Hydrogenius

Flying with a Fuel Cell

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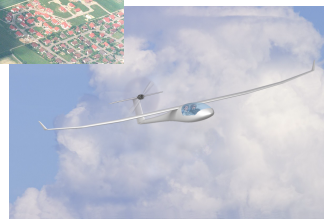
Agenda

- Research in Aircraft Design at IFB
- Berblinger Price 2006 , City of Ulm
- Fuel cell applications in aviation
- Fuel cell technology and components
- Project Hydrogenius
- Outlook

Research: Aircraft Design

Solar aircraft: icaré

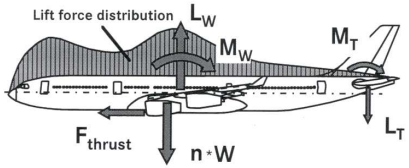


Fuel cell aircraft: Hydrogenius

Research focal point „Unmanned Aerial Vehicle“

EU, NACRE Development of an IEP

LUFO III HICON, Weight prediction for high lift devices



Weight prediction tools FAME-W, FAME-FANCY

LUFO III, „Demonstrator Model“

Hydrogenius: Team

- Prof. Dipl.-Ing. Rudolf Voit-Nitschmann:
  Project Management and Public Relations
- Dipl.-Ing. Len Schumann:
  Airframe and Aerodynamics
- Dipl.-Ing. Steffen Geinitz:
  Propulsion System and Integration

- Currently six diploma theses
- 11 student assistants for technical documentation, public relations, simulation and construction
- Eight thesis completed related to the project Hydrogenius

Hydrogenius: The Beginning

Berblinger Preis 2006

- Environmental Sustainability
- Operating Efficiency
- Reliability
- Light Weight Construction Methods

Hydrogenius: Objectives and Benefit

- Flagship initiative for fuel cell technology
  - Enormous public effect of aircrafts
  - Impressive demonstration of fuel cell performance
- Impulses for fuel-efficient mobile applications
- Experimental aircraft to investigate fuel cell systems under extreme conditions
- Certification of hydrogen and fuel cell technology in aviation
- Integration to education at the faculty
  - Already six student research projects and diploma thesis are prepared

Hydrogenius: FC Applications in Aviation

Airliner

- Substitution of Auxiliary Power Unit (APU) and Ram Air Turbine, onboard water generation for facilities etc.
- Increasing power requirements due to substitution of hydraulic and pneumatic systems by electric systems (more electric aircraft)

UAV & MALE/HALE

- Low noise operations, low thermal signatures, innovative configurations due to electric propulsion system

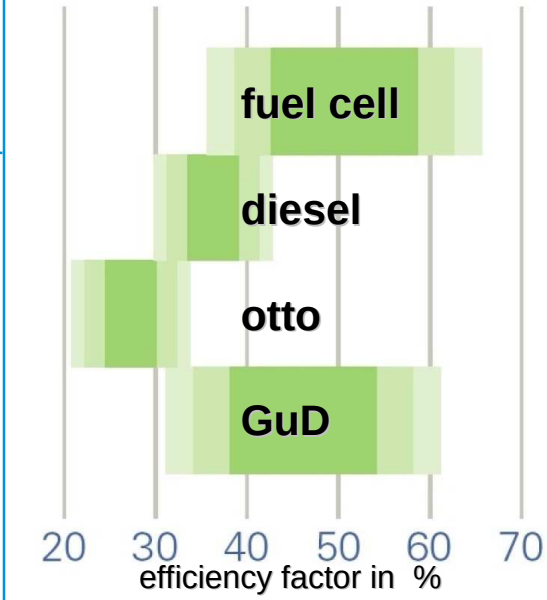
General Aviation

- Economical, ecological, quiet and comfortable operation, new configurations possible, advanced safety concepts

