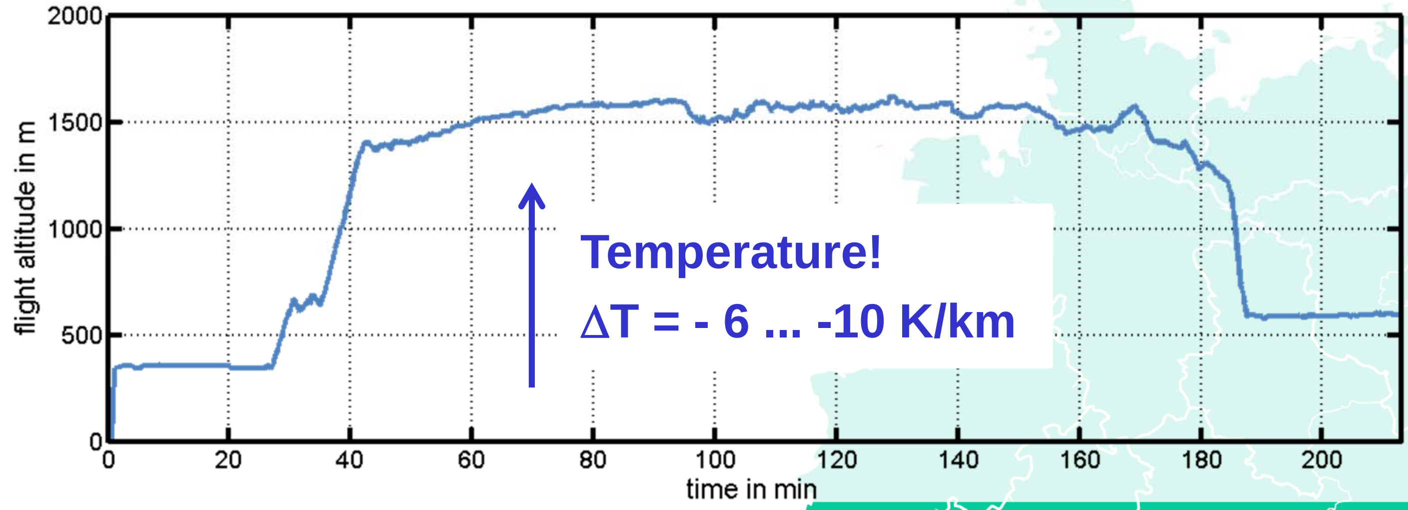


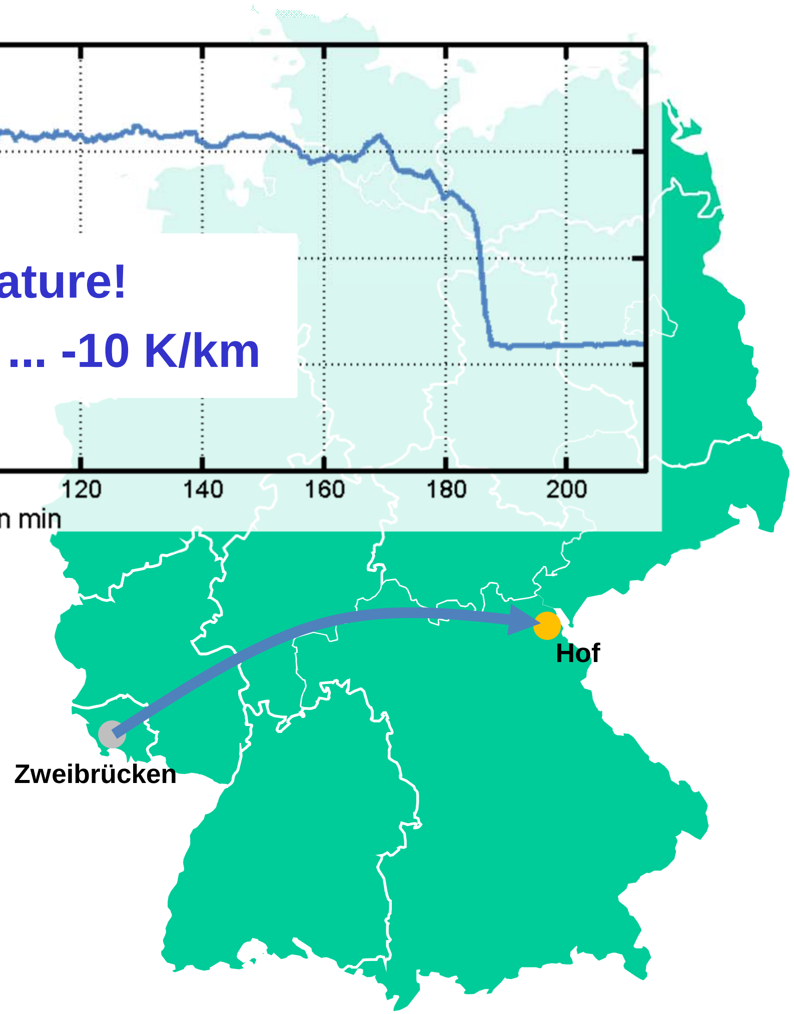
High efficient power grid
200-450V DC at 40kW

