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

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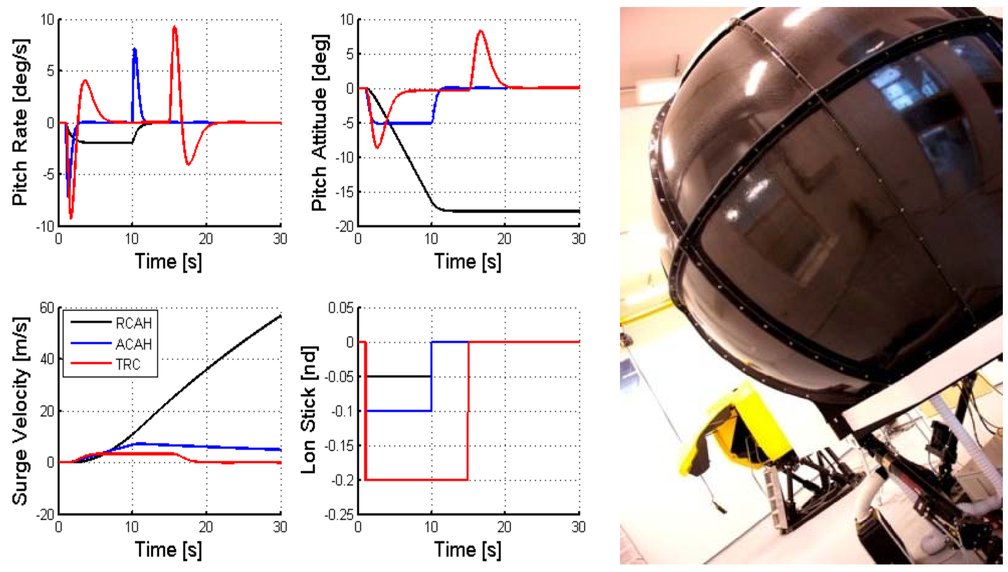
WP2, Simulation & Training: Objectives

The objectives for Work Package (WP) 2 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 qualities and training requirements

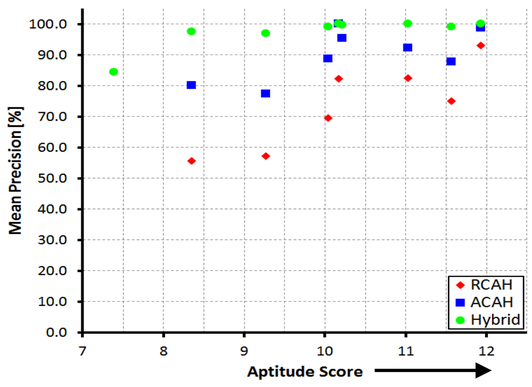
1. PAV Simulation Model

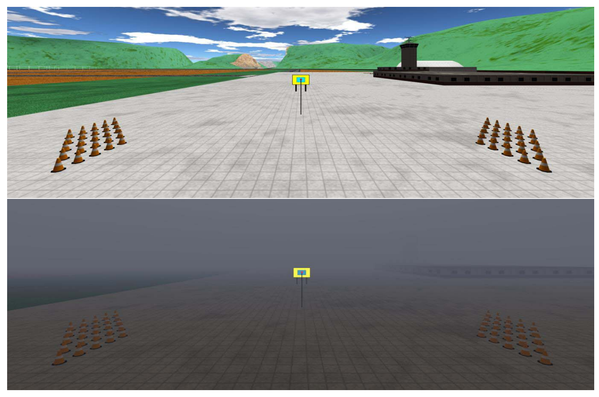
A flight dynamics model has been created using MATLAB and Simulink for use across the myCopter project. Primary vehicle motions (pitch, roll, yaw attitudes, heave velocity) follow 1st or 2nd order transfer function models of the response to a control input. This formulation of the model allowed idealised handling qualities to be directly conferred on the vehicle for different 'response types' (RCAH = Rate Command, Attitude Hold; ACAH = Attitude Command, Attitude Hold; TRC = Translational Rate Command).



2. Identify HQ Requirements for PAVS

Using both test-pilots and flight-naïve test subjects (TSs), the WP2 research showed that the TRC response type, which formed part of a 'Hybrid' control system shown in the Table below, was the most suitable of those tested for use on a future PAV. TSs with a range of aptitudes could fly manoeuvres with the greatest precision (Figure below left). This was true for both the benign and harsh environmental conditions tested (Figure below right).

