PROJECT

M-DAW

Modelling and design of advanced wing tip devices

Funding: European (5th RTD Framework Programme)
Duration: Oct 2002 - Mar 2006
Status: Complete with results

Background & policy context:

To maintain growth of the European commercial aircraft industry new, more efficient, environmentally friendly aircraft products must be launched over the next decade and existing products upgraded. Advanced wing tip devices have been identified as a technology that can deliver benefits in reducing emissions and community noise by improving aircraft efficiency at all phases of a flight. Such a technology can be retrofitted on existing aircraft products with relatively little cost.

The project M-DAW is concerned with understanding the aerodynamics of conventional wing tip devices and exploiting this to design and assess novel devices through the use of advanced CFD methods. The most promising novel design will then be demonstrated by wind tunnel testing to determine the benefit on future aircraft products.

Objectives:

“To Deliver to the European Aerospace Industry a Novel Wing Tip Device to Improve Aircraft Efficiency and Environmental Impact together with a Capability to Accurately Predict the Effect of Wing Tip Device Design on Aircraft Performance”

- Develop a deeper understanding of the aerodynamics of wing tip devices
- Delivering a unique and extensive experimental database
- Assess the capabilities of advanced CFD to predict tip device effects
- Delivering validated flow simulation methods
- Explore novel wing tip device concepts
- Delivering an assessment of a range of advanced wing tip device concepts
- Demonstrate the most promising device by wind tunnel testing
- Delivering a demonstrated performance improvement by an advanced wing tip device
- M-DAW performance targets were stated as
  - A further 1% reduction in aerodynamic drag at cruise
  - A 2% increase in L/D at take-off
  - Relative to a wing with a conventional tip device for a constant aerodynamic wing root bending moment in cruise

Methodology:

1. Experimental Investigation
   - Conventional Baseline Performance
   - Validation Data Detailed
   - Study of Flow Physics

2. Application of CFD
   - Validated CFD Design & Analysis Capability

3. Novel Wing Tip Device Design
   - Study of a Range of Concepts Combining to Deliver One Novel Device

4. Assessment, Selection & Demonstration
• Selection & Demonstration of One Novel Device

Design Studies Based on:
• Retrofit scenario
• “Equivalent Drag”

Design Studies Included:
• Novel shapes
• Optimised shapes
• Movable elements
• Aeroelastic and Structural effects

Approach:
• Vortex Lattice Method study
• Euler optimisation
• N-S analysis

Small Downward Device:
• Modest drag reduction
• Good WRBM behaviour

Analysis:
• High and low speed
• Lateral stability
• High-g structural impact

Parent Programmes:
FP5-GROWTH KA4 (AERONAUTICS) - New Perspectives in Aeronautics

Institute type: Public institution
Institute name: European Commission, Directorate-General for Research (DG Research)
Funding type: Public (EU)

Partners:

Organisation: Airbus UK Ltd
Address: Flight Physics, Aerodynamic Design and Data New Filton House
Zipcode: BS99 7AR
City: Bristol
Contact country: United Kingdom
Telephone: (+44) 117 936 2894
Fax Number: (+44) 117 936 5161

Key Results:

Advanced Downward Tip Demonstration:
Demonstrated in high and low speed tests at ETW
The performance of the M-DAW novel concept has been broadly confirmed
Good agreement with drag predictions for attached flow devices
The SPT wing deformation method confirmed the expected negligible high speed penalty of the novel device

Test Results Summary:
- Large winglet offers best drag reduction
- Fence is insensitive to Reynolds Number
- Attached flow Downward Device behaves as Winglet
- Large winglet has a significant impact on Rolling Moment and thus structural sizing
- Fence and Downward Device both display low Bending Moment penalties
- Large winglet offers the largest span and largest low speed performance benefit
- Fence is not primarily a low speed device
- Attached flow Downward Device offers an improvement over the Fence

Technical Implications

Generic Design Conclusions
- The optimum wing tip device will change depending on the aircraft and project context
- The multi-disciplinary trades, and especially the impact on the wing bending moments, can dominate the high speed design process
- Structural and aeroelastic studies, including high-g loads, are an integral part of the design and analysis process
- The focus of advanced cryogenic wind tunnel test techniques in M-DAW changed from measuring the wake to measuring the geometry
- Some aero/structural coupling approaches developed in M-DAW
- Span and attached flow are the key drivers for low speed performance
- Nothing matched the large winglet at low speed
- Whilst the practical multi-disciplinary constraints make dramatic drag reductions unlikely, improvements are possible through careful optimisation

Specific Design Conclusions
- M-DAW achievements relative to the original targets
  A further 1% reduction in aerodynamic drag at cruise
- Achieved by the anhedral winglet relative to the large winglet though low speed performance was impacted
- A 2% increase in L/D at take-off
- Achieved by the downward pointing winglet relative to the wing tip fence with similar high speed performance
- M-DAW has developed a novel downward pointing winglet that achieves a similarly low drag and bending moment to a wing tip fence due to the changed lift vector, whilst also offering an attractive low speed benefit due to its attached flow design
- Final M-DAW devices, whilst not exploiting revolutionary flow physics, do demonstrate a useful expansion of design space
- Practical multi-disciplinary issues dominated giving results that are immediately available for industrial consideration
- Downward pointing winglets can be added to the catalogue of useful wing tip devices.

STRIA Roadmaps: Vehicle design and manufacturing
Transport mode: Air transport
Transport sectors: Passenger transport, Freight transport
Geo-spatial type: Other