Fuel Cell: Pros and Cons

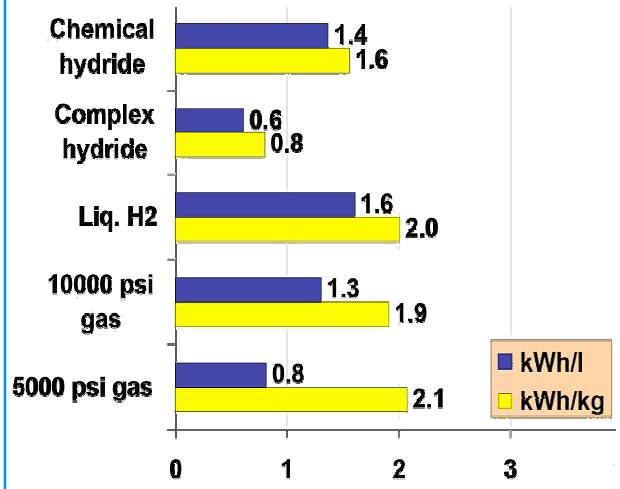
- Zero-emission
- High efficiency
- Low noise
- Vibration-free
- Electric drive allows innovative aircraft configurations
- Hydrogen can be produced renewable

- High amount of weight
- High amount of volume
- Widespread hydrogen infrastructure is missing yet
- Complex hydrogen storage and fueling



Hydrogen-Storage

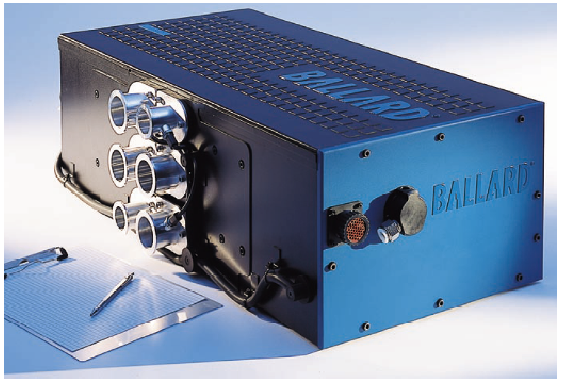
- Low energy-density of the storage system
- High pressure tank is the best solution
- Aircraft fuel tank has a capacity of 11 kWh/kg, a hydrogen tank 2,1 KWh/kg
- Lithium-polymer-akkus have a spec. Energy ~0,16 kWh/kg up to 0,2 kWh/kg
- Without tank we get 12 kWh/kg for conv. fuel and ~ 33,3 kWh/kg for hydrogen
- Tank ZM180 by Dynetek (350 bar) 4,2 kg hydrogen at a tank weight of about 93 kg caloric equivalent to 16,2 l petrol

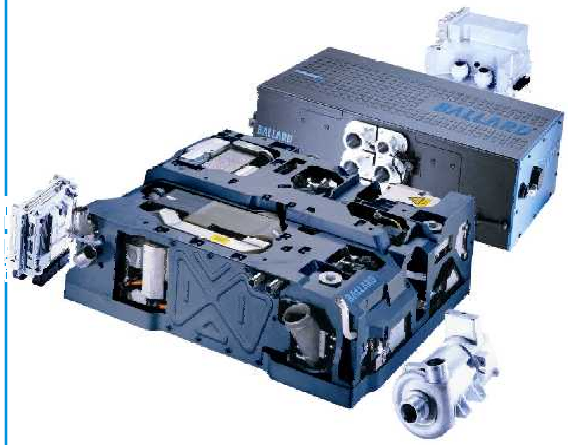


Hydrogen tank systems

Fuel Cell: System in Preliminary Design

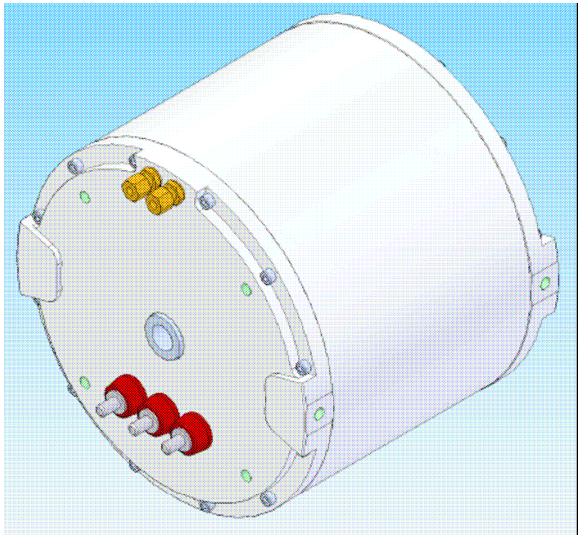
- Almost every fuel cell system offering 50-70 kW net power and weighing not more than about 250 kg is applicable
- The preliminary design uses as a reference „HY-80™“ fuel cell system of NuCellSys GmbH
  - The system delivers 68 kW maximum power and weighs about 220 kg
- Currently new fuel cell systems offer more than 85 kW at weights under 200 kg are state of the art