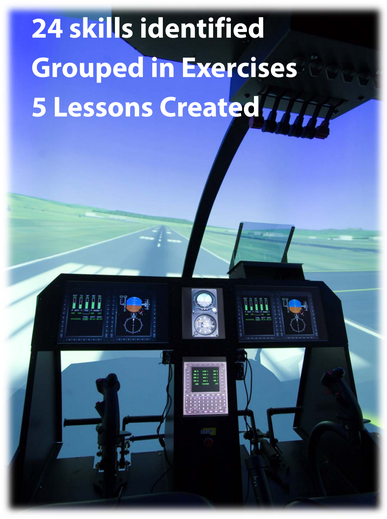




Speed Range	Pitch	Roll	Yaw	Heave
< 15kts	TRC	TRC	RC	Vertical RC
Blend	Instantaneous at 15kts(accel) and 0kts (decel);	Smoothed transition between 15-25kts	Smoothed transition between 15-25kts	Smoothed transition between 15-25kts
> 25kts	AC Speed Hold	ACAH	Sideslip Command+Turn Coordination	Flight Path Command

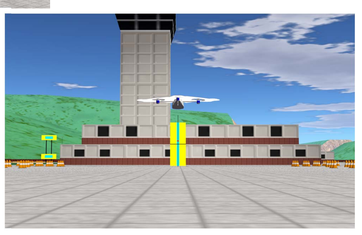
3. PAV Training Requirements

Existing driver and private-pilot training syllabi and philosophies were reviewed and a training programme developed based upon them.



5 TSs. 4 male, 1 female. Age 22 – 45. 5 – 25 years driving experience. No flying experience. 4 out of the 5 completed the training in under 5 hours. They undertook myCopter lessons…

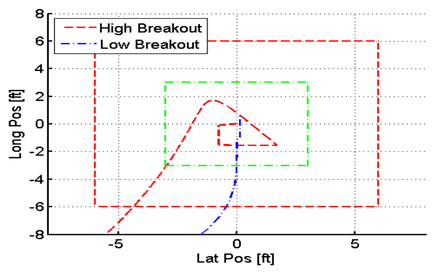
…followed by a skills test and then…

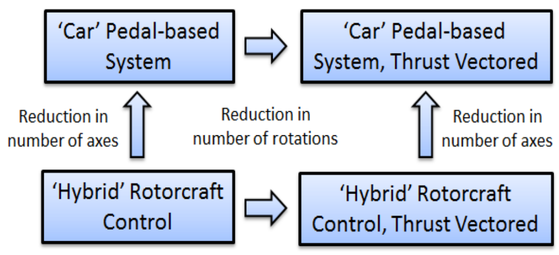


…a real world simulated commute similar, in principle, to a car driving test. The participants rated the training programme as being effective, neither too slow nor too fast whilst still being sufficiently challenging to engage them.

4. Impact of Configuration Variants

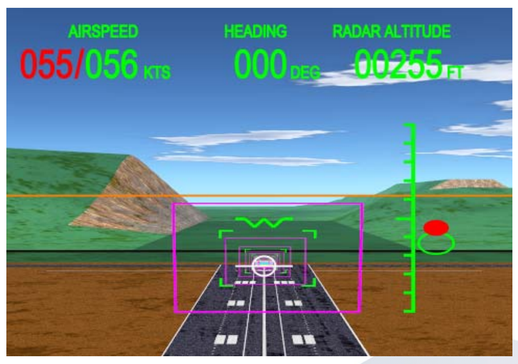
The effect of different vehicle and control force-feel settings using the HELIFLIGHT-R simulator has been investigated. A change from high to low breakout forces on the cyclic and the addition of a centring spring force on the collective has been shown to improve the precision with which the PAV can be flown (lower position drift, Figure right) whilst reducing the associated perceived workload.





An investigation into the design and use of novel methods for the control of a PAV, based around the recreation of a 'driving' experience in flight was conducted. A car-like configuration (Figure left), employing pedals for speed control, shows promise as an alternative method for the control of future PAVs, compared to traditional rotorcraft control mechanisms.

Different approach profiles were developed and assessed for automated and manual visual landings. 14 flight-naïve pilots (13 male, 1 female, with an age range of 20-43 and a mean age of 26) participated in the study. They were guided through the manual landing manoeuvre using a Highway-in-the-Sky Head-Up-Display (Figure right). It was found that the so-called "natural-feeling" profile was preferred for manual landings whilst a constant-deceleration profile was preferred for automated landings.



5. Concluding Remarks

- A rapidly reconfigurable generic PAV flight dynamics model has been developed to enable the simulation of typical PAV commuting role tasks.
- Simulation trials show that conventional rotorcraft response types such as RC and ACAH are generally unsuitable for typical PAV pilots.
- The Hybrid response type is considered to be the most suitable of those tested for use in a future PAV.
- Pseudo car-like responses have also shown promise as a potential means for PAV control.
- The so-called "natural-feeling" profile was preferred for manual landings whilst the constant-deceleration profile was preferred for automated landings.
- The training programme developed during the project was rated as being highly effective by the participants.

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