SMorph
Smart Aircraft Morphing Technologies

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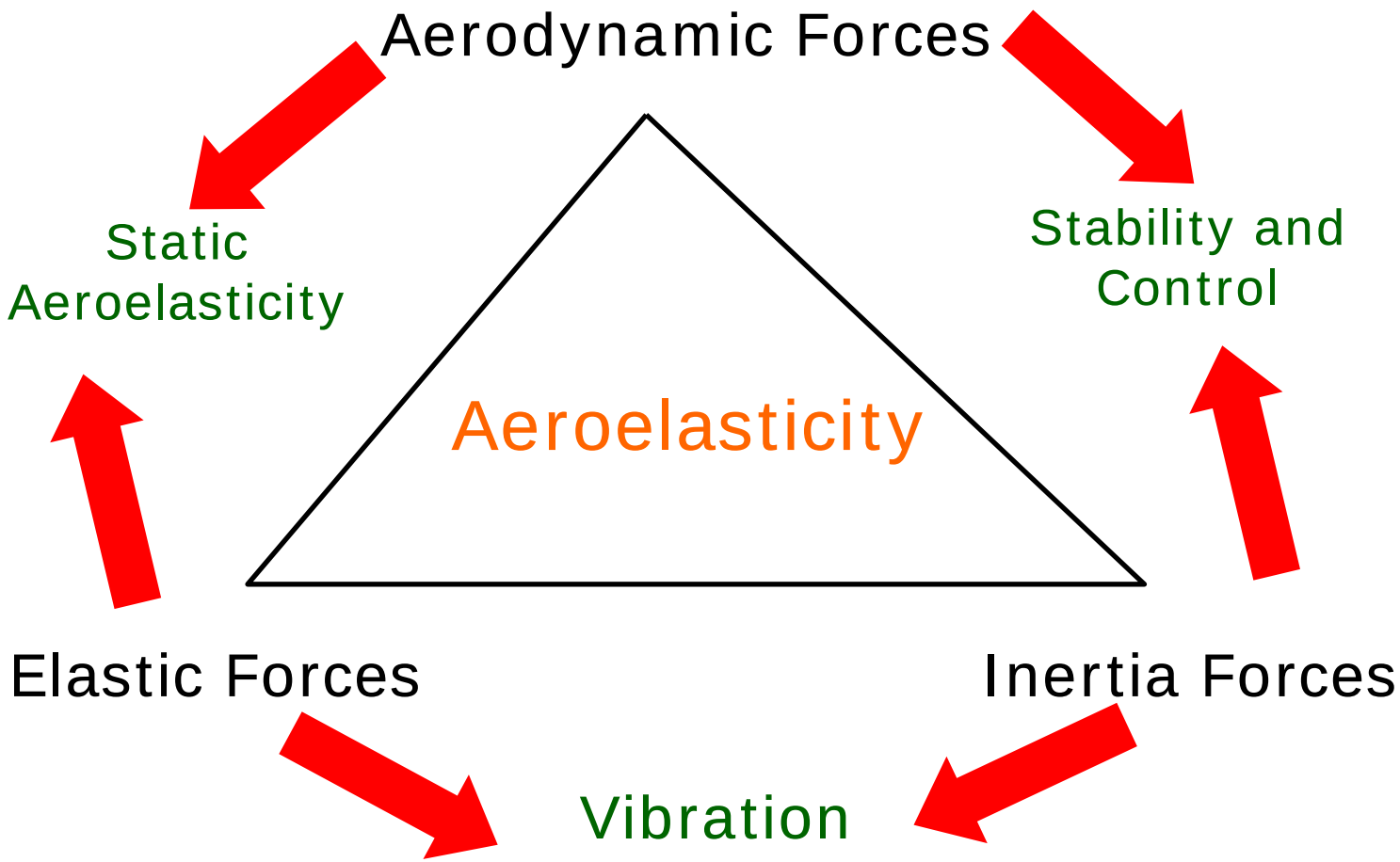
Outline

- Aeroelasticity
- Morphing
- Adaptive aeroelastic structures
- Previous work
- 3AS project
- SMorph
  - Partners
  - Aims and Objectives
  - Project outline

Aeroelasticity



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

} AEROELASTICITY

- 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)

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC01-0288-2 Date: October 24, 2001 Photo by: Tony Landis
A modified F/A-18A sporting a distinctive red, white and blue paint scheme is the test aircraft for the Active Aeroelastic Wing (AAW) project at NASA's Dryden Flight Research Center, Edwards, California.

