ENGINEERING SERVICES

AERODYNAMIC PERFORMANCE OF NLF AIRFOILS APPLIED TO LOW- AND HIGH-SPEED WINGS

Ramón LÓPEZ PEREIRA

08/October/2019

SAFRAN

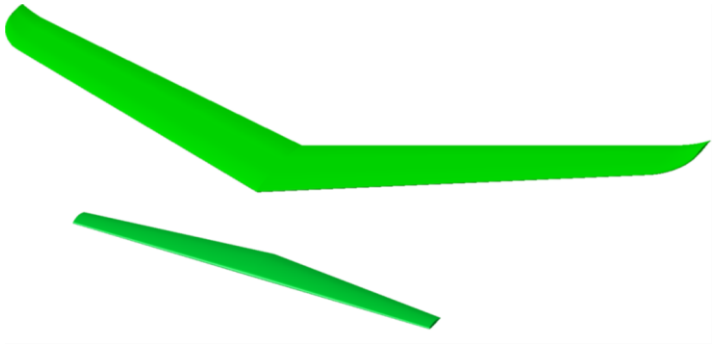
Summary

1

BACKGROUND

Background

- **This investigation was started as part of the Master Thesis „Analysis of the Aerodynamic Performance of NLF Airfoils" as required to obtain the Master of Engineering Degree on Aeronautics at Universidad Europea de Madrid.**
- **The first steps of this development are not shown in this presentation and involved the selection of the airfoils used hereafter and small-scale, low-speed wing designs.**
  - The High-Speed NLF airfoil RLPHSF(Raw Laminar Profile for High Speed Flow) was defined in this phase^.
  - The results for the CFD wing models were validated through wind tunnel testing.
  - A paper containing these development activities is WIP for release.



2

INTRODUCTION

Introduction

- **Aim: Does the use of NLF airfoils induce an improvement in terms of efficiency in cruise conditions against an equivalent 4-digit NACA airfoil?**
- **Two types of wings have been defined**
  - Low-Speed Wings with a NLF(1)-1015 airfoil and its 4-digit NACA equivalent (NACA4615).
  - High-Speed Wings with a newly developed, high-speed NLF airfoil (RLPHSF) and its NACA equivalent (NACA1709).
- **To compare performance, the Efficiency has been obtained at typical cruise conditions.**
  - Low-Speed Wings at 4900m ISA (FL160) ranging from M0.1 (30m/s, 60KTAS) to M0.3 (95m/s, 185KTAS).
  - High-Speed Wings at 11000m ISA (FL360) ranging from M0.3 (90m/s, 175KTAS) to M0.85 (250m/s, 485KTAS).
  - High-Speed Wings at 11000m ISA (FL360) and M0.77 (230m/s, 445KTAS) with LE-sweepback angles ranging from 0 to 10 degrees.
- **All cases have been modelled using the Lattice Boltzmann software XFlow.**

