Deutsches Zentrum
für Luft- und Raumfahrt

How to simulate the first flight of a PAV


DLR's research helicopter ACT/FHS.

- Eurocopter EC135 ACT/FHS
- Rotor diameter 10.2 m
- Overall length 12.2 m
- 3 seats
- Maximum take-off weight 2.9 t
- Payload up to 0.7 t
- Engines 2x Arrius 2B2, 415 kW each
- Cruise speed 120 kts
- Endurance up to 2.5 h

The ACT/FHS 'Active Control Technology / Flying Helicopter Simulator' is based on a standard Eurocopter EC135 type helicopter. It is a modern, twin engine, light helicopter with a bearingless main rotor and fan-in-fin tail rotor. The basic aircraft has been extensively modified for use as a research and test aircraft. The main difference is the implemented fly-by-wire/fly-by-light control system that allowed for the integration of a very flexible experimental system. A multitude of scientific investigations, such as handling qualities investigations, pilot assistance or in-flight simulation of other aircraft can be covered by the Flying Helicopter Simulator.

It is evident that an in-flight simulator cannot represent an aircraft with faster dynamic responses than those of the basic aircraft. Therefore, a fundamental requirement for airborne simulation is a high dynamic response capability of the basic vehicle. The EC135 is a rotorcraft with very high agility and thus has the potential for the simulation of a wide variety of existing and future helicopters. Before an actual Personal Aerial Vehicle (PAV) is ever built, the ACT/FHS is used to simulate PAV flight characteristics in flight. The experimental system supresses the original EC135 dynamics and lets the ACT/FHS behave like an easy-to-fly PAV.

Visit the Flying Helicopter Simulator in the hangar.

How to steer a PAV

PAVs can be foreseen to be a future alternative to ground-based traffic bound to conventional automobiles. In order to keep this transportation system open to the general public it must be easily understood even by flight-naïve users. The control concept of automobiles is well known to the general public. These controls have barely changed over the past century.


Steering wheel control for a Personal Aerial Vehicle.

Although new controllers like joysticks are technically feasible, all of the modern production vehicles rely on the conventional arrangement of steering wheel, accelerator and brake pedals, gear stick, and optionally clutch pedal for manual transmission. A driver's license holder can intuitively connect the usage of these controls to the movement of any typical car. On the other hand, conventional helicopter controls are not at all intuitive for non-expert pilots. Therefore, car-like steering concepts for PAVs are a promising alternative to conventional helicopter controls.

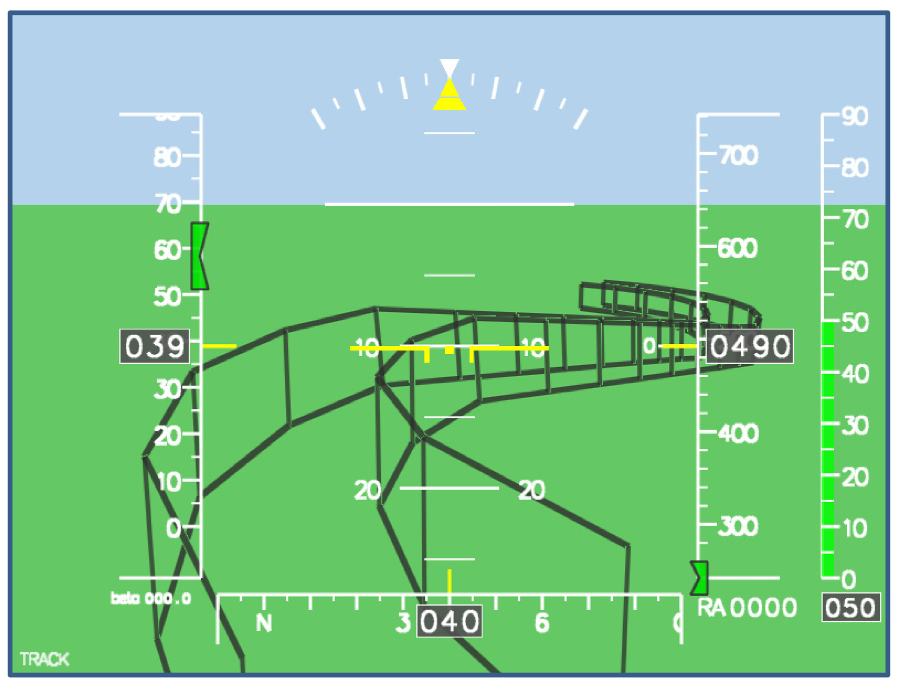
For the investigation of the most suitable steering concept a steering wheel prototype has first been integrated into the ground-based AVES simulator centre together with a PAV flight dynamics simulation. The used EC135 cockpit also features conventional helicopter controls and sidesticks. This allows the direct comparison of the different control concepts. Additionally, a steering wheel prototype has been integrated into ACT/FHS for in-flight evaluation.

