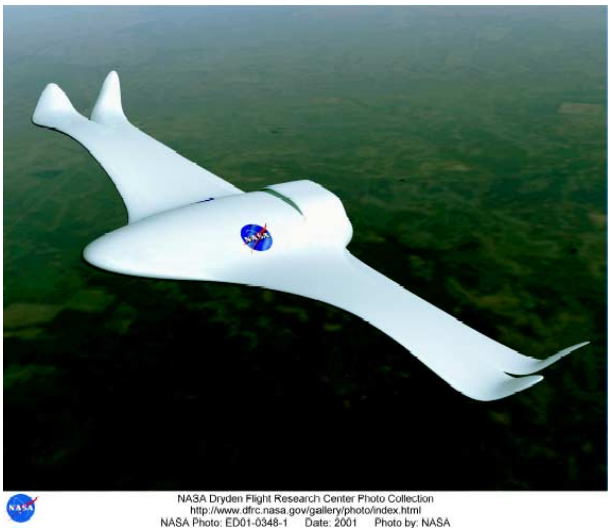
Appendix G-2

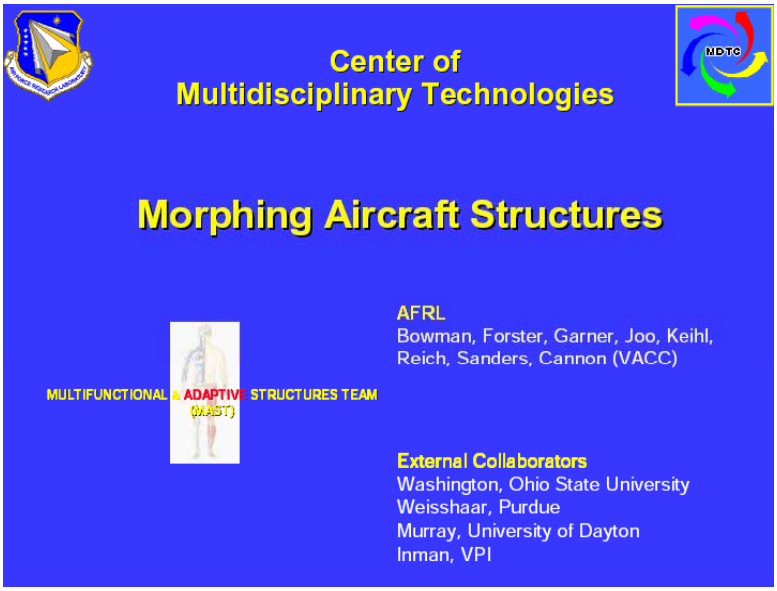
Viewgraphs Morphing Wing

by

Roger Ohayon



NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: ED01-0348-1 Date: 2001 Photo by: NASA



Relationship to VA Goals

Adaptive Structures Application to UAV's and SOV's:

Flow management
Thermal load management
Pointing devices
Stealth

- Adaptive structures required for design of sensorcraft and multimission vehicles
- *Multimission capability emphasized in VA workshop*

DARPA Morphing Aircraft Structures

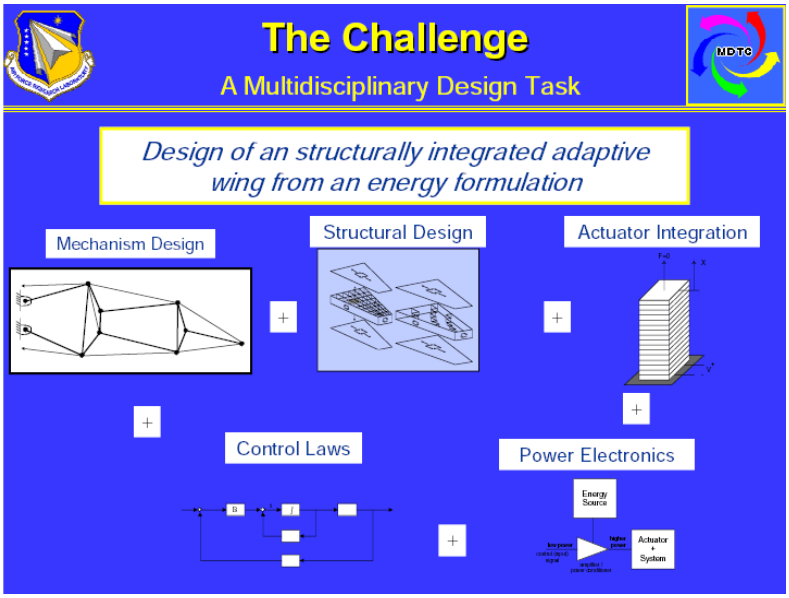
From fixed platforms to commanded, time variant, variable geometry, load-bearing structures