Introduction - Airfoil Shape Comparison NLF vs. NACA

Low-speed airfoils: NLF(1)-1015 vs. NACA4615

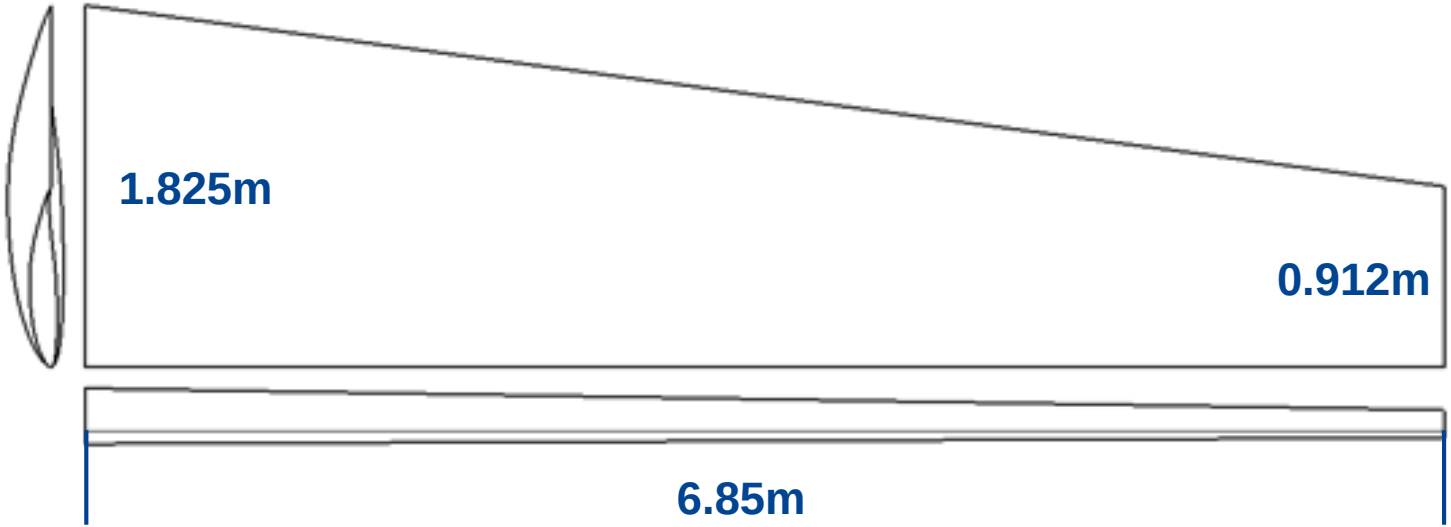
Introduction - Airfoil Shape Comparison NLF vs. NACA

