DLR
Deutsches Zentrum für Luft- und Raumfahrt

AVES Simulator Centre

- Two interchangeable cockpits
- EC135 helicopter simulator / system simulator for ACT/FHS
- Airbus A320 simulator
- Fixed-base and motion dome
- Electro-pneumatic motion system
- 15 LED projectors per dome
- 240° x 95° field of view

AVES motion dome in the front and fixed-based dome in the back.

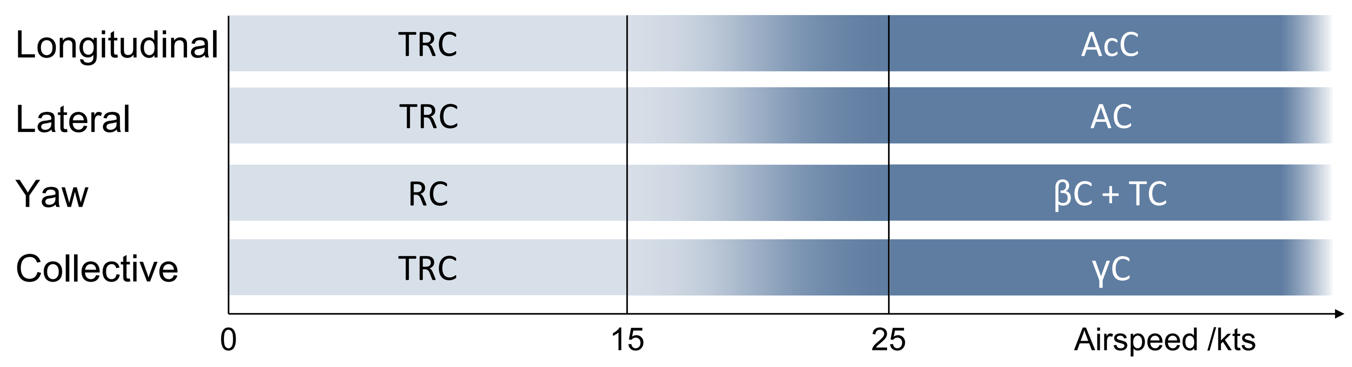
The flight simulator center AVES (Air Vehicle Simulator) features two high-fidelity simulators, one aircraft and one helicopter, for cutting edge flight research. AVES is designed as a modular, flexible platform using the latest technologies for a comprehensive exploration of flight. This modern test facility closes the gap between numeric simulations and experimental flight operations at Braunschweig's Research Airport.

An electro-mechanically driven motion system provides the best possible immersion for the cockpit crews. Both motion and fixed-base dome have a visual systems with 15 LED projectors each, that produces a 240° x 95° field of view. The two simulation cockpits of an Airbus A320 and Eurocopter EC135, are designed to Level D quality, representing the flying testbed ATRA and ACT/FHS with the highest fidelity. A sophisticated 'Roll in Roll out' cockpit exchange system allows a rapid switch from fixed base to motion simulator and back within a few hours. Unique computing infrastructure with more than 50 computers and several kilometers of data cables enable the distributed simulation of complex flying platforms. In house developed simulation components, products, and infrastructures offer maximum flexibility.

AVES also serves as system simulator for flight test preparation for the Flying Helicopter Simulator ACT/FHS. Therefore, all relevant system properties of the flying testbed are replicated in AVES as hardware-in-the-loop simulation.