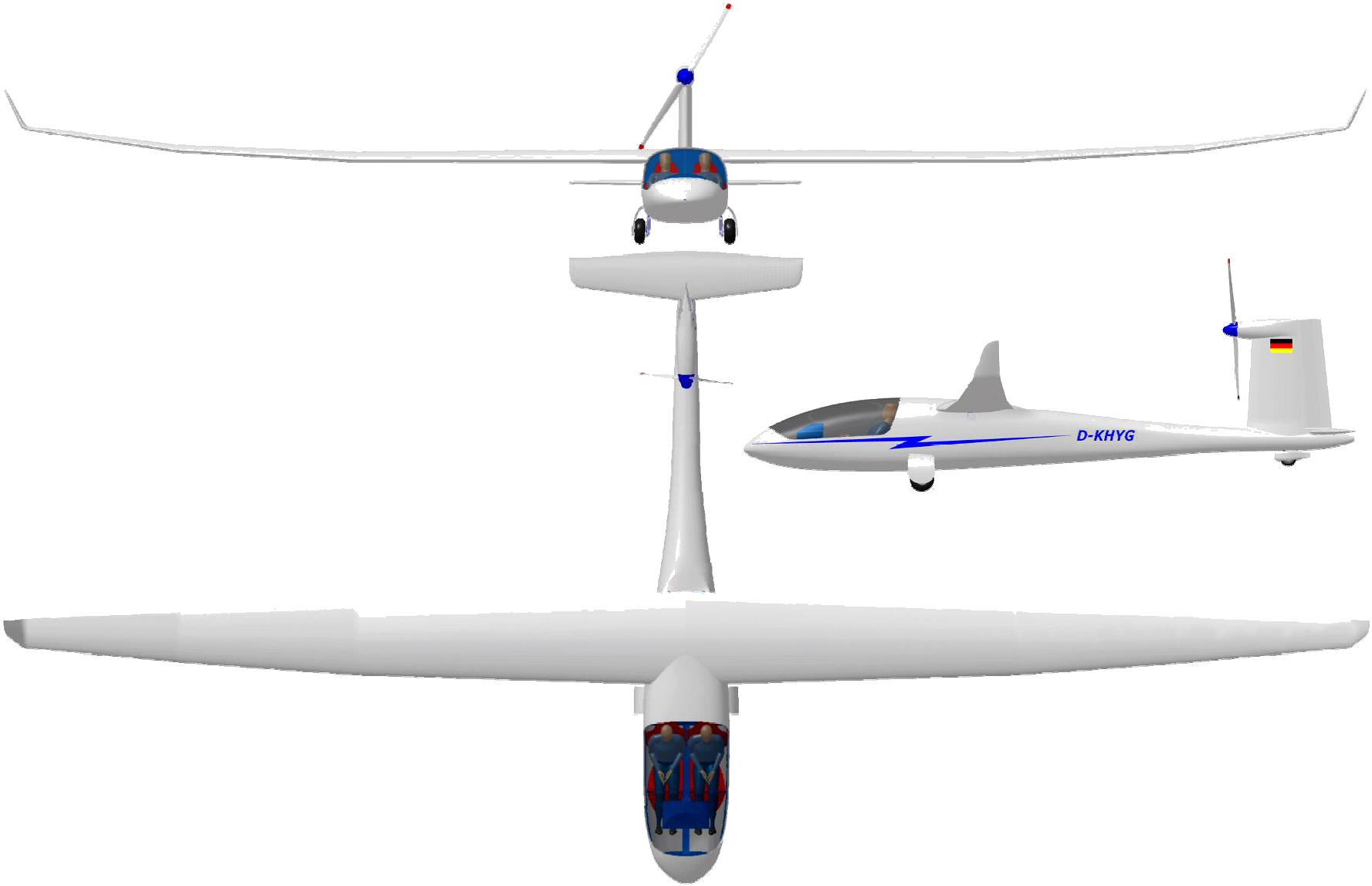
Electric Motor and Power Electronics

- electric motor by **Sineton**
  - three-phase brushless permanent magnet synchronous motor
  - weight: 25,5 kg
  - efficiency: 0,94
  - up to 72 kW at 2500 rpm (peak) and 58 kW at 2300 rpm (continuous)
- power electronics by **drivetek**
  - weight: 8 kg
  - Communication via CAN-Bus
  - Liquid cooling



