RQ18-35

1. **Research Title:** Plasma-based control of transitional flows using high-fidelity simulations

2. **Individual Sponsor:**

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

4. **Objectives:** The proposed thesis topic aims to employ direct and large-eddy simulations to identify and optimize strategies for plasma-based control of transitional flows in the subsonic or low-supersonic regimes.

5. **Description:** The extensive use of laminar flow is envisioned as a promising technology to meet energy efficiency requirements of future USAF systems. Maintaining laminar flow or delaying transition to turbulence reduces drag with direct benefits in range, payload or vehicle loiter times. However, introduction of laminar flow brings forth additional challenges. For instance, unforeseen and difficult to control dynamics may arise due to large excursions in transition location, a process which can be further exacerbated by the elastic vehicle response and by encounters with flight-path disturbances. The objectives of this proposed topic are twofold. First, we seek to identify novel flow control strategies to delay transition to turbulence and reduce drag on wing sections. Second, approaches to control transition excursions and eliminate potential system unsteadiness are desired. Given the versatility and rapid response of plasma-based control devices, these appear to be suitable candidates for initial exploration in the present application.

   To meet the aforementioned objectives, this thesis topic will employ high-fidelity, direct and large-eddy simulations to control transition on canonical swept and upswept wing configurations using dielectric barrier discharge (or DBD) actuators operating under either AC or nanosecond-pulsed excitation. Plasma modeling should be achieved through the incorporation of either existing or new phenomenological models into the flow solver in order to account for the large-scale interaction of the actuator with the transitional/turbulent flow features. Hence, no first-principles plasma modeling of devices is sought in this research. Control of Tollmien-Schlichting (T-S) and crossflow instabilities, as well as of excrescence-induced transition is the primary research target. Validation with theoretical and experimental results for the baseline case (without control) should be performed whenever possible. Exploration of actuator arrangement, location and mode of actuation (e.g., amplitude, frequency, duty cycle) should be conducted to optimize control effectiveness. Knowledge derived from this investigation should provide useful guidance to future experiments and flight tests.

6. **Research Classification/Restrictions:** This research is unclassified.

7. **Eligible Research Institutions:** Indicate to what organizations this topic should be provided.

   ☐ **DAGSI** (Wright State University, AFIT, Ohio State University, University of Dayton, Miami University, Ohio University, University of Cincinnati)