SMorph
Smart Aircraft Morphing Technologies

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Outline

• Aeroelasticity
• Morphing
• Adaptive aeroelastic structures
• Previous work
• 3AS project
• SMorph
  – Partners
  – Aims and Objectives
  – Project outline
Most Aeroelastic phenomena are undesirable / catastrophic
Aeroelastic Design

• Most aeroelastic phenomena are undesirable
• Traditional design has used stiff heavy structures to eliminate aeroelastic effects – “aeroelastic penalty”
• Recent change in design approach - use aeroelasticity in a positive manner
  – Lighter, adaptive, more efficient structures
  – Better aeroelastic effectiveness
  – Static control of twist and bending
  – Optimal drag configuration throughout flight
  – Roll control
EU 20-20 Vision

- 50% cut in fuel emissions by year 2020
- Decrease perceived noise to half the current level
- Critical technologies
  - Propulsion
  - Aerodynamics
  - Structures and materials
- New Aircraft Concepts and Breakthrough Technologies
- New opportunities for aeroelasticity
A Change of Viewpoint

• Recent research has started to consider using aeroelastic effects rather than fighting against them

• Several research programs
  – Active Aeroelastic Wing
  – Smart Wing Program
  – Morphing Program
  – Active Aeroelastic Structures (3AS)

“Back to the Future”

Ed Pendleton
Morphing, when applied to aerospace vehicles, is a technology or set of technologies applied to a vehicle that allow its characteristics to be changed to achieve better performance or to allow the vehicle to complete tasks it could not otherwise do.

Jason Bowman, AFRL/VSSV
Two Classes of Morphing (1)

- **Configuration Morphing**
  - Change in planform
    - Aircraft control
    - Aircraft performance
  - Change in mission
    - High aspect-ratio glide
    - Attack mode
Two Classes of Morphing (2)

• Performance Morphing
  – Change in structural properties
    • Stiffness
    • Camber
    • Leading / trailing edge shape
  – Aircraft control
  – Aircraft performance
    • Lift / drag
    • Roll control
    • Loads
• Adaptive Aeroelastic Structures
Not A New Concept

All-movable "drag control" devices

Active camber control

Active leading edge surfaces

(Lilienthal "Vorflügelapparat" 1895)
Wright Brother’s Wing Warping
Use Aeroelastic Deflections Beneficially

Adaptive Concepts need aeroelasticity effects in order to get full benefit.

Wright Flyer I

Langley Aerodrome

1903

2003

Active Aeroelastic Concepts

Aeroelastic Degradation

Rigid AC performance

Aeroelastic impacts

Performance

Year
3AS - Active Aeroelastic Aircraft Structures

- Development of new aircraft design concepts to improve aircraft performance by exploiting aeroelastic effects in a beneficial way
- Project duration: 3 years, April 2002 – July 2005
- 16 partners from 9 nations
- Analytical design of concepts
- Experimental verification
  - aeroelastic WT models / RPV
3AS Aircraft
Adaptive Internal Structures

- Exploit changes in internal structure
  - alter position of flexural axis
  - change 2nd moment of area / torsion constant
- Change wing deflection and twist
- All energy for twist provided by the aerodynamic lift
- Applications
  - Drag reduction
  - Roll control
- Number of concepts under consideration
Rotating Spars

- Change orientation of spars.
- Beams in horizontal position
  - stiffness minimum
- Beams in vertical position
  - stiffness maximum
- Use pairs of spars to control bending and torsion
- Influence on
  - Shear centre position
  - Torsion constant
  - Bending stiffness

High stiffness

Low stiffness
Control of $C_L$, $C_D$, $C_L/C_D$
Simulations of Achievable Roll Rate
Implementation
SMorph - Aims

• Investigate, demonstrate and assess several novel morphing / adaptive aeroelastic concepts
• Use structural deformations to
  – Improved aerodynamic efficiency / performance
  – Reduced structural loads
  – Reduced structural weight
• Use of smart materials and structures approaches
  – actuation
  – sensing
• Multidisciplinary design approaches
• Technology transfer / education
SMorph - Objectives

- Develop a range of novel morphing / adaptive / active aeroelastic concepts using smart structures and materials
- Design / build / test prototypes
- Develop multidisciplinary / multi-objective design approach in incorporate smart technologies
- Design and test multi-concept demonstrators
  - Wind tunnel model
  - RPV
## Distribution of Research Activities

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<th>Task</th>
<th>Manchester</th>
<th>Lisbon</th>
<th>Milano</th>
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<td>Development and prototype design/test of novel morphing wings</td>
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<td>Development of advanced actuators</td>
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<td>Development of adaptive stiffness devices</td>
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<td>Development of design methodologies</td>
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<td>Wind tunnel design demonstrator</td>
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<tr>
<td>RPV wing demonstrator</td>
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### Proposed Budget and Status

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