AFRL CALL FOR RESEARCH

Research Title: Vortex-Dominated Flows in Massively-Unsteady Low Reynolds Number Aerodynamics

1. **Individual Sponsor:**

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2. **Academic Area/Field and Education Level:** Aerospace and/or Mechanical Engineering (MS or Ph.D. level)

3. **Objectives:** Pursue measurements using global velocimetry methods, direct force balance measurements and other techniques, coupled with analysis and/or computation (as appropriate), exploring a targeted parameter space of prescribed unsteady motions for rigid and flexible airfoils, flat-plates and low aspect-ratio planforms using the Air Vehicles Directorate's water tunnel (see (5) for details of facility).

4. **Description:** Small Unmanned Air Vehicles (SUAV) applications of current interest feature fixed-wing configurations often with extensive structural flexibility. The element of interest is large-amplitude changes in effective local inflow angles, such as a flexible wing flying through a gust. Low Reynolds number effects, such as massive laminar separations, close-coupling of time-dependent aerodynamic loads with shedding in the near-wake, leading edge vortices and so forth, render problematic the use of classical linearized approaches from unsteady aerodynamics. Instead, we aim for a first-principles understanding of flow separation at low Reynolds number (O(10,000)). Current efforts are guided by analogy to biological prototypes. The parameter space of possible flow conditions, configuration geometry, motion kinematics, aeroelastic parameters etc. is vast. Aggressive abstraction is required to render the problem tractable. Accordingly, the Aerospace Systems Directorate has built a 3DOF pitch/plunge apparatus, termed the "High-Intensity Pitch/Plunge Oscillator" (HIPPO), capable of prescribed motions of high frequency and amplitude, relevant to problems in flapping, gust interactions, dynamic stall and so forth. Proposed work would be primarily experimental, using the HIPPO rig and its instrumentation suite in the Aerospace System Directorate's Horizontal Free-surface Water Tunnel (HFWT), to (1) assess the role of vortex dynamics vs. time-dependent loads for a given parameter space of motions, (2) verify the validity of quasi-steady or locally linearized aerodynamic models, and (3) investigate models of gust response.

5. **Research Classification/Restrictions:** This research is at the public-release (Distribution Statement "A") level, with intent to publish in the open literature.

6. **Interest in Summer USAFA Cadet: No**

7. **Eligible Research Institutions:** *Place an X in all that apply.*

■ Universities (DAGSI & AFIT) AFIT ☐nly) USAFA☐