

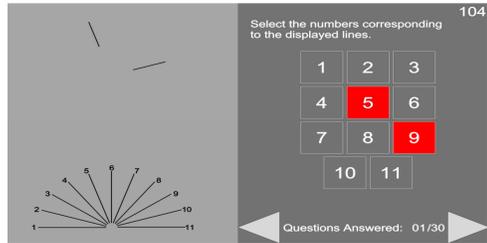
Development of Handling Qualities and Training Requirements for Future Personal Aerial Vehicles

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Aptitude Tests

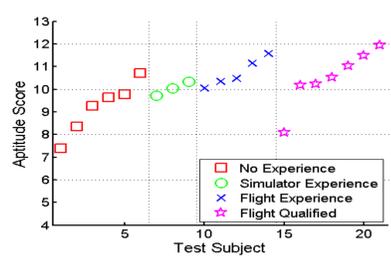
To facilitate the analysis of an individual's performance when using a given vehicle configuration, a series of flight-related aptitude tests were undertaken by each test subject.

The example shown on the right examines a subject's ability to judge the orientation of lines – useful for judging required heading changes or bank angles. The subject must select the lines from the reference image at the bottom that correspond to the pair shown in the top of the screen.



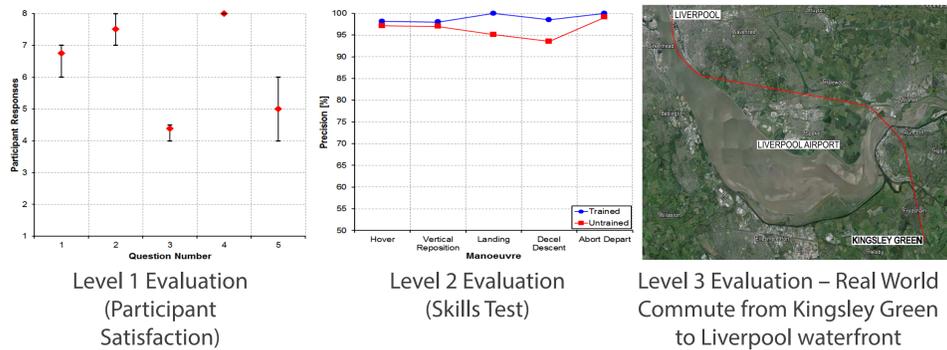
21 test subjects with a wide range of previous flight experience completed the battery of aptitude tests, prior to the simulation testing being conducted.

The aptitude test scores were correlated with the results from the simulation tests to make judgements regarding the suitability of particular sets of PAV HQs for a given level of pilot skill.



Training Requirements

A Training Needs Analysis (TNA) was undertaken to determine the skills required by a PAV pilot to safely operate the vehicle. A training programme was produced to cover the development of these skills. The programme was assessed using the first three Levels of Kirkpatrick's training evaluation model.



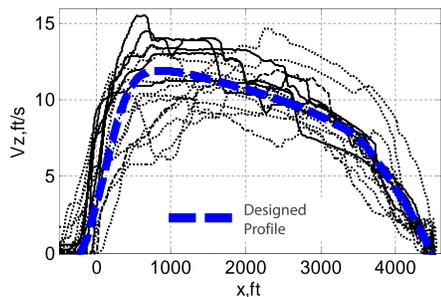
The results showed that a training duration of less than five hours was required by so-called 'flight-naïve' pilots in a simulation environment to develop the handling skills necessary for PAV flight in benign environmental conditions. However, the results also showed that the Hybrid set of response types provided an intuitive configuration to fly for those subjects that did not receive any training.

"Desired" Manoeuvre Profiles

An investigation has been conducted to explore the profiles of altitude, ground speed, and deceleration during landing manoeuvres for a PAV that feel most 'natural' to the pilot. The information will be used to develop guidelines to inform the design of future approach profile for PAVs.

NASA's computed longitudinal approach profile for professional pilots has been shown to be consistent with the test data from 11 flight-naïve subjects. Tau theory has been applied to both approach models to design a 'natural' landing profile in the vertical axis. The result is in good agreement with the visual-landing results.

