

## Active Flow Technology for Motor Vehicles up to 4,500 kilograms (Ramot)

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### The Invention

Miniature Air Vehicles (MAV's) with Active Flow Control (AFC) is an aviation invention in which the means for thrust generation, flight control and lift augmentation are created by the same fluidic actuators, located within the MAV. This can solve many of the problems that inhibit further development of the field. The most compelling reason for using AFC for MAV's, is that traditional control surfaces, as well as external motor-driven propellers, are eliminated and the only physically detectable evidence of the actuators is the streaming jet flow (with zero-mass flux) issuing from slots on the surface of the vehicle. Linkages, push-rods, propellers, hinges and moving surfaces are also eliminated. This brings with it the potential for robustness and field-worthiness, hitherto considered unattainable within the context of MAV's as well as radical improvements in the performance of low Reynolds numbers air vehicles.

### Need and Advantages

The Miniature Air Vehicle (MAV) with Active Flow Control (AFC) is essentially a flying wing, which is made up of two half-wings that are swept-back at an angle, a configuration based on the YB-35 and B-2 flying-wing bombers.

The span and mean-chord of the wing of one example are approximately 450mm and 100mm, respectively and the vehicle's weight is 2.25N. The invention integrates the three major flight systems (lift, guidance and thrust) into one. The wing has no traditional external control surfaces or propulsion means, and externally is extremely robust and simple. Instead, the wing incorporates a number of spanwise oriented slots, which contain arrays of fluidic actuators, each of which provides approximately 0.01N of thrust for each 1 Watt of power. These actuators supply enough thrust to fly the wing at 10-15 m/s. Several rows of such internally-mounted actuators also provide guidance, by proper distribution of the actuation authority along the chord and across the span of the vehicle. Real-time control is provided in a manner that ensures smooth and rapid handling qualities. Control laws allow a human operator to remotely fly the MAV by utilizing a flight control computer in conjunction with fuzzy logic algorithms. The proposed MAV exhibits structural robustness, large storage capabilities and low drag. A similar concept could be used to enhance the effectiveness of axisymmetric bodies and with robust actuators, currently under development, operate up to Mach numbers of 0.5.

### Potential Applications

There has been increasing interest in the development of very small flight vehicles. This is a result of new military and environmental needs, as well as the maturation of the technological feasibility. It is now widely believed that MAVs will be capable of providing the individual soldier with on-demand information about his surroundings, resulting in unprecedented situational awareness, greater effectiveness and fewer casualties. Moreover, technological spin-offs will soon find their way to other applications such as detection of toxic or radioactive waste or assistance in law enforcement.

### Patents

Granted US

### Supporting Publications

Pack, L.G. and Seifert, A., "Periodic Excitation for Jet Vectoring and Enhanced Spreading", (AIAA paper 99-0672), J. Aircraft, May-June 2001, V38, N3, pp. 486-495. Avihar, E., Shemesh, N., Pack, L.G. and Seifert, A., "Rotation of a Rectangular Jet by Periodic Excitation", J. Aircraft, 40 (1): pp. 217-219 Jan-Feb 2003. Rapoport, D., Fono, I., Cohen, K. and Seifert, A., "Closed-loop Vectoring Control of a Turbulent Jet Using Periodic Excitation", (AIAA paper 2002-3073), J. Propulsion and Power, V19, N4, Jul-Aug 2003, pp. 646-654.

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