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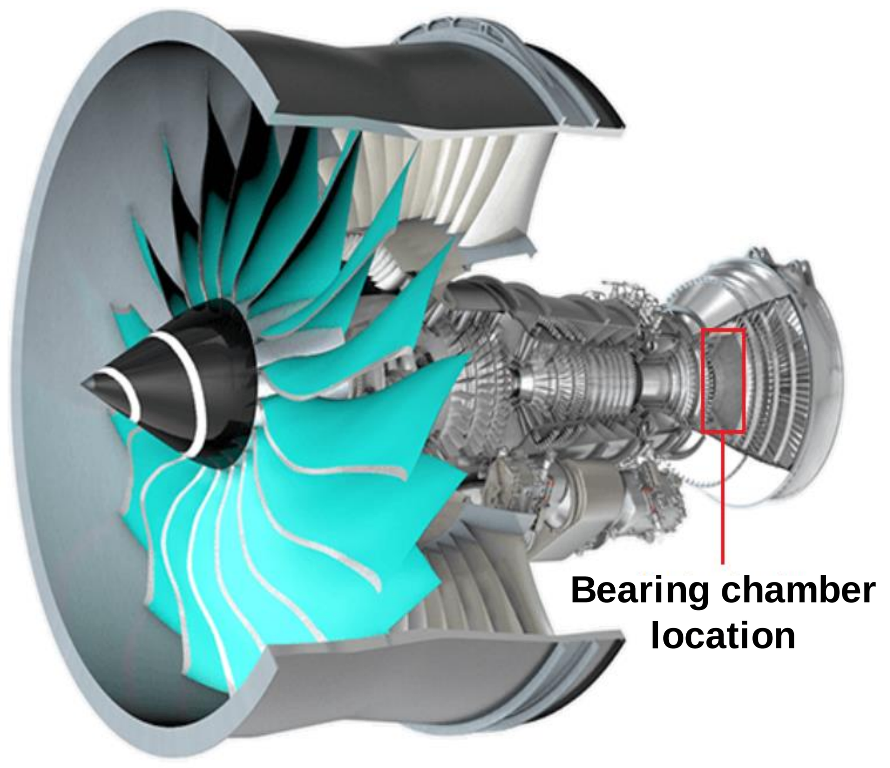
Modelling gas-liquid shearing flows in aero-engine bearing chambers using CFD coupled with Machine Learning

PhD Student: Luc Bertolotti
Academic Staff: Dr Richard Jefferson-Loveday, Dr Stephen Ambrose

Background and Problem statement

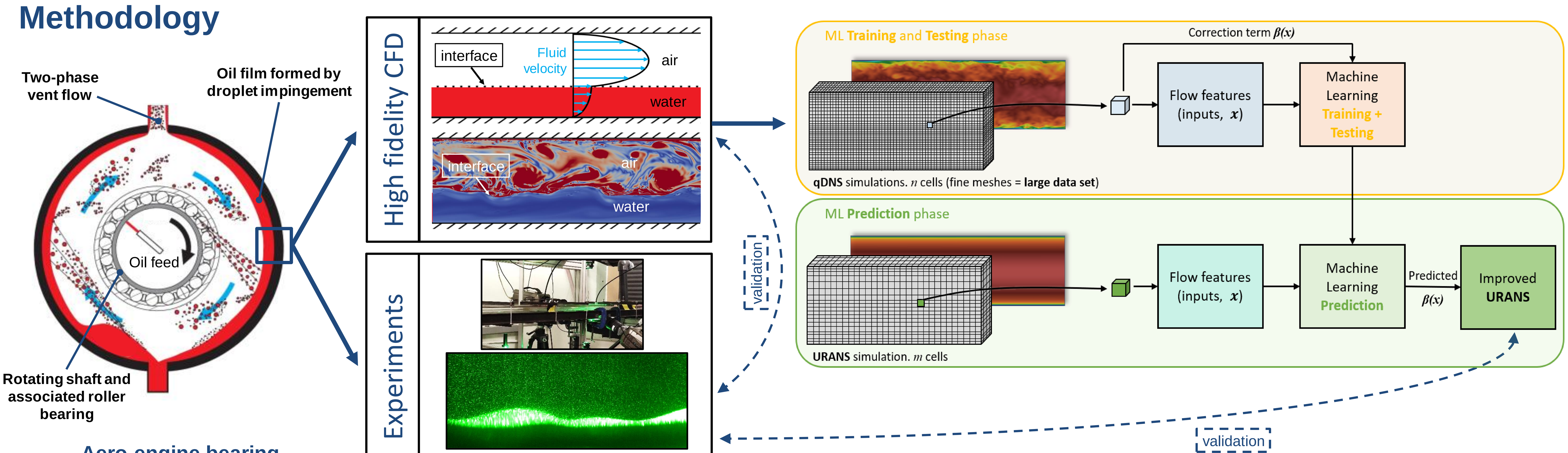
A **shearing flow** is the result of adjacent fluid phases moving at different velocities. In aero-engine bearing chambers, shearing flows are formed by air and oil, creating strong stresses where they interface due to large velocity and density differences.

