Aeroelastic Prediction Workshop
High Speed Working Group Overview and Results

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NASA
DPW-8/AePW-4, Aviation 2026

Distribution Statement A:
DPW-8/AePW-4

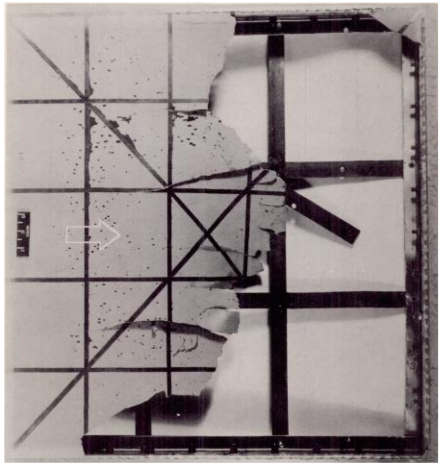
SHAPING THE FUTURE OF AEROSPACE

Presentation Outline

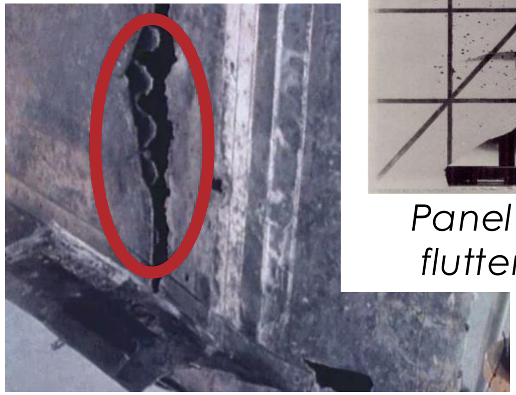
- **Background/Motivation**
- **High-Speed Working Group (HSWG) Overview**
- **HSWG Key Questions**
- **HSWG Challenge Problems**
  – AFRL Research-Cell 19 (RC-19)
  – UNSW HyMAX
- **RC-19 Overview**
- **Participant Presentations**
- **Model Evaluation**
- **Findings & Takeaways**

Background/Motivation

- **Extreme, complex loads in high-speed flows (transition, turbulence, separation, SBLI, 3D-effects) combined with flight-weight structures necessitates aerothermoelastic (ATE) considerations**
- **Nonlinear coupling drives unanticipated behaviors that are path-dependent and evolve over long durations**
- **Experiments necessary for model validation, but:**
  - Challenging to identify mechanisms governing behavior
  - Cost/resource limits restrict exploration of operational space
- **Computational models must play a role but there are open questions regarding accuracy bounds**
- ***Closing the design loop & reducing conservatism for high-speed platforms requires:***
  - *Improved understating of conditions driving ATE behaviors*
  - *Characterizing model accuracy & fidelity requirements*



Panel failure during flutter [Dixon, 1962]



Pylon Rip due to SBLI

HSWG Overview

- **Primary objective: Assess the SoA of ATE toolsets in high-speed applications**
  - Define degree of model fidelity and coupling required to simulate ATE behavior
  - Characterize predictive accuracy of and/or uncertainty in SoA models
  - Develop guidelines/metrics for simulating ATE behavior
  - Identify gaps in experimental datasets to provide feedback for future experiments
- **Format:**
  - Two different configurations selected with setup data packages provided for each
  - "Blind" prediction – Measured structural response provided after submission of results
- **Logistics and metrics:**
  - Kickoff meeting at SciTech 2023
  - Informal meetups in 2024 (AIAA SciTech) and 2025 (AIAA SciTech and Aviation)
  - Monthly meetings in 2023 – 2026 highlighting participants' progress
  - Participation: 109 members,11 of which worked on selected problems

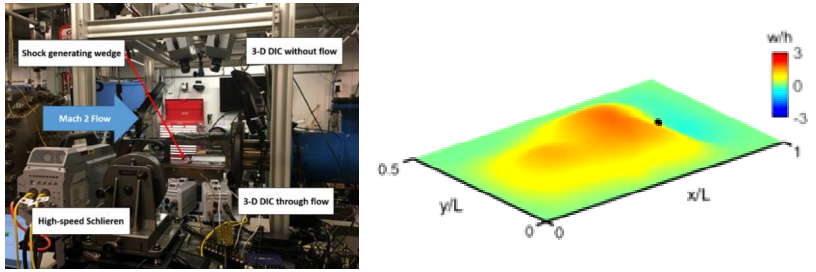
HSWG Key Questions

Objective: Assess the SoA of aerothermoelastic toolsets in high speed applications

