An Overview of the Finite Element Models Available for the DPW-8 / AePW-4 Hybrid Working Groups

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https://www.aiaa-dpw.org
https://nescacademy.larc.nasa.gov/workshops/AePW4/public

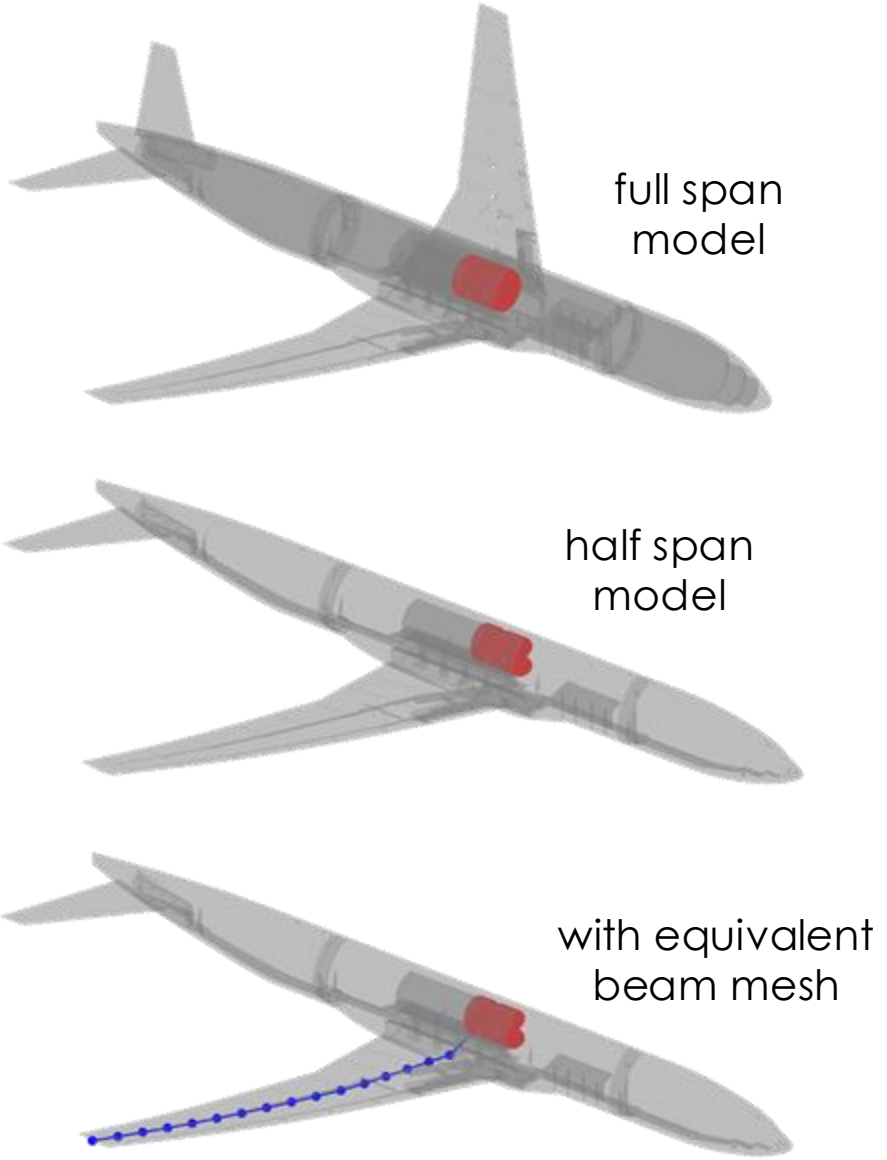
Introduction

- **Two hybrid working groups for the DPW-8 / AePW-4 effort**
  1. Static Deformation Working Group
     - Sting-mounted Common Research Model (CRM) tested at the LaRC NTF
     - A finite element model is needed for all of the aeroelastic simulations conducted in this WG
  2. Buffet Working Group
     - Sting-mounted Common Research Model tested at JAXA
     - This WG has an initial focus on unsteady simulations of rigid configurations
     - But later test cases will consider flexible CRM models, necessitating a finite element model

- **This presentation will give a brief overview of the finite element models provided to workshop participants for both WGs**