"Back to the Future"

Ed Pendleton

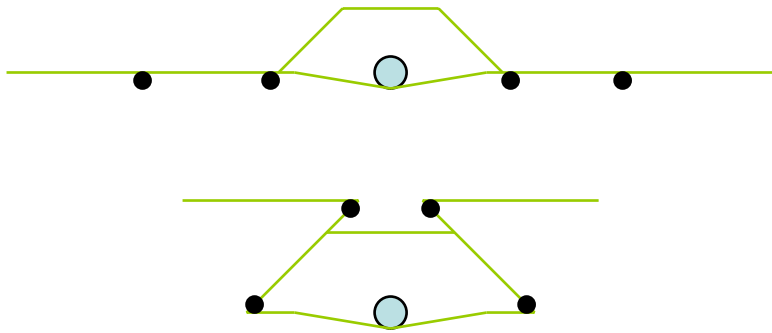
Aerospace Morphing

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

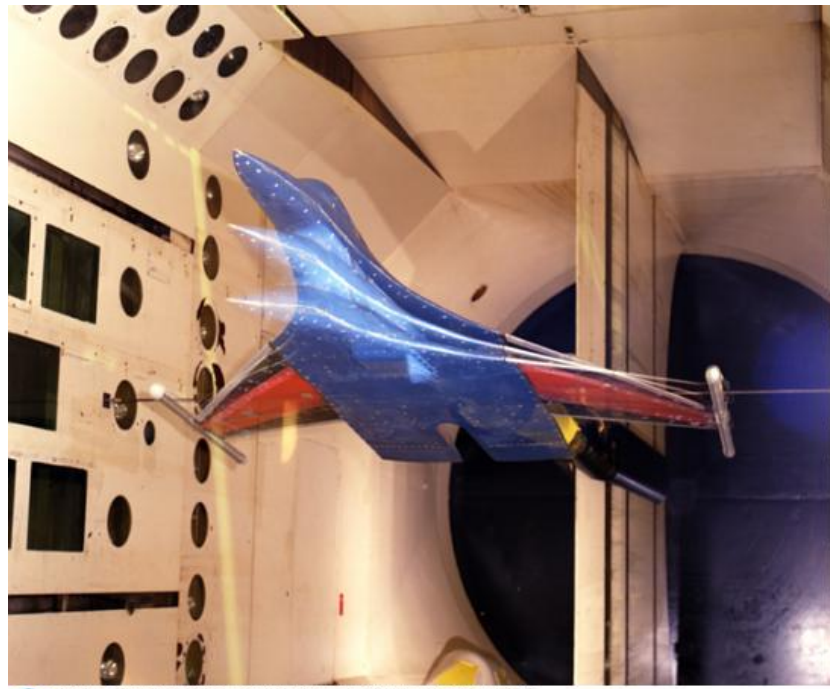
Two Classes of Morphing (1)

- Configuration Morphing
  - Change in planform
    - Aircraft control
    - Aircraft performance
  - Change in mission
    - High aspect-ratio glide
    - Attack mode



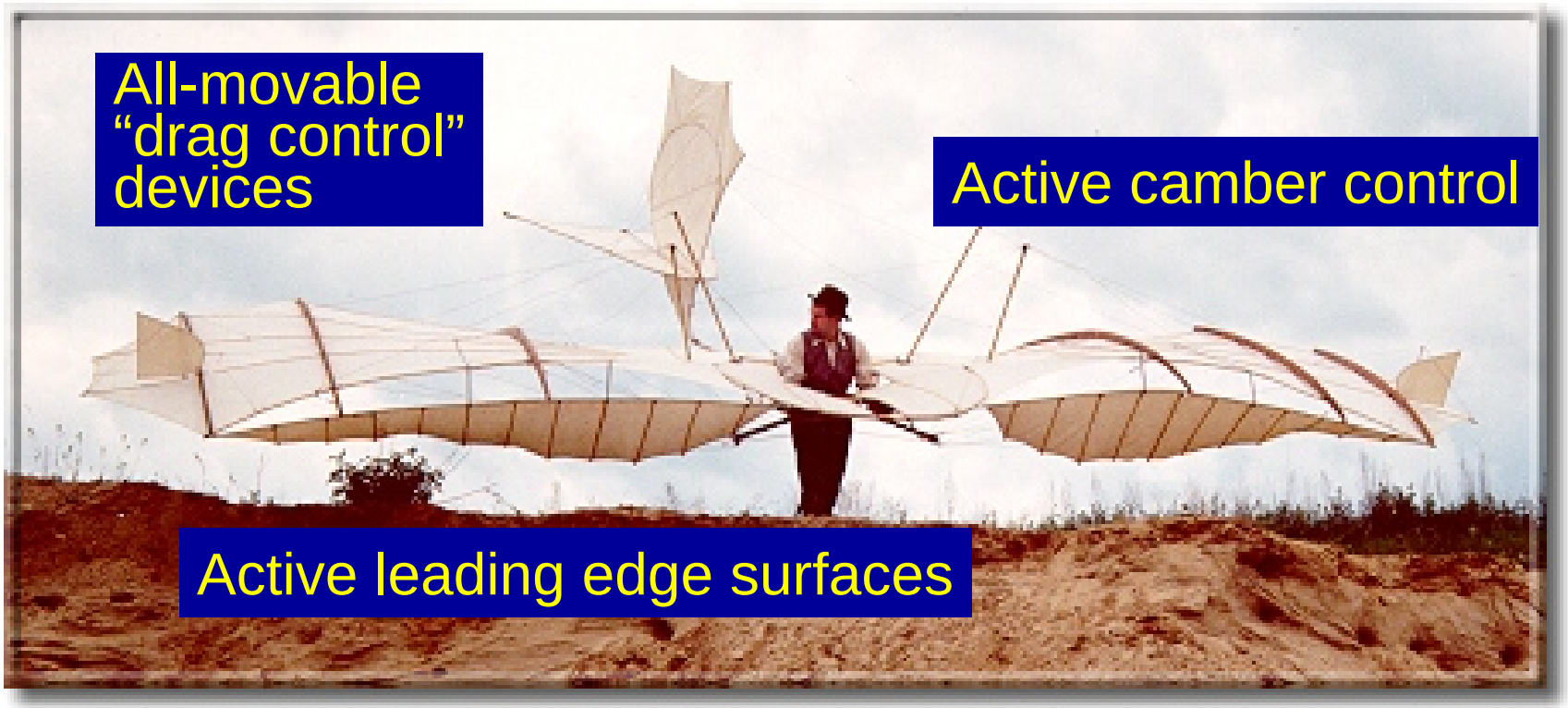
Two Classes of Morphing (2)

