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THE AEROSPACE ECOSYSTEM

Aerodynamic and Stability Optimisation of Non-planar Wings

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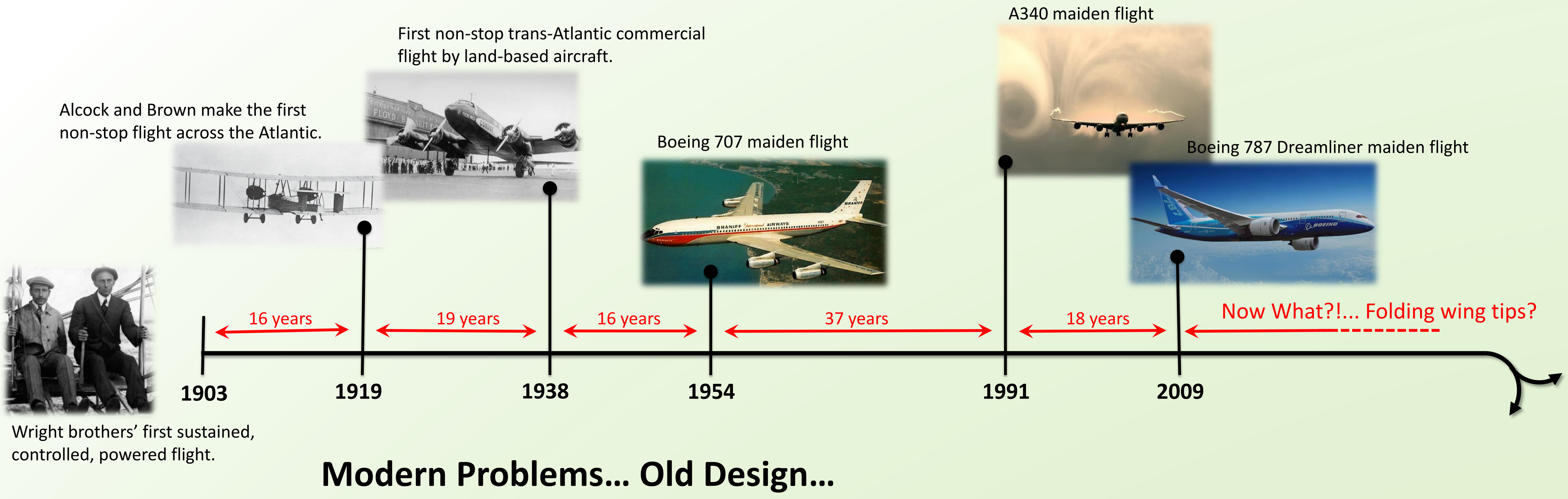
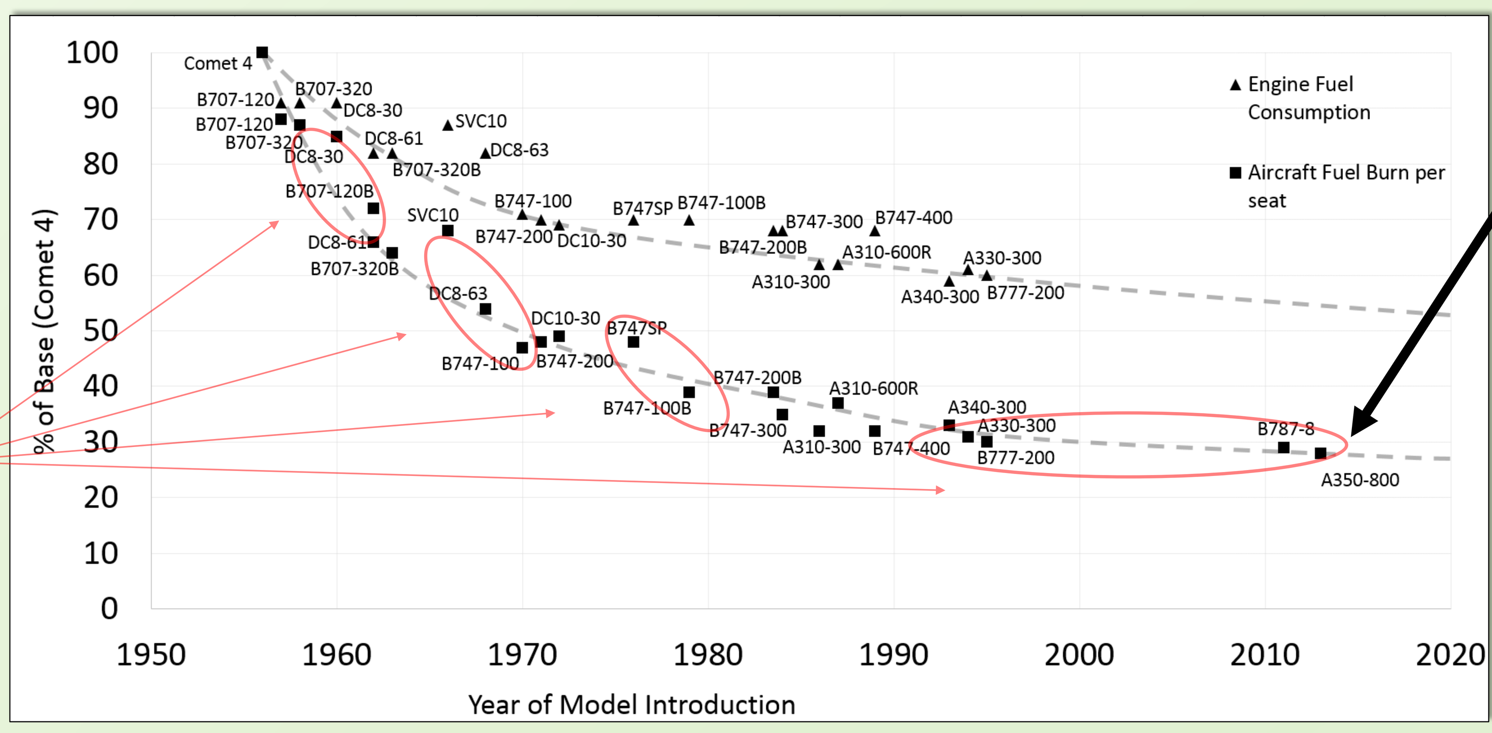
Introduction