- What are the physical mechanisms that drive the various types of aerothermoelastic instabilities in high-speed flows?
- How accurately can dynamic aerothermoelastic instabilities be calculated? (Identifying onset of the instability vs the post-threshold behavior)
- Develop guidelines/metrics for modeling instabilities: What level of model fidelity is required? How much accuracy is lost when using lower fidelity methods?
- What is the uncertainty in our models? How does uncertainty propagate when coupling multiple models?
- What are the gaps/uncertainties in current experimental datasets that need to be addressed with follow-on or new experiments?
- How well do the SoA models handle complex structures and flow environments (transition, separation, SBLI, 3-D effects)?

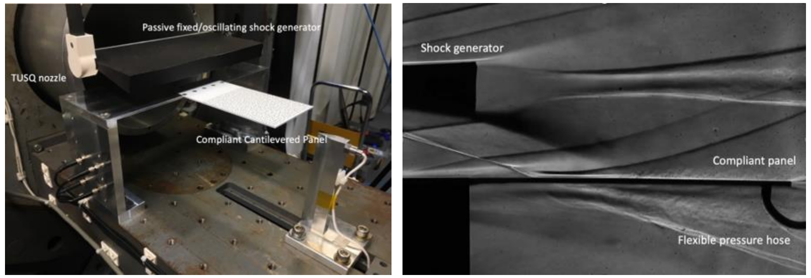
HSWG Challenge Problems

- **AFRL RC-19:**
  - Motivated by skin panels on hot, reusable vehicles
  - Continuous, supersonic flows with and without attached shock/boundary layer interaction (SBLI)
  - Large-amplitude, ***nonlinear*** dynamics of clamped panel



AFRL RC-19

- **UNSW HyMAX:**
  - Motivated by control surfaces on high-speed vehicles
  - Short-duration (i.e. blow-down facility) hypersonic flow with laminar and transitional SBLI
  - Shock-induced ***linear*** response of cantilevered plate



UNSW HyMAX

	Duke	NASA	DLR	UNSW	MIT	Stevens	UC/ARL	Cadence	UCF	MSU	Technion
RC-19	✓	✓	✓	✓			✓	✓	✓	✓	✓
HyMAX	✓				✓	✓	✓				

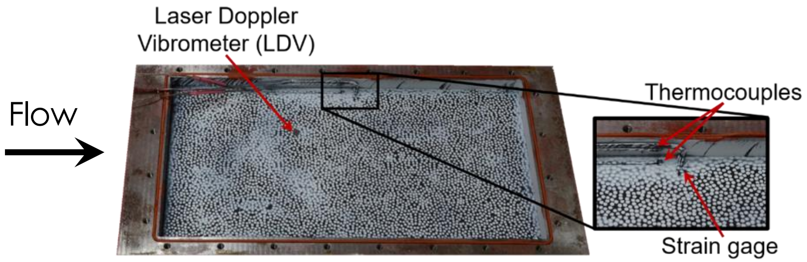
* Simulations completed & compared with experiments   ** Simulations in-progress