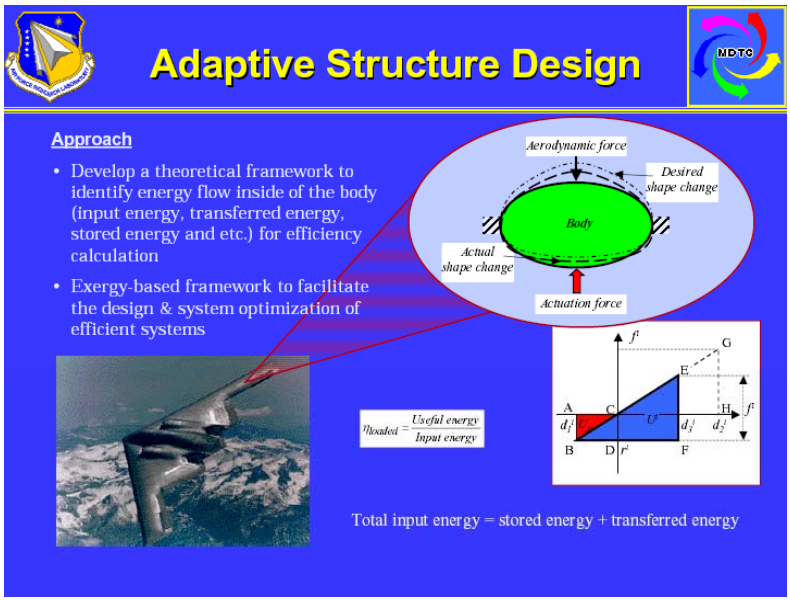
Variable Geometry Wings

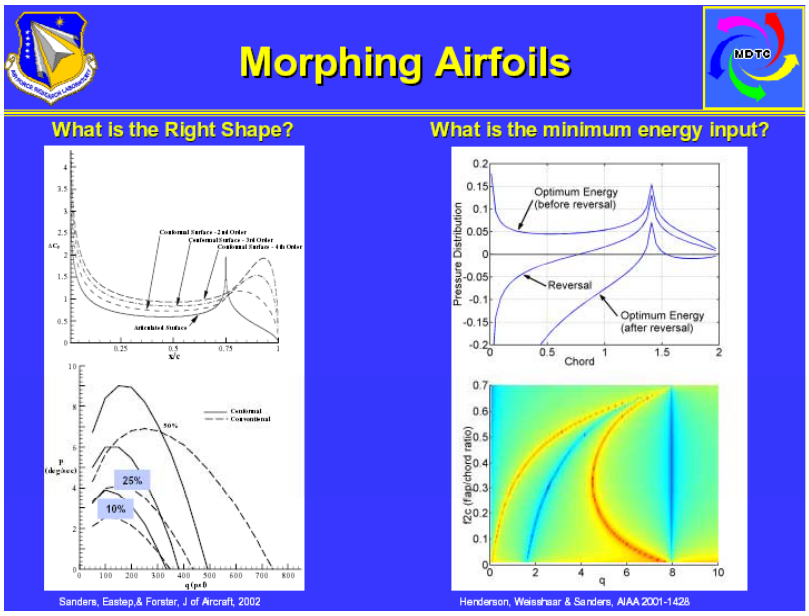
- Aircraft are currently designed around specific missions
- Can we develop aircraft capable of multiple missions?
  - e.g., reconnaissance air vehicles transform into effective ground attack vehicles

Fuselage & Propulsion System

First challenge: Morph the wing


The Challenge
A Multidisciplinary Design Task
MDTC
Design of an structurally integrated adaptive wing from an energy formulation
Mechanism Design
Structural Design
Actuator Integration
Control Laws
Power Electronics
Energy Source
Actuator + System


Adaptive Structure Design
MDTC
Approach
• Develop a theoretical framework to identify energy flow inside of the body (input energy, transferred energy, stored energy and etc.) for efficiency calculation
• Exergy-based framework to facilitate the design & system optimization of efficient systems
Aerodynamic force
Desired shape change
Body
Actual shape change
Actuation force
$\eta_{loaded} = \frac{Useful\ energy}{Input\ energy}$
Total input energy = stored energy + transferred energy


Morphing Airfoils
MDTC
What is the Right Shape?
What is the minimum energy input?
Conformal Surface - 2nd Order
Conformal Surface - 3rd Order
Conformal Surface - 4th Order
Articulated Surface
X/c
Conformal
Conventional
50%
25%
10%
Sanders, Eastep,& Forster, J of Aircraft, 2002
Optimum Energy
(before reversal)
Reversal
Optimum Energy
(after reversal)
Pressure Distribution
Chord
f25 (flap chord ratio)
q
Henderson, Weisshaar & Sanders, AIAA 2001-1428