Non-planar lifting systems exhibit reductions in drag when compared to conventional planar systems.[1] Drag reduction in aircraft results is a direct decrease of operational costs and an in-direct decrease in noise and emissions.[2] In the cruise phase of large transport aircraft, typically 90% of flight time[3], drag consists of friction and induced drag, where induced drag contributes **40%-45% of total drag budget**.[4] C-wing configurations have been recognised for their potential to enhance large transport aircraft and reduce induced drag.[5]
The **European Commission** and the **Advisory Council for Aeronautics Research** (ACARE) have joint strategic goals in place to address these issues while considering economic and social benefits. Some specific goals highlighted in their **Flightpath 2050**[6] plan include a **75% reduction of Co_2 emissions** per passenger kilometre whilst also **reducing observed noise emissions of flying aircraft by 65%** regardless of traffic growth. It is recognised that the world is entering a new age in which challenges in globalisation, fluctuating financial systems, climate change, realisation of our finite recourses, and the demand for an evermore efficient/sustainable infrastructure is driving modern innovations.



Modern Problems... Old Design...

Tube-Wing aircraft: old cheap design… but it works…Large long-range aircraft performance is maturing. Most significant performance improvement has rooted from bypass engine refinement, with 4 noticeable technological jumps.



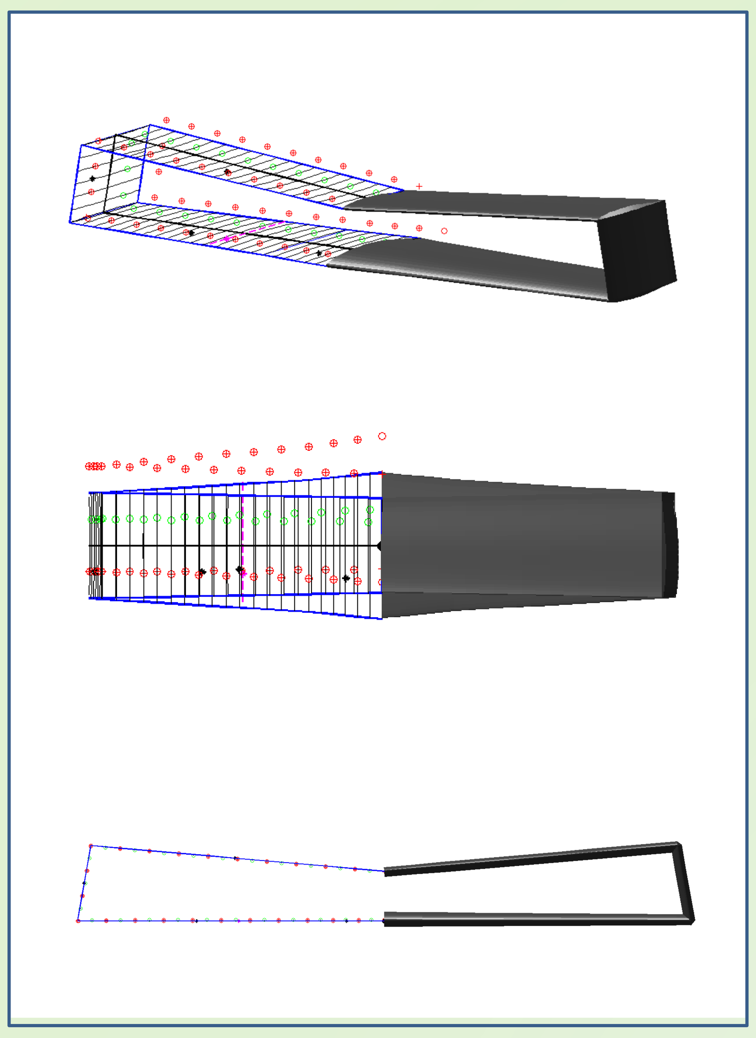
Further performance improvement to long-range commercial aircraft is becoming stagnant!

Further improvement in bypass technology is hindered by limitations in propulsive and thermal efficiency.