High-speed airfoils: RLPHSF vs. NACA1709

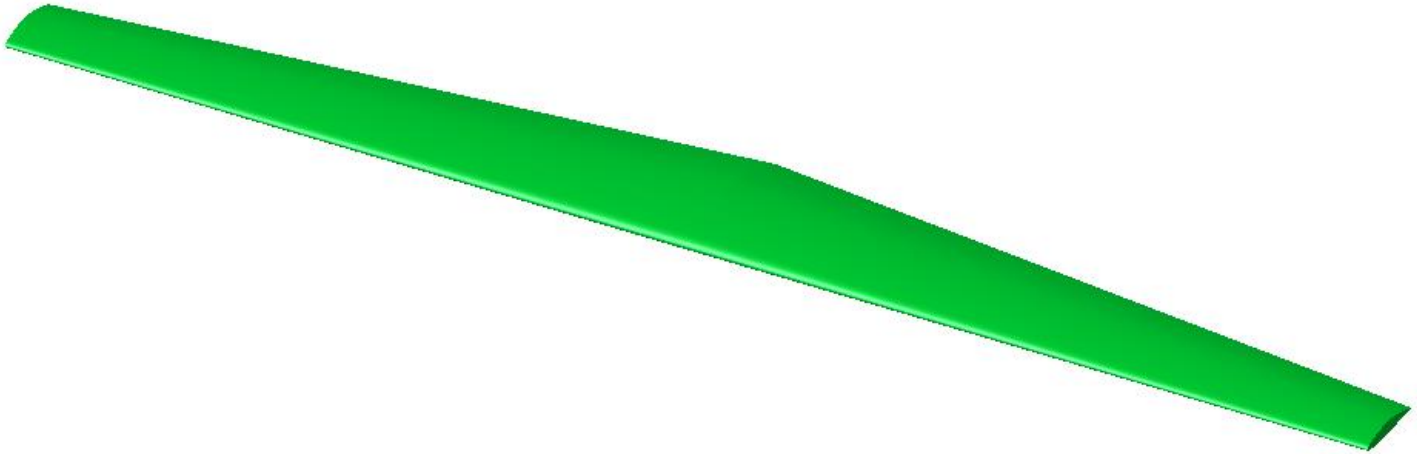
3

LOW-SPEED WING ANALYSIS: MACH SWEEP

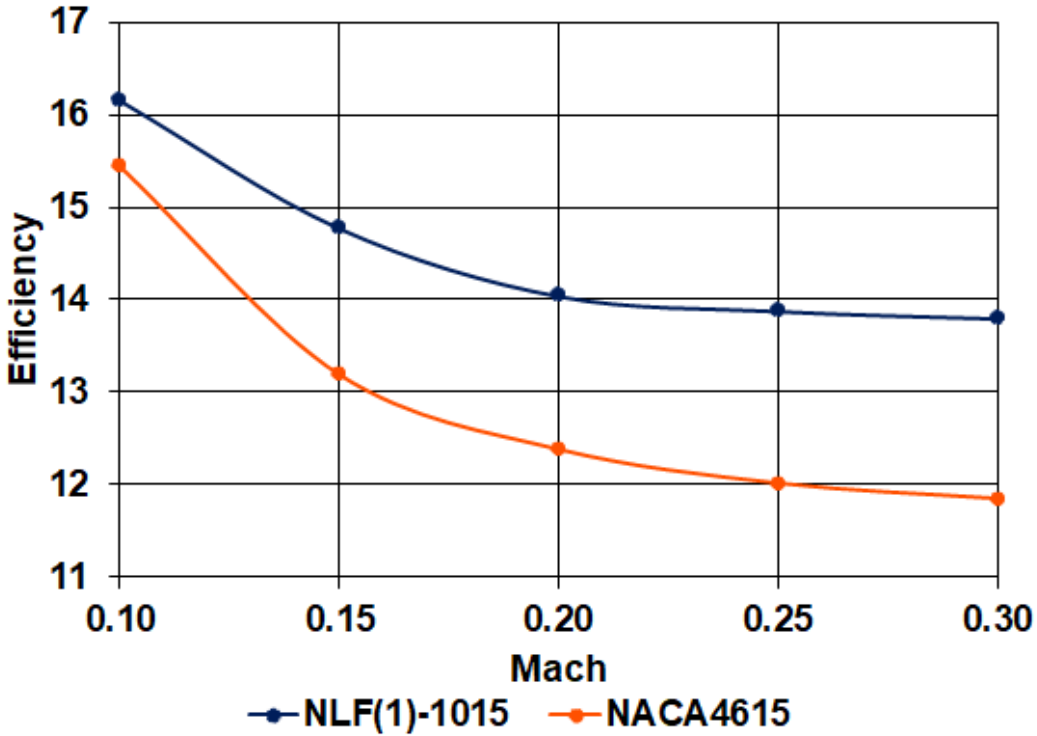
