Offshore Helicopter Related Research at the University of Liverpool

Dr Mark D White

mdw@liverpool.ac.uk

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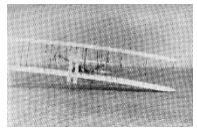
Flight Science and Technology

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**

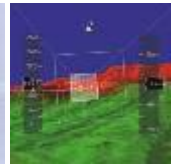


Aircraft HQ and Flight Control

- 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

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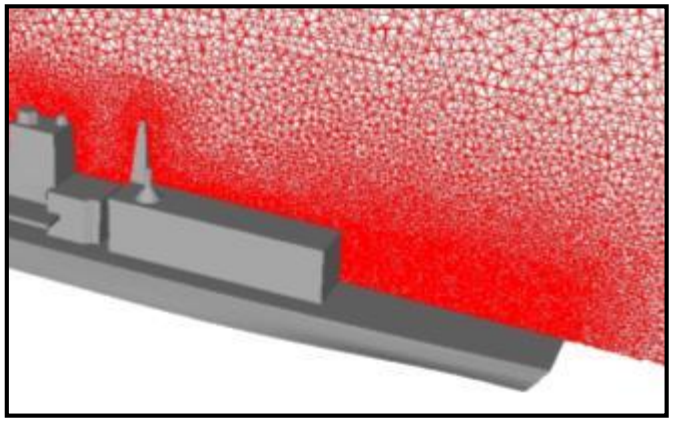
Helicopter-Ship Dynamic Interface
Funding: QQ, dstl, MoD, BAE, AW/LH

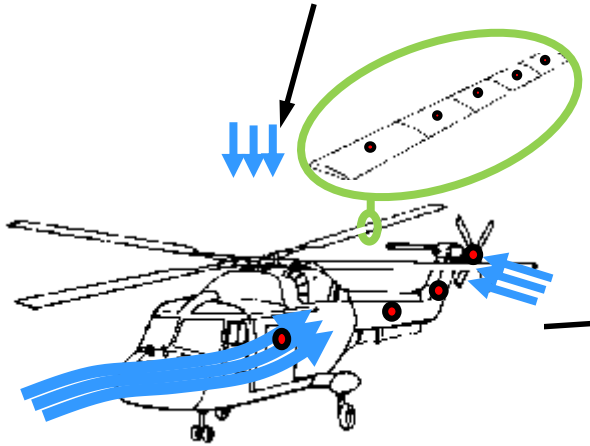
Questions:

- 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?

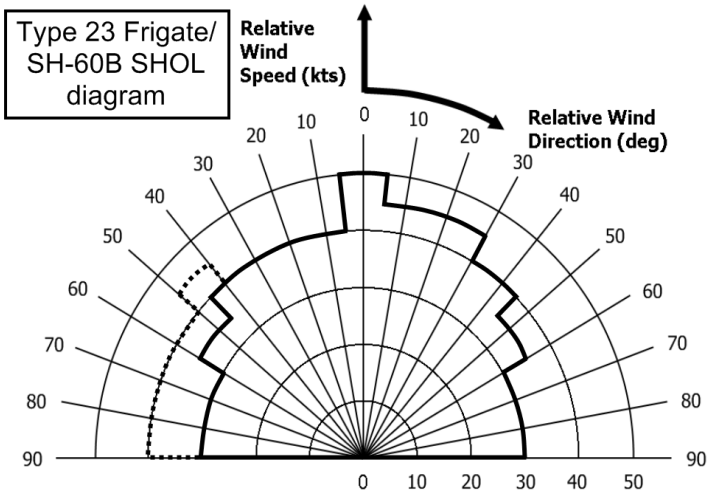
Creating the Simulated SHOL



Unstructured, Time-Accurate CFD data (Fluent)



FLIGHTLAB Rotorcraft Model



Simulated SHOL

Motion Base Flight Sim
Maritime Visual Environment
Ship Motion

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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

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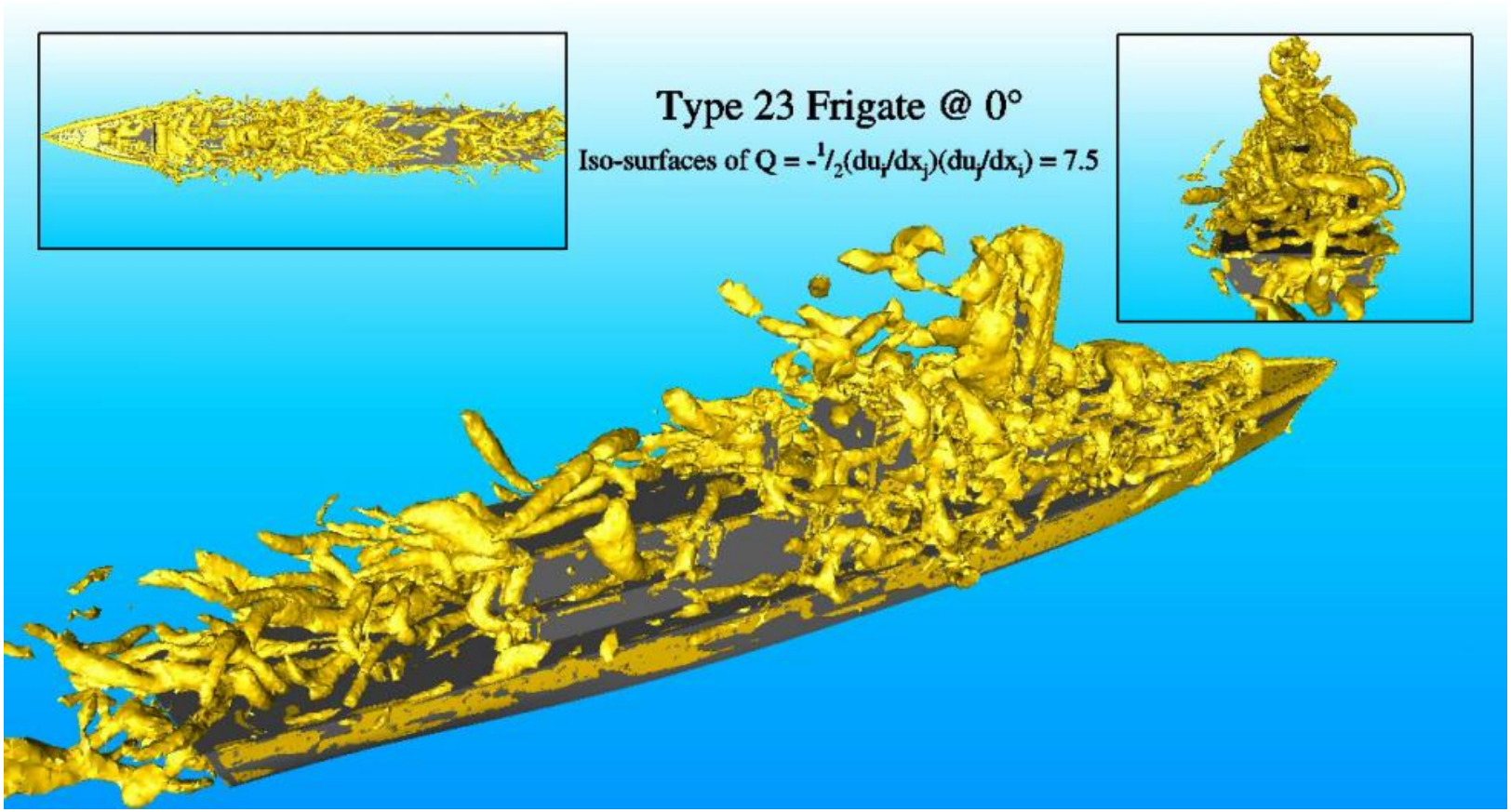
T23 Airwake



