UNIVERSITY OF LIVERPOOL

Handling Qualities and Training Requirements for Personal Aerial Vehicles

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mycopter

http://www.mycopter.eu

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Personal aviation

European Commission, Out of the box – Ideas about the future of air transport, 2007

mycopter

Enabling Technologies for
Personal Aerial Transportation Systems

Max-Planck-Institut
für biologische Kybernetik

UNIVERSITY OF
LIVERPOOL

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

KIT
Karlsruhe Institute of Technology

DLR

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Automation (vision-based)

- Navigation
- Landing place assessment
- Collision avoidance

Piloting PAVs

- Handling Qualities for PAVs
- Training requirements

Human-machine interfaces

- Control interfaces and displays
- Multi-sensory feedback

Exploring the socio-technological environment

- Acceptance: safety, noise, fuel, cars overhead
- Integration into current transport systems

Piloted PAVS?

- "Under no circumstances will the pilot responsibility be replaced by technologies in the foreseeable future" *ICAO Circular 328*
- → Remotely Piloted Aerial Systems, RPAS. Remote Pilots?
- Practicality of 'certifying' autonomy software for PAVs affordably under e.g. guidance document DO178C/ED-12C

Objectives

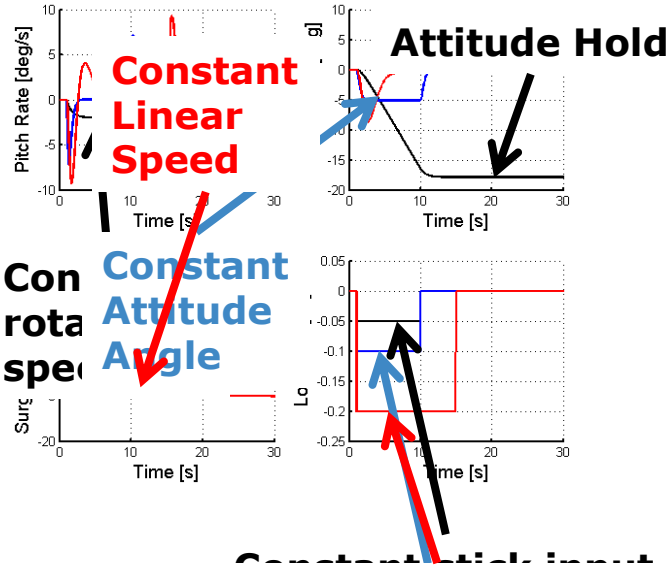
- To build a medium to high fidelity simulation model of a likely PAV configuration.
- To quantify the flying qualities and training requirements for various levels of PAV response characteristics

A Handling Qualities Approach

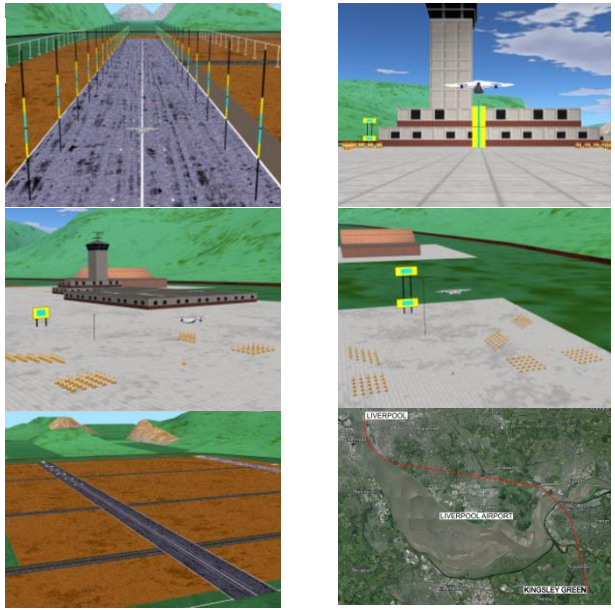
- Handling Qualities – "*those qualities or characteristics of an aircraft that govern the ease and precision with which a pilot is able to perform the tasks required in support of an aircraft role*"

- Approach from: ADS33E-PRF, Aeronautical Design Standard Performance Specification Handling Qualities Requirements for Military Rotorcraft → 'state-of-the-art'