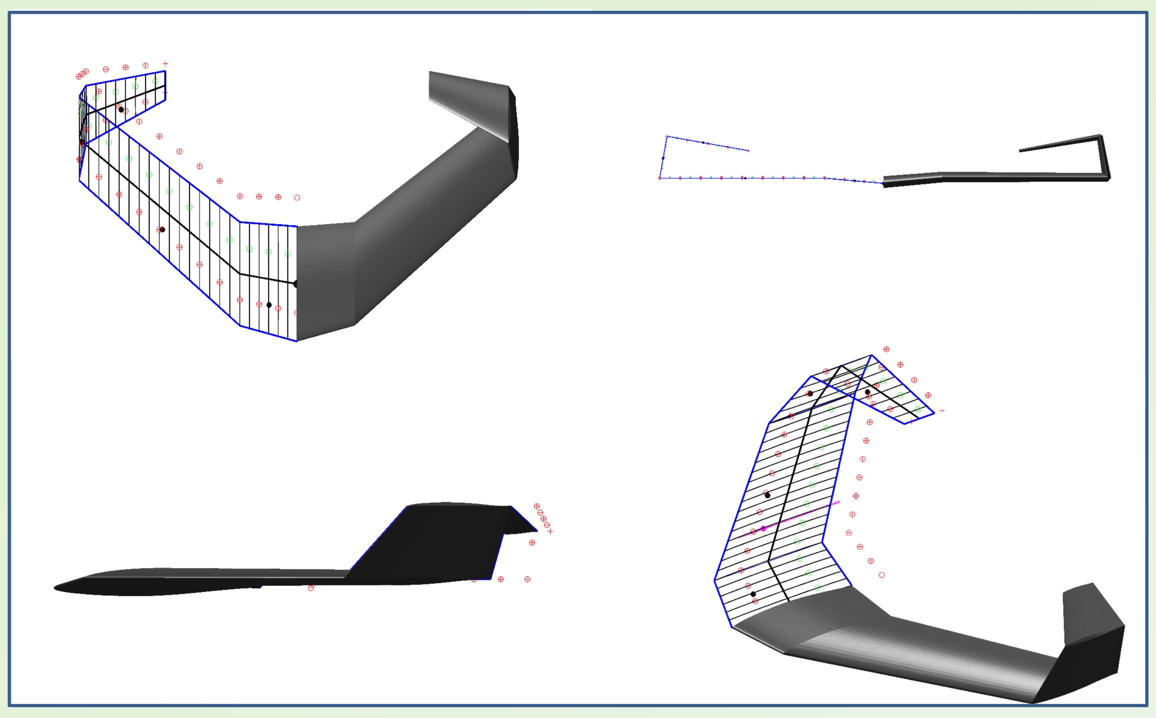
Aerodynamic Optimisation

- A novel population structured Genetic Algorithm coupled with a vortex ring method explores and exploits a user defined search space to identify optimal solutions. The vortex ring method is capable of meshing non-planar lifting surfaces automatically while accounting for aerofoil thickness and camber to a used defined fidelity. Wake and Trefftz plane (for induced drag calculation)[7] are included in mesh sequence.
- Up to 33 variables including: angle of attack, root chord, tip chord, span, twist, taper, sweep, dihedral and aerofoil section over 5 independently activated wing sections. Canard configuration also possible.
- Aerodynamic optimisation can be coupled with interdisciplinary optimisation for static aeroelastic deformation and pitch stability allowing multi-objective design trade-off.

Minimum induced drag solution

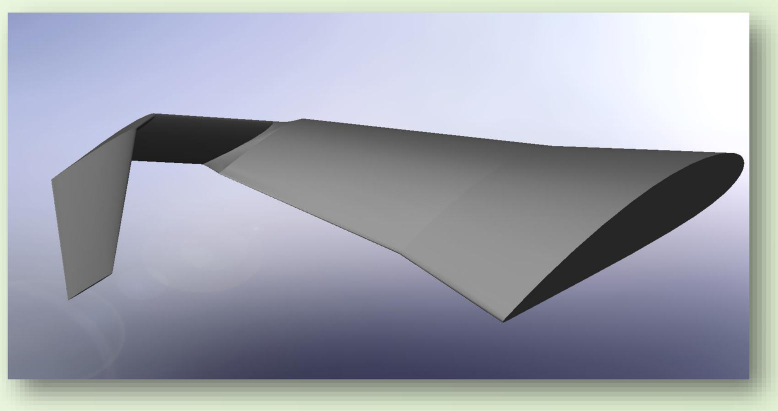


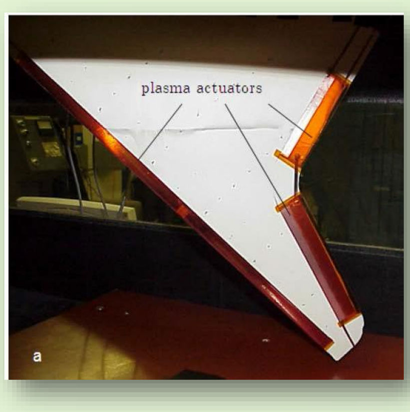
Minimised drag (induced + viscous) and root bending moment solution with a static margin of 0.2



To The Future…

Development of the aerostructural design/optimisation algorithm will endeavour toward the fabrication of a highly non-planar lifting surface; concept shown bellow. This will lead into gust response, structural dynamic characterisation and application of active flow control techniques such as plasma actuators as shown bellow.





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C-Wing Configuration: What is the Point?[5,8]

- Reduce wing span
- Reduce tip vortex strength
- Reduced vortex drag (improved lift/drag ratio)
- Efficient trim with shorter, tailless fuselage
- Improved lateral handling
- Potential aero-elastic control
- Control at high angles of attack
- Gust control & load alleviation
- Aero/structural performance though span loading

References
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