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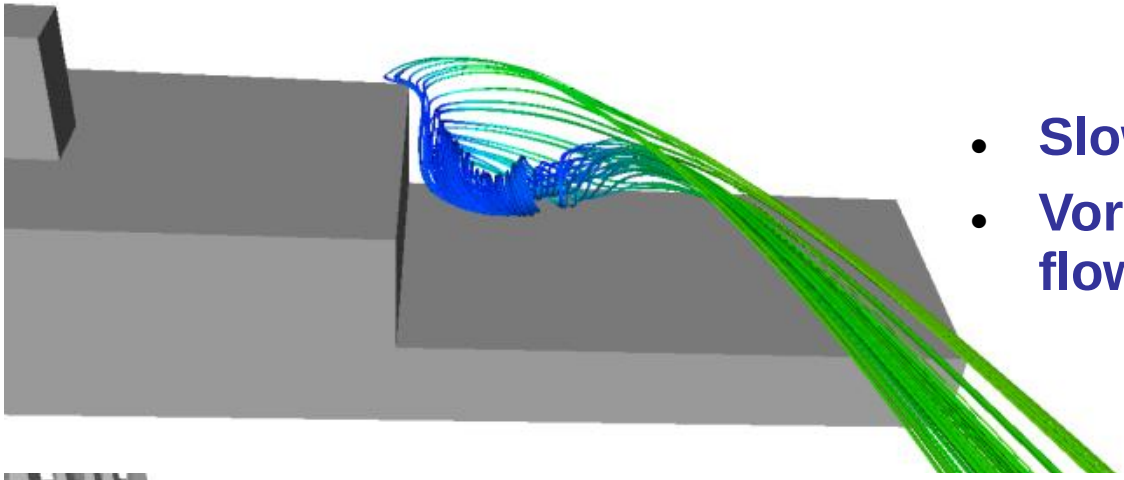
CFD Airwake Analysis