- Performance Morphing
  - Change in structural properties
    - Stiffness
    - Camber
    - Leading / trailing edge shape
  - Aircraft control
  - Aircraft performance
    - Lift / drag
    - Roll control
    - Loads
- Adaptive Aeroelastic Structures



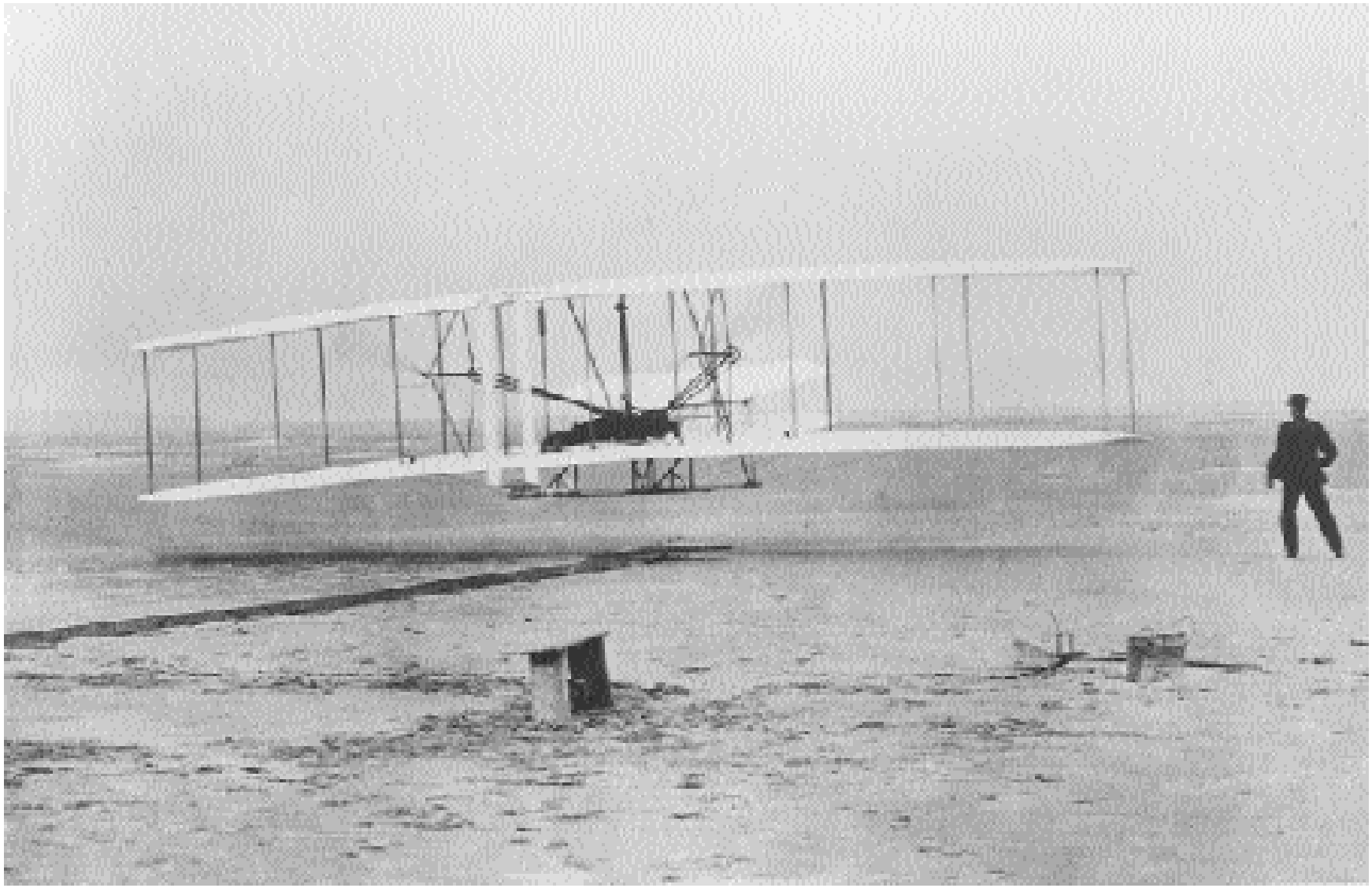
Active Flexible Wing model mounted in the Langley TDT
NASA Langley Research Center 3/1/1991 Image # EL-1996-00022

