Improving Wind Model Profile for “1-cos” Discrete Gust

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There is increasing interest in air vehicles for planetary exploration with numerous rotor and fixed wing aircraft being proposed in light of the accomplishments from the ingenuity helicopter. For airframe reliability under varying environments, it is important to consider the aeroelastic effects because they affect the aerodynamic performance, maneuverability, and control of a spacecraft. All these factors will cause peak aerodynamic structural loads. Therefore, the design of a new spacecraft for planetary exploration should consider the effects of wind gusts to assure reliability and stability. Such missions target the atmosphere of Mars, Venus, and Titan where the effects of sudden variations in airflows can't be ignored, yet facilities to produce controlled gusts at low Reynolds number are limited.

There are two models to describe atmospheric turbulence defined in the FAR and CS: a continuous model and a discrete model. For extreme turbulent cases, the discrete model is defined to be a “1-cos” shape. To model a synthetic wind gust, oscillating vanes are placed at the inlet of the test section and possess a symmetric airfoil. These vanes are actuated with a time-varying oscillation and induce a vertical component into the freestream which propagates down the test section. Oscillating vanes have been proven to be the system of choice for gust generation because of its repeatability, so multiple tests can be conducted under the same gust conditions.

Creating an artificial “1-cos” gust profile is the focus of this research. Following literature, the constructed system consists of composite vanes, mounted on bearings, and actuated by servo motors. The input to the system is angular vane positions with respect to time. The generated gust (the output of the system) is measured with a two-dimensional hot-wire probe situated downstream where future spacecraft models would be mounted. Preliminary results revealed that a “1-cos” vane angle function produced undesired characteristics in gust response. Literature suggests that a more complex parametrically defined angle-time function is required to minimize these characteristics. Based on iterative wind tunnel experiments, the parameters for this new input function were identified for different flow velocities and gust parameters. A motor input to gust output was established for a specific range of desired gust amplitudes and gust frequencies, thus completing the commissioning of the low-speed wind gust generator at the University of Arizona. Finally, this work will present this gust generator as available for the comprehensive study and development of future atmospheric spacecraft designs.

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