ARMD Transformative Aeronautics Concepts Program
CONVERGENT AERONAUTICS SOLUTIONS PROJECT

Spanwise Adaptive Wing

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Enabling Reconfigurable Aircraft Through The **Spanwise Adaptive Wing (SAW)** Concept

- Increasing aircraft efficiency by reducing the rudder through the incorporation of SAW
- Articulating the outboard portions of the wing via Shape Memory actuation
- Lateral-directional stability and control augmentation
- Supersonic - Increased compression lift and reduced wave drag
  - Enabler for supersonic flying wing design
SAW Development Path

Flight test

Ground test

CAS Objective: to develop all of the sub-systems for full scale infusion
• Technology and tool development and validation
• Scale-up validation
• A plan for the next a larger demonstration in a more relevant environment
Reconfigurable Aircraft

F-111 Mission Adaptable Wing

Adaptive Compliant Trailing Edge

Flexsys Flex Foil™

Historical Perspective

Morphing Aircraft

Folding wing aircraft

XB-70 Valkyrie
Ground Folding
A New Way to Actuate

• Shape Memory Alloy (SMA)
  – NiTiHf
  ➢ Alloys that have a “memory.” These materials have the ability to remember and recover their original shapes with load or temperature.
  ➢ SMAs exhibit a solid-to-solid, reversible phase transformation
  ➢ Can be ALL-Electric driven

Multifunctional Properties
- Shape Memory Effect
- Superelasticity
- Hardness
- Corrosion Proof
- Sensing
- Bio-Compatibility
- Impact Resistant
- Energy Harvesting
- Damping
- Actuation
- Energy Absorption
Current State-of-the-Art Rotary Actuators

SMA Actuator
Model # CAS2016

- Size ~450 in³
- Weight ~58.5 lbs
- Temperatures~ tunable based on alloy used
- Torque ~ 100,000 in-lbs
- Angle ~ 90 deg

Non-traditional – Revolutionary – Transformative

Assessment of Current Technology- With ARMD Thrusts in Mind

Current Technologies (hydraulic, pneumatic, or magnetic motors) do not provide a step-change towards “Big Leaps” in efficiency & environmental performance

- Heavy, and bulky – other options include gear boxes – large systems
- With SMA technology: 20% the weight & 15% the size of comparable hydraulic system
Flight testing out of the box ideas

PTERA
Prototype-Technology Evaluation and Research Aircraft

• Roughly based on an 11%-scale 737
• Baseline configuration has an 11.3ft span, 12ft length, and 4.3ft height
• ~200lb gross takeoff weight (40lb payload)
• Powered by two JetCat P200 turbojet engines (50 lbs thrust each)
• Flown 13 times (SysID, performance evals)
Flight Test Experiment

Trade space evaluation

For the PTERA demonstration SAW produces nearly 40% of total rudder authority. Can this be used to reduce rudder size?
Flight Test

- Two flight campaigns on Edwards Air Force Base dry lakebed
- First flight late October/Early November 2017
WORKING TOWARD FULL SCALE
NiTiHf Alloy Processed in Large Scale

- **60lbs of NiTi-20Hf material were melted**
  - Melting process scalable from 1 lbs to >100 lbs
  - Repeatable properties (for lab verification, actuator back ups, and future flights.

- **Extrusion to rod and tubing**
  - From 4” to 0.5” in diameter and from 1.2” to 0.5” in diameter reduction

- **Tubes drilled and splined**
  - Final form of actuator before training and instrumentation.
Ground Test: Large tube testing underway

- 1” tube
- 10” long

- 20,000 in-lbf test rig
- Fully instrumented for SMA large tube testing
3 Mechanisms for Ground Test

- Use 0.5” and 1” tubes
- Target for 90 degrees of rotation
- 5000 in-lbf torque
- Explore locking features
F-18 Demonstration?

Figure 1: View of the analyzed SAW F-18 geometry (-70 deg wing deflection)

Figure 2: Percentage changes in lift coefficient for different wing deflections, from Cart3D
Fin