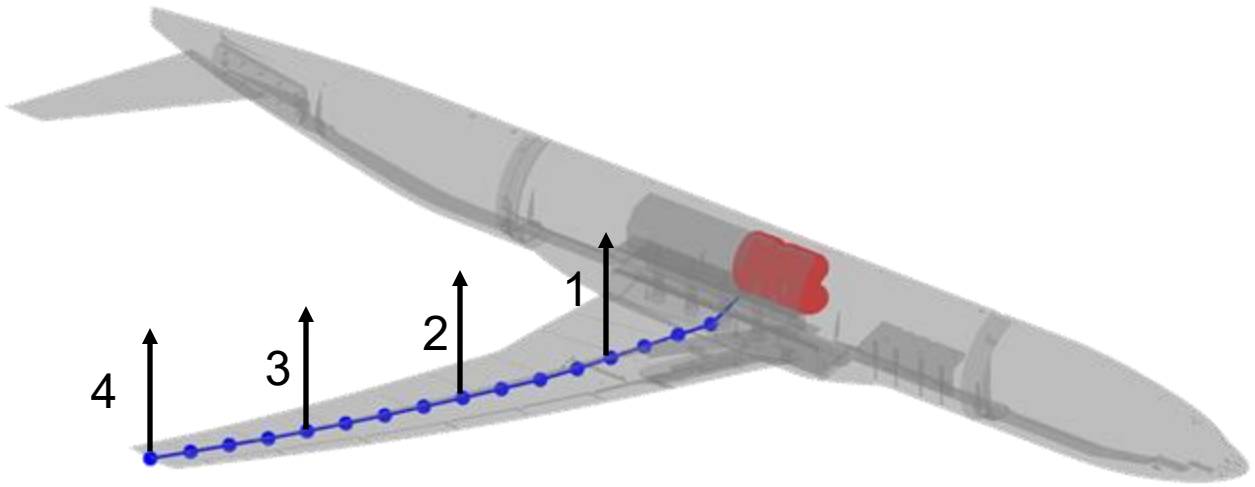
Static Deformation WG: FEMs

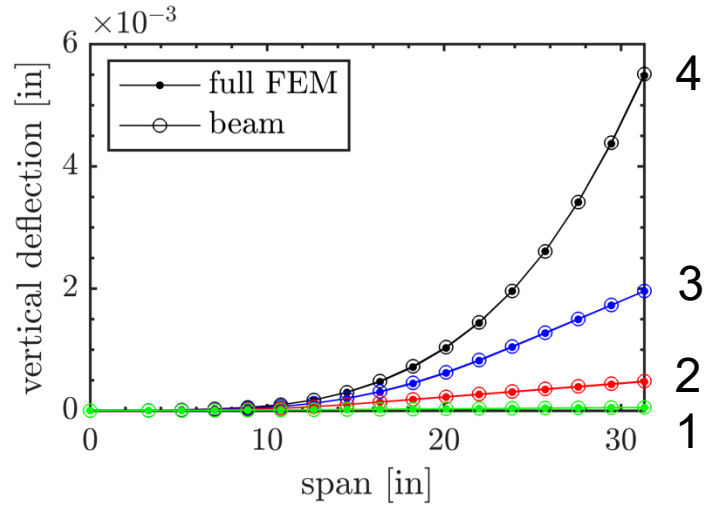
- **Tet-blasted Nastran full-span FEM, clamped inside the fuselage in-between the wings (red cylinder)**
  - Created for DPW-5 by J. Moore at LaRC
  - Used occasionally by participants since DPW-5, but never validated experimentally
- **We've halved the model to accommodate the half span CFD**
  - Not easy to do: the original FEM had elements that lived on both sides of the symmetry plane
- **We've also created an equivalent beam model**

