Development of Handling Qualities and Training Requirements for Future Personal Aerial Vehicles

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Work Package (WP)2 Background: Flight Simulation & Training

WP2 were grouped into three main categories. The first was the development of a set of flight dynamics simulation models representative of various potential Personal Aerial Vehicle (PAV) configurations. The second was the assessment of those configurations and the associated cockpit characteristics to select the configuration that can be flown with the greatest ease and precision. The third was the development and testing of the associated training regimen to ensure safe PAV operations

As such, the key objectives of WP2 were:

- Develop a PAV simulation model for use in this and other work packages
- Identify the handling qualities (HQs) requirements for PAVs
- Determine the training requirements for the PAV
- Assess the impact of different PAV cockpit configurations – such as inceptors, display symbology etc. – on the handling and training requirements

PAV Simulation Model Development

A flight dynamics model was created using MATLAB® and Simulink® for use across the myCopter project WPs. Primary vehicle motions (pitch, roll, yaw attitudes, heave velocity) follow 1st or 2nd order transfer function models in response to a control input; this permits a precise specification of the desired vehicle handling qualities.

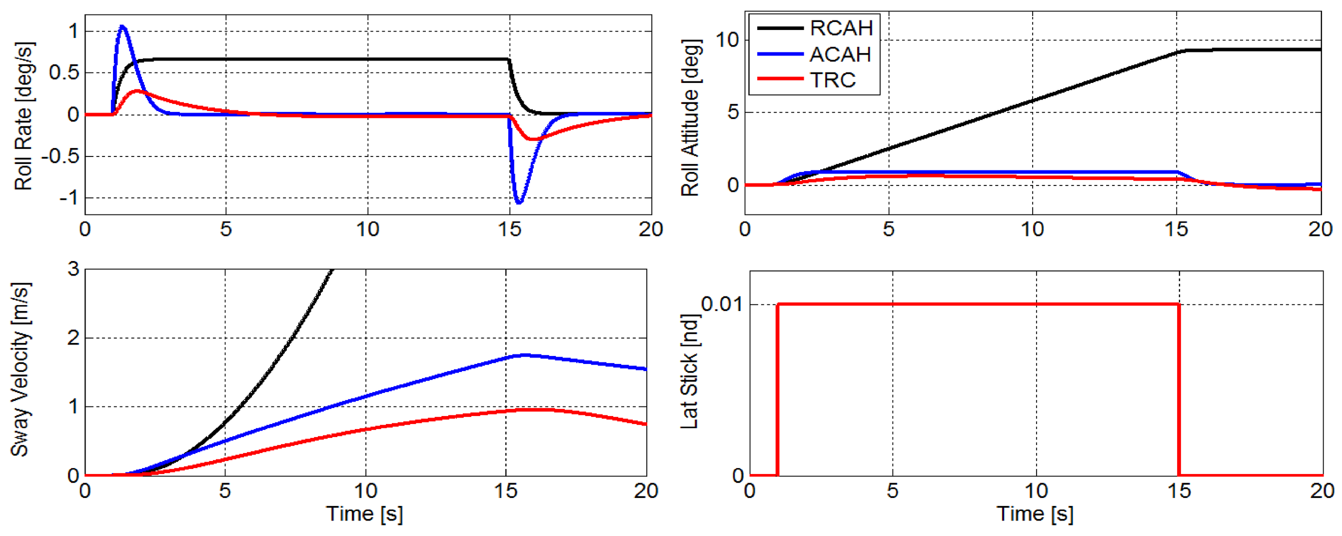
The model can be rapidly configured to deliver a wide range of different response types (e.g., RCAH and ACAH). The Hybrid configuration, shown in the table below, was ultimately selected as the configuration that was most suitable for flight-naïve pilot training.