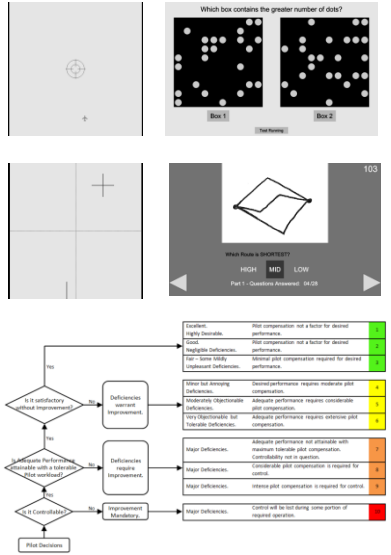
Flight Dynamics Simulation Models



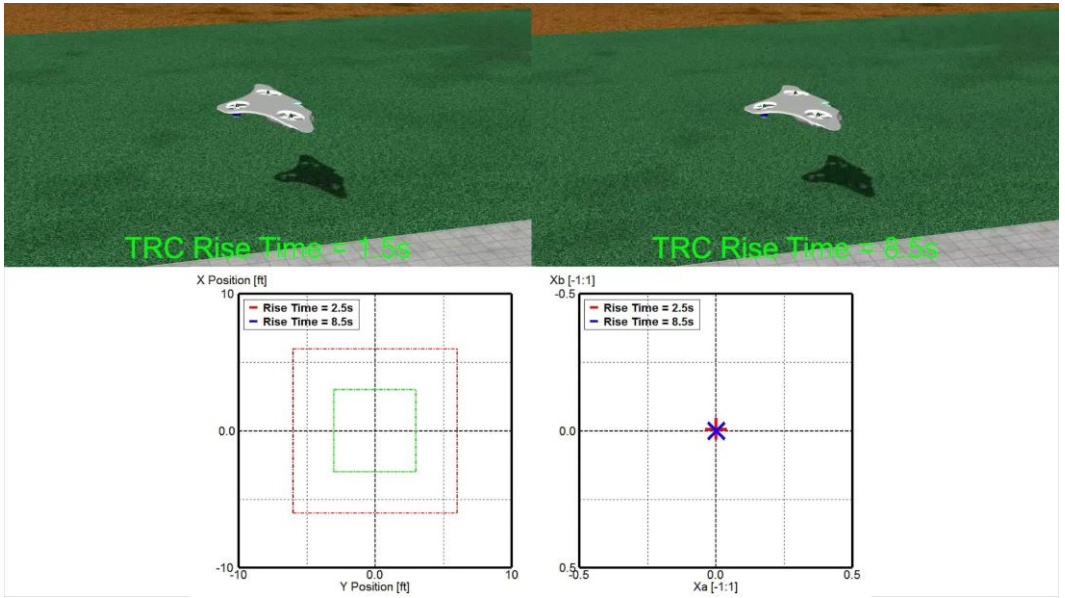
Virtual Test Environments / Courses



Test Subject Assessments

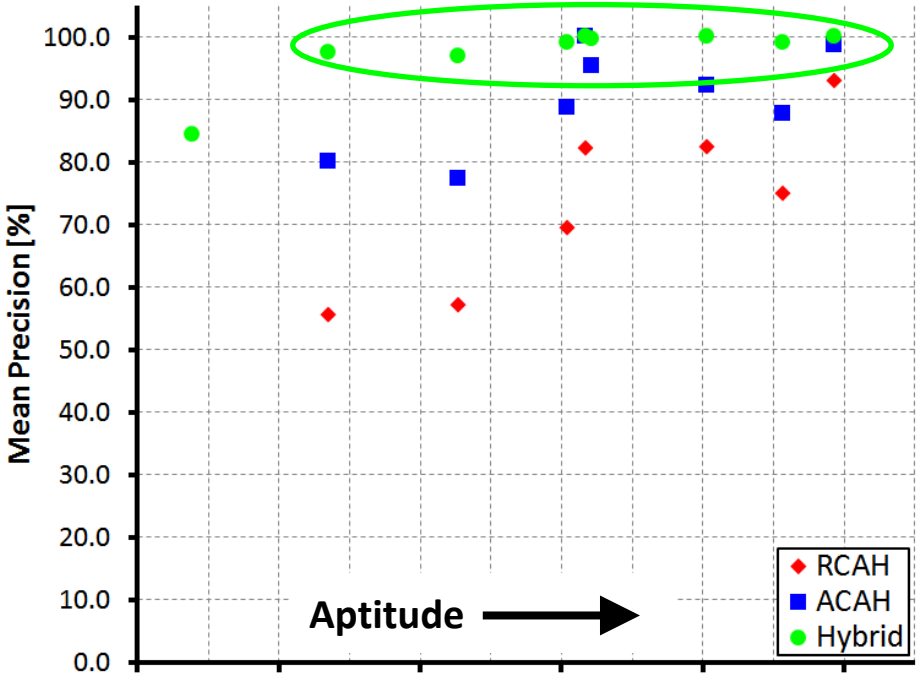


- A range of response types, configurations and control characteristics were evaluated in simulation to find the ‘optimum’
- E.g. ‘rise time’ for translational rate command system response

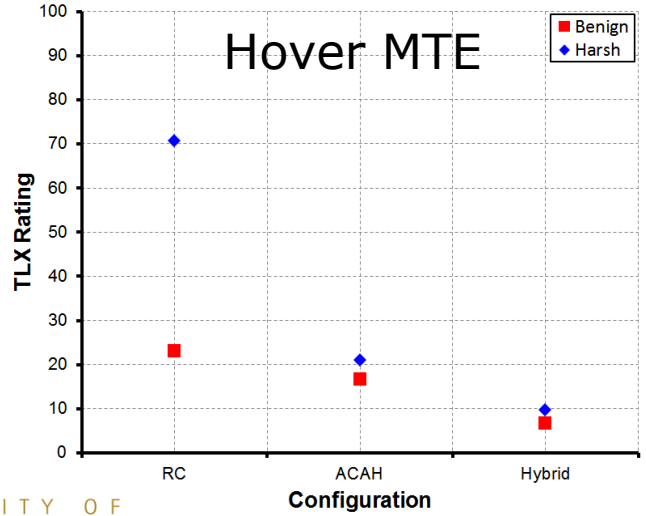


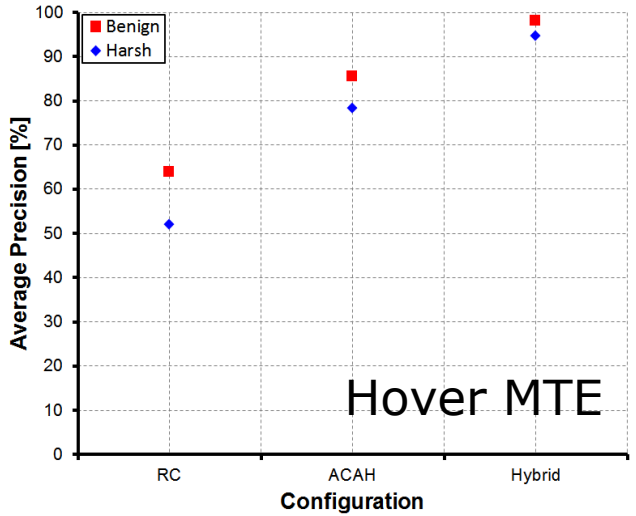
- The research showed that the Translational Rate Command (TRC) response type of a 'Hybrid' system was most suitable for use on a future PAV for hover and low speed flight in benign and harsh conditions

Broad spectrum of aptitude levels able to achieve excellent precision



- It has also been shown that TRC response type was suitable for hover and low speed flight in a ‘harsh’ environment
- Interesting, as ADS33 shows increased augmentation required for Level 1 HQs as UCE degrades for professional pilotage





