ACTE Wing Loads Analysis

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About Me

• The Ohio State University, Columbus, OH
• 3rd year student
• Double Major: Aerospace Engineering & Aviation
• AERO Institute
• Code RS: Aerostructures
• Mentor: Josué Cruz
Background

• ACTE – Adaptive Compliant Trailing Edge
• Joint project between NASA, AFRL, FlexSys
• Modified GIII
• Flexible Flap – Seamless Transition
• Multifunctional Structure contributes to:
  • Noise Reduction
  • Wing Load Alleviation
  • Cruise Drag Optimization
• ACTE Project Goal: Prove full scale flap structure could be manufactured and flown in a relevant flight environment
Background

• Wing Loads Analysis needed with new modification

• Includes CFD analysis and flight tests

• Important load characteristics include: shear force, bending and torsion moments
Background

- Previously TRANAIR used as CFD software
- Worked well for initial testing at lower Mach numbers
- Higher fidelity code required for testing at higher Mach numbers (near transition region)
- Star-CCM+ chosen for further testing
- Outputs TECPLOT format
Objective

• CFD output is ran through MATLAB utility
• Calculates wing loads from aerodynamic and inertial data
• Needed updating/replacement to work with TECPLOT format before further flight testing could be conducted
Star-CCM+ Output

- Outputs data file in TECPLOT format
- Post-processing tool
- Many CFD programs output in this format
- Contains data for free-stream and aircraft
- Surrounding air is unnecessary – only need GIII surface data
• Original file only contains node and $C_p$ data
• TECPLLOT used to calculate other important variables
• Saved as ASCII format
• New file contains all variables
TECPLLOT Output

File Header

Zone Header

Zone Data
Extract.m

- Prompts user for inputs: file name, zones, translation/rotation, scaling
- ACTE custom input

extract_TECPLOT.m

- Checks file format for correct variables
- Extracts data from selected zones
- Scales then removes data inboard BL 45
- Translates & rotates data

Output

- Saves data as MATLAB file
- Includes within each zone: panel center, $C_p$, area, unit normal vector
ACTE_Load_Case_M_TECPLOT.m

Prompts User for Inputs → Calculate Aerodynamic Forces → Calculate Inertial Forces

Data Output ← Calculate Loads (Shear, Bending, & Torsion) ← Transform to Other Coordinate Systems
Load Case: Inputs

• Old program required manual input (physically changing script each time)

• New program: Just hit “run”

• Prompts User:
  • File from Extract.m output
  • Wing Weights File(s)
  • Flight Conditions:
    • Dynamic Pressure (q)
    • Maneuvering Load (Nz)
    • CG & Roll Rate/Acceleration (only for rolling maneuvers)
  • Wing Stations for Load Analysis
Load Case: Forces

- **Aerodynamic Force:**
  - \( F = C_p \times q \times \text{Area} \times \text{Unit Norm} \)

- **Inertial Force:**
  - \( F = ma \)
  - **No Roll:**
    - \( F = \rho \times \text{Area} \times N_z \)
  - **With Roll:**
    - Lots more math…
Load Case: Coordinate Sys

- Points/Forces need to be transformed to new coordinate system
- GIII reference frame is located at nose
  - Useless for wing loads
- New reference systems created to give loads with reasonable values
  - Un-swept
  - Swept
  - ACTE
Load Case: Calculate Loads

- Sum forces/moments created by each panel
- Shear = $\sum F_Z$
- Bending =
  $\sum [(F_Z \times Y) - (F_Y \times Z)]$
- Torsion =
  $\sum [(F_X \times Z) - (F_Z \times X)]$
Data Output

• Displays total wing loads as well as loads for specific stations
• Graphs shear, bending, and torsion in un-swept, swept, and ACTE reference frames
• Saves load data as MATLAB file
• Saves graphs as .png
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Questions?