The term 'electromobility' is generally associated with road traffic, where the share of electric vehicles is expected to rise considerably in the coming years. But the well-known benefits of electric drives, such as environmental friendliness, compactness, low maintenance and low noise emissions, are also of great interest for aviation. For example, using electric motors in aircraft can significantly reduce the maintenance work for turbine and piston engines, which is generally high and expensive. Therefore, it comes as no surprise that many aircraft manufacturers and suppliers worldwide are exploring the potential of electric drives for aviation.

ELIAS – All-Electric Flight Demonstrator for Unmanned Tasks

ELIAS (ELectric Aircraft IABG AcentisS) is mainly used to test technologies for an unmanned, electric reconnaissance and surveillance system (figure 2). The initial development at IABG and its member ACENTISS started in 2012 when the research center bought an Elektra One aircraft from PC Aero and converted it to the ELIAS system demonstrator with a video camera, data link, and a ground control station. ELIAS can be operated manually by a pilot or automatically. In the current configuration, the pilot performs take-off and landing. Then, the aircraft automation takes over and flies the plane in a controlled manner according to predefined waypoints, which can be modified during the flight, or according to direct input from the ground station, such as altitude, airspeed, and direction. The aerodynamic control surfaces of the plane are controlled by electric actuators with an integrated electromagnetic clutch. With a simple push of a button, the pilot can take control of the plane at any time. Ground staff can use a joystick at the ground control station to control the sensors that are located below the fuselage, e.g., to pan the camera, infrared sensor or laser rangefinder, or to zoom into the recorded image. In cooperation with Geiger Engineering, ACENTISS developed two dual motors with 30 kW and 40 kW of take-off power, respectively. Each dual motor consists of two motors that drive one propeller via an overrunning clutch. If one motor fails, the other motor can continue to drive the propeller, albeit with slightly reduced power. The setup

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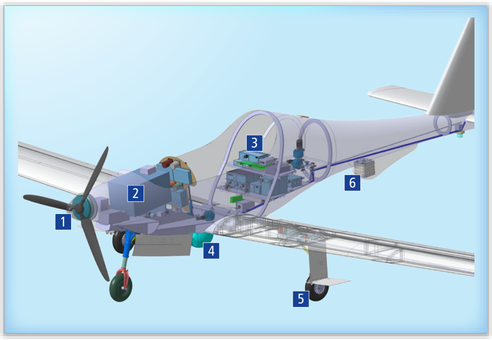
Figure 1: Aircraft-in-the-loop simulation is used for comprehensive testing of the flight control algorithms on the ground.

Developing a fully electric and autonomous aircraft

Electric Take-Off

With ELIAS, ACENTISS GmbH has developed a fully electric plane as a test platform for reconnaissance and surveillance systems. It can be operated with or without a pilot. A MicroAutoBox II from dSPACE is used as the onboard flight guidance computer.



1. Electric drive with 20 kW of take-off power and controllable pitch propellers
2. Li-ion battery pack
3. Avionics – incl. dSPACE MicroAutoBox II as the flight guidance system, inertial reference system, radar altimeter, and satellite navigation system with SBAS[1] support
4. Sensors (video camera, infrared sensor, laser rangefinder)
5. Electric retractable landing gear
6. Data link antenna

[1] Satellite Based Augmentation System – a specialized satellite navigation system for high-precision positioning.

Technical Details

Max. take-off weight	350 kg
Wing span	11 m
Wing area	8.2 m²
Max. speed	150 km/h
Cruise speed	110 km/h
Max. motor power	20 kW
Max. range	>150 km
Max. flight time	Approx. 1.5 h

Figure 2: ELIAS setup. An onboard dSPACE MicroAutoBox takes on the role of the flight guidance system.

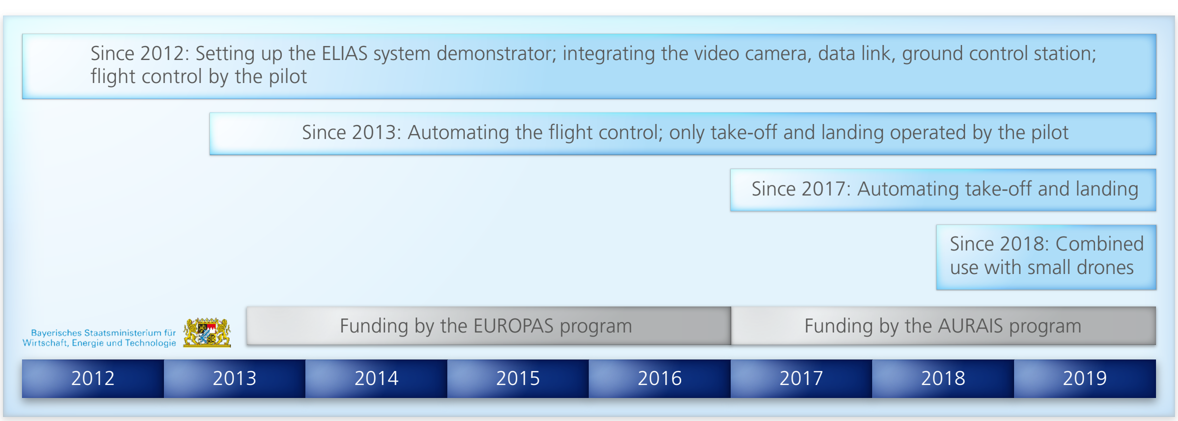
> "MicroAutoBox II is a flexible and reliable onboard flight guidance system. It lets us quickly implement new algorithms to drive innovation."
>
> *Andreas Rohr, ACENTISS*

