

Viewgraphs Morphing Wing

by

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



**Center of
Multidisciplinary Technologies**



Morphing Aircraft Structures



**MULTIFUNCTIONAL & ADAPTIVE STRUCTURES TEAM
(MAAST)**

AFRL
 Bowman, Forster, Garner, Joo, Keihl,
 Reich, Sanders, Cannon (VACC)

External Collaborators
 Washington, Ohio State University
 Weisshaar, Purdue
 Murray, University of Dayton
 Inman, VPI



Relationship to VA Goals




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




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

Flow management
Thermal load management
Pointing devices
Stealth






DARPA Morphing Aircraft Structures




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

Variable Geometry Wings




- dihedral
- wing α
- wing planform



- sweep
- aspect ratio
- twist

- 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

Design of a structurally integrated adaptive wing from an energy formulation

The diagram illustrates the integration of five key design areas:

- Mechanism Design:** Represented by a truss structure diagram.
- Structural Design:** Represented by a wing cross-section with internal actuators.
- Actuator Integration:** Represented by a stack of actuators.
- Control Laws:** Represented by a block diagram showing feedback loops.
- Power Electronics:** Represented by a diagram showing an Energy Source connected to an Actuator + System.

Adaptive Structure Design

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

The diagram illustrates the energy flow and shape change of a body:

- Body:** A green oval representing the body, with **Aerodynamic force** (downward arrow) and **Actuation force** (upward arrow).
- Shape Change:** **Actual shape change** (dashed line) and **Desired shape change** (solid line).
- Energy Flow Diagram:** A graph with force f on the vertical axis and displacement d on the horizontal axis. The area under the curve is divided into regions A, B, C, D, E, F, G, H, I, representing different energy states.

$\eta_{loaded} = \frac{\text{Useful energy}}{\text{Input energy}}$

Total input energy = stored energy + transferred energy

