Offshore Helicopter Related Research at the University of Liverpool

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FS&T RESEARCH CAPABILITIES – FLIGHT SIMULATION

**Modelling & Simulation**
- Simulation fidelity; development of criteria and validation methods for rotary wing aircraft
- Helicopter interactions with turbulent wakes, vortex wakes of fixed wing aircraft and ship airwakes
- NATO AVT-296 “Rotorcraft Flight Simulation Model Fidelity Improvement and Assessment”
- 3.5 year EPSRC Rotorcraft Simulation Fidelity Project

**Aircraft HQ and Flight Control**
- Helicopter control and handling qualities research, handling qualities in degraded conditions and structural load alleviation concepts

**Advanced Configurations**
- Handling qualities and control of tilt rotor aircraft – handling qualities criteria, flight control systems, control laws
- Aircraft-pilot couplings and pilot in the loop oscillations; criteria and design solutions

**Visual Perception and Displays**
- Design of vision aids for fixed wing and rotary wing flight in degraded visual environments
- Pilot-vehicle interface technologies
HELICOPTER SHIP DYNAMIC INTERFACE
Questions:
• Can flight simulation be used to inform the determination of Ship Helicopter Operation Limits (SHOLs)?
• Can it provide a safe and realistic environment for pilot training?
• How can simulator activities inform the design of new ships?
• What are the fidelity specifications required to achieve the above?
Creating the Simulated SHOL

Unstructured, Time-Accurate CFD data (Fluent)

FLIGHTLAB Rotorcraft Model

Simulated SHOL

Type 23 Frigate/SH-60B SHOL diagram

Relative Wind Speed (kts)

Relative Wind Direction (deg)

Motion Base Flight Sim
Maritime Visual Environment
Ship Motion
HELIFLIGHT-R

- A high quality motion base simulator
- A flight mechanics mathematical model of a maritime helicopter
- Visual Scene
- Ship model and ship motion
- An accurate unsteady airwake

SHOL Research Summary

Modelling the airwake
Required level of visual scene content
Ship Design for improved DI operations
Assessment of motion fidelity
**Use of UoL Simulator Fidelity Rating Scale**
T23 Airwake

Type 23 Frigate @ 0°
Iso-surfaces of $Q = -\frac{1}{2} (du/dx_2)(du/dx_3) = 7.5$
CFD Airwake Analysis
Deck-edge vortices

- Slow rotating core
- Vortex aligned with flow direction

- High speed vortex core
- Aligned longitudinally with deck
- Vortex expands radially towards the stern
Unsteady Airwakes

Type 23 Frigate

Wave Class Auxiliary Oiler

Type 45 Destroyer
Future Combat Ship

Superstructure Aerodynamics

- Effect of geometric features on airwake & helicopter
- Anemometer placement
- Engine exhaust efflux
- RWUAS
Exhaust Plume Analysis, Headwind
Isosurfaces of Exhaust Temperature for Headwind WOD

Mean CFD Data

Temperature criteria domain as defined by CAP 437
Merlin in high hover position with underslung load

Instantaneous CFD Data

Merlin in conventional hover position

Mean Temperature (above ambient):
1°C 2°C 5°C
Temperatures remain at elevated levels above the flight deck, in this case at 350% hangar height (28 m).
Queen Elizabeth Carrier Flight Simulation

- Work with BAE to produce QEC flight simulation environment at Warton and Liverpool, 2 PhDs
- Create validated airwakes
- Develop techniques for handling large airwakes
- Develop generic STOVL flight mechanics model
QEC Flight Simulation

Creation of CAD model for:

• CFD – unsteady airwake for flight simulation

• Experimental model (1.4m long) for 3-D velocity measurements in water tunnel

QEC 1:202 – mean $w$-component velocity along SRVL glideslope.
Initial UoL Sim Testing
2 x 2 day trials with ex-RN Test Pilots

NATO AVT-315 “Comparative Assessment of Modelling and Simulation Methods of Shipboard Launch and Recovery of Helicopters”
Future Dynamic Interface Challenges

- Try and answer the question: “How good is good enough?”
- Rotor/wake/moving deck interactions
- Visualisation of Rotor/Airwake
- Simulator motion tuning
- Ship Design Guidelines for Improved Rotorcraft operations
- Develop “Hazardous” Training Landscape

Search and Rescue training

Oil rig heli-deck simulation

Tall building helipads
ROTORCRAFT/WIND TURBINE WAKE ENCOUNTERS
General Aviation Aircraft Encounters with Helicopter and Wind Turbine Wakes

- Joint project between UoL and UK CAA

- Select appropriate wake model for rotorcraft and wind turbines

- Carry out simulated flight trials to assess hazard posed by different wakes

- Couple the wake of the rotary wing and fixed wing aircraft
  - Dauphin & Grob Tutor

- Present guidelines for the separation distance from helicopters and wind turbines
Results: A most severe case. Rating D/F

Objective assessment of data, looking at roll criteria, control power etc.
Existing Wind Turbine Installations

Caernarfon Airport

East Midlands Airport
HC/AG-23 Status

- **Wind turbine wake and helicopter operations**
  
  Project duration: 3 years, Kick-off 6 November 2014, DLR-Braunschweig

**Objectives**

- To understand the behaviour of helicopters in a wind turbine wake
- To identify the safety hazards of helicopter wind turbine wake encounters
- To define measures to mitigate identified safety issues

**By**

- Analysing helicopter dynamics on wind turbine wake encounters
- Providing guidance to mitigate safety hazards
- Providing recommendations for legislation
- Disseminating the findings to the appropriate authorities and parties concerned
- Wake Vortex Encounter scale used for rating

30 KNOT WAKE, 20 KNOTS, 3D (30.03.17 RUN 4)

D – corrective action requires immediate and considerable pilot effort
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ESR 7 Mitigation of Airwake Hazards

ULIV + UoG
ULIV: Mark White
UoG: George Barakos
Tools and strategies to reduce the threat posed by wake encounters are lacking in the helicopter community.

What safety metrics and standards need to be developed to improve safety of rotorcraft operations in turbulent environment?

How can technology (hardware and software) and training be used to reduce the risk of an incident when operating in such environments?
develop new training and operating paradigms to improve rotorcraft safety in “turbulent” environments.

develop and demonstrate the tools needed to provide a pilot with a real-time wake information capability.

produce a synthetic display to aid the pilot’s ability to manage the risk during operations in turbulent environments.

develop new methodologies for characterising the hazard presented by airwakes and assess the fidelity requirements for airwakes for use in piloted simulation activities.
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Development of Severity/HQ Criteria