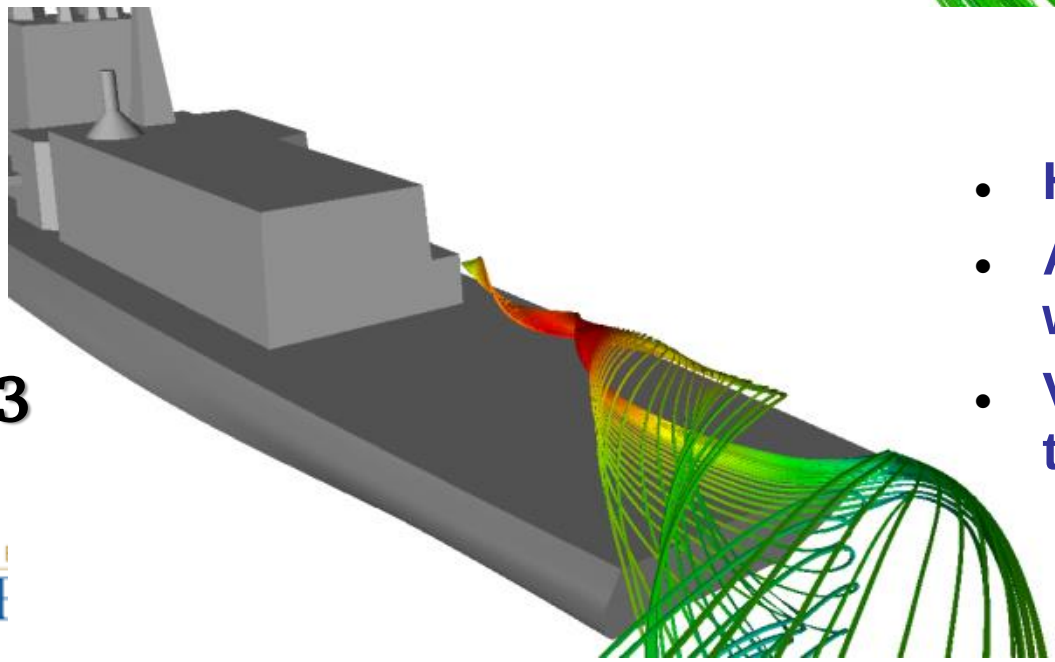
Deck-edge vortices

SFS2



- Slow rotating core
- Vortex aligned with flow direction

Type 23



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

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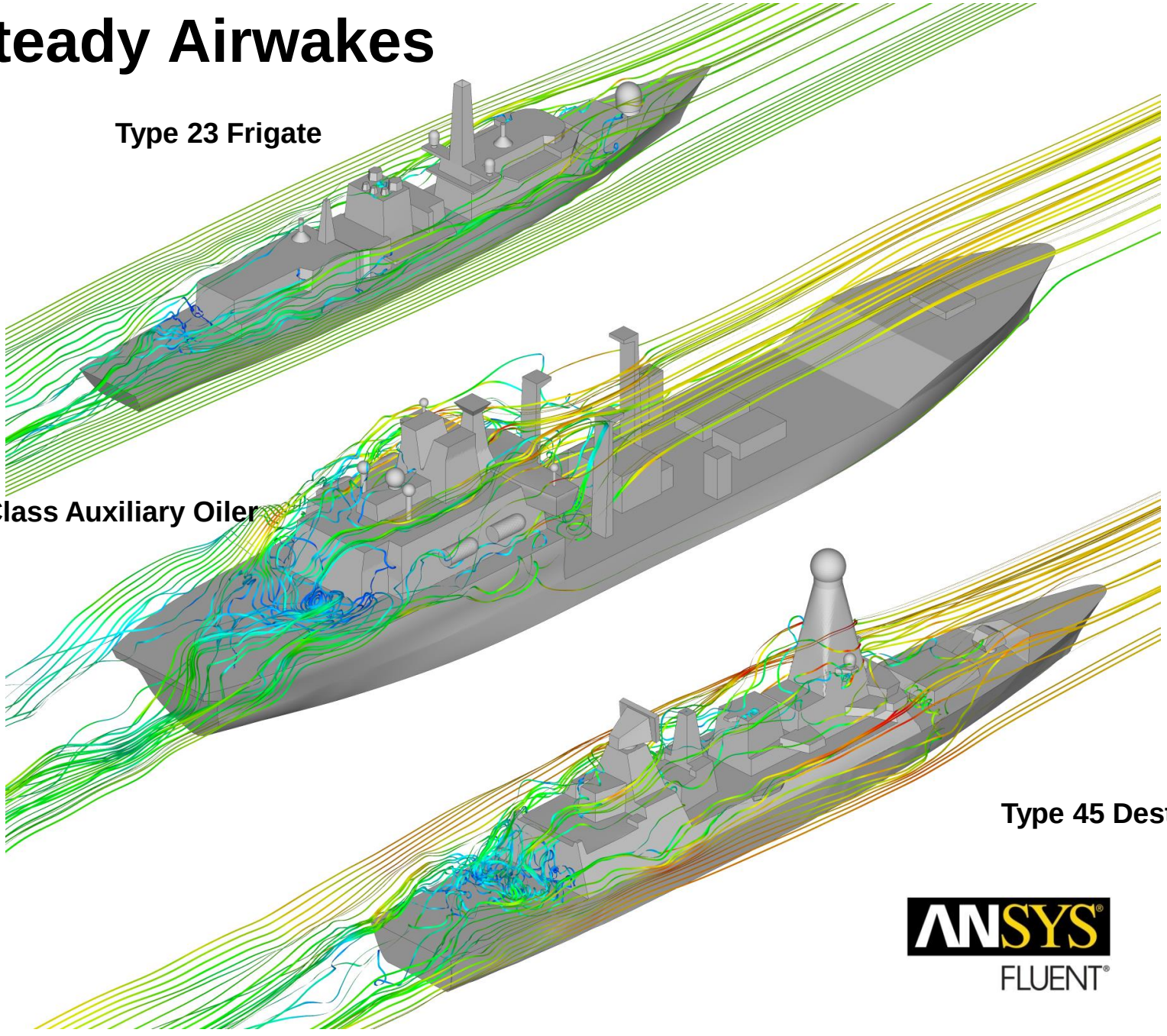
ANSYS FLUENT

Unsteady Airwakes



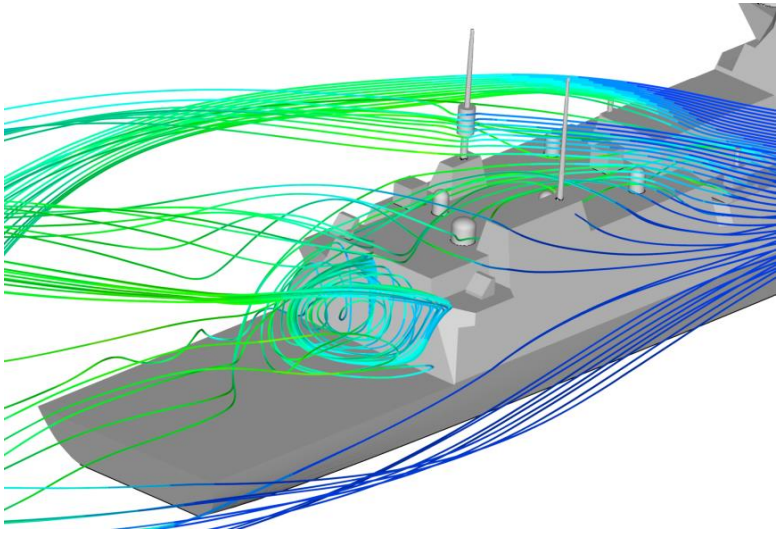
ANSYS® FLUENT®

Future Combat Ship

BAE SYSTEMS

Superstructure Aerodynamics

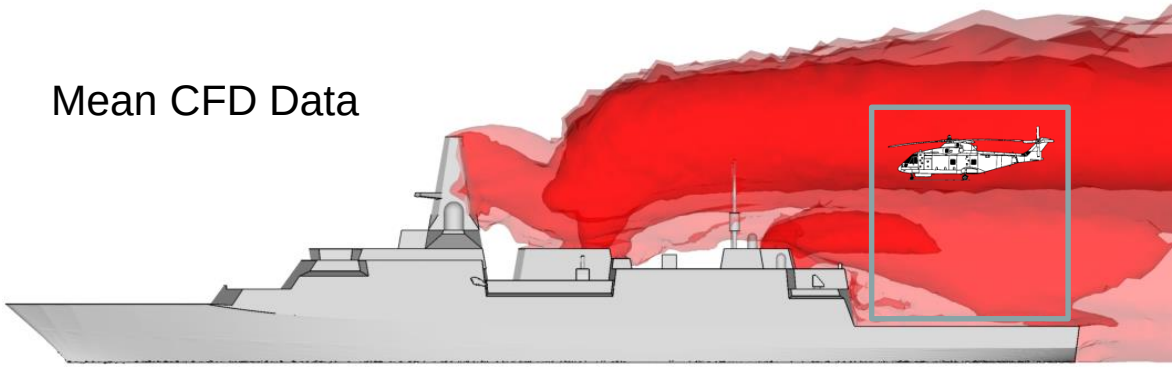
- Effect of geometric features on airwake & helicopter
- Anemometer placement
- Engine exhaust efflux
- RWUAS