Energy Delivering System
approx. 33kW

Very high efficiency and reliability due to:
- Direct coupling of the motor electronic to the fuel cell/energy source, without DC/DC
- High reliability due to direct, parallel use of an optional battery

Aircraft application: Flight profile





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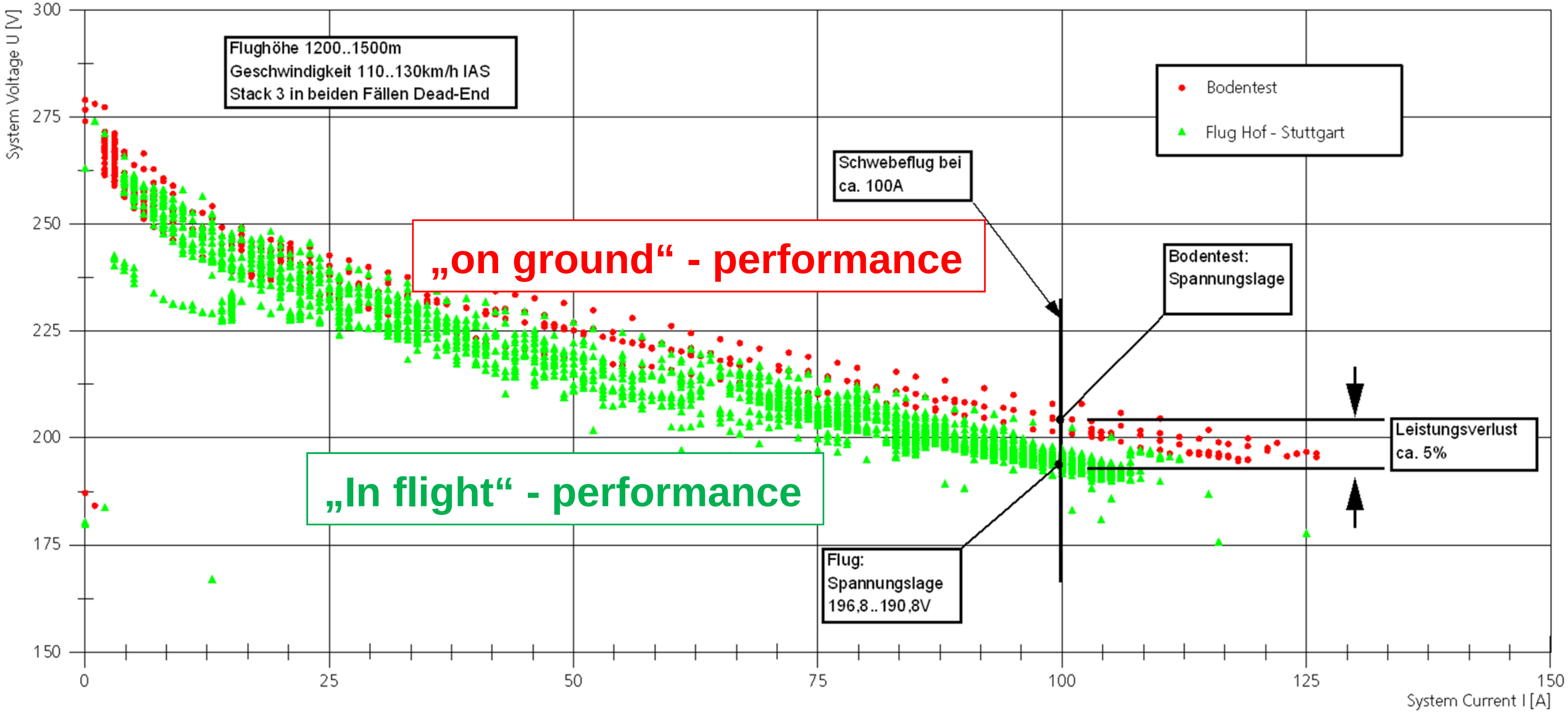
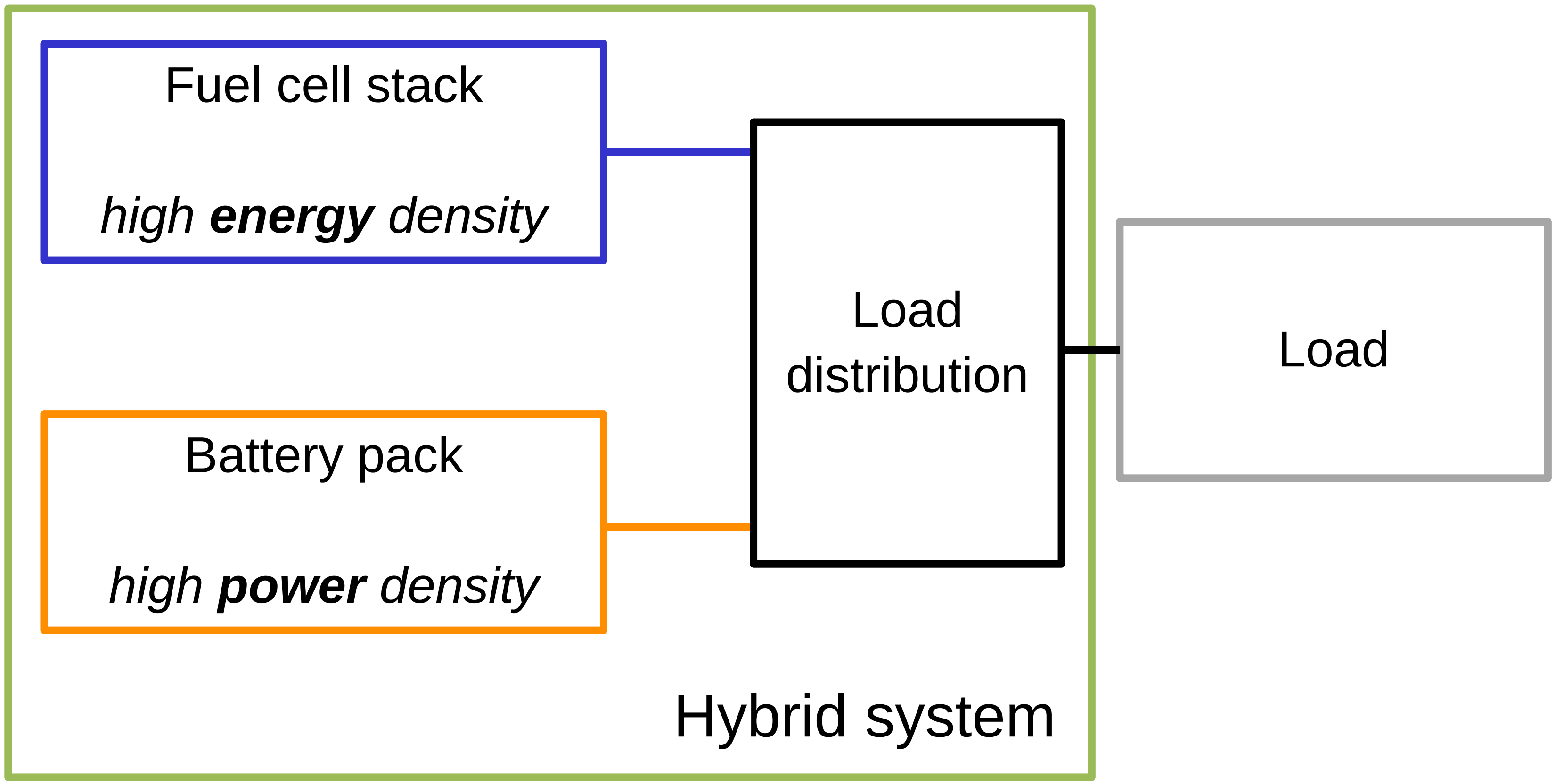
Fuel cell system performance „on ground“ (150m) vs. „in flight“ (1200-1600m)