Not A New Concept

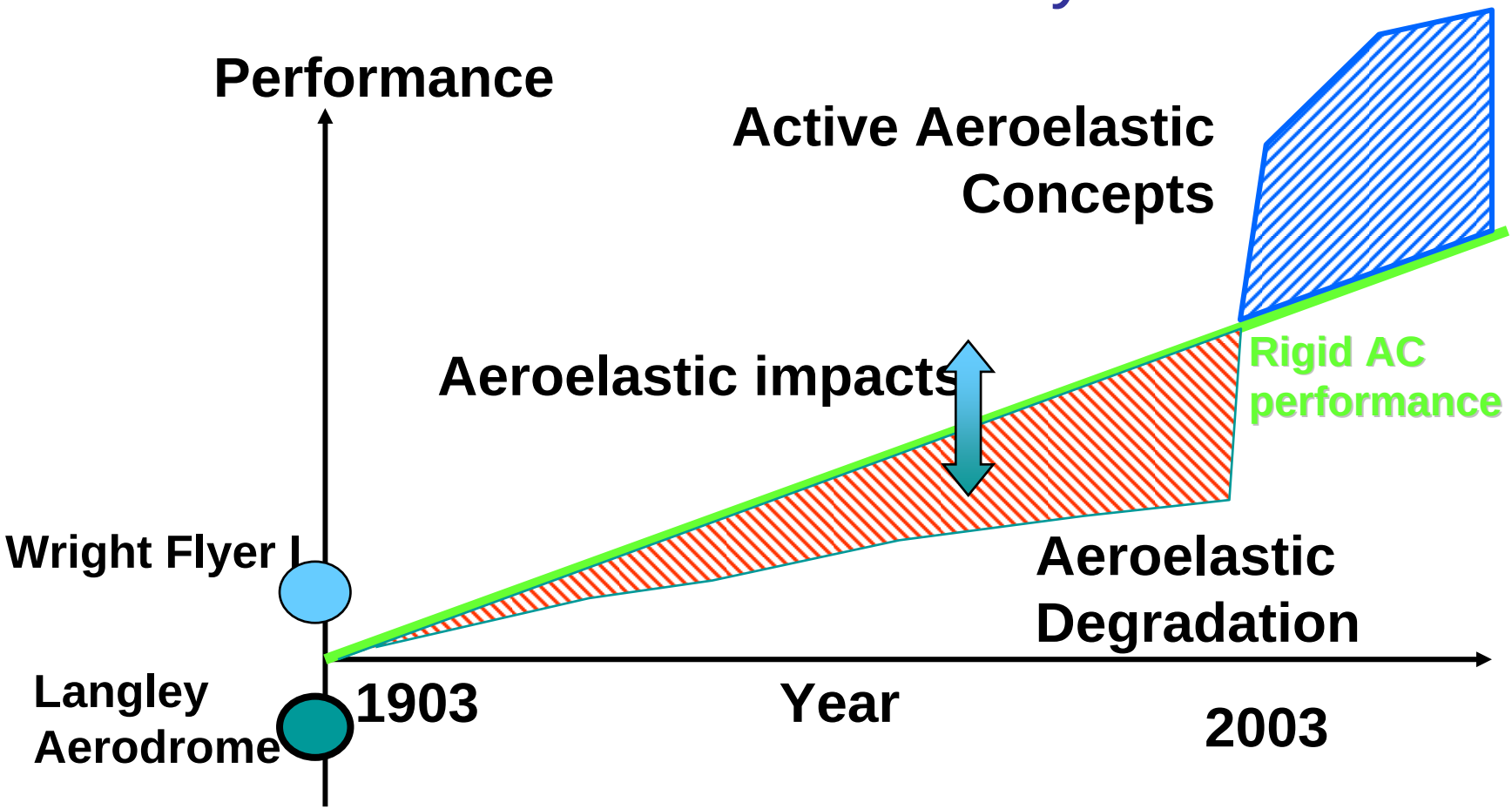


(Lilienthal "Vorflügelapparat" 1895)