Low-Speed Wing Analysis: Overview



Low-Speed Wing Analysis: Overview



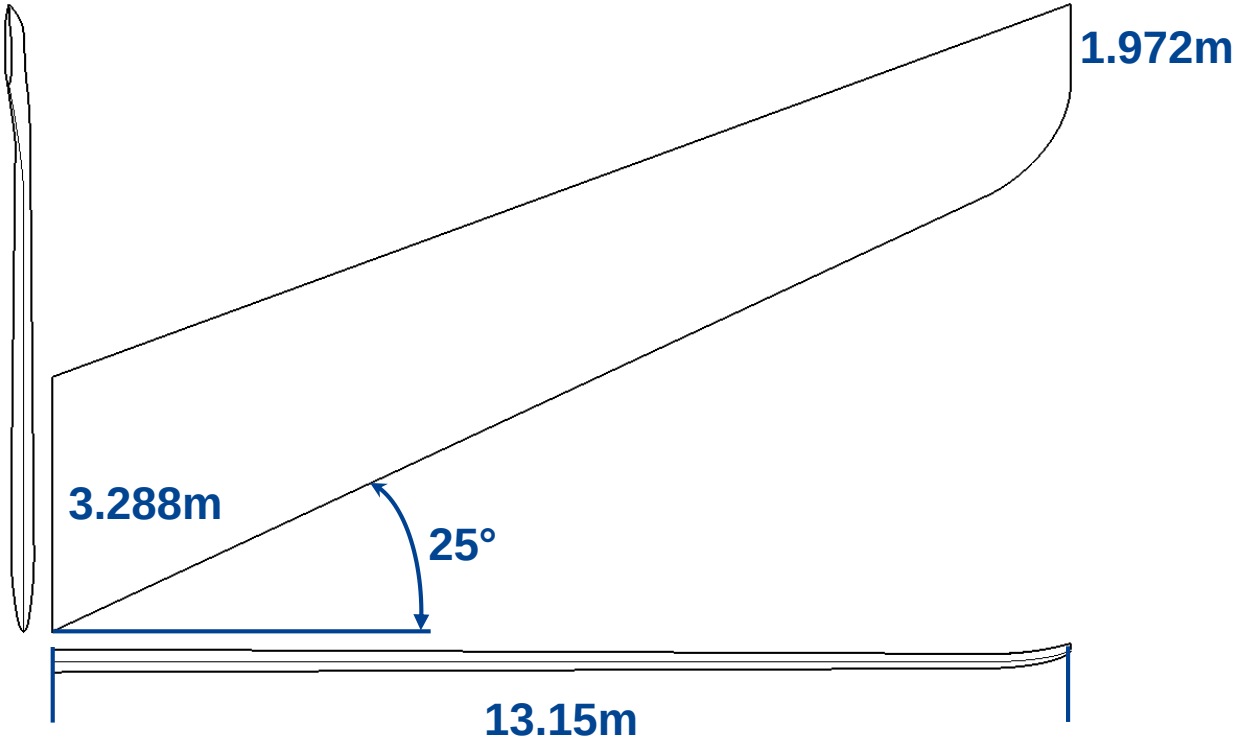
Low-Speed Wing Analysis: Results