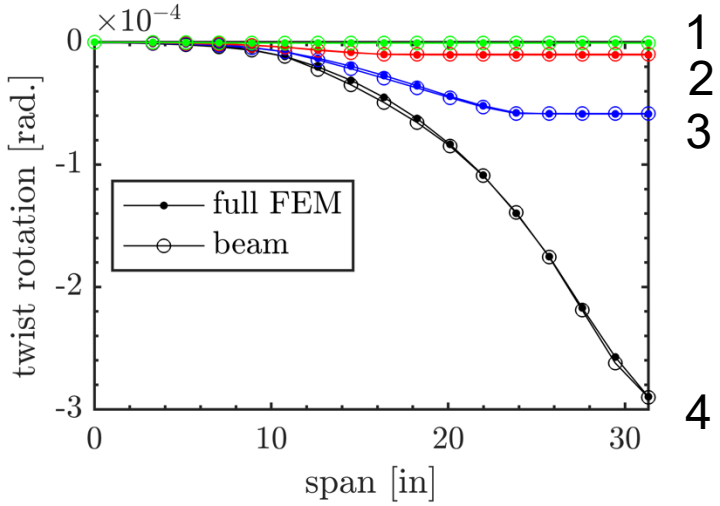


Static Deformation WG: Eq. Beam Verification

- **Four unit (1-lb) vertical load cases:**

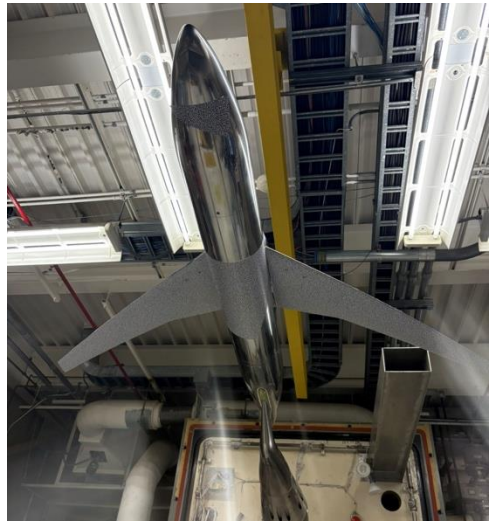


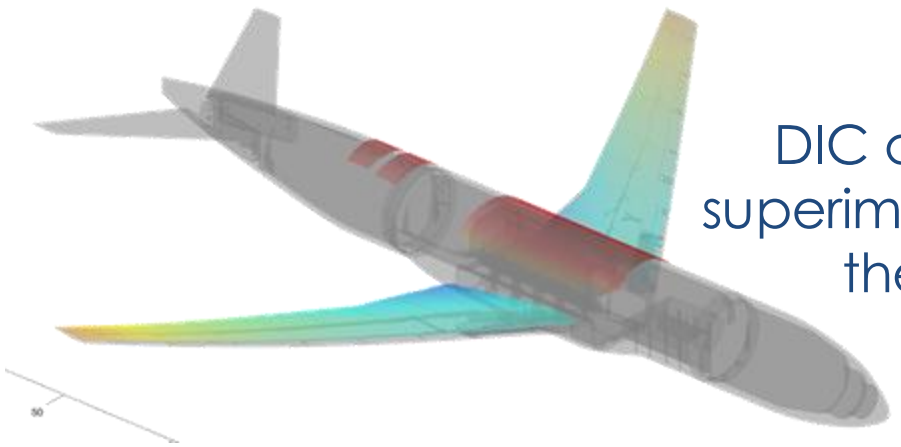




Static Deformation WG: FEM Validation

- In April 2025, we performed a static loads test, and a tap test, of the CRM model
- Digital image correlation (DIC) was used to track model deformation under loads, with a speckle pattern adhered to the two wings and fuselage
- We are still working to parse the DIC data, recreate the load cases in the FEM, and compare the two
- We will also compare the tap-test data with a modal analysis of the FEM