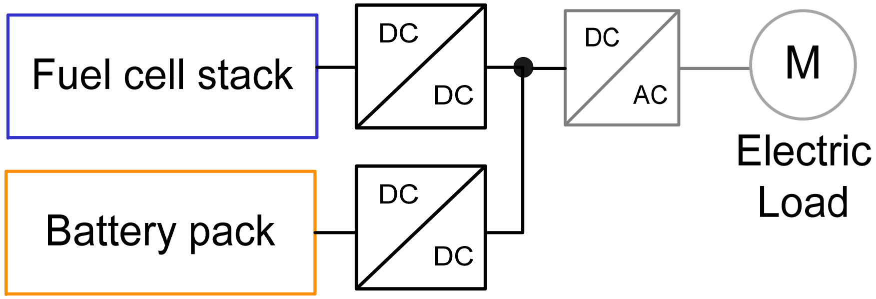
- summarized performance loss „in flight“ due to altitude and cooling effects ca. 5%

Concept of the direct hybrid



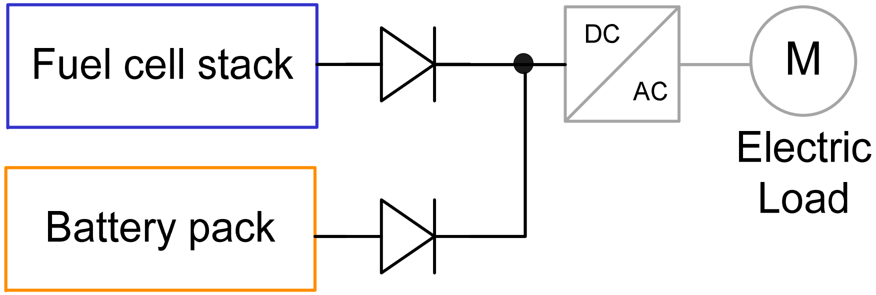
Concept of the direct hybrid

Conventional hybrid systems



- × DC/DC converter for potential separation
- × DC/DC converter are expensive
- × DC/DC converter require cooling system

Direct hybrid system



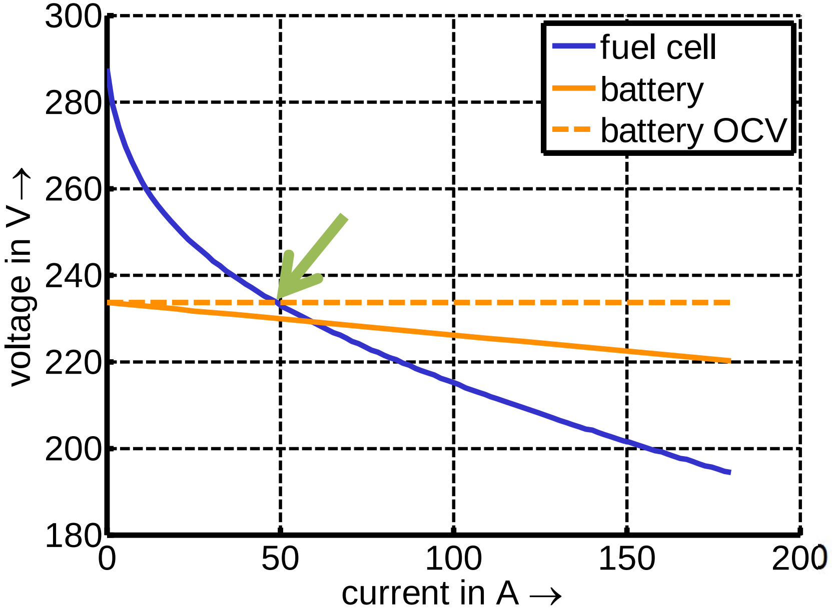
<u>Advantages</u>

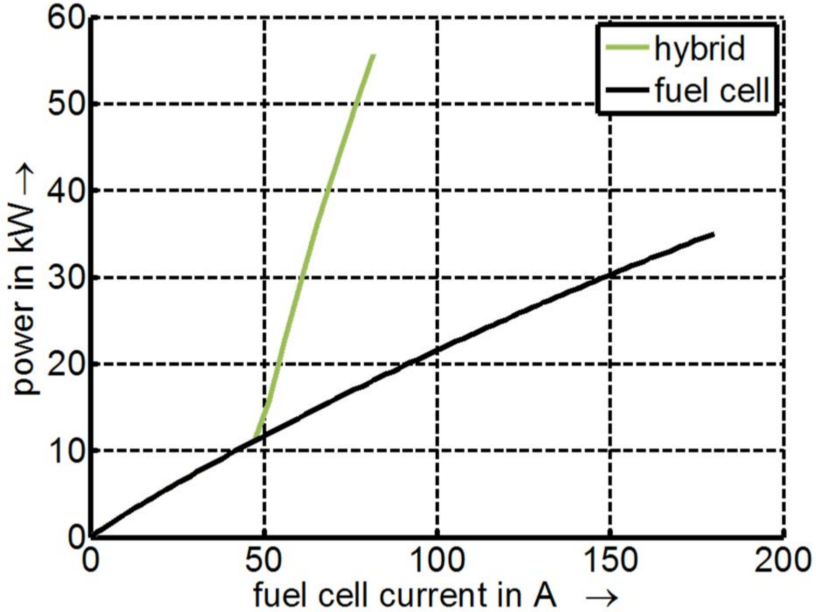
- ✓ No inductance
- ✓ High efficiency
- ✓ Lower cost
- ✓ Light weight
- ✓ Reliable
- ✓ Passive elements