Wright Brother's Wing Warping



Use Aeroelastic Deflections Beneficially

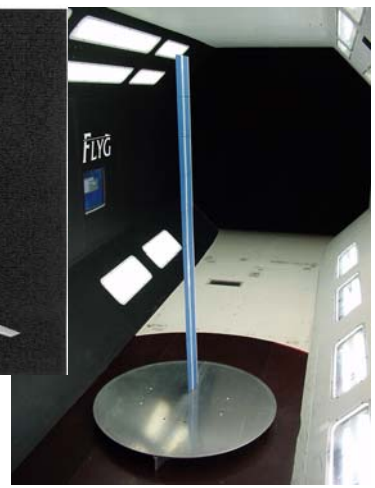


Adaptive Concepts need aeroelasticity effects in order to get full benefit

3AS - Active Aeroelastic Aircraft Structures

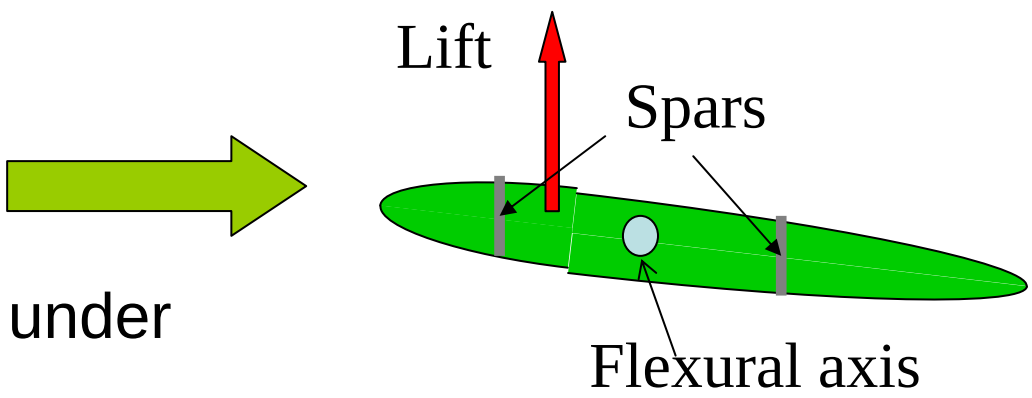
- Development of new aircraft design concepts to improve aircraft performance by exploiting aeroelastic effects in a beneficial way
- Project duration: 3 years, April 2002 – July 2005
- 16 partners from 9 nations
- Analytical design of concepts
- Experimental verification
  - aeroelastic WT models /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