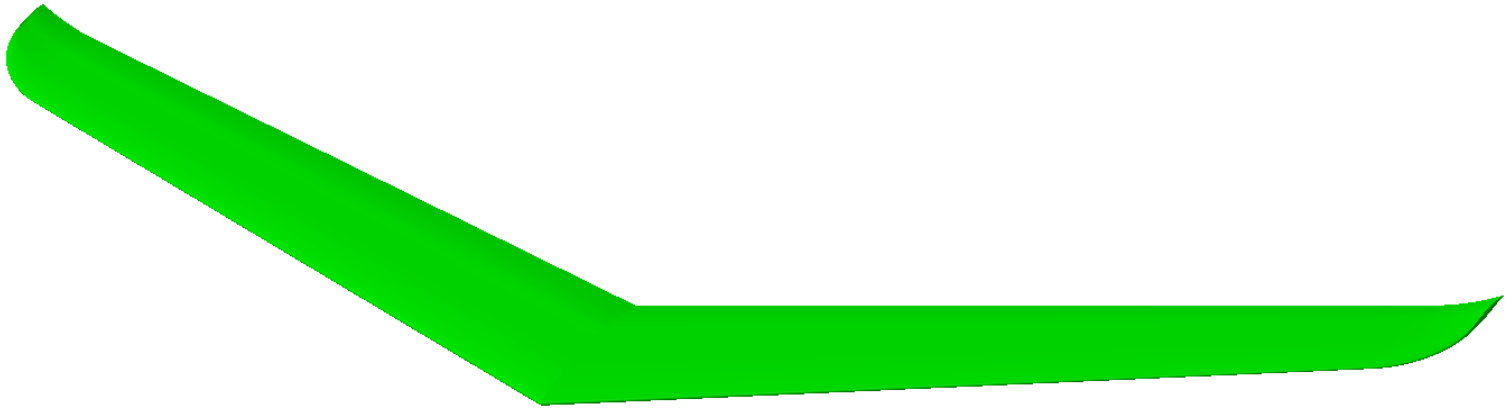
4

HIGH-SPEED WING ANALYSIS: MACH SWEEP

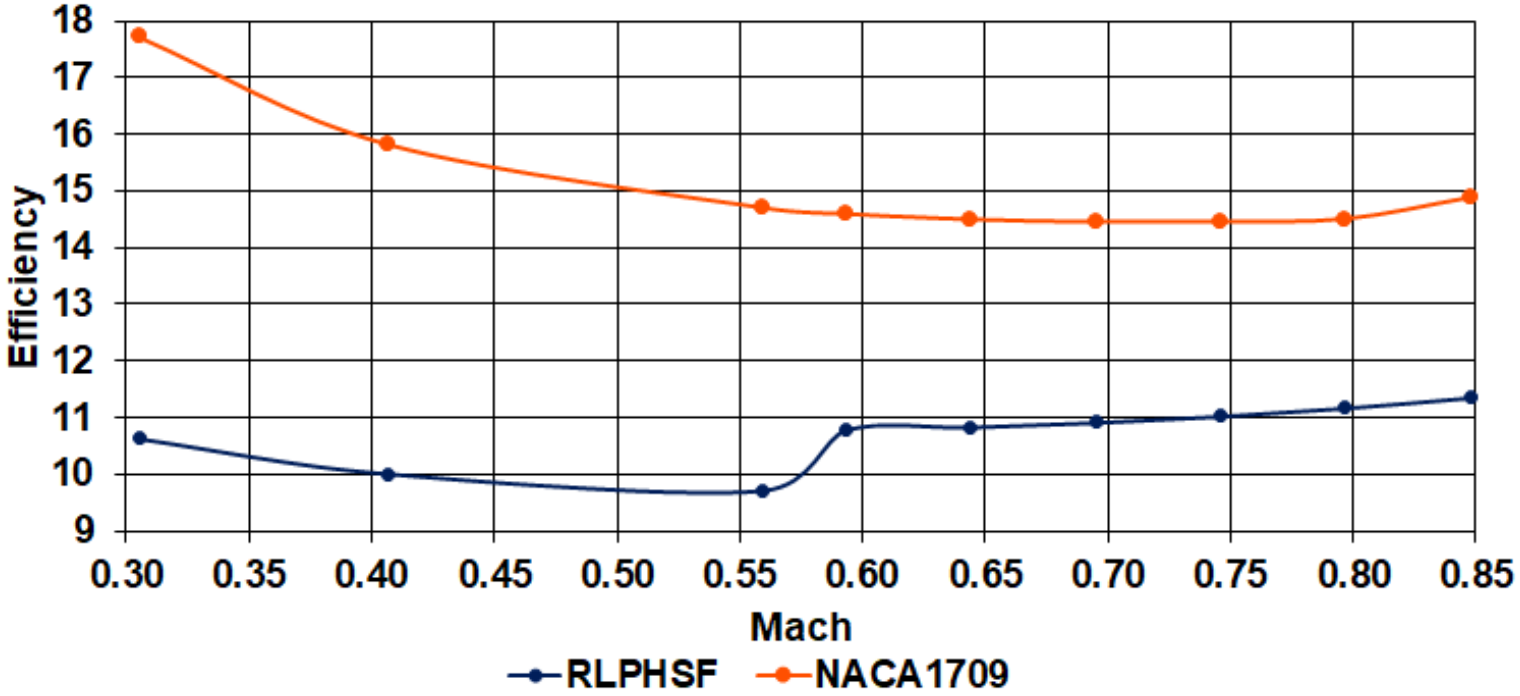
High-Speed Wing Analysis - Mach Sweep: Overview