Speed Range	Pitch	Roll	Yaw	Heave
< 15kts	TRC	TRC	RC	VRC
Blend	Instantaneous at 15kts(accel) and 0kts (decel); internal logic to eliminate transients	Smoothed transition between 15-25kts	Smoothed transition between 15-25kts	Smoothed transition between 15-25kts
> 25kts	ACSH	ACAH	βC+TC	γC

Where the available response types are:

- RC – Rate Command
- RCAH – Rate Command, Attitude Hold
- ACAH – Attitude Command, Attitude Hold
- ACSH – Acceleration Command, Speed Hold
- TRC – Translational Rate Command
- VRC – Vertical Rate Command
- βC – Sideslip Angle Command
- TC – Turn Coordination
- γC – Flight Path Angle Command

The key response types (RCAH, ACAH, TRC) are illustrated below:

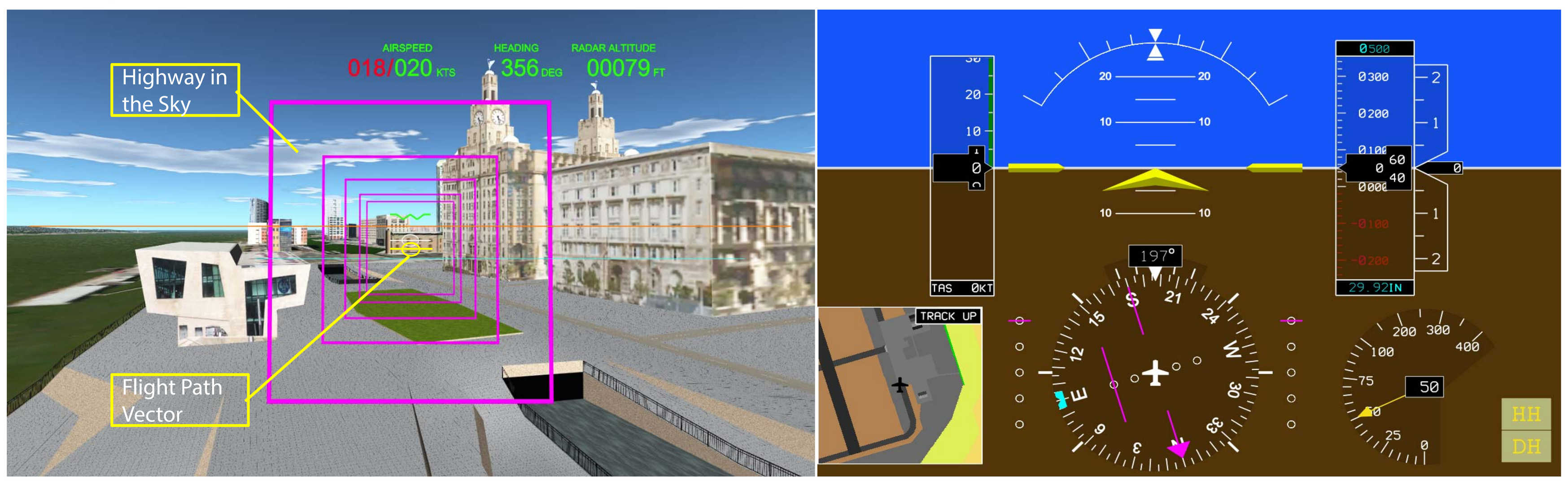


HELIFLIGHT-R

The HELIFLIGHT-R simulator was used to achieve the WP objectives. It consists of a projection dome mounted on top of a six degree-of-freedom electric motion platform. Three HD projectors permit a seamless outside world image to be created on the surface of the dome, covering a field of view of 210 degrees horizontally by 70 degrees vertically.