Exhaust Plume Analysis, Headwind

Isosurfaces of Exhaust Temperature for Headwind WOD

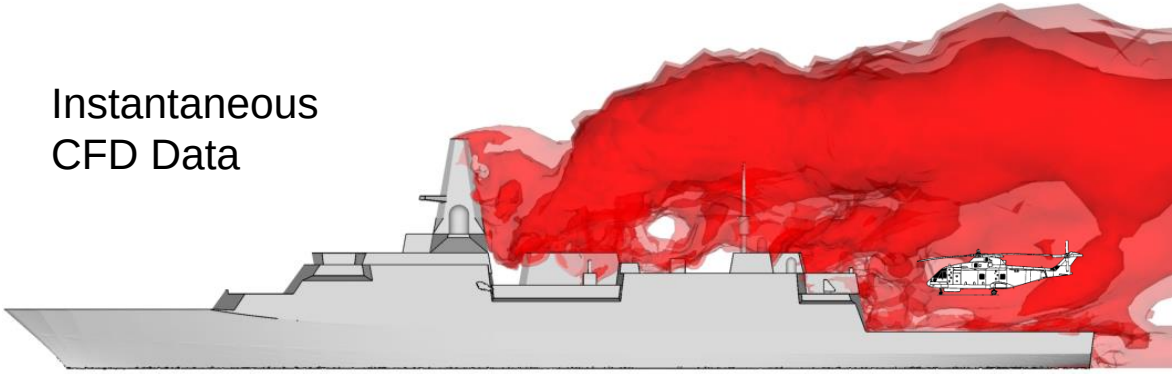
Mean CFD Data



Temperature criteria domain as defined by CAP 437

Merlin in high hover position with underslung load

Instantaneous CFD Data



Merlin in conventional hover position

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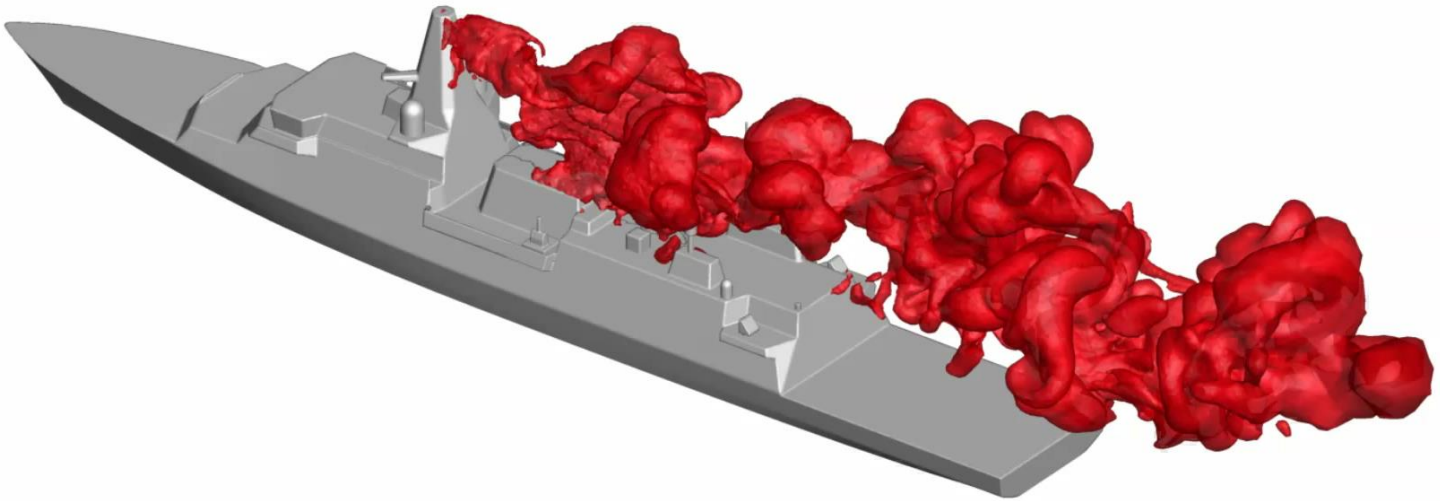
Mean Temperature (above ambient): 1°C 2°C 5°C



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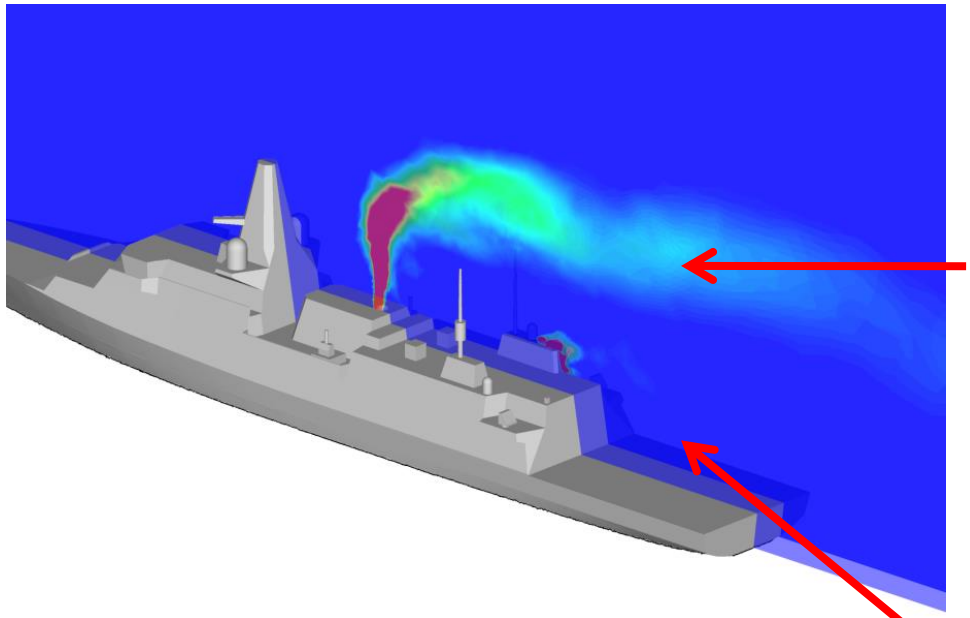
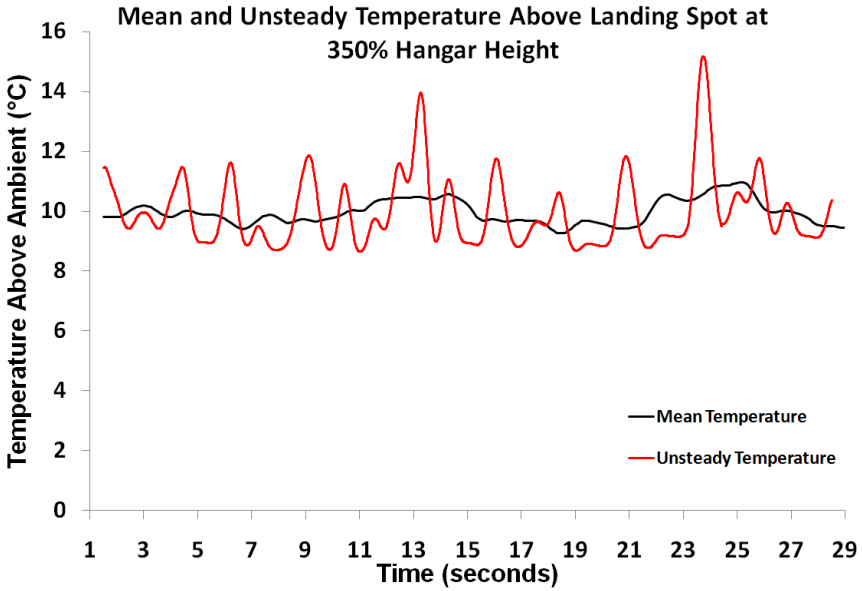
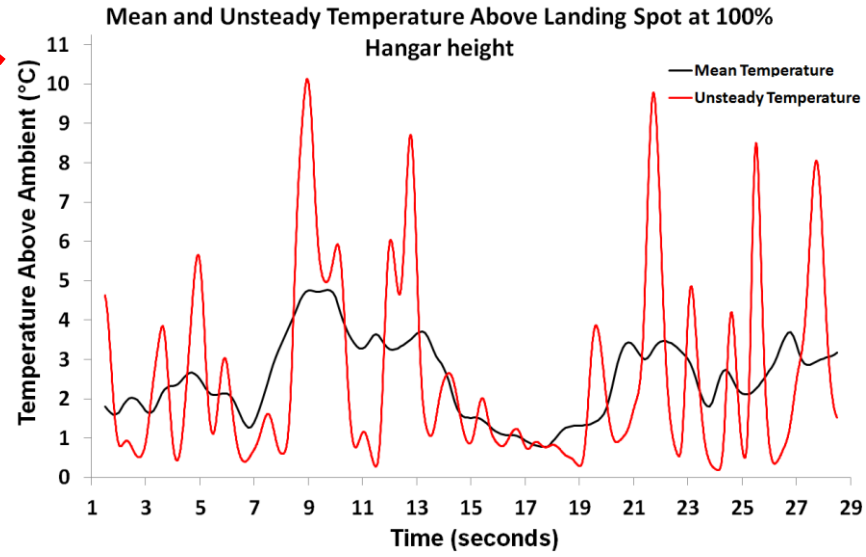
Exhaust Plume Analysis