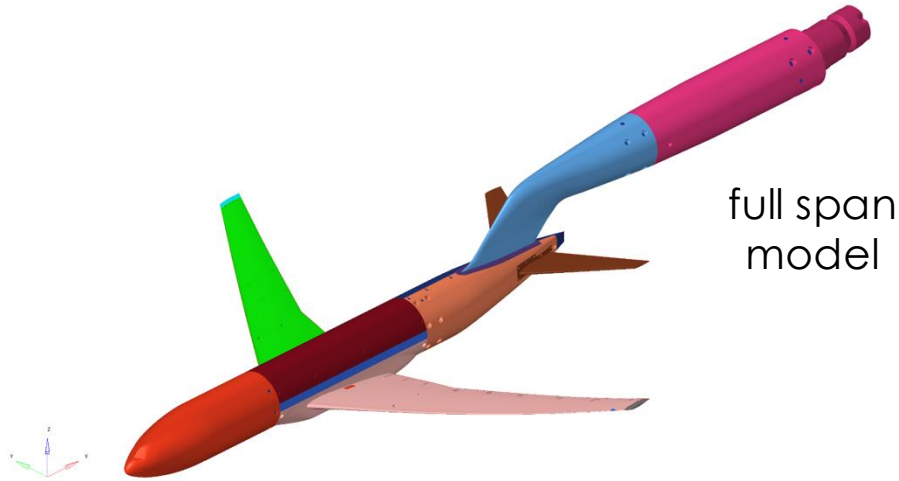




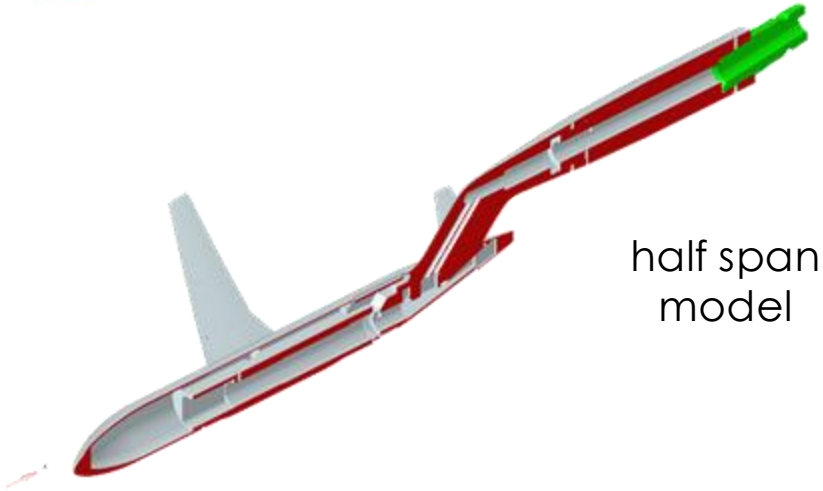
DIC data (colors) superimposed upon the FEM (gray)

Buffet WG: FEMs

- JAXA has created tet-blasted full and half span Nastran FEM models, including the sting assembly
- The clamped boundary condition is applied at the end of the sting support
- These FEMs will not be released, but a simpler stick/plate model has been publicly released



