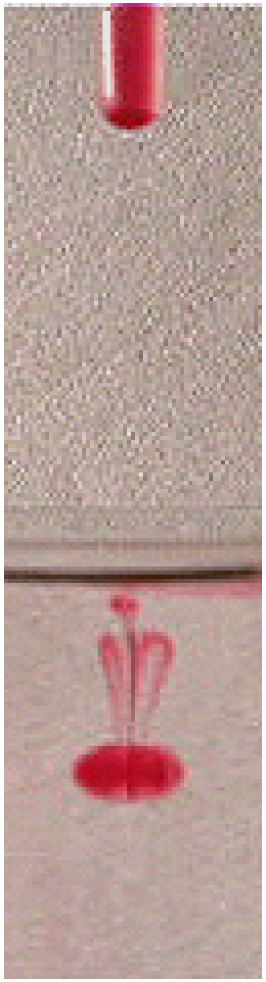
Fluid/Aero-dynamics of Nature

Vortex rings in Nature



- Bats
- Birds
- Insects

- Fish & aquatic animals

- Flying Seeds
- Trees
- Crops

- Atmosphere
- Wind Flow pattern
- Ocean flow pattern
- Tornadoes

- Blood flow
- Respiratory flow

"Once upon a time some scientists and engineers or college professors (different versions have different names and specialties) were at a dinner party. The subject of bee flight came up and the aerodynamic engineer that just happened to be present decided to do a quick calculation on bee aerodynamics. He used a conventional stiff airfoil-shaped wing, with steady state, or partially steady state, air flow analysis techniques, and lo and behold, the calculations did not work for the bee. Someone jokingly said, "I guess that proves bees can't fly", and they all had a good laugh. But, of course, they all knew it just proved that bee flight is too complicated to analyze with conventional airplane aerodynamic methods."

REBEL WITHOUT A CAUSE. VIOLATOR OF PHYSICS LAWS.

IS THIS SMUG LOOKING SOCIAL INSECT VIOLATING THE SACRED LAWS OF AERODYNAMICS?

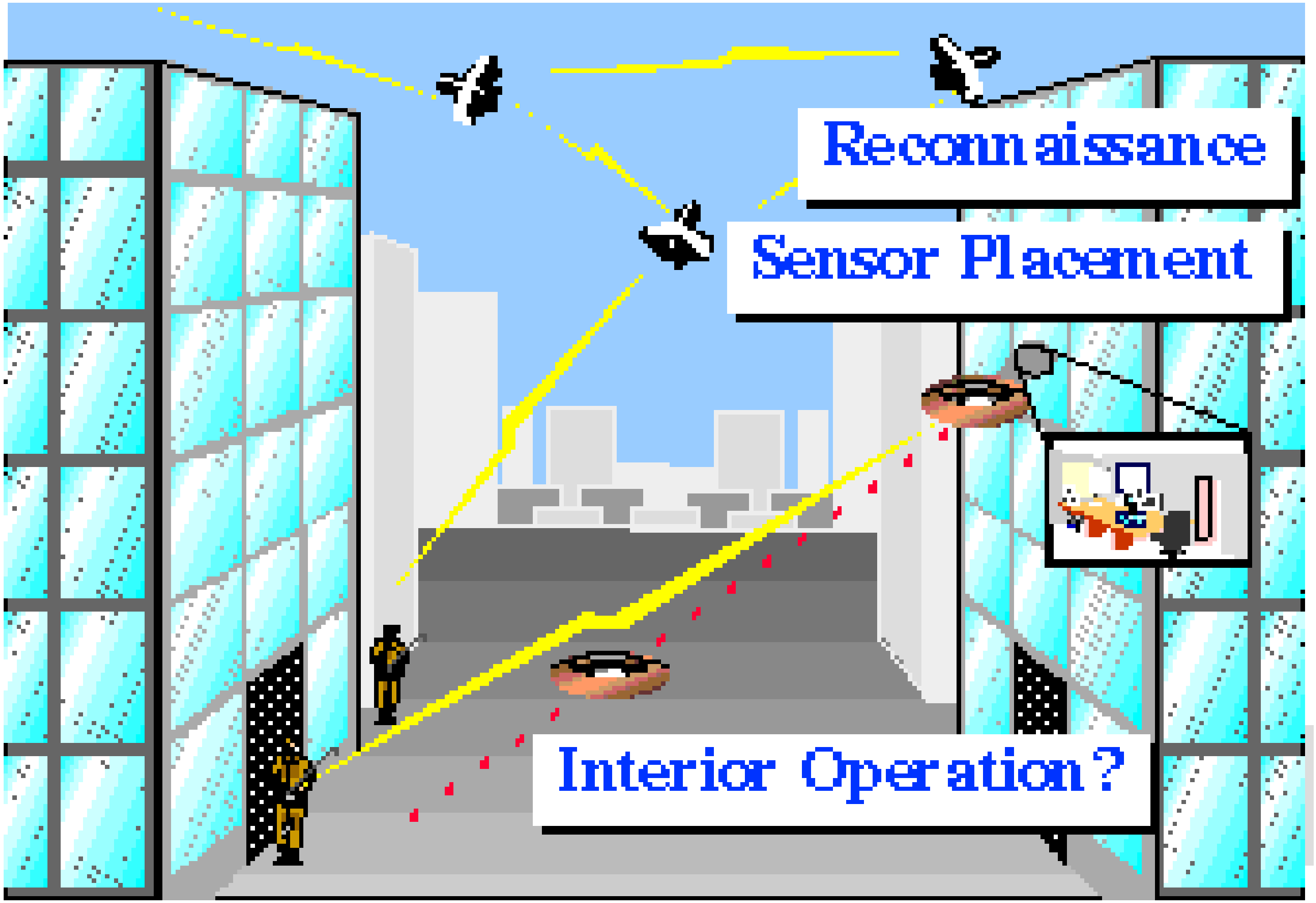
Here is the basis of the problem:

Conventional aerodynamic calculations are relatively simple, being based on large fixed wings and steady state or quasi-steady state flow.

Insect wings are small, flat, rough surfaced, and flexible. During flight they flex and twist in all kinds of horribly complicated ways. Also they are so small that important dimensional fluid analysis numbers like the Reynold's Number are very different, resulting in significantly different fluid characteristics when compared to the bigger wings of birds and airplanes (even a sparrow wing is huge compared to most insect wings). In addition, the small size and high speed of most insect wings makes it very difficult to study insect flight (imagine trying to attach a pressure sensor to an insect wing). Finally, the pressures and flow characteristics of the air around the wings are very unsteady, constantly changing as the wind flaps, bends, and twists, unlike aircraft wings which are stiff with relatively simple constant flow patterns and pressures.

Conventional aerodynamic analysis methods simply don't apply to insect wings.

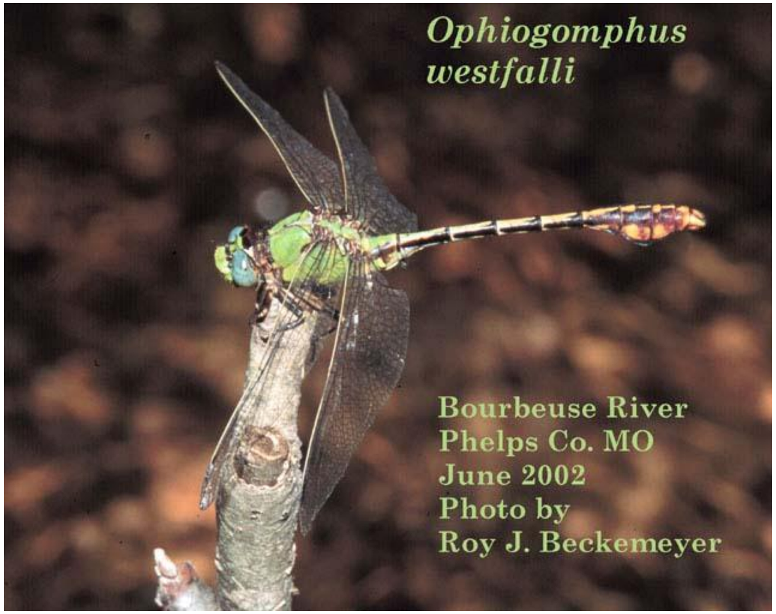
Typical Applications



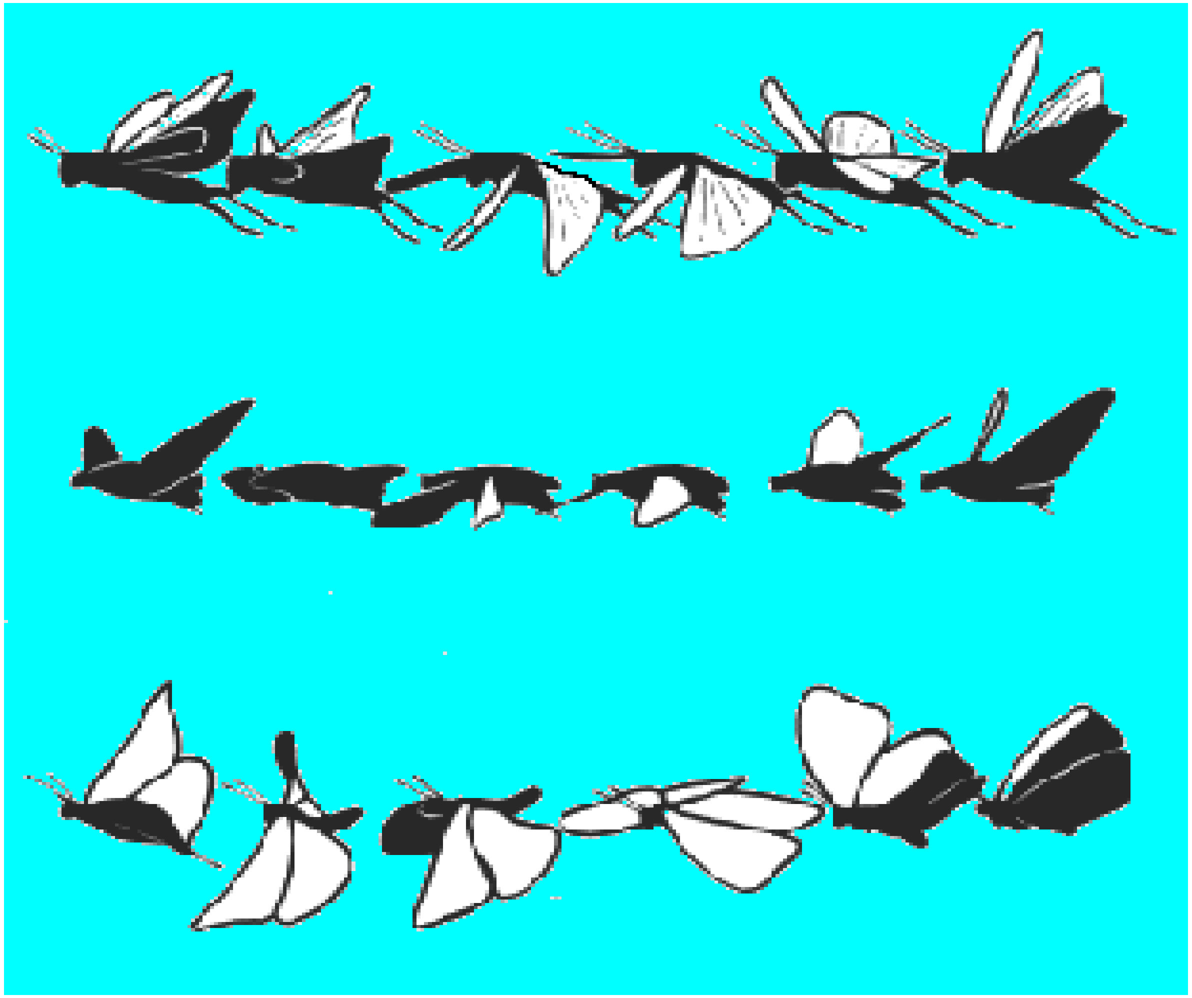
A Stealth Aircraft: Designed by nature

Vanessa atalanta

A Case Study

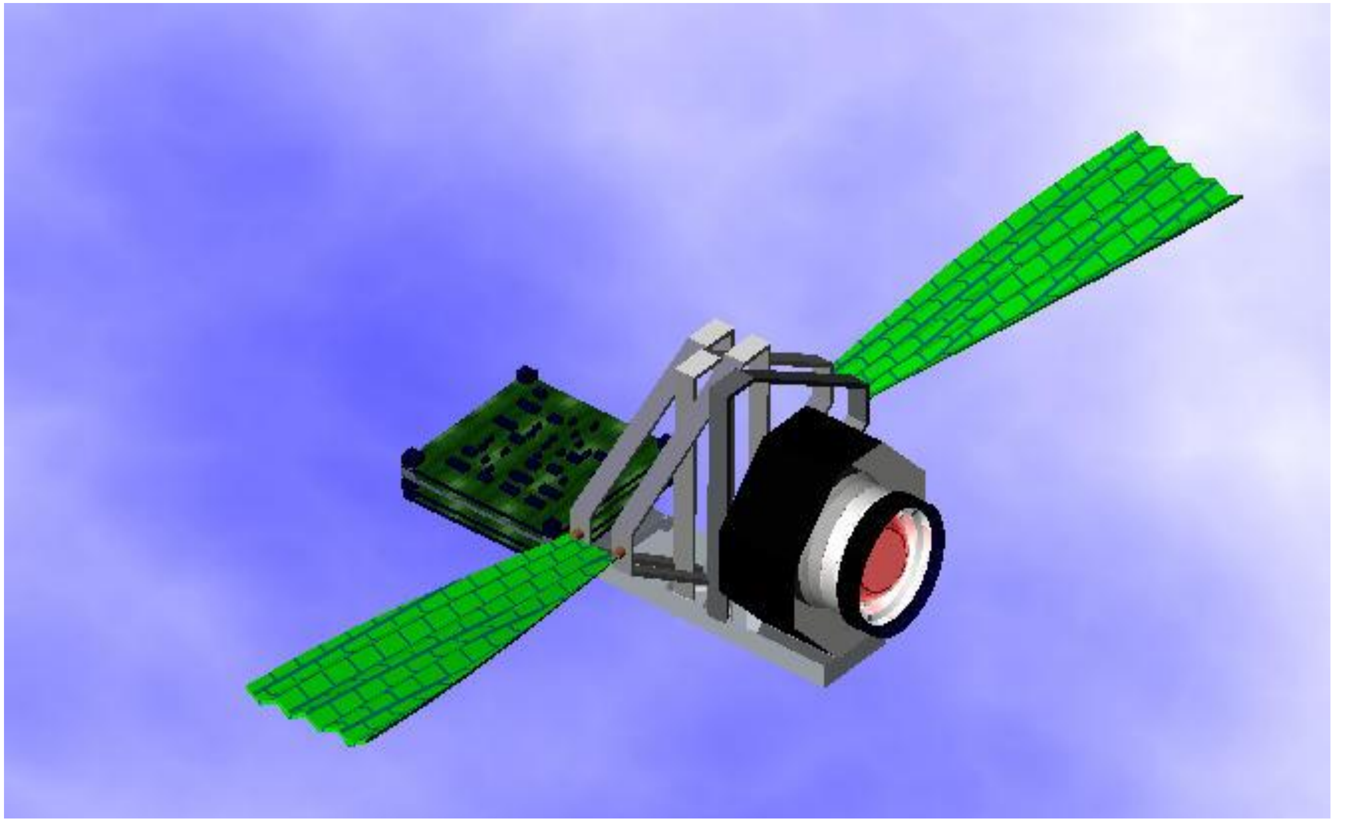