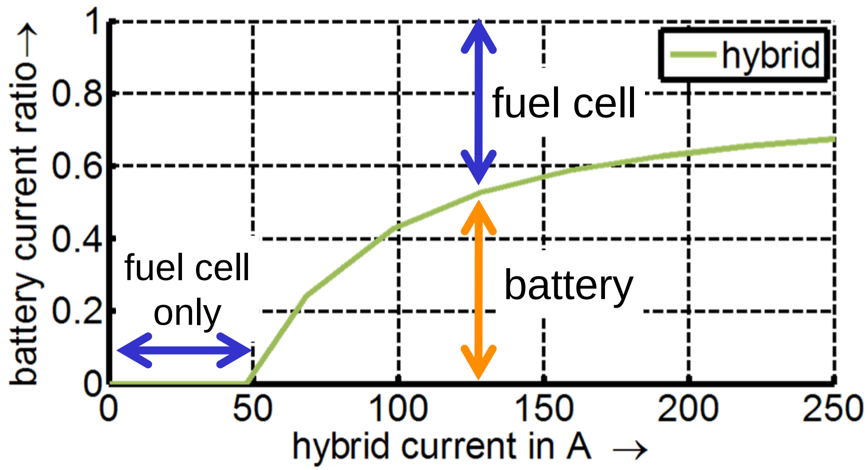
<u>Disadvantages</u>

High voltage spread

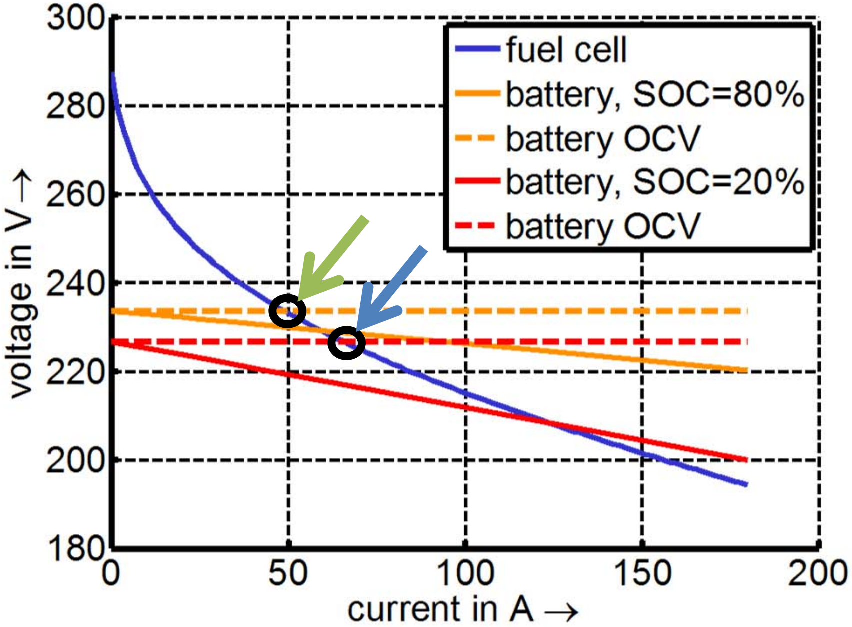
Concept of the direct hybrid

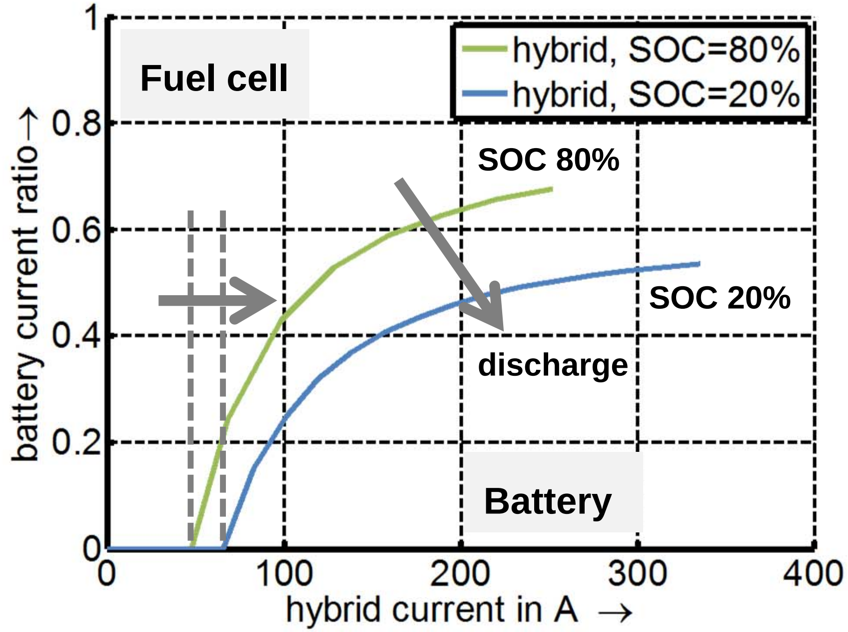






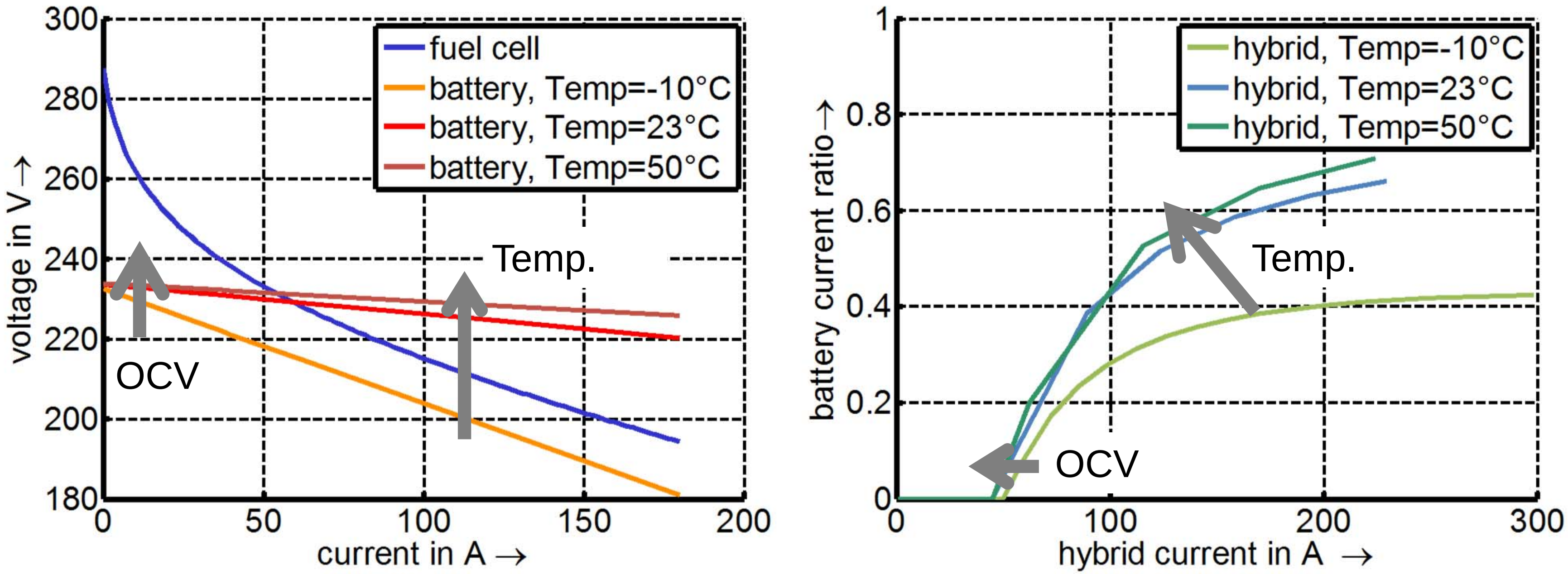