SINETON
RESEARCH AND DEVELOPMENT

drivetek ag
development powerhouse

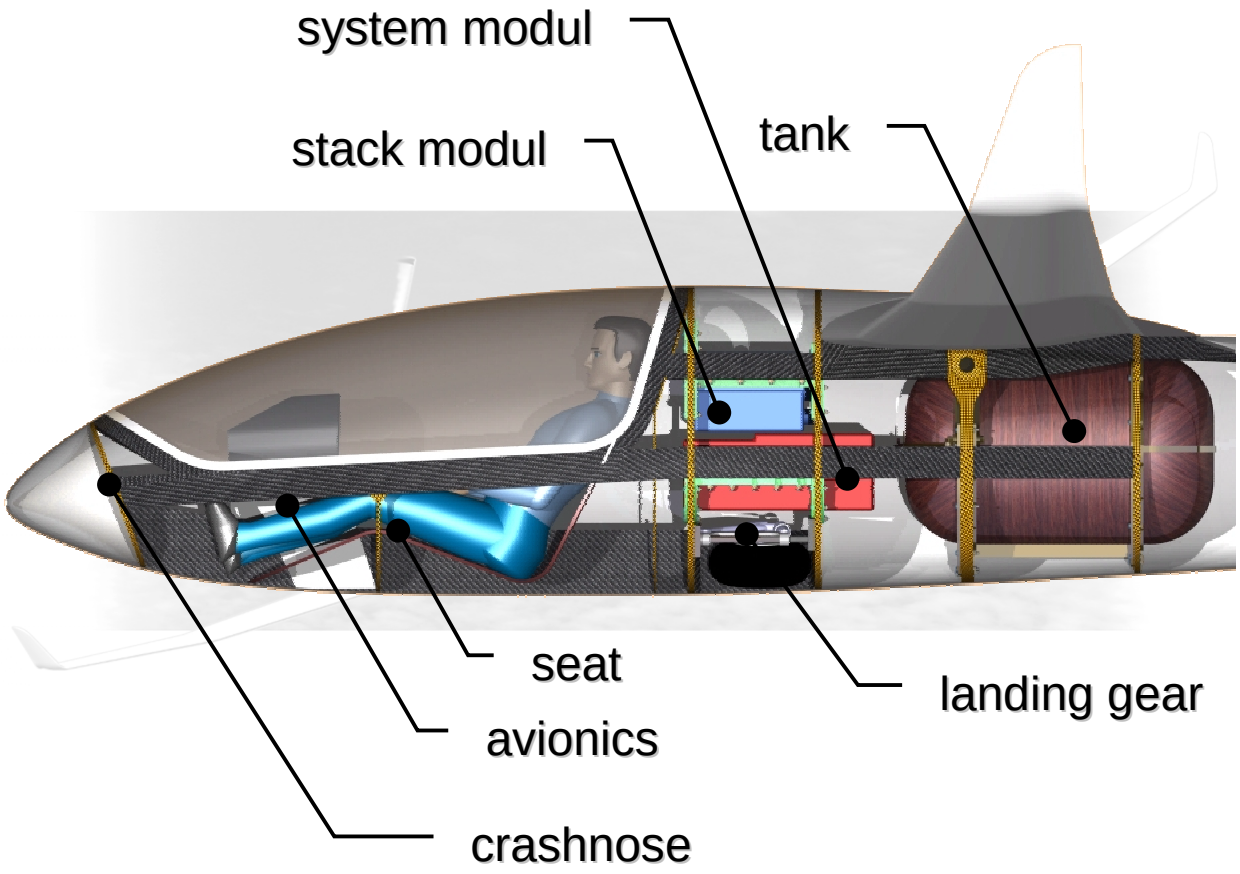

D-KHYG

Hydrogenius: Multidisciplinary optimized Configuration

- Separation of „power“ and „propulsion“ generation
- Very large variable pitch propeller for increased efficiency
- Slow turning propeller for low noise operation
- Propeller turns in nearly undisturbed incident flow
- Small and light retractable landing gear
- Fuel cell system enclosed in the airframe

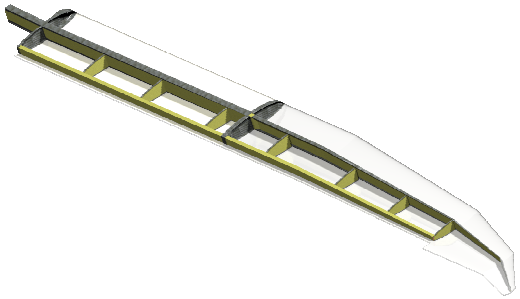
- Optimized aerodynamics, with reduced drag similar to sailplanes