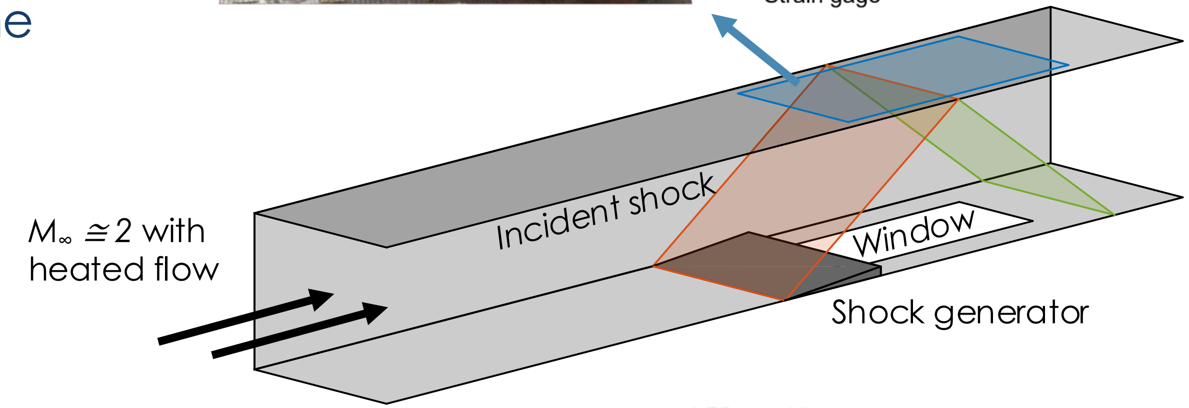
RC-19 Experimental Overview

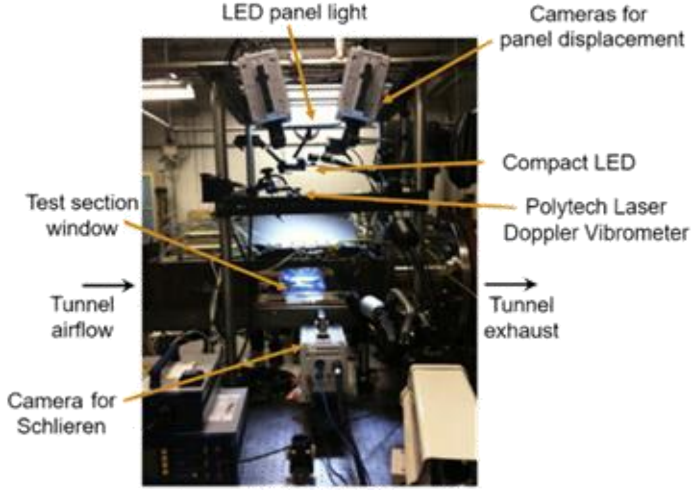
- **Discrete instrumentation:**
  - Strain gage
  - Laser Doppler Vibrometer (LDV)
  - Type K thermocouples (TC) on panel and frame
  - Downstream Kulite pressure transducer

- **Full-field, non-contact instrumentation:**
  - High-speed Schlieren imaging
  - 3D digital image correlation (DIC)
  - Fast-response pressure sensitive paint (PSP)

- **Thin panel data acquisition:**
  - Start tunnel and allow transients to diminish (set p_c using downstream pressure port to avoid yield)
  - Modulate p_c and record strain, LDV, p_c, and ΔT_{TC} (monitored)
  - If observe dynamics in strain, record 3 sec. of full-field data