of controllers and Lithium-ion batteries is also redundant. This means that a single motor achieves the level of safety of an aircraft with two motors. Before the in-flight propulsion tests, ACENTISS uses its own motor test bench and the wind tunnel of TU Munich for extensive testing. A prototype of the 40 kW dual motor is currently being used for in-flight tests. The innovative retractable landing gear, which is made of high-strength aluminum, is actuated electrically. The elastomeric components used for the landing gear make it practically maintenance-free, the only exception being the brakes. The landing gear has already been used for several years. Thanks to the square profile of the suspension strut, complex torsion links are not required.

MicroAutoBox II Guides the Flight

On board ELIAS, a dSPACE MicroAutoBox II performs the core flight guidance tasks and executes the commands of the ground control station during unmanned flights. The MicroAutoBox II is connected to the flight controller via a CAN-aerospace bus. The flight controller controls the electric actuators for the deflection of the aerodynamic control surfaces as well as the thrust for a stable and safe flight. If required, MicroAutoBox II can be extended by an Embedded PC. A Simulink model

Figure 3: Chronology of the development tasks.



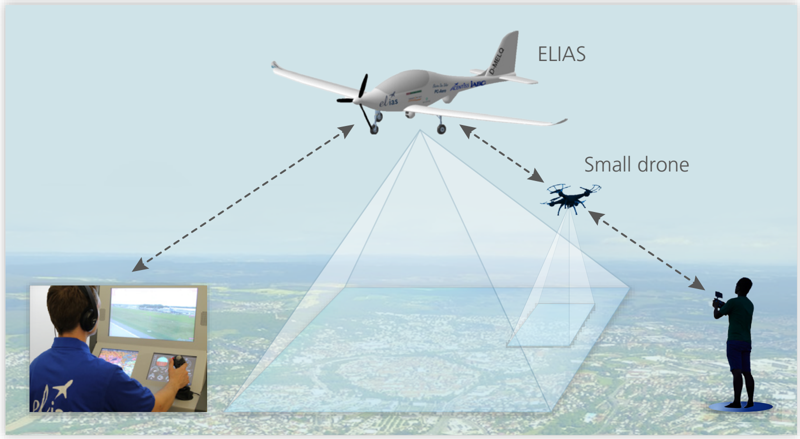


Figure 4: When ELIAS is used with small drones, the aircraft provides a rough overview of a large area and acts as a data link relay for the drone. In contrast to ELIAS, the smaller, more agile drones are able to hover, which is useful for close reconnaissance, and provide more detailed information on the selected area. They can be controlled by pilots in the field or by the ground station.

is used on MicroAutoBox II that calculates the trajectories as a function of the specified destination, the captured wind conditions, and the navigation data. It then sends the trajectory to the flight controller in the form of georeferenced waypoints and also transfers altitude and airspeed information. The MicroAutoBox II also controls the retraction and extraction of the landing gear during take-off and landing, respectively, and monitors the state of charge of the batteries. A major benefit is the direct connection between the MicroAutoBox II and MATLAB®/Simulink®, which makes it possible to quickly implement changes to the flight control algorithms. This lets the researches continuously develop the flight guidance software and adjust it to the different tasks. After the laboratory tests, the software can be loaded to the prototyping system for the aircraft-in-the-loop (HIL/ACIL) simulation and for test flights.

Testing on the Ground and in the Air

To prepare the real test flights in the air, the aircraft is intensively tested on the ground in the ACIL simulation at IABG, the parent company of ACENTISS (figure 1). The engineers not only validate the automatic flight itself, they also test the smooth switching from manual to automated flight mode. The ground control station can be connected to the aircraft via radio or cable.

Supported by Funding Programs

The development of the technology required for unmanned fully electric flight is supported by the Bavarian Ministry of Economic Affairs, Energy and Technology as part of the Bavarian aviation research and technology program. As part of the EUROPAS sponsorship program, partners from the industry and research joined ACENTISS in developing the automatic flight control with flight guidance system, the electric retractable landing gear, a 30 kW and a 40 kW dual motor as well as an electronic data link for the connection between the ground control station and the aircraft. The system was successfully demonstrated in a test flight in late 2016. In the follow-up sponsorship program AURAIS (All-Electric Unmanned Reconnaissance & Aerial Imaging Airborne System), which started in 2017, the automatic take-off and landing capabilities and a ground control station for the combined use with small drones are developed (figure 4).

Outlook

The current development for the combined use of ELIAS and small drones aims at enabling efficient close reconnaissance (figure 4). At the same time, the compact, mobile ground station is optimized for the future tasks. Test flights are scheduled for 2019 to test the preprogrammed ground-controlled missions with automatic take-offs and landings as well as the combined use with small drones in the field.

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