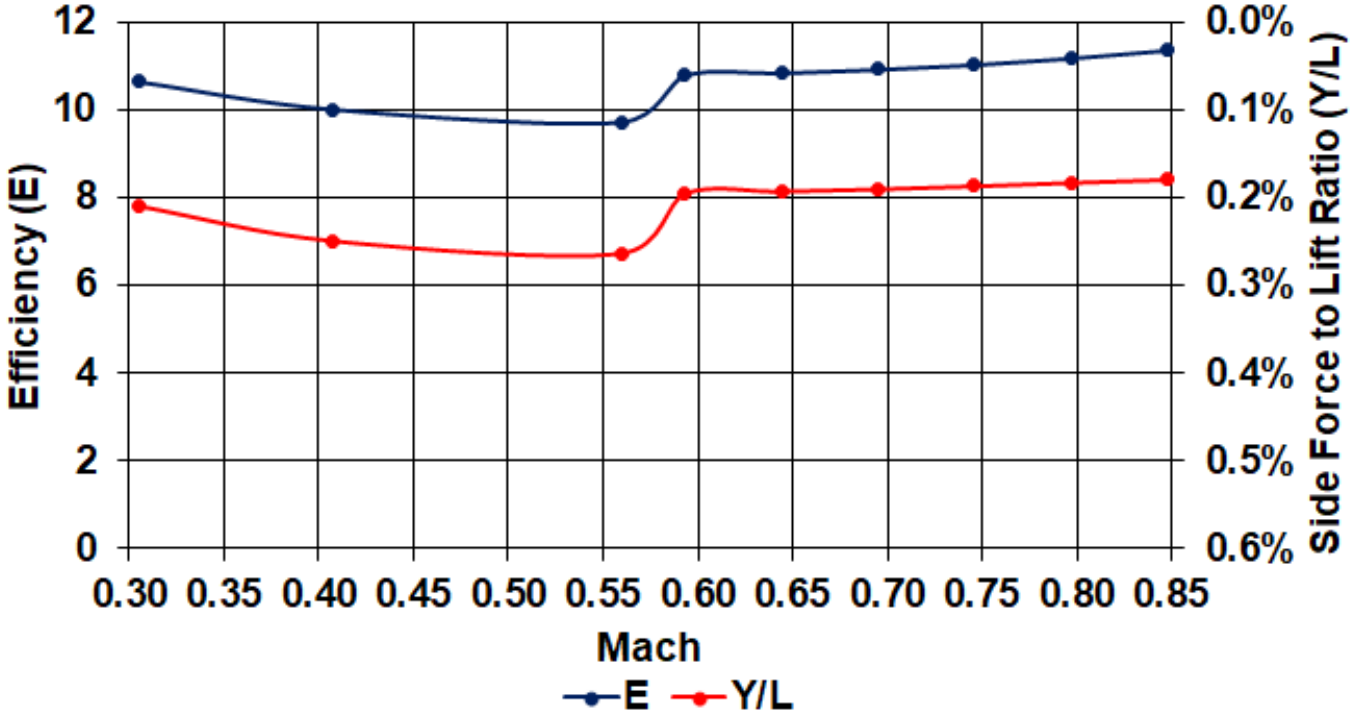
High-Speed Wing Analysis - Mach Sweep: Overview



High-Speed Wing Analysis - Mach Sweep: Results



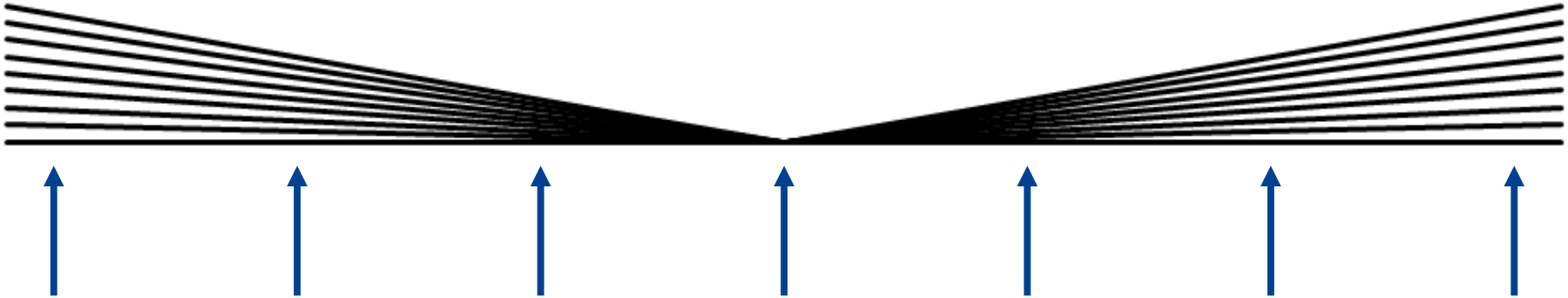
High-Speed Wing Analysis - Mach Sweep: Results