Experience your personal flight in the AVES simulator centre.

How to navigate in the air

Future PAV users will need a high level of assistance in navigating their vehicle through the airspace safely. Conventional helicopter cockpits feature an instrument panel with a variety of instruments that the pilot has to check continuously. For PAV pilots who will have only a minimal training compared to today's helicopter pilots a more intuitively understood instrument panel must be designed. For this purpose DLR developed a Highway-in-the-Sky (HITS) display.

HITS displays combine the information of artificial horizon together with a three-dimensional highway or tunnel that shows the selected flight path in a virtual environment. While remaining in the centre of this tunnel the pilot can correct flight path deviations intuitively.



Highway-in-the-sky navigation display.

The display consists of an artificial horizon with a 3D tunnel geometry and an overlaid 2D primary flight display showing current flight data such as airspeed, altitude, attitude and heading data as well as the current torque value. Target indicators let the pilot monitor the flight states that are proposed by the navigation system.

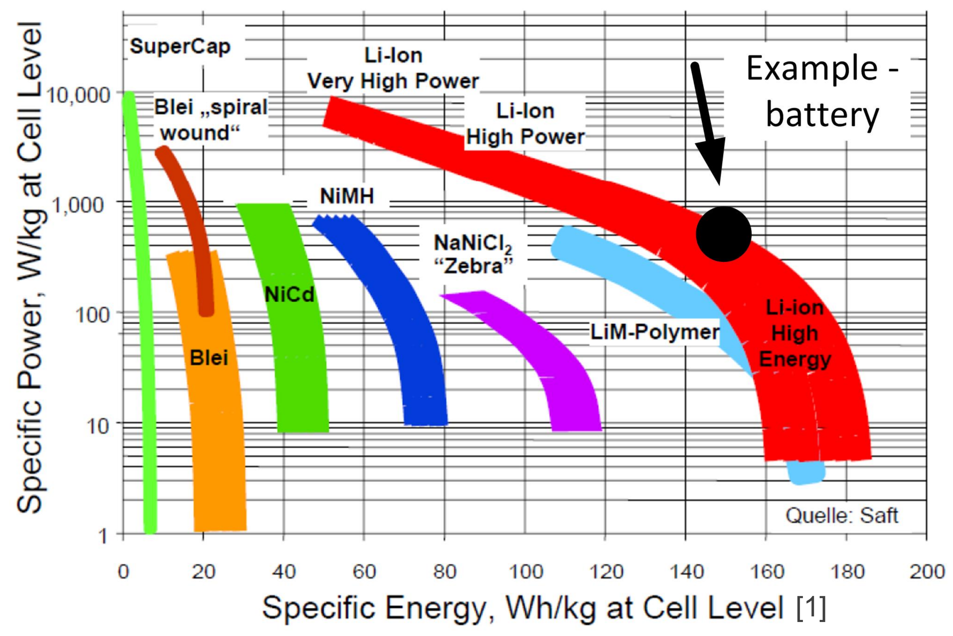
Take a look at the highway-in-the-sky display in the AVES helicopter cockpit.

How to power a PAV

Motivated by politics and the demand for cleaner mobility, electric propulsion for PAVs is a prospective way. Advantages of electrical powered vehicles are the simple and flexible structure and low maintenance costs.

A sample calculation was conducted to examine the applicability of an electric PAV for a reference flight. Here, a four-rotor PAV weighing 450 kg has to climb up to 500 m, travel 30 km at 175 km/h and descend to ground. The calculation has identified a power demand of 66.5 kW and an energy demand of 12.8 kWh. Through research and industry electric propulsion systems achieve continuous improvement. Modern electric engines have high specific powers of 3.5 kW/kg. The best energy supply is currently the lithium ion battery. Specific energies of about 150 Wh/kg are achieved.

This calculation comes to the conclusion, that the required battery would have a minimum weight of 85 kg without any safety margin. Its small energy density is the limiting factor. Nevertheless, electric powered flying for short distance and time is possible today. Further system improvements are expected from research and industry that will make practical flying become more realistic.



[1] Vanhaelst, R., *Redox Flow Batterien für Elektroautos,* 5. Greifswalder Forum „Umwelt und Verkehr“, 2010.

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