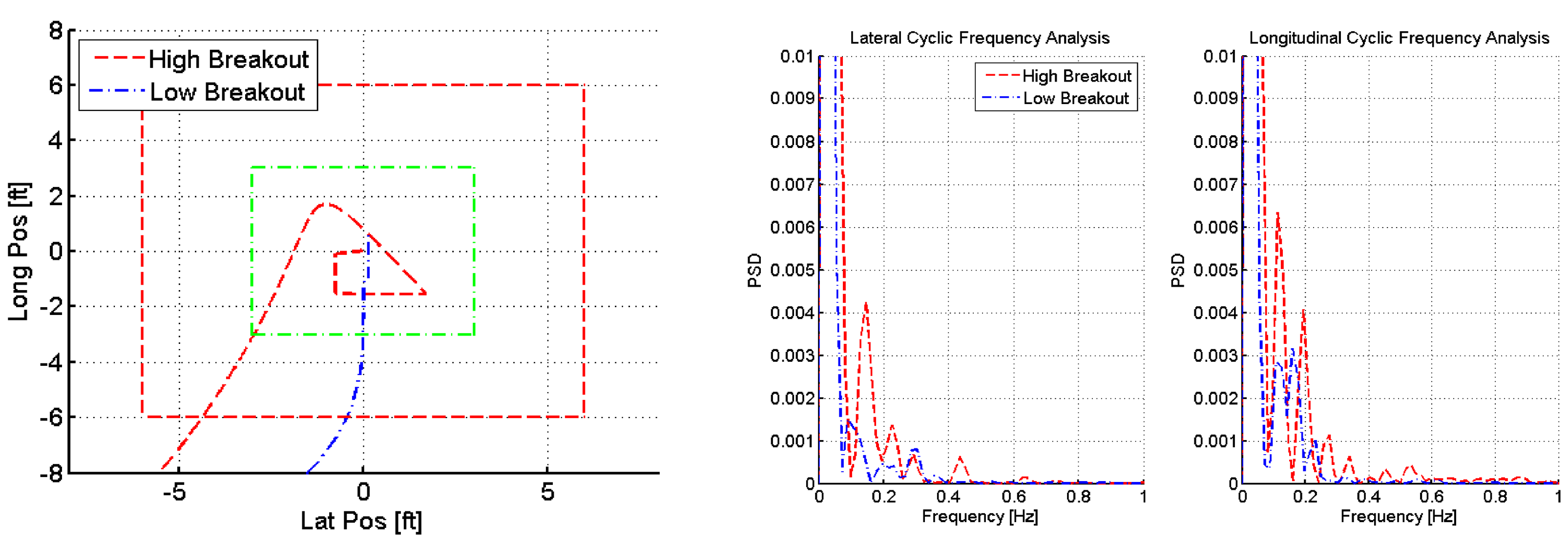
Instruments

The PAV simulation includes a glass-cockpit instrument panel (based on the Garmin G1000) and a representation of a basic Head-Up Display (HUD) projected into the pilot's field of view. The HUD permits the display of both numerical status information (height, heading, airspeed) and attitude and flight path data.



Inceptor Force-Feel

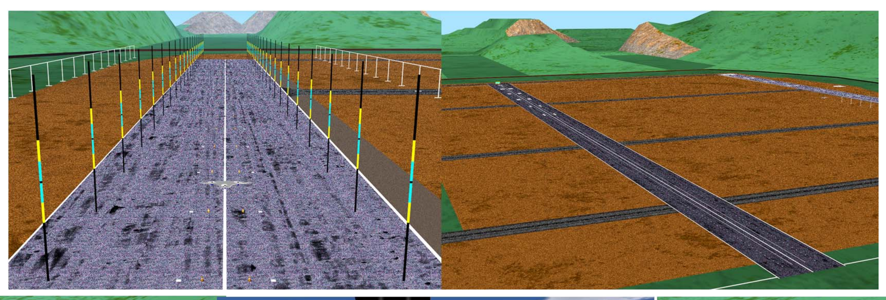
The effect of different control feel settings on the HELIFLIGHT-R inceptors has been investigated during the setup and development of the PAV simulation. A change from high to low breakout forces on the cyclic and the addition of a centring spring force on the collective has been shown to improve the precision with which the PAV can be flown (lower position drift, left-hand Figure, below) whilst reducing workload (lower peaks, right-hand Figure, below).



Visual Database

A series of experimental mission task elements, representative of manoeuvres within the envisaged PAV commuting scenario, were developed. Hover and low speed tasks, and the transition between hover and forward flight were tested extensively

Aborted Departure: Accelerate to 40kts, abort and return to hover as quickly as possible



Decelerating Descent: Transition from cruising flight to hover at a landing point

Hover: Capture hover and maintain position for 30 seconds

Landing: Touch down at prescribed location

Vertical Reposition: Climb or descend from one height to another while maintaining position over ground

myCopter

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