Battery characteristics: State of charge (SOC)





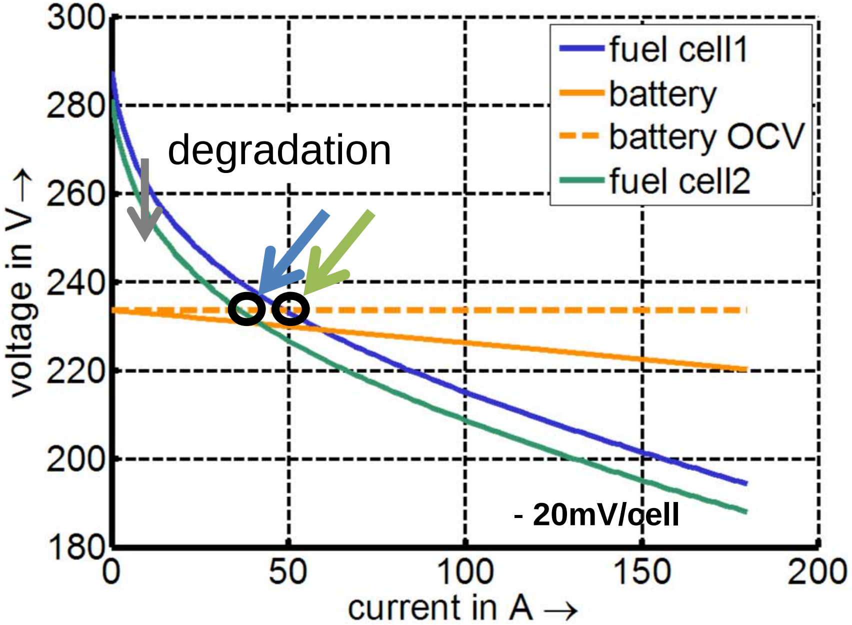
- Battery voltages depend on SOC and current
- I-U-characteristics change while battery is discharged
- Battery current ratio reduces at lower SOC