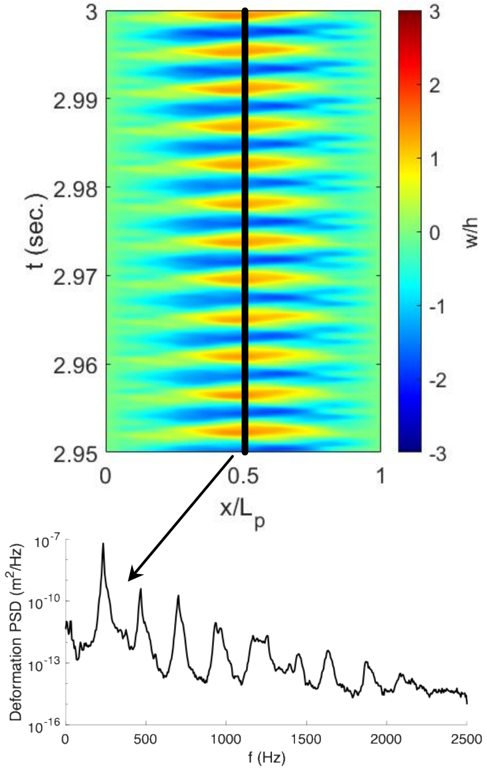


RC-19 Experimental Overview

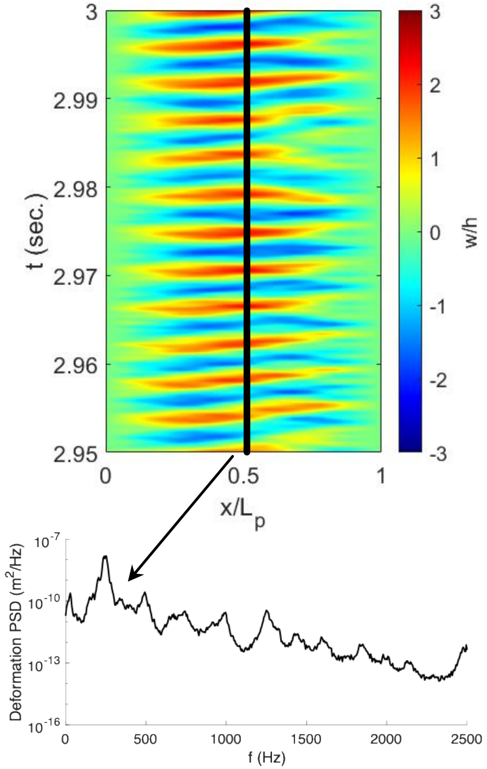
Observed/measured nonlinear aeroelastic instabilities which were sensitive to cavity pressure (p_c), temperature differential (ΔT), and shock impingement

Thermal buckling in turbulent flow leading to periodic and chaotic oscillations

p_c = 50.4 kPa, ΔT = 12.8 K

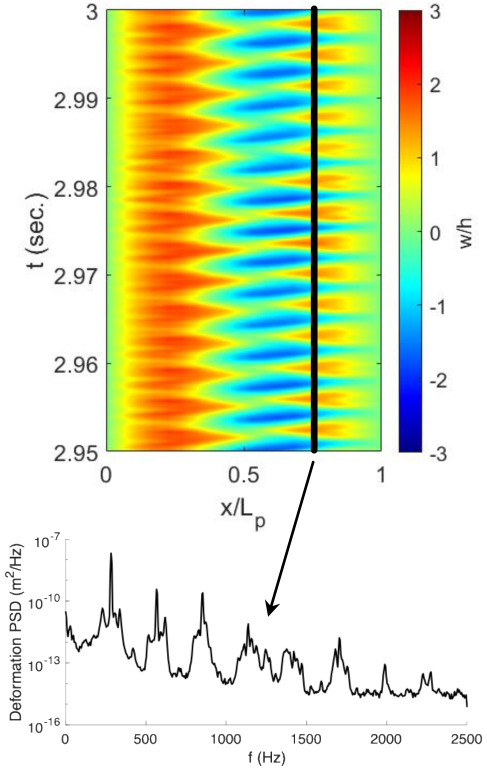


p_c = 51.5 kPa, ΔT = 14.7 K



Attached SBLI-induced limit cycle oscillations

p_c = 68.9 kPa, ΔT = 13.4 K



RC-19 Data Packages

Setup Files

- **Provided to all participants and available on NASA AePW website**
- **Provided as MATLAB data file with:**
  - Nozzle & test section geometries
  - Dimension & position of wedge
  - Thin panel dimensions & measured mode shapes/frequencies
  - Rigid baseline: Unheated flow operating conditions, boundary layer thickness, and surface pressure
  - Heated flow operating conditions for thin panel challenge problem
- **MATLAB scripts to extract/plot setup data**
- **Error bounds provided for uncertain data**

Results Files

- **Only provided when results obtained**
- **Provided as MATLAB data file with:**
  - Measured full-field mean and standard deviation of deformation
  - Average oscillation amplitude and PSD at 9 selected locations
  - Parameters used to compute PSDs
- **MATLAB scripts to extract/plot results**
- **Error bounds provided for uncertain data**

Participant Presentations

- **Duke – ROMs (Luisa Piccolo Serafim)**
- **NASA – CFD + FE (Bret Standford)**
- **AFRL – ROMs (Kirk Brouwer)**
- **Cadence – RANS + FE (Rodrigo Gutierrez)**

Questions?

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