A flock of birds colliding with an aircraft can knock out its engines and its power supply. When this happens, emergency power systems have to supply energy to vital onboard systems.

Developing an aircraft emergency power system based on a fuel cell

Never Without Power

The electricity an aircraft requires during a flight is normally generated via the engines. To ensure that there will always be a sufficient current supply to the flight controls and essential onboard functions even if the engines fail completely, modern aircraft have a ram air turbine (RAT) – a deployable turbine that generates current via the airstream. RATs have a disadvantage, however: Their output depends on the flight situation. Liebherr-Aerospace Lindenberg GmbH is using dSPACE hardware and software to develop an alternative, fuel-cell-based emergency power system that supplies electricity no matter what the situation is.

The "Miracle on the Hudson"

A good example of what RATs can do was seen when an Airbus A320 ditched in New York's Hudson River in January 2009. Multiple bird strikes had significantly damaged all the Airbus´ engines and greatly reduced its regular power supply. The RAT deployed immediately, supplying additional energy to vital onboard systems so that the aircrew could execute safe emergency ditching. However, RATs can only save lives if they have sufficient air speed. In some flight situations, such as when the plane is gliding at a difficult angle, the power can drop dramatically because the airstream is too weak. Liebherr-Aerospace Lindenberg is therefore working on a backup power system based on a fuel cell that will provide power in any situation regardless of ambient factors.

The FCEPS Backup System

The Fuel Cell Emergency Power System (FCEPS) consists of a fuel cell and two tanks, one for hydrogen and one for oxygen, that are connected to the fuel cell via pressure reducers. When the two gases in the fuel cell react with each other, electric current is generated. This current is independent of ambient conditions and can be used in an emergency to ensure that the aircraft's vital systems – the electric flight control and important cockpit instruments – function reliably so that the pilot can maintain control of the plane. The fuel cell itself also generates heat, which is transferred via a liquid cooling circuit to a heat exchanger that takes the heat to a suitable heat sink. The water that is produced (in addition to exhaust gas) is removed by separators and reused within the process.

Figure 1: In an emergency, ram air turbines can be deployed into the airstream (as shown here below the aircraft's right wing) to generate power for vital onboard systems. The weakness of the RATs is that the power they supply depends on the speed of the airstream. Liebherr-Aerospace Lindenberg is therefore working on an alternative system with the aid of dSPACE equipment.

Dirk Metzler

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The Test Bench with dSPACE Equipment

The dSPACE system consists of a PX extension box with various I/O boards, a RapidPro Signal Conditioning Unit and a RapidPro Power Unit. The ControlDesk test and experiment software provides the graphical user interface for input, signal recording, and monitoring of all processes. With this system, between 70 and 100 signals are examined on the FCEPS test bench at a rate of 100 Hz. The signals cover a wide range of parameters such as the hydrogen/oxygen supply and cooling, and electrical parameters for the fuel cell and power electronics, such as total voltage, voltage of individual cell elements (minimum, maximum, mean value), current and power.

Comprehensive Tests on Different Scenarios

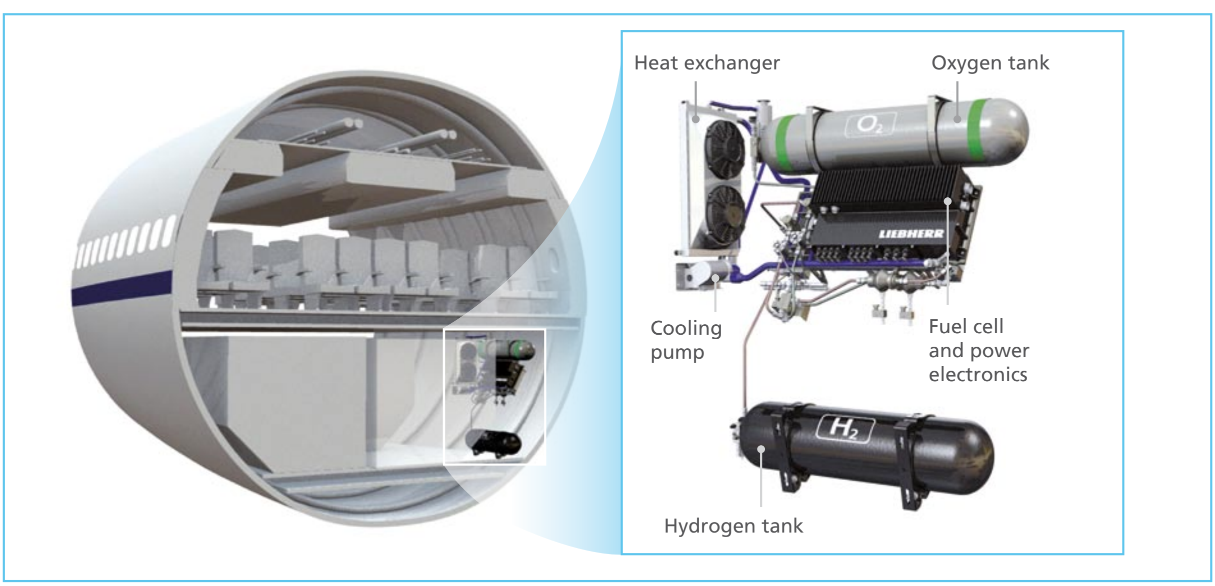
With the dSPACE system, the FCEPS can be tested comprehensively by simulating different operating states and realistic scenarios. The control models were designed by means of MATLAB®/Simulink®. Testing mainly focuses on the system's quick start capability and on control optimization for the cooling circuit.
If the FCEPS is ever modified or extended (for example, for extra tasks in addition to backup power supply), the dSPACE system still has plenty of free capacity. With its modular design, it can be adapted to modified tasks very quickly. Liebherr-Aerospace Lindenberg intends to carry out tests with such a system in an aircraft environment; the existing dSPACE platform with a suitable extension (the dSPACE AutoBox) is ideal for this.