Subsequent testing showed that for manually flown landings, the "natural-feeling" profiles were the most favoured when compared to constant deceleration and constant optical flow variants.

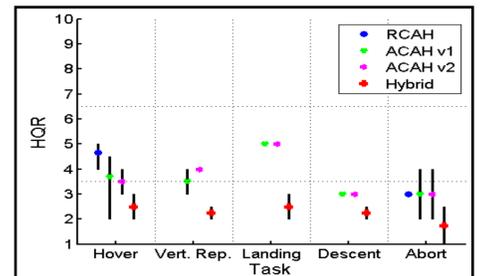


The Figure shows that the designed vertical velocity profile has a good agreement with the test data.

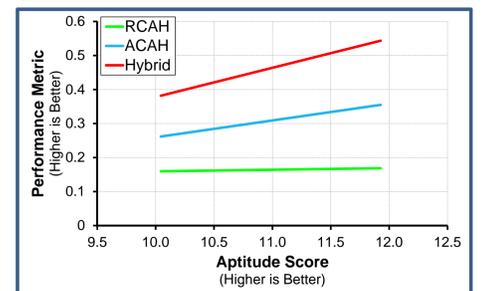
Handling Qualities Requirement

A group of 'pilots' with widely differing levels of flight experience – ranging from those who hold a PPL(A) or PPL(H) to those with none, or minimal, formal training or experience – flew candidate sets of PAV handling characteristics in the HELIFLIGHT-R simulator. The performance and workload of each 'pilot' was monitored and subsequently analysed using the previously developed mission task elements.

A group of test pilots evaluated each candidate PAV vehicle configuration using the traditional method of awarding a Handling Qualities Rating (HQR) to the vehicle for the mission task elements. These results show that both ACAH configurations as well as the Hybrid configuration would be acceptable for professional line pilots.

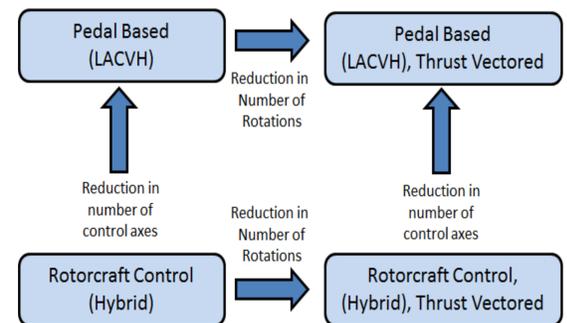


However, testing with the group of non-professional pilots showed that their task performance increased as the response type became more advanced. It also showed that the Hybrid configuration could be flown most successfully by pilots with the widest range of aptitudes compared to when those same pilots flew the RCAH or ACAH configurations.



"Novel" Configurations

The Hybrid configuration has been progressively extended to make it more representative of the experience of driving a car. This has been achieved by altering the inceptors used to control each response (e.g. pedals control vehicle speed rather than heading), and by implementing a 'thrust-vector'd version of the simulation that does not pitch or roll.



Results suggest that, the car-like configuration is more suitable for control of a PAV than an augmented set of helicopter-style response types. This is shown through increased performance, improved HQRs and a reduction in subjective NASA TLX ratings. Overall, removal of pitch and roll dynamics was not found to significantly affect task performance in the car-like system, but resulted in a decrease in performance for the rotorcraft-style response type configurations tested

Conclusions

- A rapidly reconfigurable generic PAV flight dynamics model has been developed to enable the simulation of a range of tasks that are representative of a typical PAV operating in a commuting role.
- Simulation trials shows that conventional rotorcraft response types such as RC, AC and ACAH are generally unsuitable for typical PAV pilots.
- The hybrid response type is considered as being the most suitable of those tested for use in a future PAV. Moreover, this response type remains suitable for use by 'flight-naïve' pilots for harsh and benign conditions. This result differs from ADS33 where the response types has to be increasingly augmented to achieve the best HQs as the visual environment degrades.
- A landing profile has been developed and the evaluation results show that it is favoured by the TSs during the manual landing process.
- The evaluation results have shown that the developed training programme was effective in terms of engaging the trainees with the task, and in terms of developing the skills required to fly a series of PAV-mission related tasks in a flight simulator.

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