- Side-by-side cockpit for increased comfort and installation space
- Suitable for daily use

Hydrogenius: System Integration



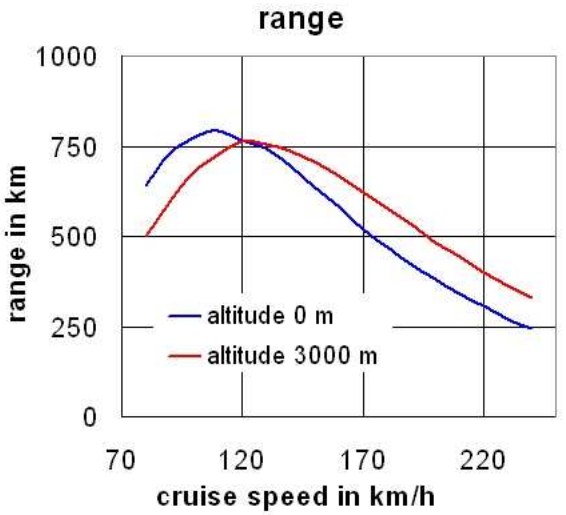
Hydrogenius: Structure and Safety

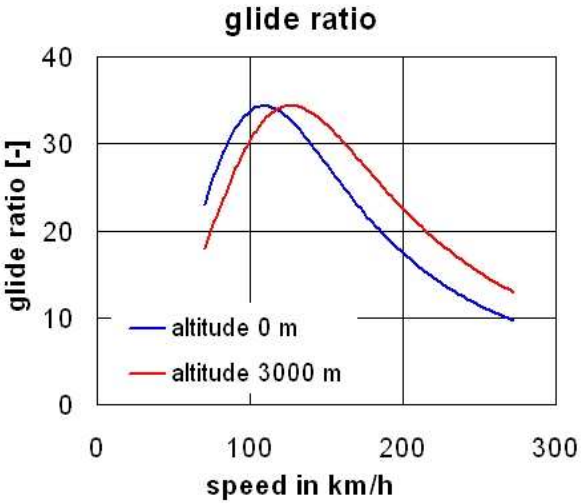
- Side-by-side cockpit
  - Large installation space for fuel cell system
  - Variably constructed (weight balancing)
- Light weight sandwich structures
- Safety structure for increased passenger protection
  - Use of carbon-/aramid fiber hybrid fabrics for crash energy absorption
- Backup battery system
- Complete aircraft parachute rescue system