Computational Fluid Dynamics (**CFD**) can be used to predict the flow behaviour and the oil film thickness distribution in bearing chambers. Averaged models (**URANS**) are used for industrial purposes to reduce computation costs. However current models are inaccurate resulting in an **overestimation** of the **interfacial turbulence**. Corrected models including turbulence damping have been proposed but are very case sensitive and no guidelines on the use of turbulence damping exist [2].



Rolls-Royce UltraFan aero-engine [1]

Methodology



Aero-engine bearing chamber section

Channel PIV measurements [3]

Aim

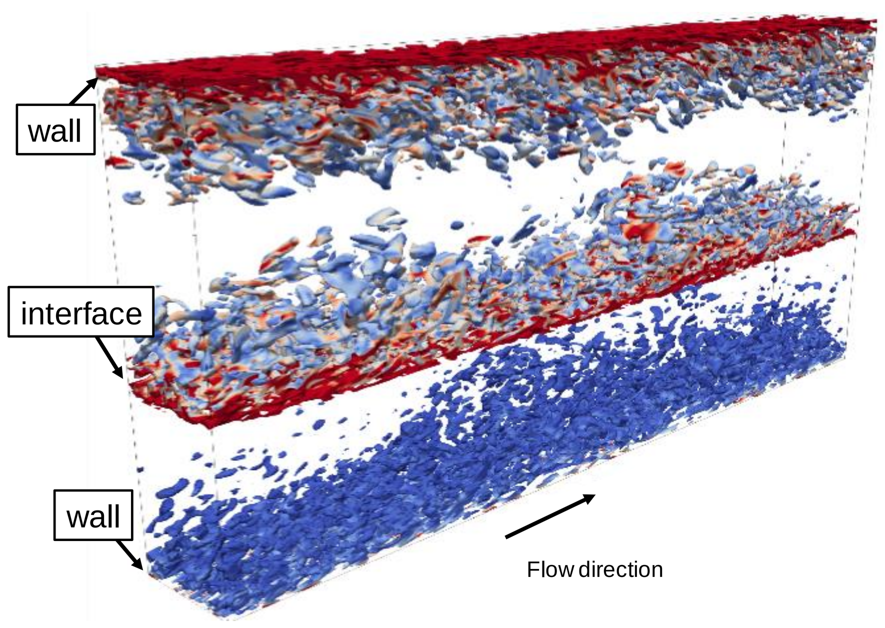
Improve **URANS** models used for shearing flows in bearing chambers by informing the **interfacial turbulence** with high fidelity CFD simulation such as quasi Direct Numerical Simulation (**qDNS**) and apply an appropriate correction.

Objectives

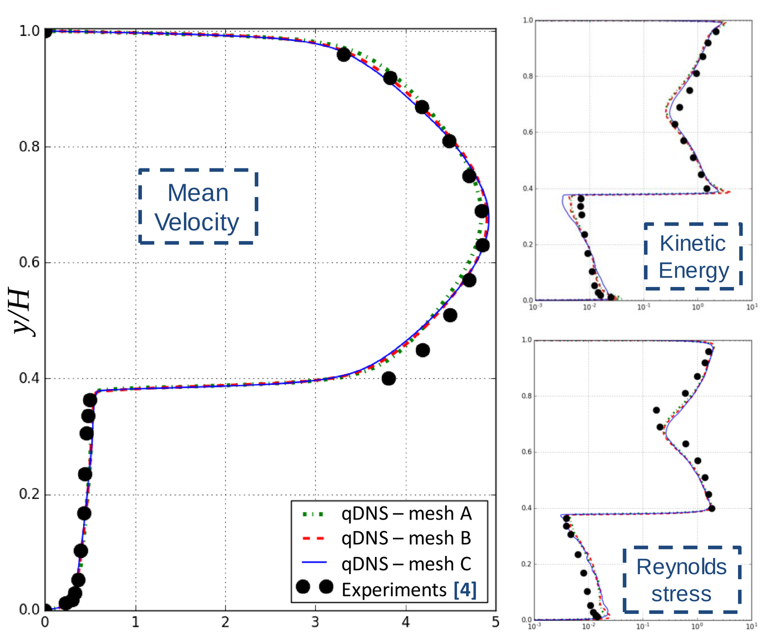
- Run **high fidelity CFD** for a range of flow conditions;
- Implement a **Neural Network algorithm** – Machine Learning model (ML) trained by high fidelity CFD data to correct URANS turbulence models' transport equations;
- Validate the corrected URANS models with experiments [3].

Preliminary results and high fidelity CFD

- Numerical results are compared to existing experiments [4];
- The VOF multiphase method was found to be computationally cheaper than the Euler-Euler method with OpenFOAM [5].



Interfacial and wall turbulence in qDNS represented with Q-criterion isosurfaces



Profile comparison: qDNS simulations vs experiments of [4]

Conclusions and future work

High-fidelity simulations on two-phase shearing flows in a horizontal channel will provide good datasets for the training of the ML model. An assessment will be made on the choice of ML input functions and their impact on the performance of the RANS model informed by ML. This will be achieved through coupling the RANS and ML models.

Acknowledgments

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References

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