3AS Aircraft



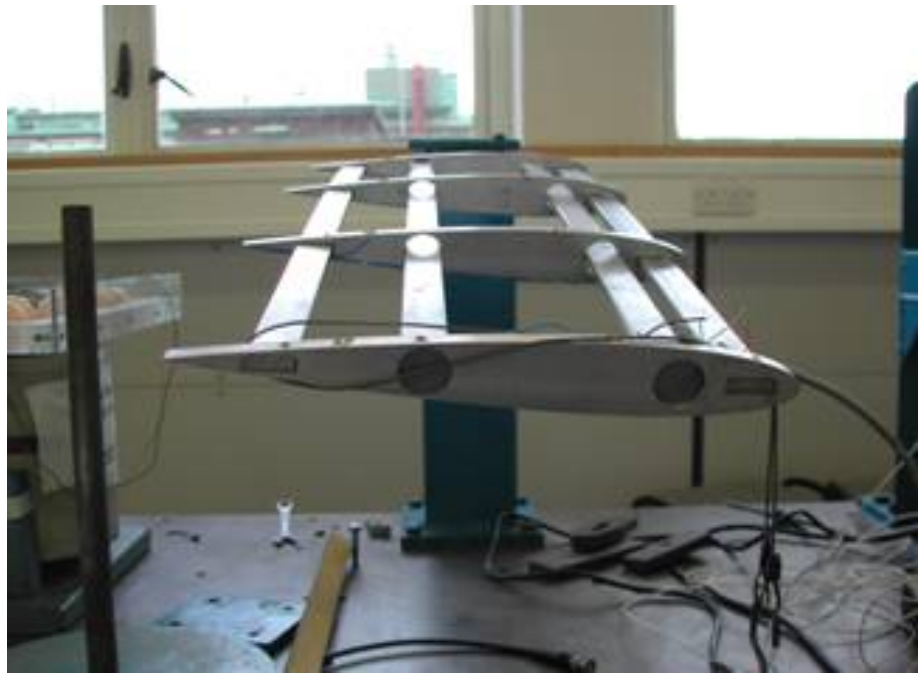
Adaptive Internal Structures

- 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

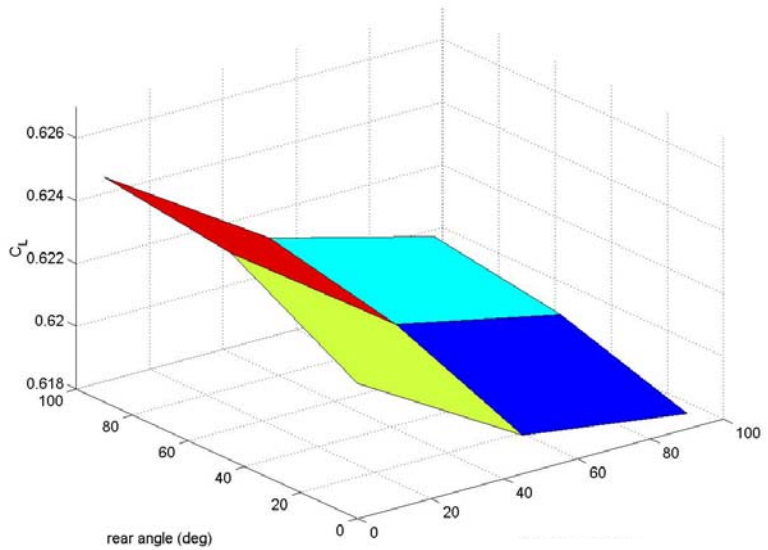


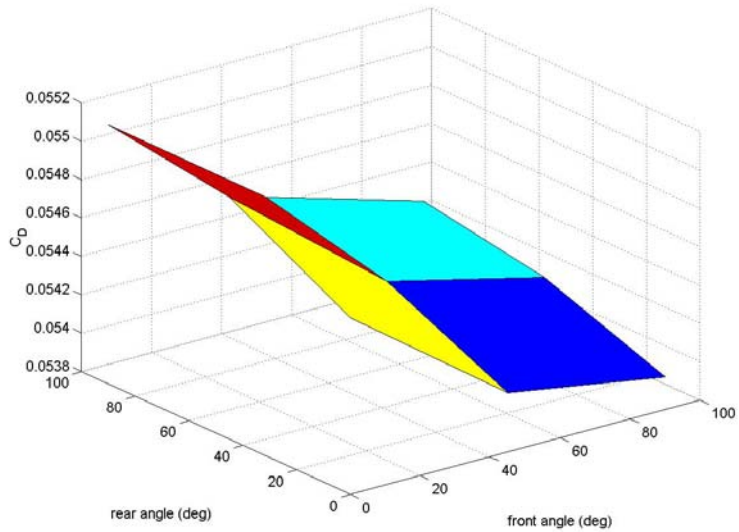
Rotating Spars

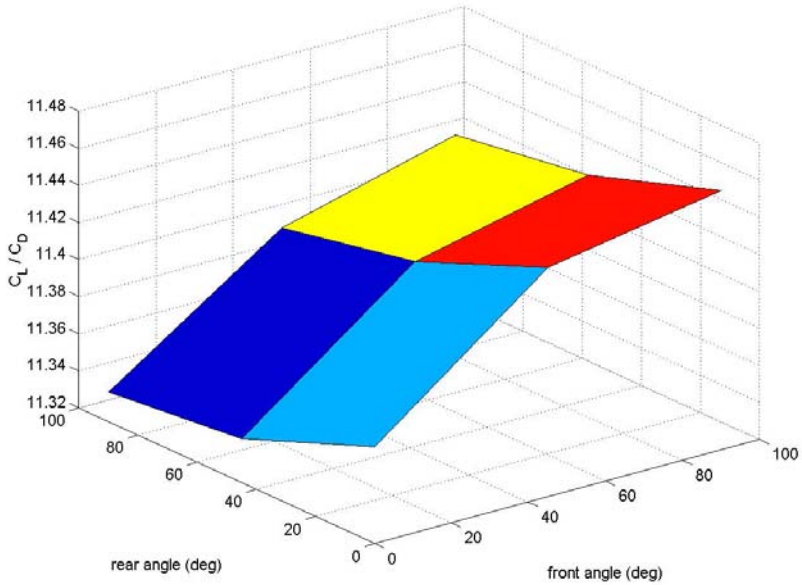
- Change orientation of spars.
- Beams in horizontal position
  - stiffness minimum
- Beams in vertical position
  - stiffness maximum
- Use pairs of spars to control bending and torsion
- Influence on
  - Shear centre position
  - Torsion constant
  - Bending stiffness