full span model

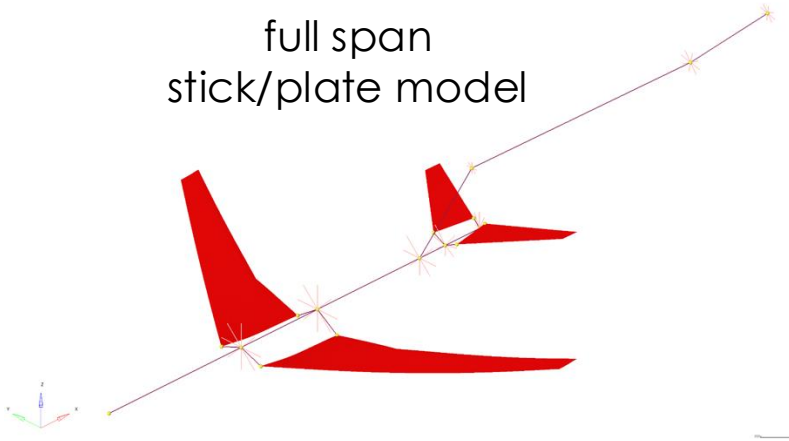


half span model

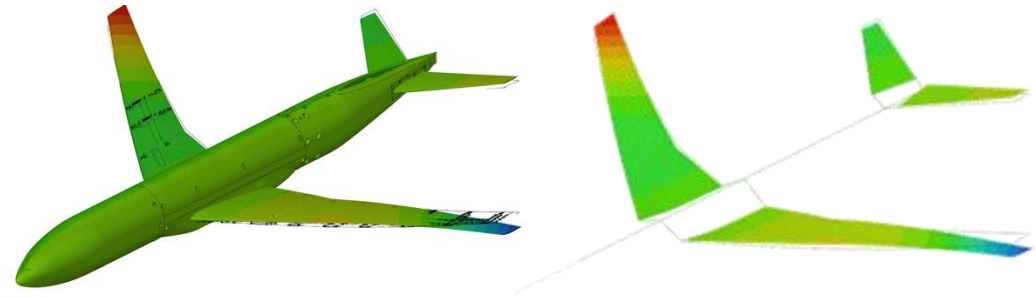
Buffet WG: Stick/Plate Models

- In the Static Deformation WG, we tuned the stiffness/inertial properties of the beam model to match the full-FEM model
- Here: the full-FEM modal content is simply mapped/interpolated onto the stick/plate

full span
stick/plate model



- If participants will couple their CFD solver to a modal structural solver for unsteady simulations (which is probably typical for most), then this stick/plate model will suffice
- If participants need to couple their CFD solver to a full FEM, this will not be possible: since a real FEM of the stick/plate model does not exist



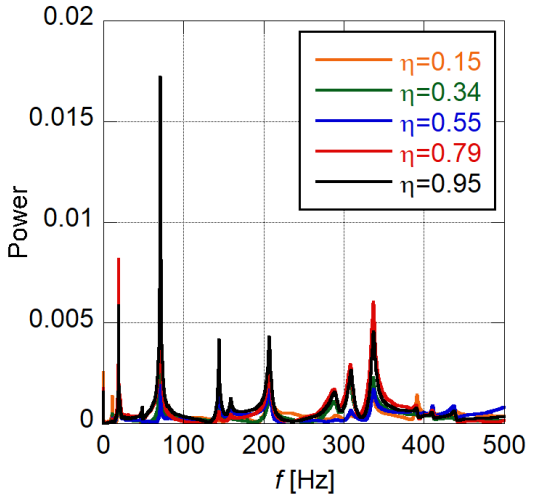
antisymmetric bending mode

Buffet WG: FEM Validation

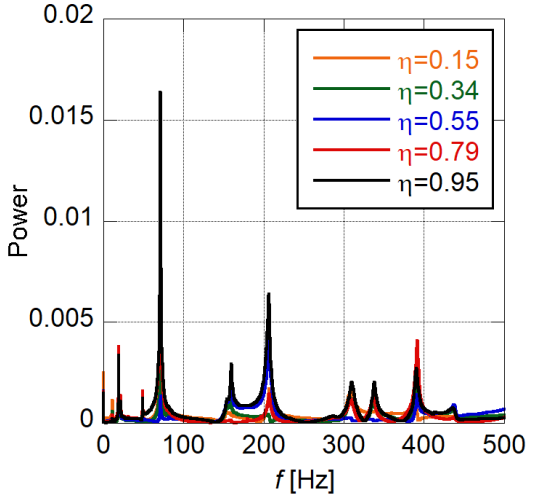
- **Natural frequencies measured via a tap test of the model were compared against computed natural frequencies**
  - Left wing: 19, 71, 144, 206, and 337 Hz
  - Right wing: 19, 50, 71, 159, 206, and 337 Hz

- **Good comparison with the computed frequencies:**
  - 19.51 Hz: vertical sting pitch
  - 51.99 Hz: first symmetric bending
  - 72.66 Hz: first antisymmetric bending

left wing



right wing



FEM Status and Outlook

- **Static Deformation WG:**
  - Full span, half span, and beam models live here:
  - https://dpw.larc.nasa.gov/DPW8/Static_Deformation/Test_Case_2/FEM_Models/
  - We are still working to compare these FEM models against recent static-loads and tap-test data
  - Assuming some (hopefully small) change is needed to the FEM, it is unclear the best way to make that change
- **Buffet WG:**
  - Full and half span beam/stick models (both grids and mode shapes) live here:
  - https://cfdws.chofu.jaxa.jp/apc/dpw/
  - Validation of this FEM is complete
  - For participants who will couple their CFD solvers to a modal representation of the structure, this is sufficient
  - But this will not work for any participants needing a full-FEM for coupling