UCE = 2

- Hybrid configuration selected to train flight-naïve pilots

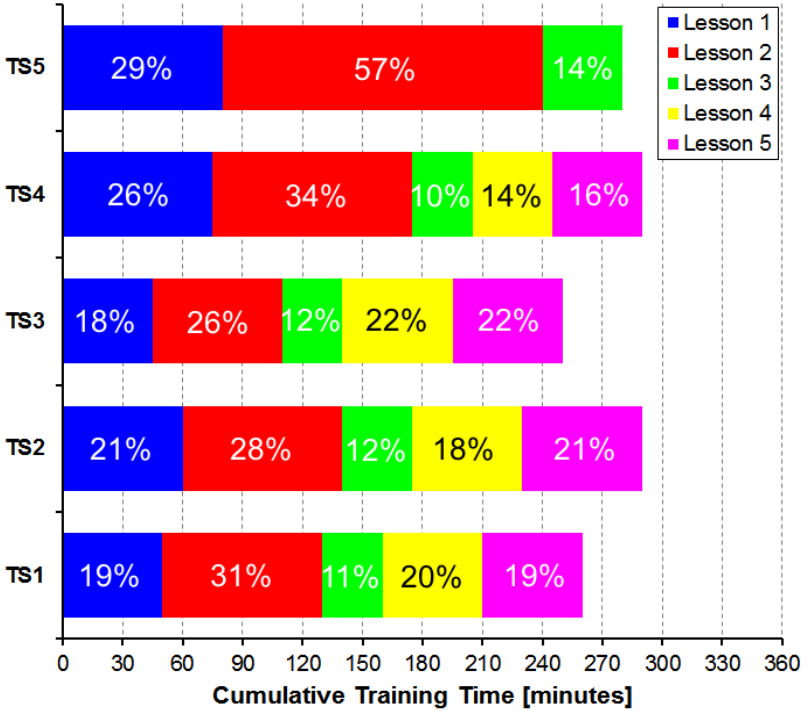
Speed Range	Pitch	Roll	Yaw	Heave
<15kts	TRC	TRC	RC	VRC
blend	Instantaneous at 15kts (accel) and 0kts (decel); internal logic to eliminate transients	Smoothed transition between 15-25kts	Smoothed transition between 15-25kts	Smoothed transition between 15-25kts
>25kts	ACSH	ACAH	βC + TC	γC

Training Programme

- Existing relevant (UK) syllabi and philosophies for driver and private pilot training were reviewed
  - Interview with Driving Instructor instructors
  - Interview with Private Pilot instructor
- Training programme developed based upon this review
- 24 skills required to fly a PAV → 5 lessons created
- 5 test subjects (4 male, 1 female. Age 22 – 45. 5 – 25 years driving experience. No flying experience)

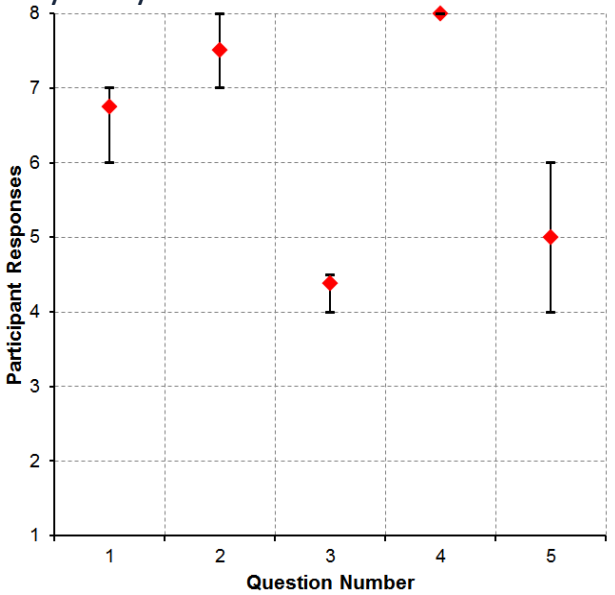
Training Programme

- 4 out of 5 completed the training in less than 5 hours



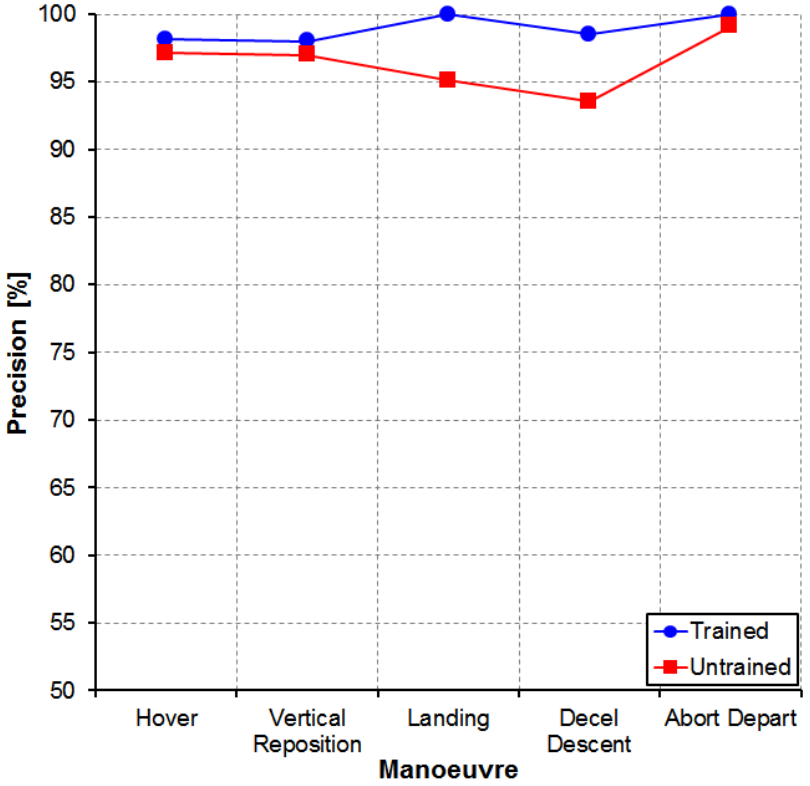
Level 1 Evaluation – Participant Satisfaction