Temperatures remain at elevated levels above the flight deck, in this case at 350% hangar height (28 m).

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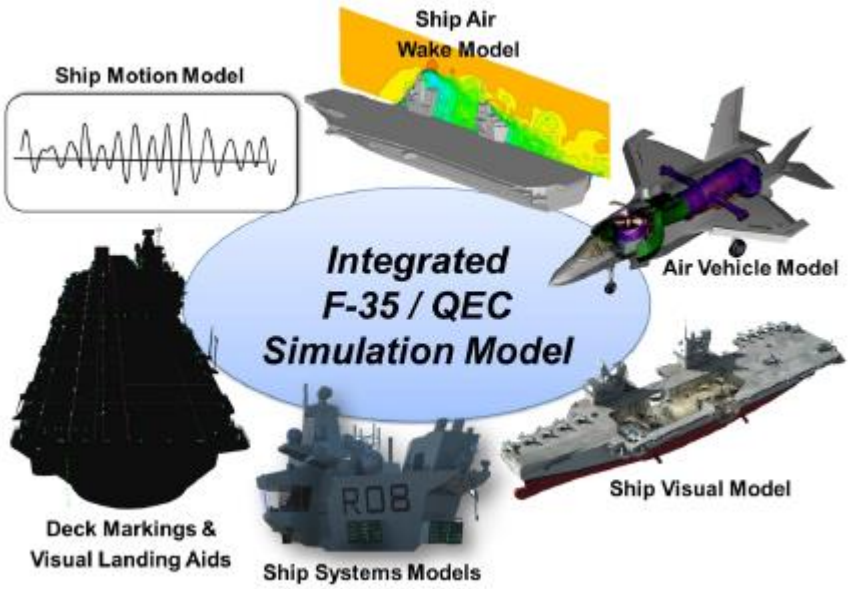
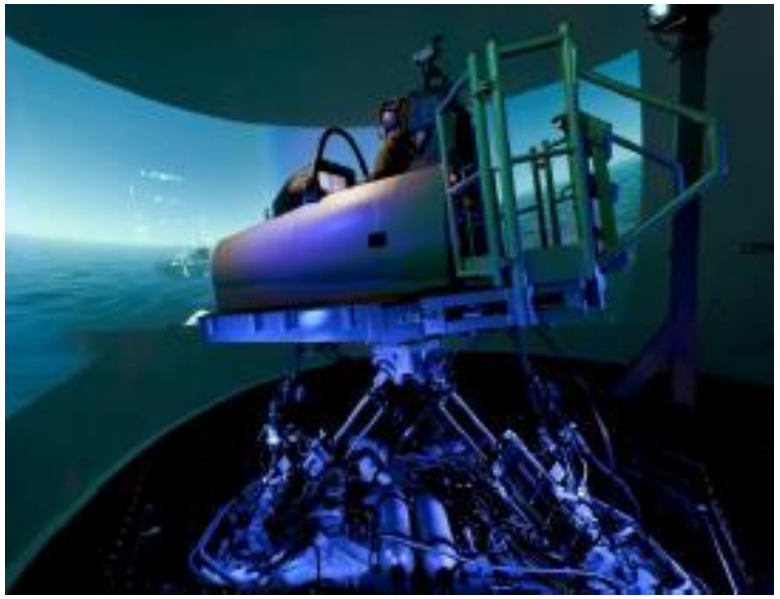
Queen Elizabeth Carrier Flight Simulation

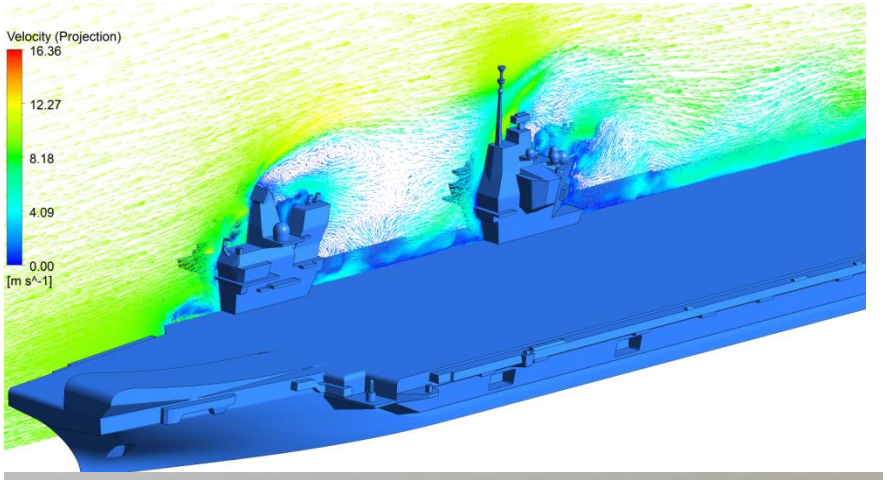
- Work with BAE to produce QEC flight simulation environment at Warton and Liverpool, **2 PhDs**
- Create validated airwakes
- Develop techniques for handling large airwakes
- Develop generic STOVL flight mechanics model