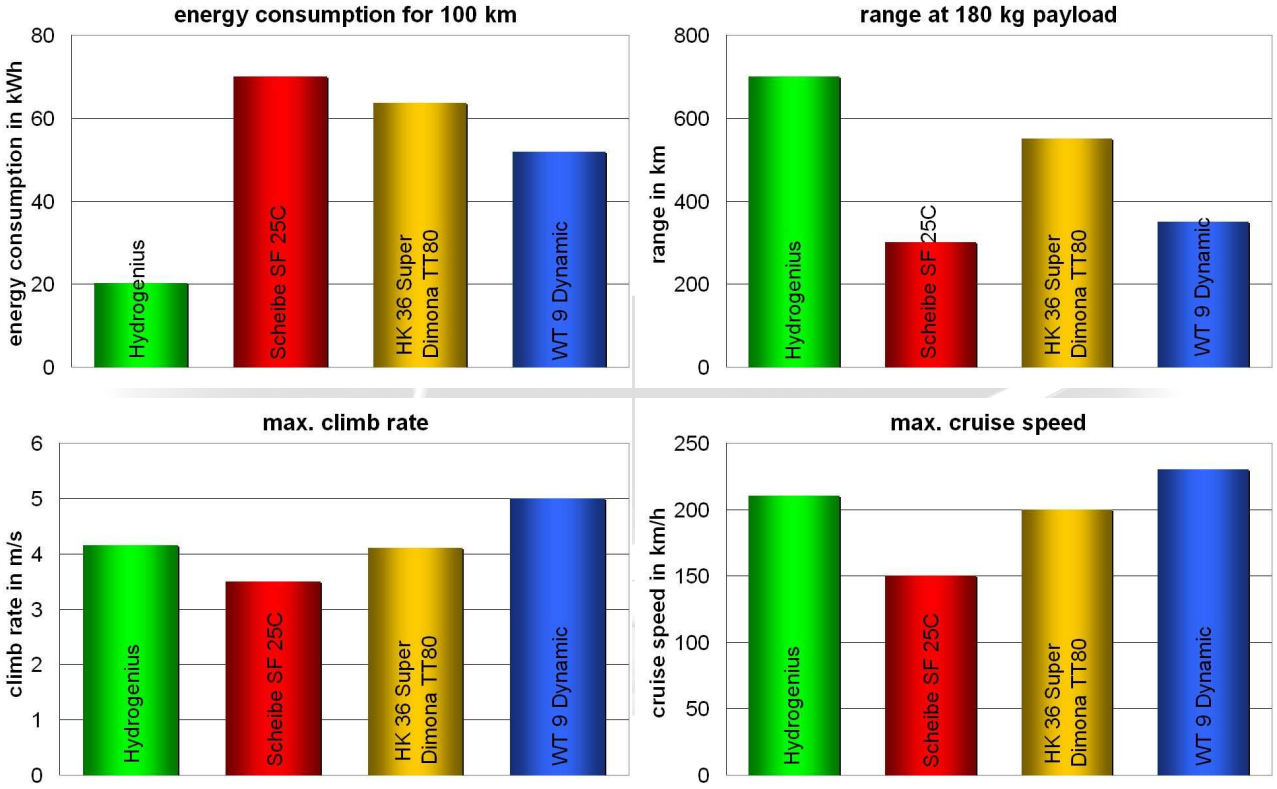
Hydrogenius: Technical Data

Motor power:	~ 60	kW
Max. speed:	> 270	km/h
Best climb rate:	> 4	m/s
Take-off distance:	< 450	m
Fuel capacity H2:	4,2	kg
Service ceiling:	> 4000	m
Span:	16,86	m
Wing area:	14,10	m²
Wing loading	60,3	kg/m²
Length:	8,11	m
Empty weight:	663	kg
MTOW:	850	kg
Payload:	180	kg
Certification according CS-22		





Hydrogenius: Comparison



Hydrogenius

HK 36 Super Dimona TT80

Scheibe SF 25C

WT 9 Dynamic

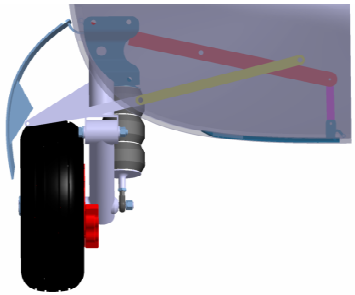
Hydrogenius: Current Status

Technical:

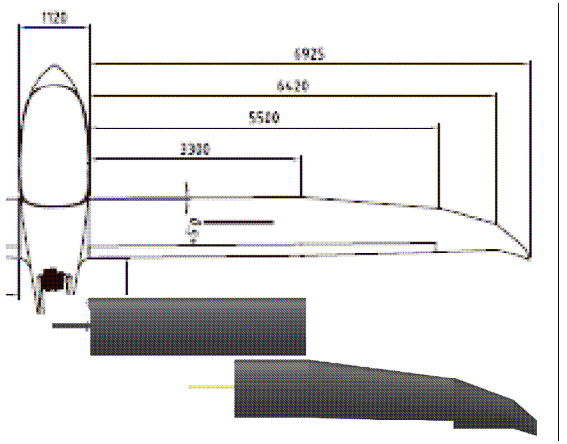
- Preliminary design is completed
- Currently: Construction of wing, fuselage, empennage and retractable landing gear in cooperation with PIPISTREL, coolant system, as well as integration of aircraft parachute system

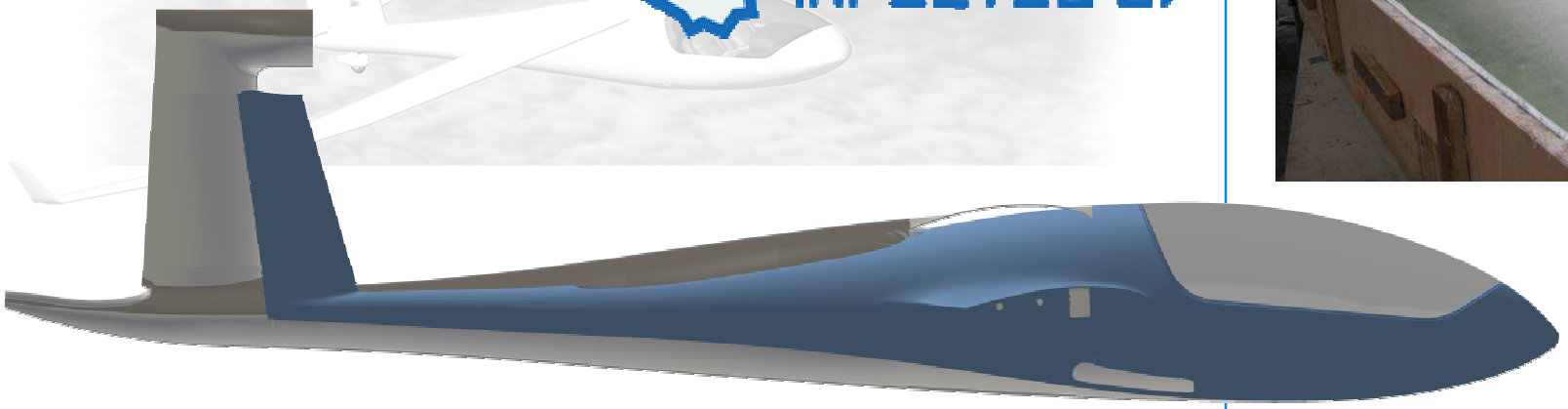
Organizational:

- Acquisition (necessary funds and tangible means)
- Acquisition of a fuel cell system
- Acquisition of the powertrain components
- Public relations and trade show participation (e.g. AERO Friedrichshafen)



Hydrogenius: Cooperation with Pipistrel





Experiences gained from icaré II

- icaré II has is maiden flight in 1996 and was completely developed and constructed at the faculty of Aerospace Engineering and Geodesy. Thereby knowledge in
  - unconventional configurations for low energy consumption
  - light weight structure
  - electrical propulsion systems
  - funding via sponsors

icaré II is still the most powerful manned Solar powered aircraft and still in use for research

Hydrogenius: Sponsoring

- So far sponsored by nearly 20 companies, institutes, foundations and private persons
- Supported by the whole aerospace faculty of the university of Stuttgart with its nine specialized institutes