5

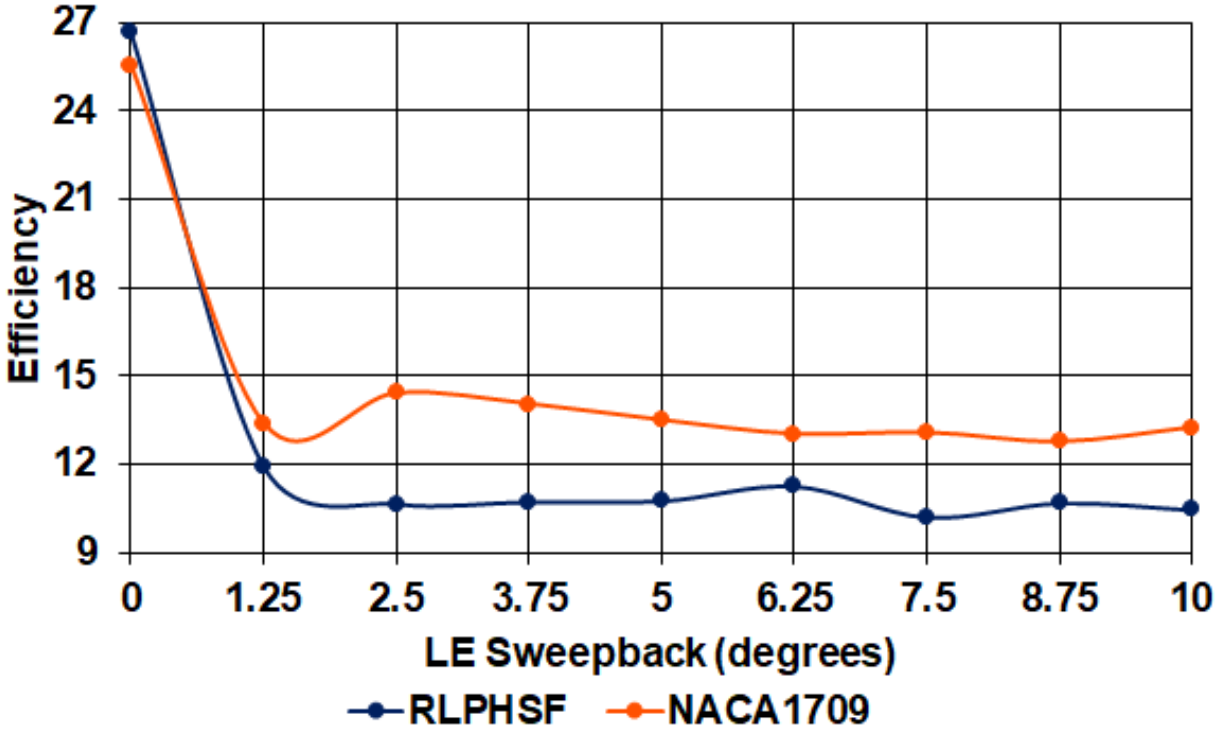
HIGH-SPEED WING ANALYSIS: SWEEPBACK ANGLE VARIATION

High-Speed Wing Analysis - Sweepback Angle Variation: Overview

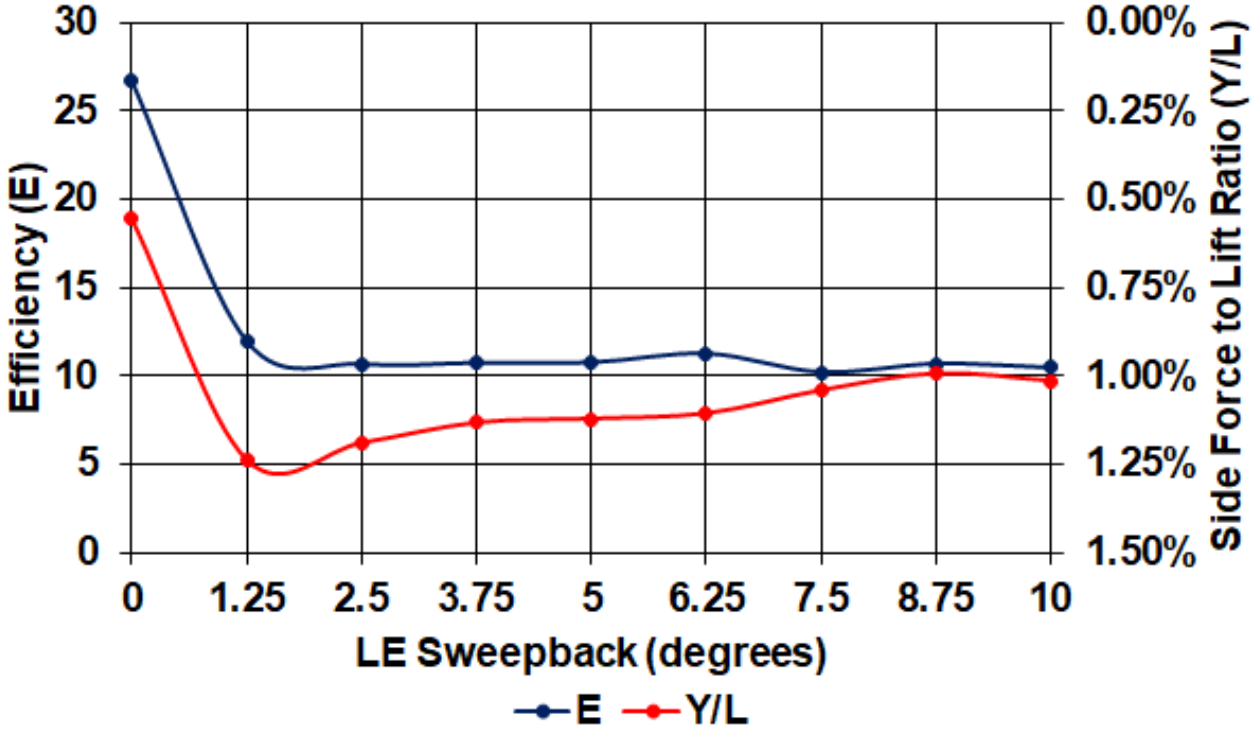


FLOW DIRECTION

High-Speed Wing Analysis - Sweepback Angle Variation: Results



High-Speed Wing Analysis - Sweepback Angle Variation: Results



6

CONCLUSIONS

Conclusions

- **For the Low-speed wings, it could be confirmed that the use of NLF airfoils in a standard wing configuration is of advantage (15%+ higher efficiency).**
- **For a standard high-speed wing configuration (with sweepback) NLF airfoils will not be more efficient.**
  - > This is due to the destabilizing effect of the lateral forces on the laminar boundary layer.
- **In a concrete high-speed configuration, there is a direct relation between the side forces and the efficiency of the NLF wing when changing speed.**
  - > The efficiency grows steadily when increasing the cruise speed from M0.6.
- **It was observed that not applying a sweepback to the leading edge in high-speed wings is optimal and duplicates the efficiency with respect to adding any angle.**
- **Moreover, this is the only case observed where the efficiency of the laminar wing is higher (4%) than its NACA equivalent.**

Thank you for your attention

QUESTIONS?

Contact:

Ramón LÓPEZ PEREIRA

ramlopper@gmail.com

ramon.lopez-pereira@safrangroup.com

POWERED
BY TRUST