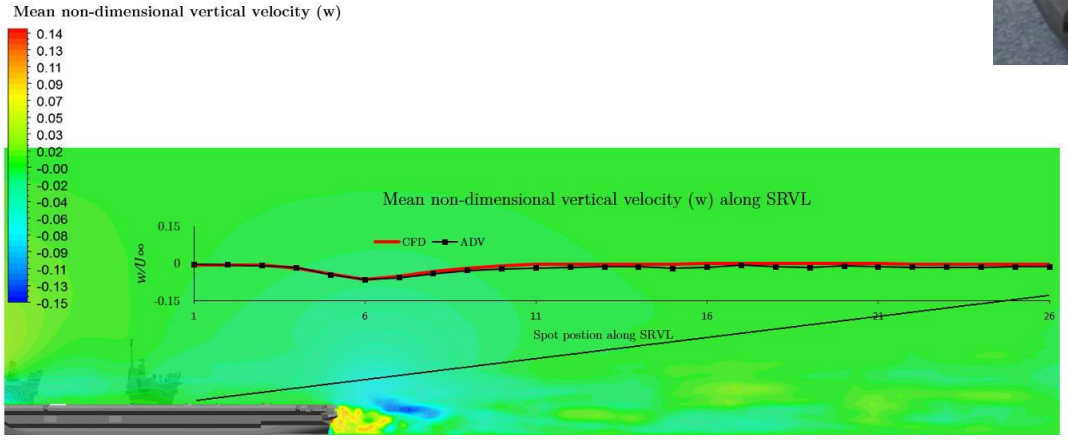
BAE SYSTEMS

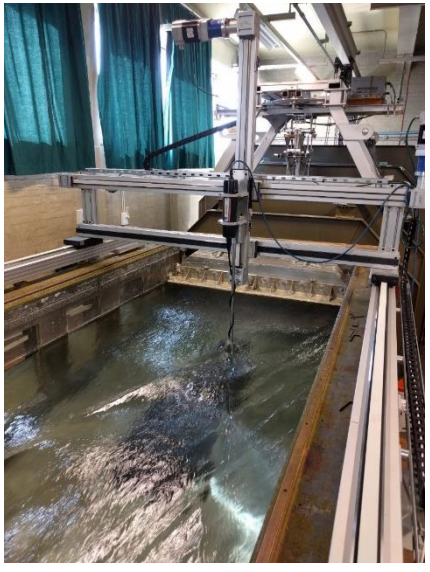
QEC Flight Simulation



Creation of CAD model for:

- CFD – unsteady airwake for flight simulation
- Experimental model (1.4m long) for 3-D velocity measurements in water tunnel

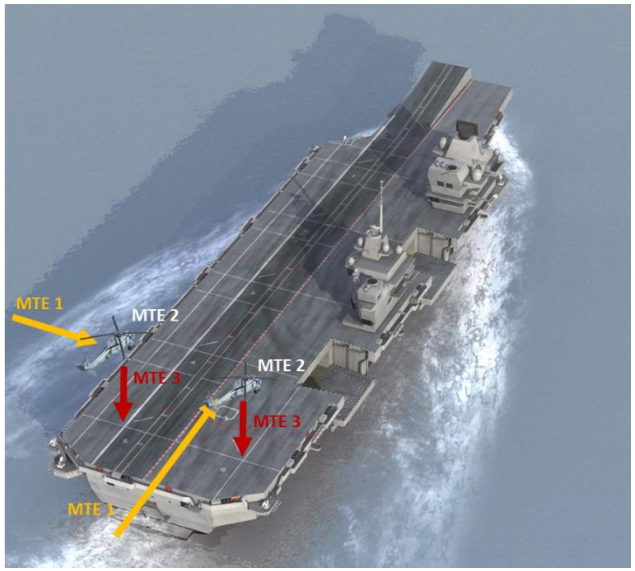


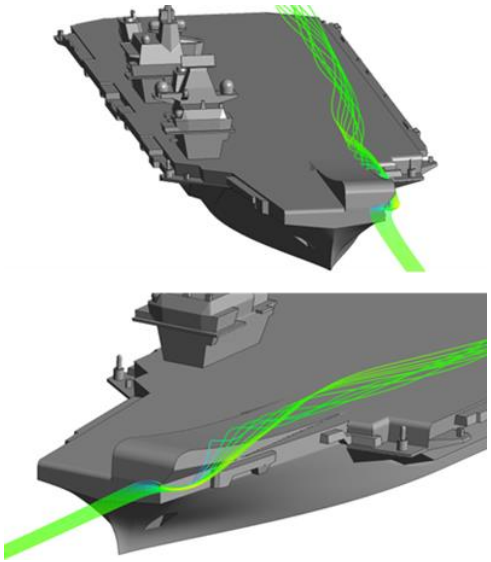


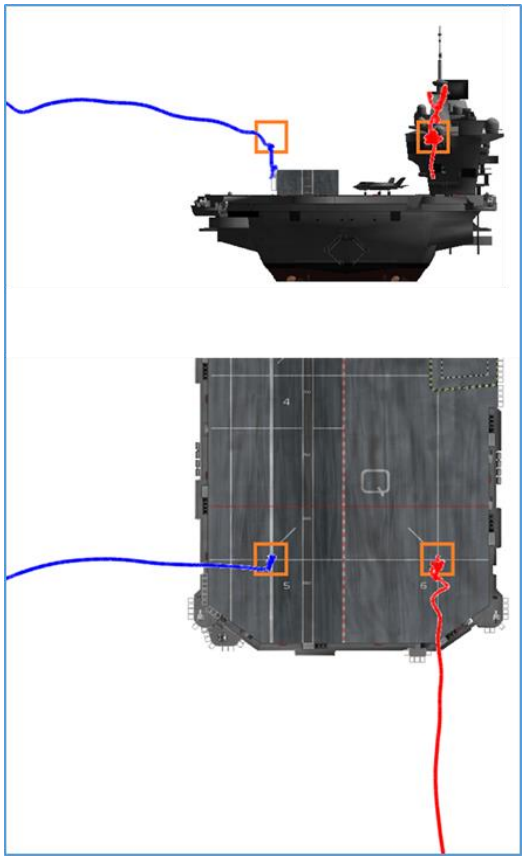
QEC 1:202 – mean *w*-component velocity along SRVL glideslope.

Initial UoL Sim Testing

2 x 2 day trials with ex-RN Test Pilots







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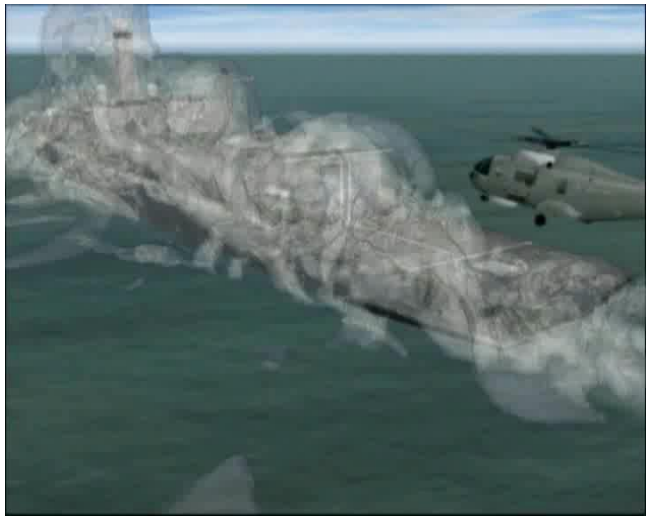
NATO AVT-315 “Comparative Assessment of Modelling and Simulation Methods of Shipboard Launch and Recovery of Helicopters”

