Combined Linear Aeroelastic and Aero-viscoelastic Effects in
da Vinci–Euler–Bernoulli and Timoshenko Spars with
Random Properties, Loads and Physical Starting Transients,
and with Moving Shear Centers and Neutral Axes
Part II: Aero-viscoelastic System of Systems, Material
Failures and Parallel Coordinate Visualizations

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Work statement

The present paper is a continuation and expansion of a preceding project [1] to emphasize material failure
conditions in conjunction with aeroelastic and aero-viscoelastic phenomena. Inclusive analyses are formulated
for elastic and viscoelastic combined unsymmetrical bending-torsion during level flight and for vehicle rolling,
plunging, in plane and chord-wise motions. Bending-torsion effects on and changes in angles of attack due to the
rolling velocity as well as the influence of moving shear centers and neutral axes and of material failures are
considered during simultaneous occurrences. The final goal is to establish conditions for bending and torsional
flutter, torsional divergence, control effectiveness and ultimate survival time of the wing due to material failures
and structural instabilities (buckling) with future extensions to the entire vehicle under the rubric of system of
systems (SoS) approach, leading to a single pair of critical velocities and frequencies including material failure
effects and minimum structural weight. A new stress invariant stochastic generalization to the original Shanley-
Ryder stress ratio failure criterion is derived and utilized. The latter has the advantage of having an unlimited
number of arbitrary coefficients to be used in fitting analytical expressions to stochastic experimental data.

After student understands the theoretical developments, he/she will be instructed to do numerical analyses
and multidimensional graphing. At all times close one on one instruction and supervision will be maintained
by Prof. Hilton.

Student’s learning opportunities

The project is to be considered as a learning opportunity for the student. Student will meet with Prof. Hilton a
minimum of three times per week for an hour each time and additionally as needed. Student will work directly
with Prof. Hilton. He/she will be taught about aeroelasticity, material properties (stress-strain relations, failure
theories), system concepts, viscoelasticity, multi-dimensional graphing, etc.).

Student will further benefit professionally by being a co-author of a paper to be published in an archival
journal [2].

“Part I: Theoretical modeling and analysis,” Transdisciplinary International Journal of Mathematics, En-

UROP proposal. To be submitted to MESA Journal.

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