The Future: More Than Just Emergency Power

The next major challenges for the fuel cell team will be to optimize the start time and the weight of the FCEPS. Airbus, Boeing and other aircraft manufacturers have expressed an interest in FCEPS. So the FCEPS is more than just a backup power system, it is also a pioneer for further

> "Thanks to the dSPACE equipment, we were able to implement the fuel cell system and test it comprehensively – quickly and conveniently."
>
> *Dirk Metzler, Liebherr-Aerospace Lindenberg GmbH*

Figure 2: The FCEPS backup system from Liebherr-Aerospace Lindenberg can be installed almost anywhere in the fuselage – unlike RATs, which can be installed in only a few places because they have to be deployed into the airstream.



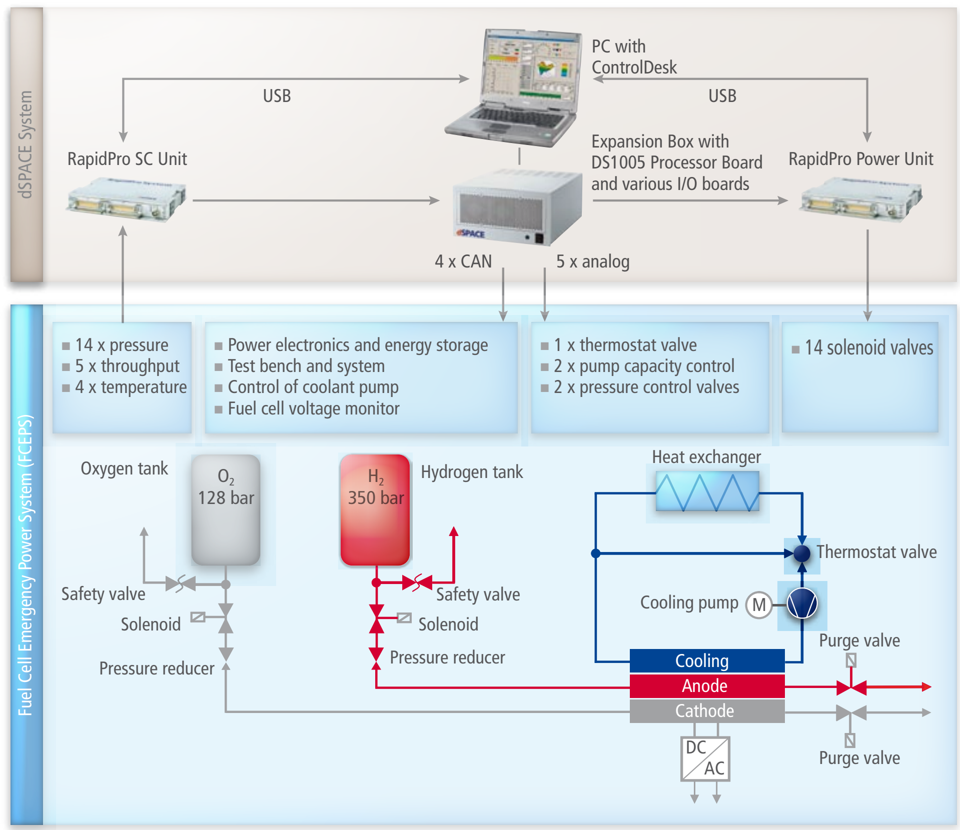


Figure 3: Schematic of the FCEPS and the dSPACE system on the test bench. Up to 100 signals are recorded, and then monitored and regulated with dSPACE ControlDesk. This system allows a wide range of scenarios to be tested thoroughly and comprehensively.

fuel cell applications in aircraft. There are plans to run a fuel cellsystem nonstop to generate all the electricity required in an aircraft, instead of using the engines for this as at present. The waste air from the fuel cell system could also be used for inerting the fuel tanks (i.e., preventing explosive gas mixtures), and the water could be recycled on board – incidentally also reducing the quantity of water carried onboard to save weight. ■

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Figure 4: The ControlDesk user interface shows the structure of the FCEPS (see figure 3). Window on left: The oxygen and hydrogen tanks at top left, the fuel cell in the middle, the heat exchanger and exhaust gas system at bottom right. Center window: The cockpit consists of command switches for the system, an area for the cooling control, and optical LEDs for indicating status and errors. Two control loops have been implemented for the cooling circuit, one for the fuel cell's input temperature and one for its output temperature. Various operating states can be simulated.