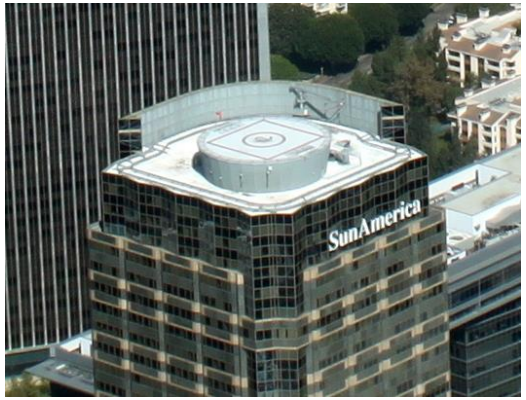
Future Dynamic Interface Challenges

- 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

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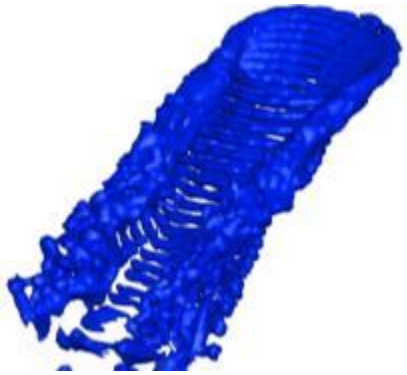
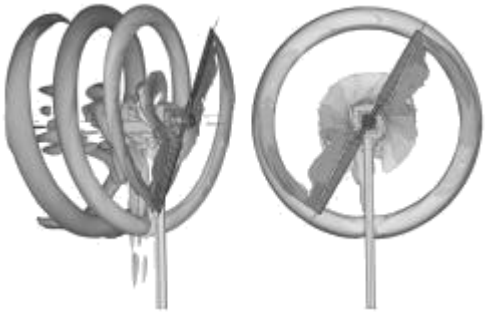
General Aviation Aircraft Encounters with Helicopter and Wind Turbine Wakes

- 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



Free-wake simulation of the Dauphin rotor



OPTIMAL

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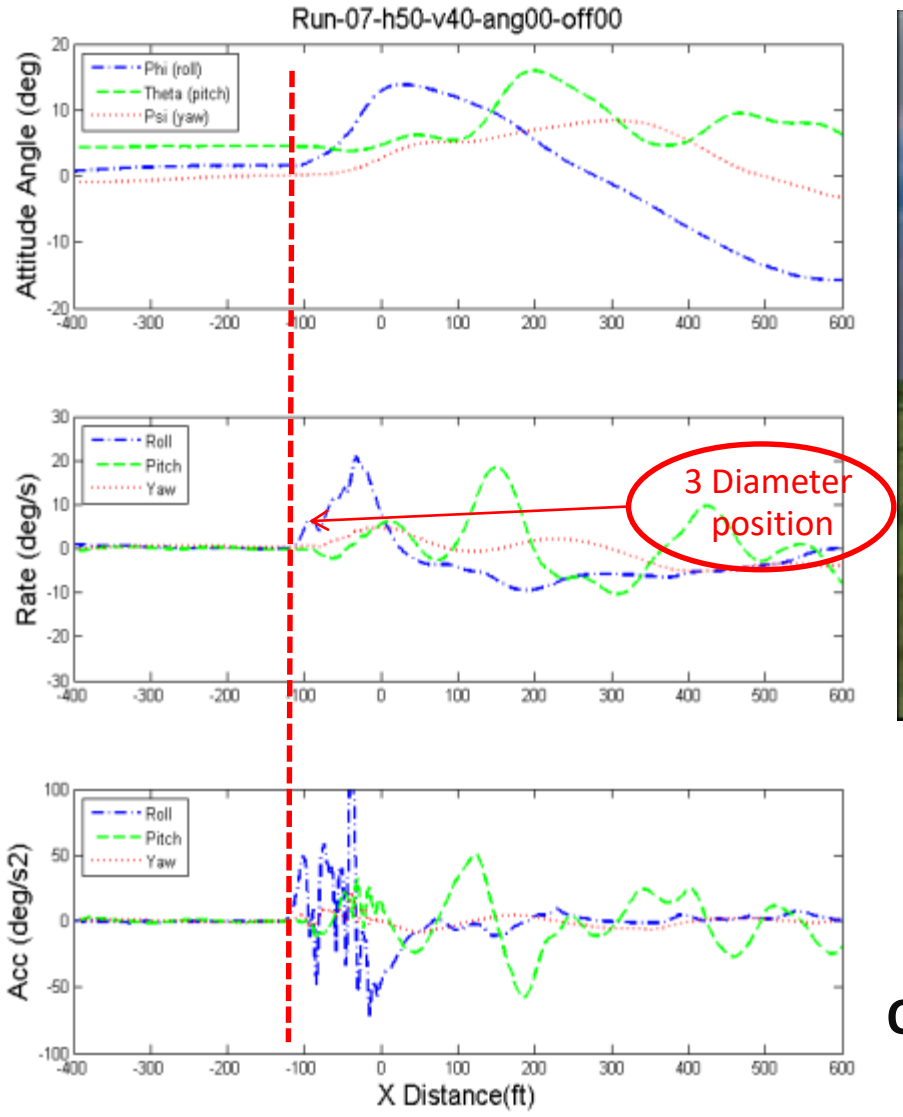
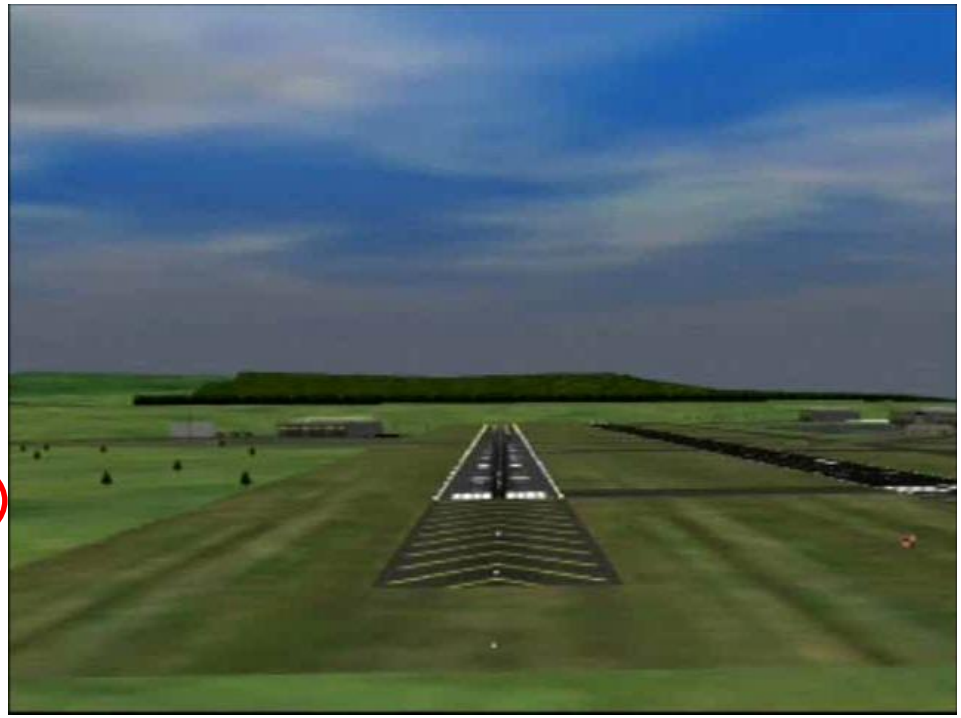
Civil Aviation Authority