The insect thorax is shielded by cuticles of thin-walled chitinous shells, joined with an elastic material, *resilin*. The wings and the thorax shell form a distributed vibration system.



The sequence of insect flight: Cruising Mode (Sir J. Lighthill)

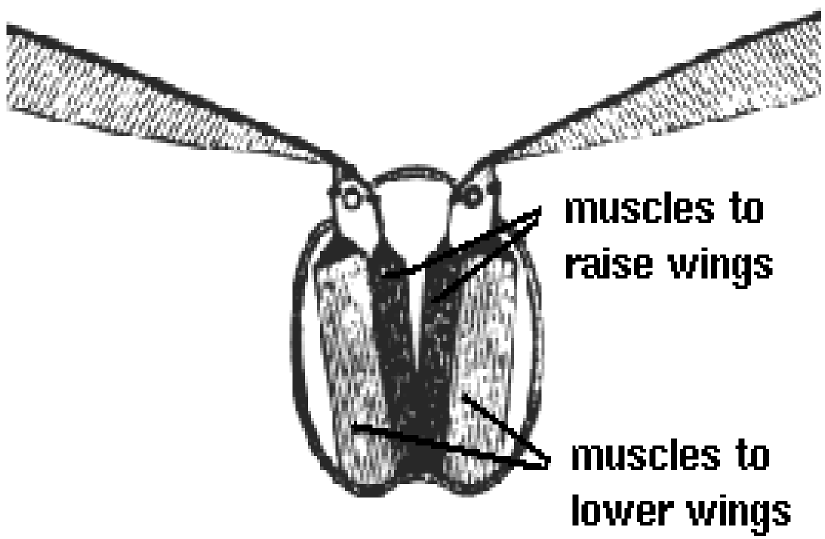
Recent Attempts (UC, Berkeley)



Flapping Wings using a fourbar mechanism: piezo-electric actuators driving a mechanical amplifying thorax structure

In some insects the wing movements are produced by wing muscles directly inserted into the base of the wing.

In others, these are produced by muscles that pull on the thorax shell, while the shell movement moves the wings.



A bit of Aerodynamics: Weis-Fogh Mechanism [Clap and fling (peel)]

Srygley & Thomas (Nature: 2002)