PAV Flight Simulation

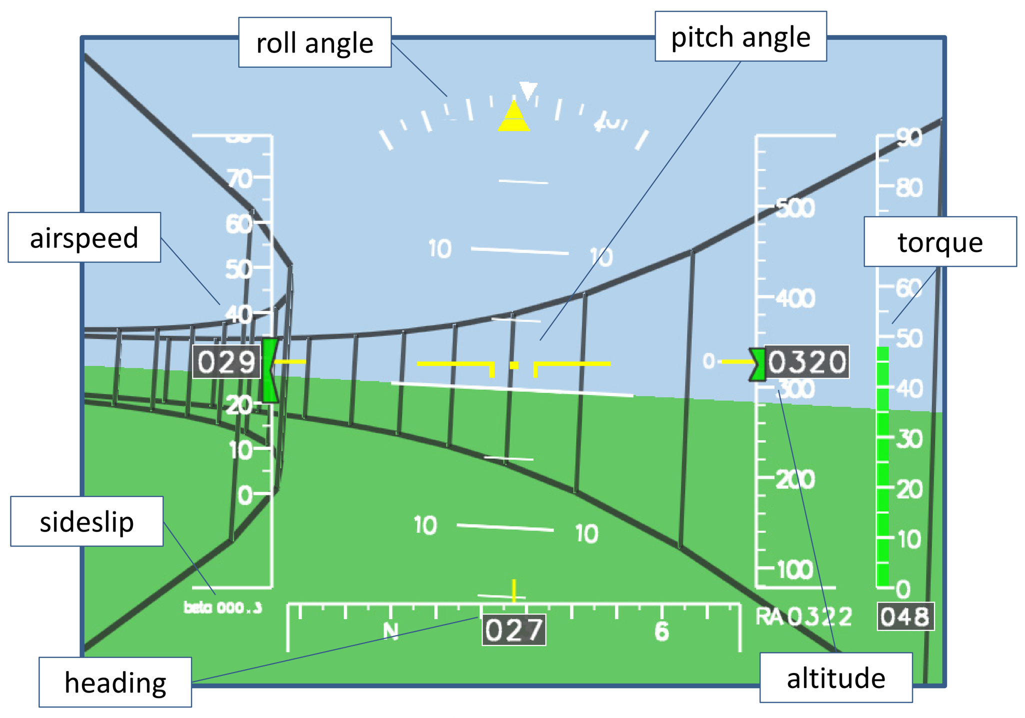
A PAV simulation model with ideal handling qualities has been developed. In the pitch axis a Translational Rate Command (TRC) is implemented. This response type connects control deflection to forward speed linearly. When the inceptor is returned to the neutral position, the PAV returns to hover. Above 15 kts blending starts towards the forward flight mode which is an Acceleration Command (AcC). The aircraft's longitudinal acceleration is proportional to the inceptor's deflection in the forward flight mode. This implies that the current airspeed is held when the inceptor is returned to neutral. The roll axis has a speed independent behaviour. For all airspeeds an Attitude Command (AC) with attitude hold is implemented. A lateral control input results in a proportional roll angle. In hover and up to 15 kts forward speed the yaw axis is designed as Rate Command (RC) response type. The yaw rate is proportional to the pedal inputs. In faster forward flight the response type changes to a Sideslip Angle Command (βC) with Turn Coordination (TC). This increases directional stability and allows flying coordinated turns (free of sideslip) in forward flight without additional pilot inputs. The altitude is controlled via TRC response type in hover mode and changes to Flight Path Angle Command (γC) in forward flight. Inter-axis coupling is not present in the selected response type configuration.



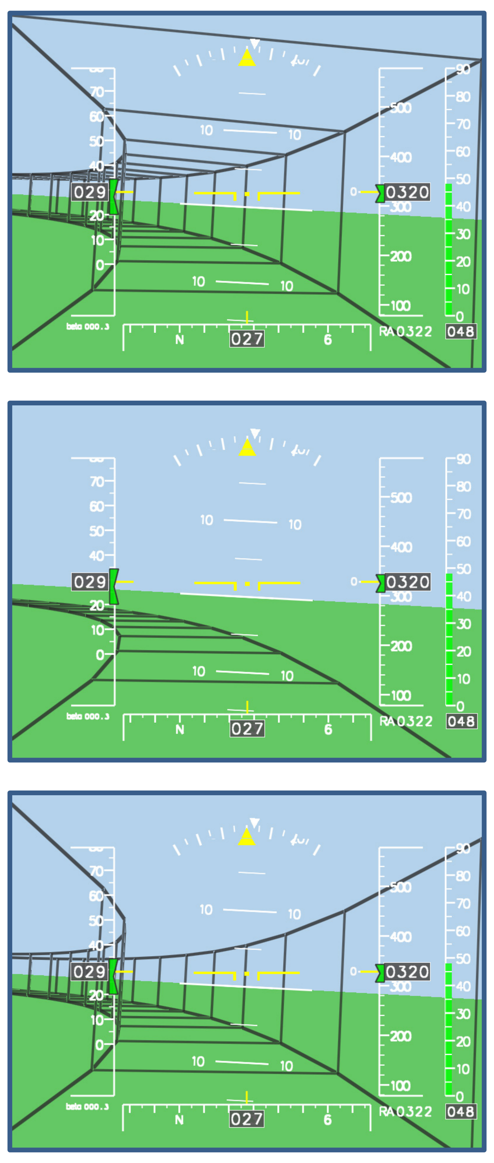
Flight dynamics response types depending of airspeed for conventional inceptors.

The described PAV dynamics model has extensively been tested at the University of Liverpool. Both pilots and flight-naïve test participants had the chance to fly a PAV in a motion simulator. The described model configuration generally received very good ratings regarding handling qualities and is foreseen to be most suitable for future PAVs. For steering wheel control the response types have been adapted at DLR as shown below.

Highway-in-the-Sky Display



HITS display for intuitive navigation.

