Readers' Forum

Comment on "Monte Carlo Turbulence Simulation Using Rational Approximations to von Kármán Spectra"

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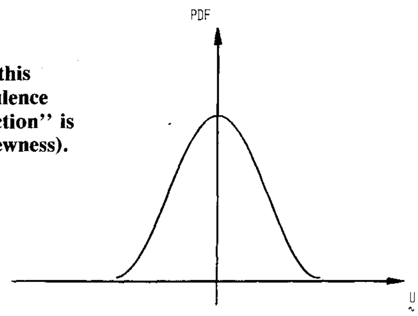

Fig. 2 Gaussian pdf; this pdf characterizes turbulence only when "self-interaction" is negligibly small (no skewness).

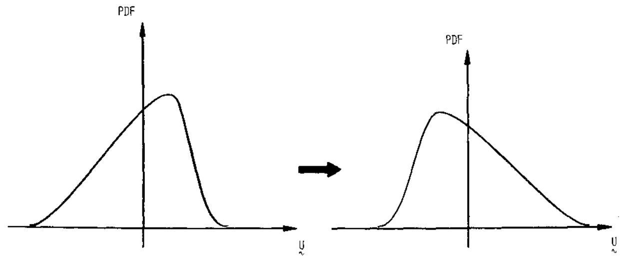

Fig. 3 Possible spatial evolution in the pdf due to the nonhomogeneous nature of turbulence.

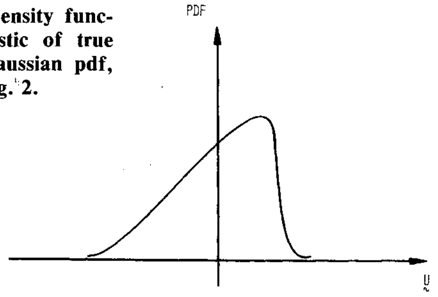

Fig. 1 Probability density function more characteristic of true turbulence than a Gaussian pdf, such as depicted in Fig. 2.

I CONGRATULATE Dr. Campbell on his very clever and efficient Monte Carlo simulation scheme.[1] The problem he is tackling is certainly of cardinal importance in the field of aviation safety. However, there is serious doubt that his simulated output is really "turbulence." The output is indeed *random* and its spectrum does approximate the von Kármán; however, the true test of its turbulent nature is not in the mere characterization of second-order moments such as $\langle w(t)w(t+\tau)\rangle$. On the contrary, the proof of the pudding is in how well it emulates the *physical* forces actually present in the hydrodynamic fluid. After all, these forces are what the airplane undeniably "senses" during a turbulence encounter. To this end, any Gaussian time history cannot recreate the "self-interaction" eminently characteristic of any true turbulence. This self-interaction is engendered of the *nonlinear* convective term present in the Navier-Stokes equation; to neglect this effect means that the turbulence is nothing more than diffusion.[2] A Gaussian time history requires that odd-order moments be indentically zero and, therefore, that the pdf be symmetric about $u=0$. This symmetry is also characteristic of the modern "modified" Gaussian time-history approach. For such cases, correlations such as $\langle w(t)u(t)w(t+\tau)\rangle$, $\langle w(t)v(t)w(t+\tau)\rangle$, and $\langle w(t)w(t)w(t+\tau)\rangle$ cannot exist, and these are the terms that unfortunately introduce the all-important culprit convective effect explicitly into the turbulence structure.

In short, there is no such species as Gaussian turbulence, at least not in the atmosphere (see Figs. 1-3), and the analysis of same does not even provide a viable "limiting case" analysis of the phenomenon. This is perhaps why pilots subjected to Gaussian "simulands" in state-of-the-art flight simulators often complain that the simulated input does not have the right "feel" of atmospheric turbulence. A quite common pilot description of the simuland is that it lacks the "element of surprise." The necessary nonsymmetry and its importance have been reported by the author as the result of related work,[3] and the effects of ground-level wind shear on turbulence are currently under investigation.[4] Skewness values for modeled wind gusts are reported in Ref. 5.

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References

[1]Campbell, C. W., "Monte Carlo Turbulence Simulation Using Rational Approximations to von Kármán Spectra," *AIAA Journal*, Vol. 24, Jan. 1986, pp. 62-66.

[2]Batchelor, G. K., *Theory of Homogeneous Turbulence*, Cambridge University Press, Cambridge, 1967.

[3]Treviño, G., "Turbulence for Flight Simulation," *Journal of Aircraft*, Vol. 23, April 1986, pp. 348-349.

[4]Treviño, G., "Airplane Flight Through Wind Shear Turbulence," *Journal of Aircraft*, to be published.

[5]Schiess, J. R., "Composite Statistical Method for Modeling Wind Gusts," *Journal of Aircraft*, Vol. 23, Feb. 1986, pp. 131-135.

Reply by Author to G. Treviño

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