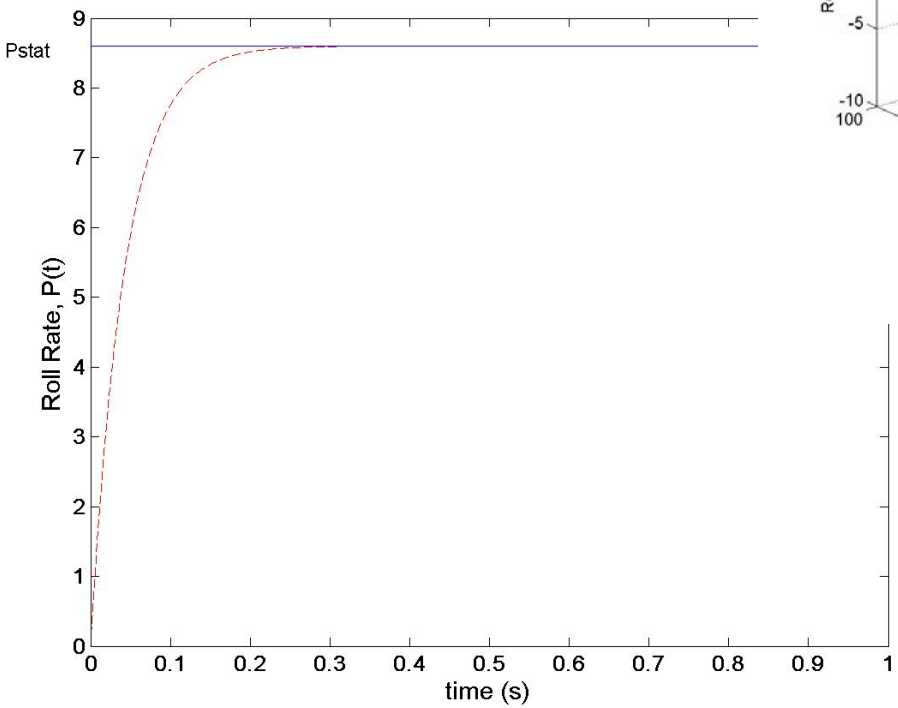
Control of C_L, C_D, C_L/C_D

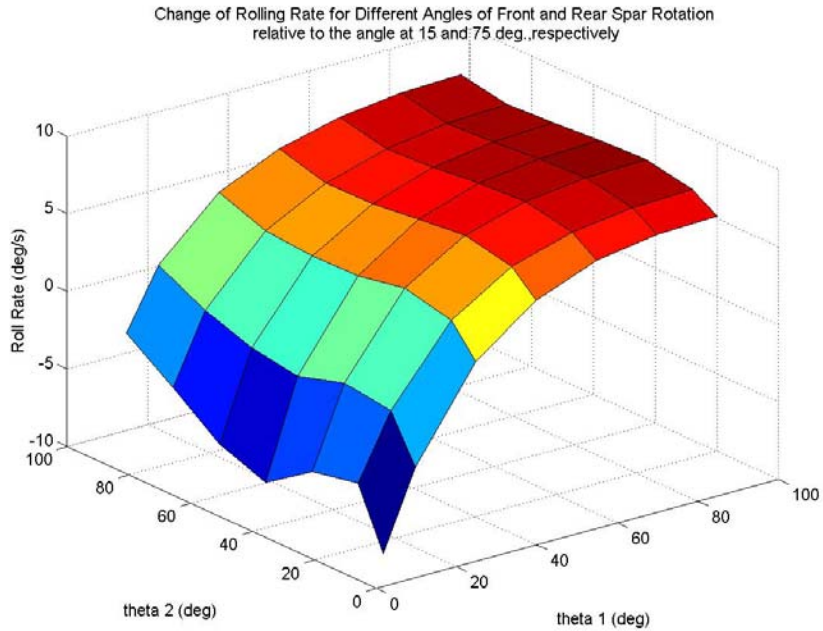




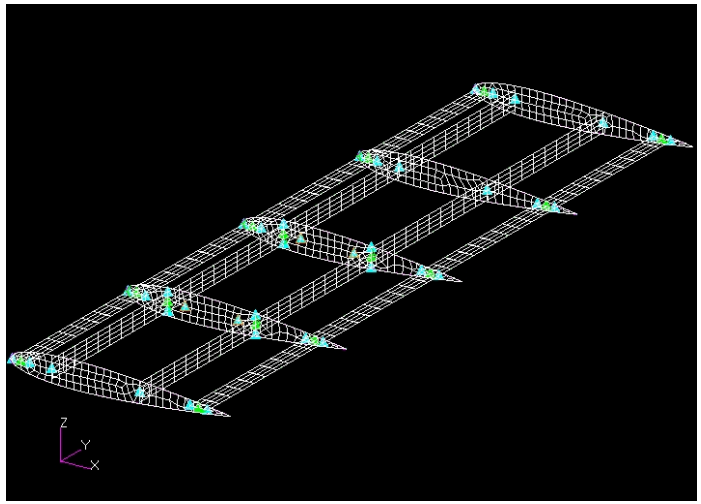


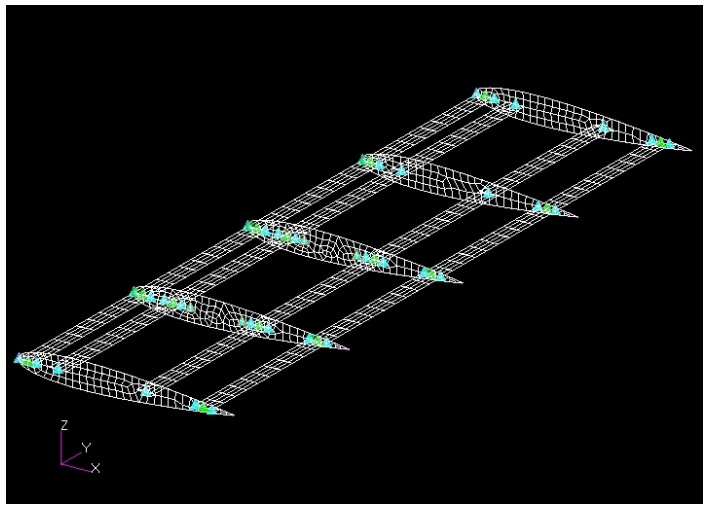
Simulations of Achievable Roll Rate

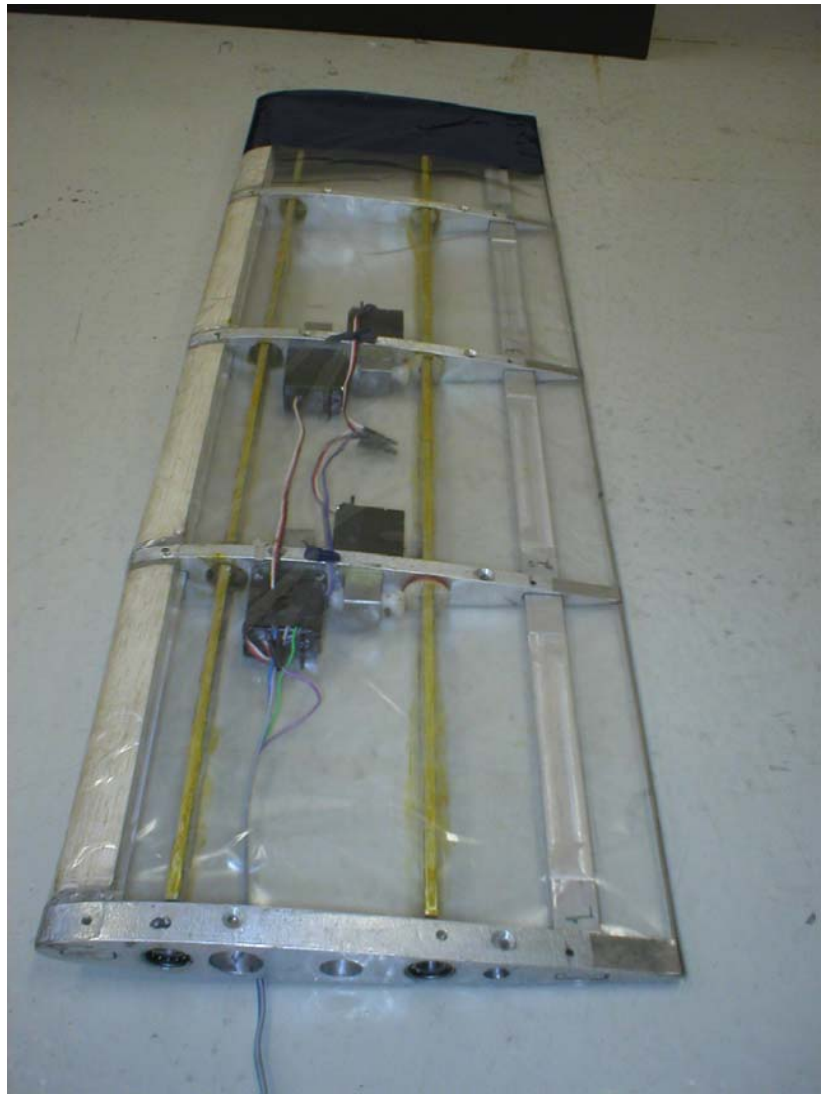




Implementation







SMorph Partners

University of Manchester

Prof Jonathan Cooper

Instituto Superior Technico,Lisbon

Prof Afzal Sulemann

Politechnico di Milano, Milan

Prof Sergio Ricci

Builds upon expertise of 3AS project

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

Task	Manchester	Lisbon	Milano
Development and prototype design/test of novel morphing wings	X	X	X
Development of advanced actuators		X	
Development of adaptive stiffness devices	X		
Development of design methodologies			X
Wind tunnel design demonstrator	X		X
RPV wing demonstrator		X	

Proposed Budget and Status

Partner	Cost (Euros)	Status
Manchester	201600	Start 1-10-06
Lisbon	200688	Starting autumn
Milano	192120	Funded elsewhere
Total	**594408**	