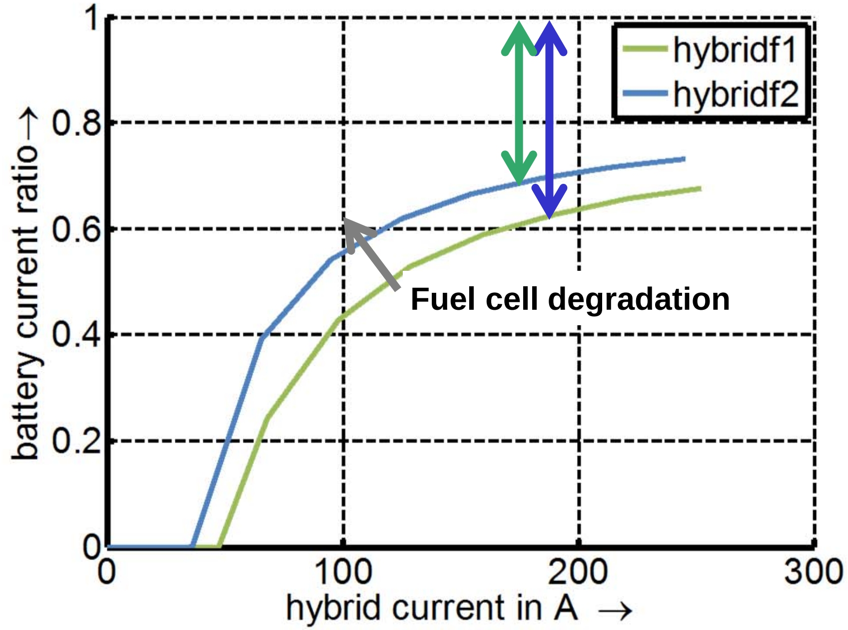
Battery characteristics: Temperature



- Battery resistances decreases with higher temperature
- Battery current ratio decreases at lower temperature
- OCV slightly reduces at lower temperature
- Battery heats up over time due to ohmic losses