- 5 specific questions with quantitative answers plus a number of open questions to explore their responses
  1. To what extent do you feel that you have learned the skills necessary to fly a PAV from the programme?
  2. Was the programme stimulating?
  3. Was the pace of the programme appropriate for you?
  4. Was the programme sufficiently flexible to meet your needs?
  5. Was the programme challenging?
- Rated as being effective
- Neither too slow not too fast
- Sufficient challenge to engage



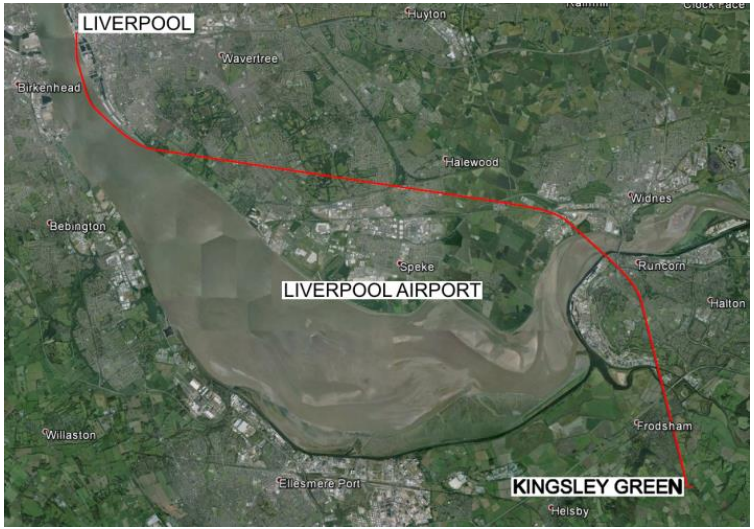
Level 2 Evaluation – Skills Test

- Skills test consisted of 5 MTEs defined earlier in the project
- 'Desired' performance boundaries set
- 'Precision' – a measure of time spent within desired boundaries
- Some improvement, but TRC has already been shown to be 'intuitive'



Level 3 Evaluation – Real World Commute

- Psuedo-equivalent to ‘driving test’ or ‘qualifying cross country’
- Check to see if skills developed allowed the TS to fly a ‘real-world’ task
- Commute from Kingsley Green to Liverpool waterfront



Level 3 Evaluation – Real World Commute

- 4 TS's that completed their training also completed this test without incident
- TLX average of 24, maximum 30 (c.f. 55 – 60 for simulated urban environment)

Key Results

- Quantify Response Types/Flying Qualities Requirements
  - → Different start point for professional/flight-naïve pilots in good conditions
  - → Same end point for professional/flight-naïve pilots in degraded conditions
  - → 'Hybrid' configuration found to be intuitive, selected for training program
- Training Requirements
  - → flight-naïve pilots can gain the required PAV handling skills in a 'reasonable' number of hours of training (in simulation).
- Use of conventional rotorcraft pedals as car-like controls
  - → showed promise to allow precise and easy PAV control.
- Approach profiles
  - → Flight-naïve pilots preference depends upon manual or automatic flight.

Key Results

- doi: http://arc.aiaa.org/doi/abs/10.2514/1.G000862
- doi: http://arc.aiaa.org/doi/abs/10.2514/1.G001073
- doi: http://dx.doi.org/10.2514/1.G001608
- See mycopter website for other publications

Thank you for your attention

QUESTIONS?

The work reported in this presentation was funded by the EC FP7 research funding mechanism under grant agreement no. 266470

Image courtesy Flight Stability and Control