Flight Science and Technology

LABORATORY

Piloted Simulation Trial





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

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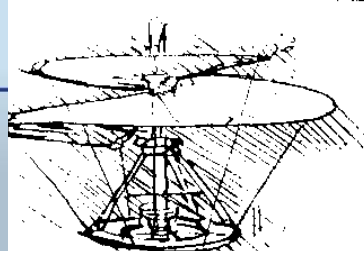


HC/AG-23 Status

- **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

D – corrective action requires immediate and considerable pilot effort

NITR S

ENGINEERING FOR ROTORCRAFT SAFETY

Mark White
University of Liverpool
Coordinator

SIMULATION AND PREVENTION OF ICE FORMATION AND SHEDDING ON ROTORCRAFT

IN SERVICE HEALTH MONITORING FOR ROTORCRAFT STRUCTURES

INNOVATIVE DESIGN FOR TILTROTOR COCKPIT FOR THE REDUCTION OF PILOT WORKLOAD

ROBUST FLIGHT CONTROL OF ROTORCRAFT MANOEUVRES IMMERSED IN OBSTACLE'S TURBULENCE

ROTORCRAFT WAKE MODELLING

DEVELOPMENT OF THE PHASE AGGRESSION CRITERION FOR ADVERSE ROTORCRAFT PILOT COUPLING PREDICTION AND REAL-TIME DETECTION (PAC)

MITIGATION OF AIRWAKE HAZARDS

MODELLING OF BROWN/WHITE-OUT

ENHANCED HELICOPTER HANDLING QUALITIES THROUGH VIBRATORY LOADS EXPLORATION

REVEALING ADVERSE ROTORCRAFT PILOT COUPLINGS INDUCED BY FLIGHT CONTROL SYSTEMS

UNDERSTANDING THE USE OF AUTOMATION IN HELICOPTERS

ALLEVIATING FLIGHT SIMULATOR NEGATIVE TRANSFERENCE FOR HELICOPTER OPERATIONS

THE PARTNERSHIP

NITROS

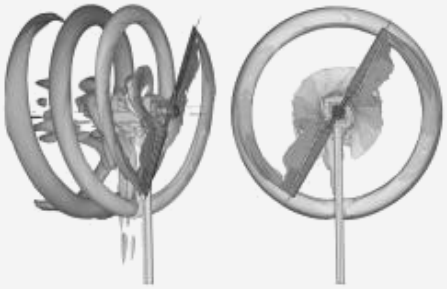
ENGINEERING FOR ROTORCRAFT SAFETY

ESR 7 Mitigation of Airwake Hazards

ULIV + UoG
ULIV: Mark White
UoG: George Barakos

Key Problem ESR7

- 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?



Research Outcomes ESR7

- 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

Offshore Helicopter Related Research at the University of Liverpool

Dr Mark D White

mdw@liverpool.ac.uk

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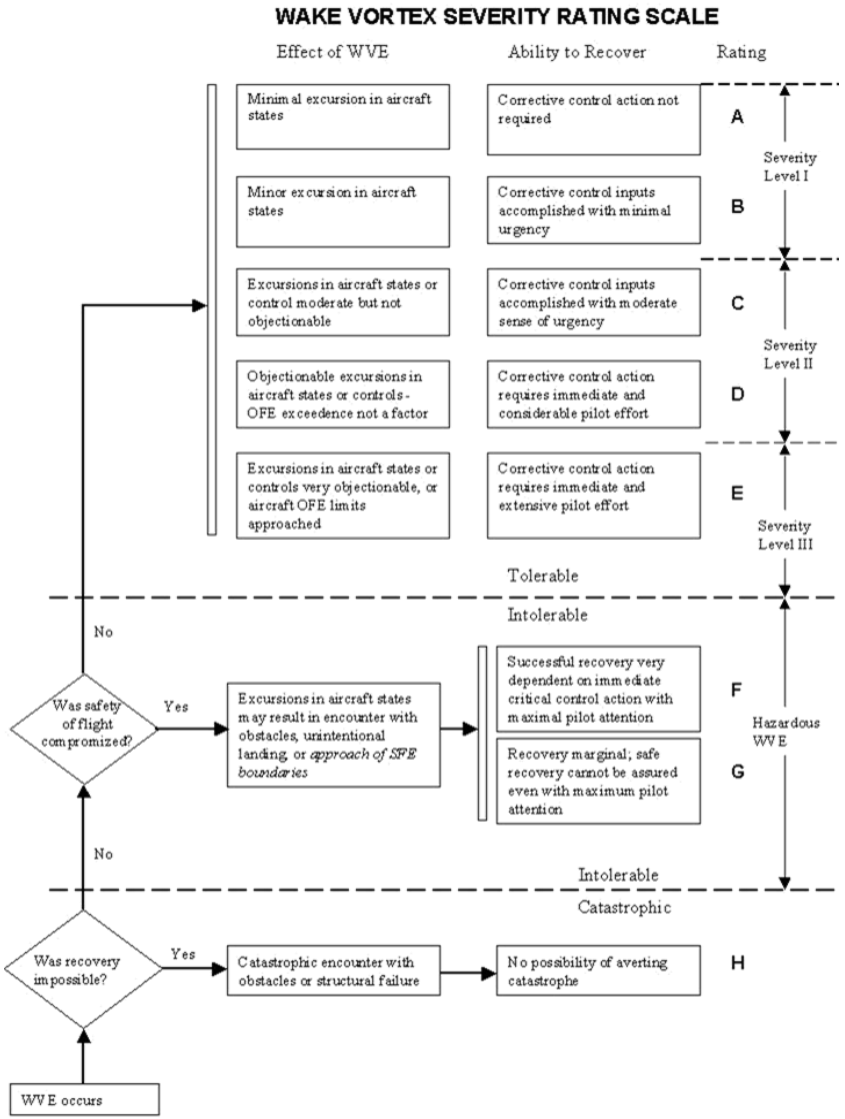

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Development of Severity/HQ Criteria