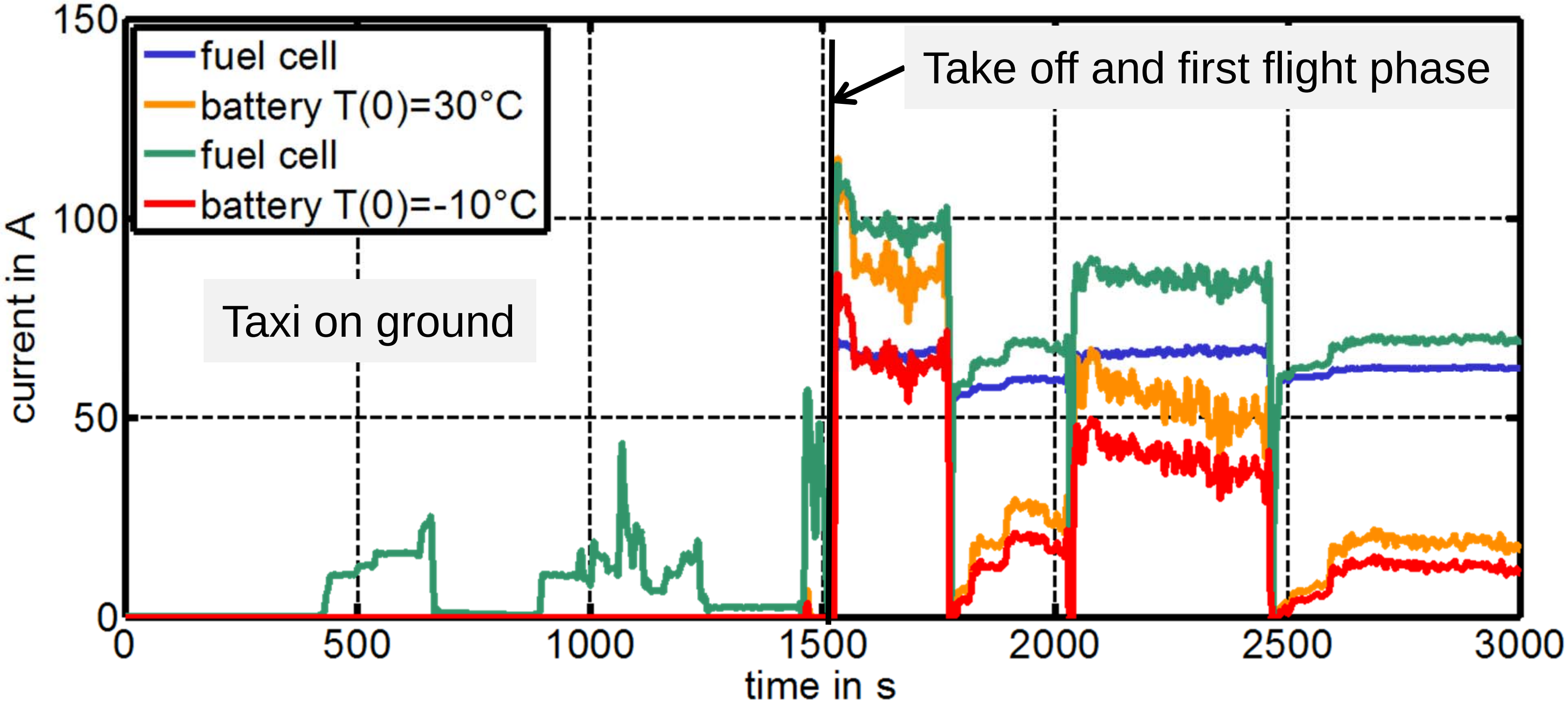
Fuel cell degradation





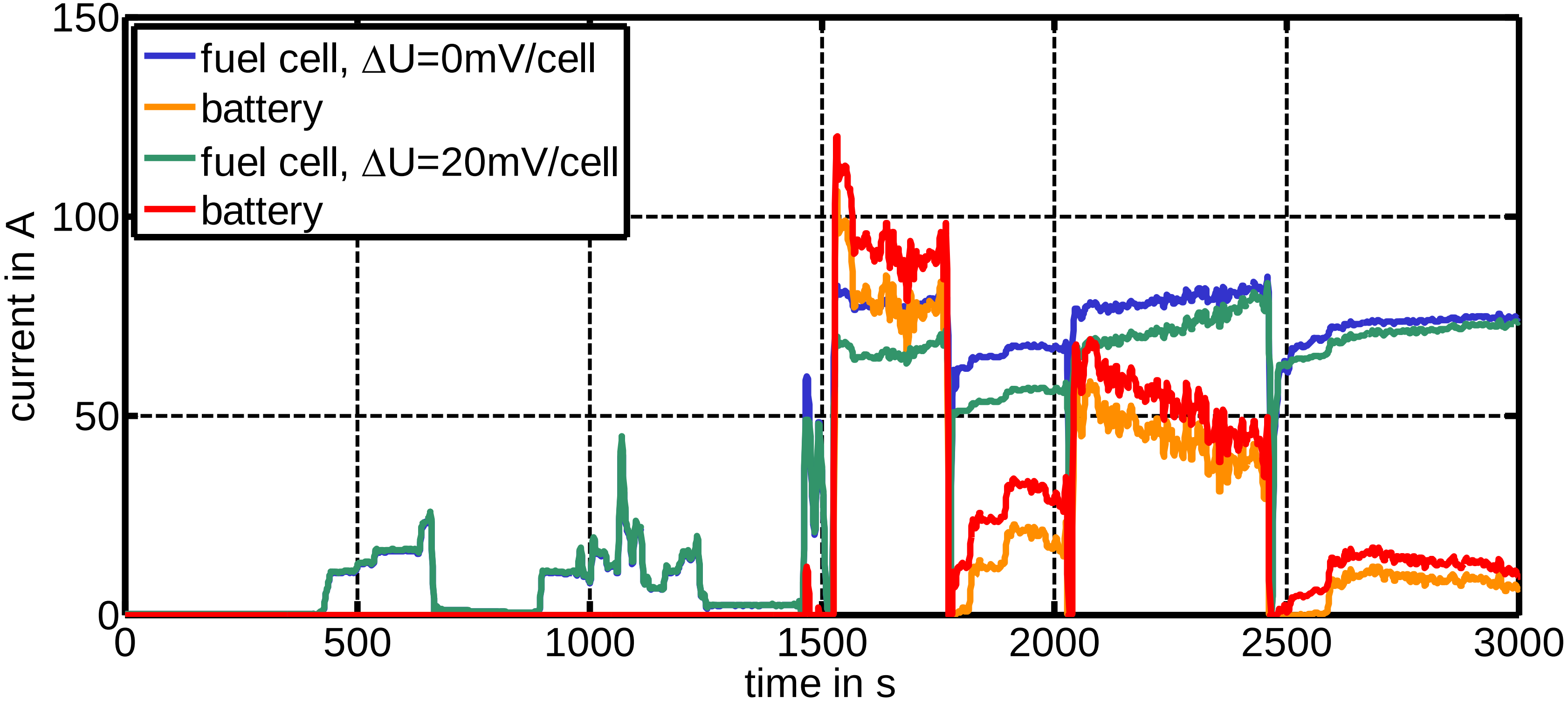
- Fuel cell degrades over time: voltages decreases
- Fuel cell current ratio is reduced over time

Aircraft application: Battery Temperature



- Hybrid system/battery used only at high power requests
- Different initial battery temperatures
- Higher fuel cell current at lower temperature
- Battery heats up due to ohmic losses – less influence

Aircraft application: Fuel cell degradation



- Comparison between new and degraded fuel cell at room temperature
- Fuel cell current ratio decreases over time

Conclusions and Outlook

- Hybrid characteristics influenced by
  - Battery state of charge/temperature
  - Fuel cell degradation
- Reliable design for aircraft application
  - Low cost, high efficient, light weight
  - Support fuel cell at high power request (e.g. flight start)
- Very promising results for aircraft application

- **Next step:** Integration and test with Antares DLR-H2 with improved FC Power

- **Further work:** Efficient dynamic applications

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Thank you for your attention!