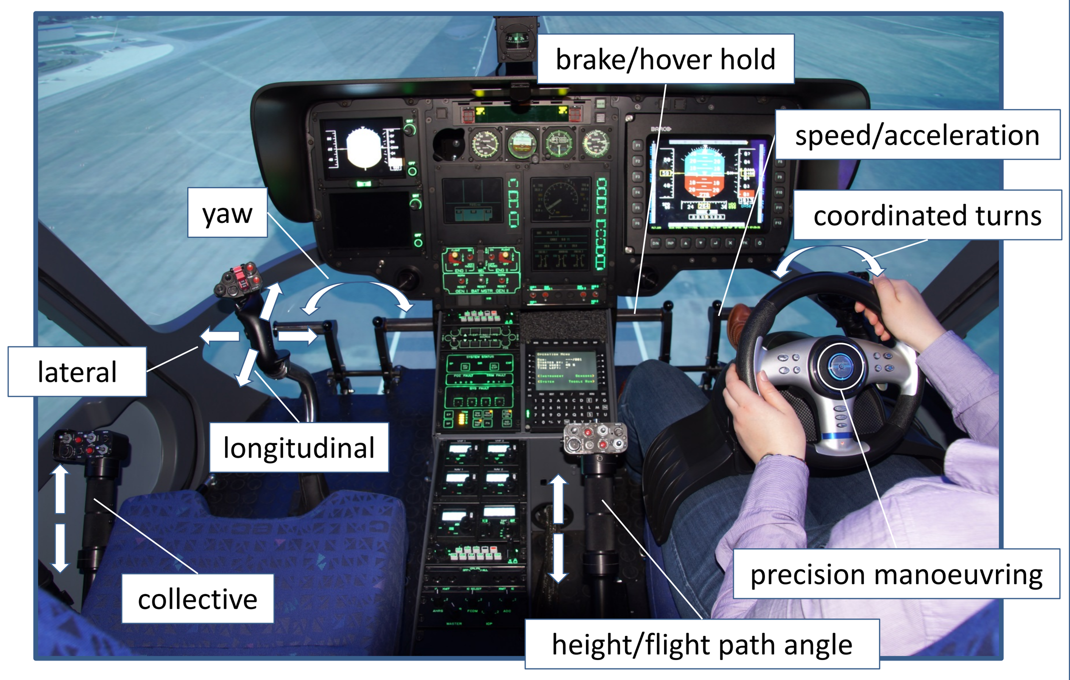


Different tunnel shapes can be selected: walls, box, highway and u-shape.

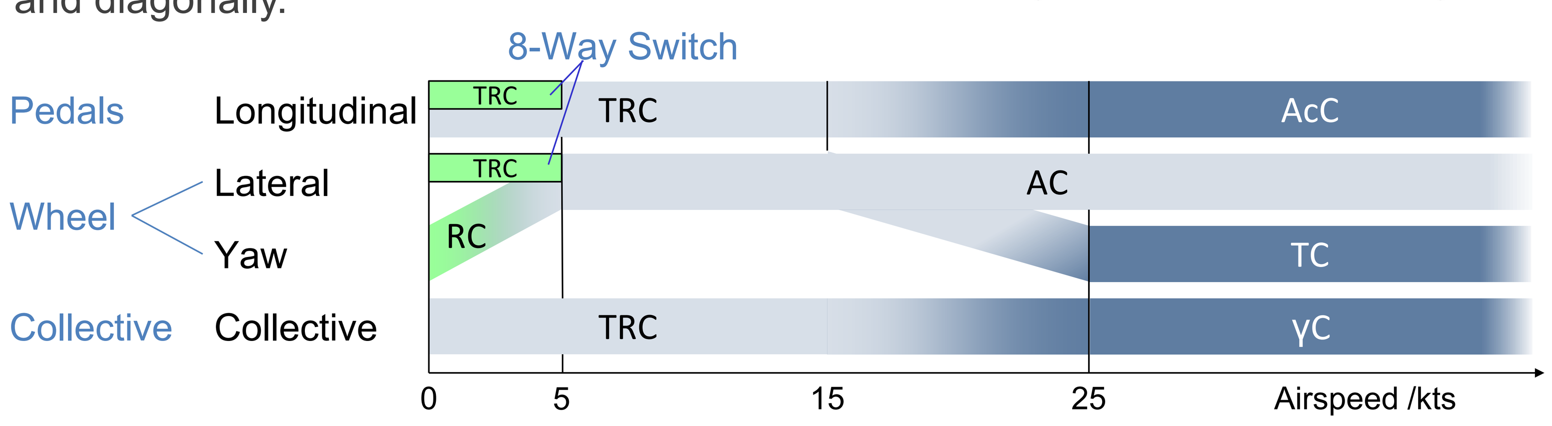
In manual or semi-autonomous flight the pilot of a PAV needs guidance to find his way through the airspace. For this purpose a Highway-in-the-Sky (HITS) display has been developed for intuitive navigation. The display consists of an artificial horizon with a 3D tunnel geometry and an overlaid 2D primary flight display. Target indicators (so called bugs) let the pilot monitor the flight states that are proposed by the navigation system. Several predefined tunnel shapes can be selected. DLR pilots flying the ACT/FHS research helicopter with the HITS display prefer the wall shaped tunnel.

Steering Wheel Control for PAVs

The steering wheel is used for commanding coordinated turns – a combination of roll and yaw motion depending on the current airspeed. The pedals are now used for controlling the longitudinal movement. The response to inputs from the collective lever does not change compared to the conventional setup. The central 8-way switch is used for precision manoeuvring – forward, backward, sideward and diagonally.



AVES helicopter cockpit with conventional inceptors on the left side and steering wheel control on the right.



Response types adaption for steering wheel control.

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