Preliminary Design of Ultra High Aspect Ratio Wings Incorporation Floating Folding Wing-tips

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There is currently much interest in the development of high Aspect Ratio Wings due to the inherent reduction in induced drag that they provide; however, there are a number of potential problems including the increased structural weight and the limits on the wingspan imposed by the airport gate sizes. The use of floating folding wingtips (often referred to as the Semi-Aeroelastic Hinge (SAH)) (see figure 1) has been shown to not only enable aircraft to meet the operational conditions in airports but also to reduce gust and manoeuvre loads imposed on the wing, enabling improved aerodynamic performance with no further weight gain[1], and improved roll performance [2]. Along with several proof of concept wind tunnel models [3], Airbus recently flew the AlbatrossONE flight demonstrator which validated the mathematical models (figure 2)[4].

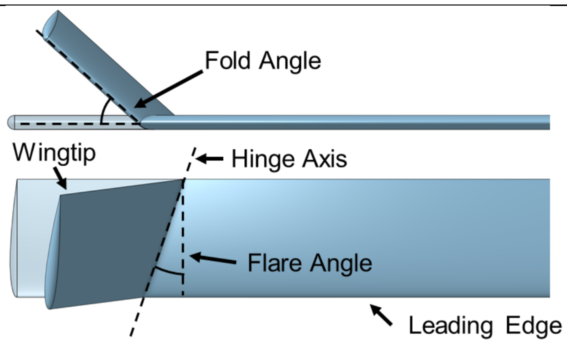

Figure 1. Floating Folding Wingtip Concept

Figure 2. AlbatrossONE Flight Demonstrator

What has been missing so far with the on-going work into the application of the SAH is how it affects the preliminary design process. The current CS2 U-HARWARD project is investigating designs of ultra-high aspect ratio wings, including the use of floating folding wingtips.

In this work, a comprehensive sizing of aircraft models is performed for a range of aspect ratios and different sized folding wing tips incorporating the semi-aeroelastic hinge. The hinge is locked during cruise allowing the optimum aerodynamic performance to be obtained, while releasing it during gust and manoeuvres to achieve effective load alleviation. The optimisation process uses a gradient based optimiser interacting with NASTRAN and to either minimise the weight or maximise the range subject to stress, strain, buckling and aeroelastic constraints. It was found that the wing-box mass reduces linearly with increasing proportions of the folding wingtip and around a 15% reduction in wing weight can be achieved by extending the folding wingtip up to 40% of the wingspan, leading to an improved range performance at the overall system level of about 3% (preliminary results - likely to change by the time the final paper is completed).

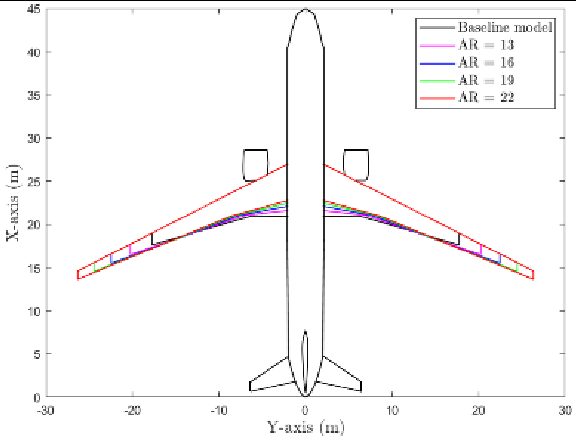

Figure 3. Different Aspect Ratios Considered

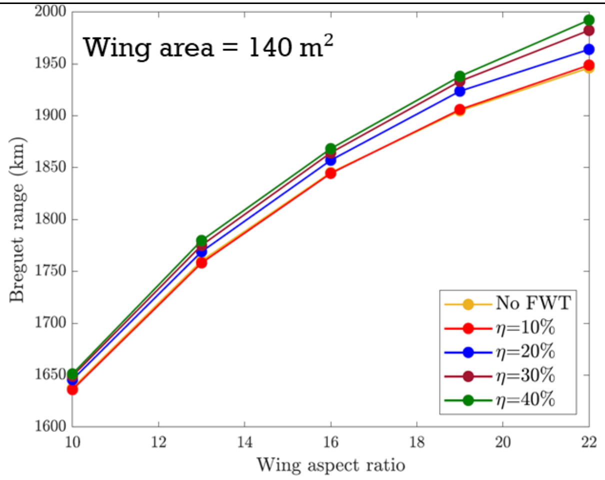

Figure 4. Effect of Folding Wingtip on Range

References

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