ISSUE 12

APOGEE

PEAK OF FLIGHT

NEWSLETTER

The Soaring Methods of Birds

By Tim Van Milligan

Nature has provided the impetus of flight with examples provided by birds, bats, and other flying creatures (various types of insects, flying fish, reptiles, and mammals). The study of the flight mechanics of these creatures is very interesting, and for the model rocketeer, could yield some revisions and enhancements that may allow better flights of boost- and rocket-gliders.

Birds are a good choice of study, because they are plentiful, and all it takes is to look out in your backyard to view them to confirm any theories you may have about their flight behaviors. All the fathers of aeronautics studied the flight of birds, including Octave Chanute, Otto Lilienthal, and Wilbur and Orville Wright. So if it was good enough for those great pioneers, it should be good enough for us rocketeers.

Soaring is the name given to that portion of flight in which the animal uses the minimum amount of energy to maintain flight. This is the portion of a birds flight that most closely resembles a model rocket glider in flight. During this period, energy is extrated from the natural winds and converted to potential (height gain) or kinetic (speed gain) energy. Soaring birds usually glide using horizontal and vertical air movements, and exert muscular energy only to correct position and to hold their wings down in the horizontal position.

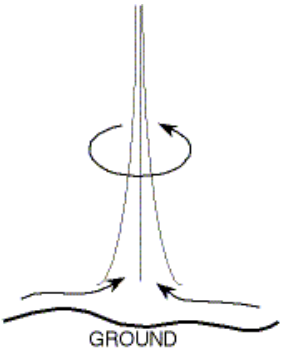
Soaring that depends on vertical movements of the atmosphere has been termed as static soaring, as opposed to dynamic soaring where energy is extracted from variations in horizontal wind speed. A rocket modeler may be able to exploit these methods, particularly if it is the radio control variety, but regular gliders may be also use some of these same techniques too.

Static Soaring

There are three methods of static soaring, all of them depend on vertical movements of the air. The most obvious is thermal soaring. This occurs in thermals, which are rising volumes of warm air. Thermals vary in form and structure but occur as two main types, the columnar type (like the shape of a swirling tornado, or dust devil), and the bubble or vortex ring type.

For more information on detecting thermals, visit: http://www.apogeerockets.com/education/detecting_thermals.asp

Dust-devils are triggered by solar heating of the ground and consist of rapidly rotating columns of air with zones of reduced pressure up the middle caused by centrifugal force. A bird or glider can maintain or increase height by circling in the upward stream of air. These columns last only for a few minutes, and according to one author, they seldom provide usable lift beyond 500-1000 meters above the ground. But this is plenty of altitude for a model to gain, and still be in view from the ground.



These types of thermals are abundant under the base of a big cumulus cloud. The big clouds need lots of hot air to be able to build the high cloud column. So they suck air in from the surrounding ground. If you fly rocket boosted gliders on hot afternoons, look for these types of clouds. Wait for them to be overhead, and then launch your rocket. If you do, you'll have a good chance of getting caught in a boomer thermal.

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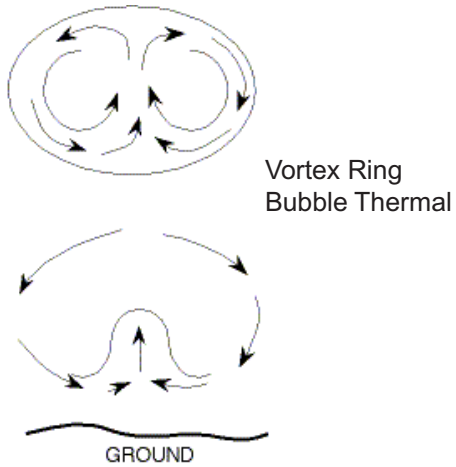
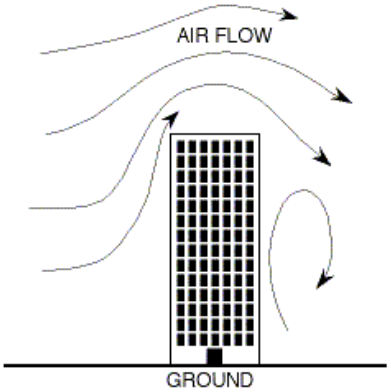
Thermals of the vortex-ring variety may be triggered directly from the heated ground, and they rise through the atmosphere as distinct bubbles. As the bubble rises it increases in size because the lowered surrounding air pressure with increased altitude. The life of a vortex-ring can be more than a half an hour, and birds (or models) inside may climb to an altitude of more than 2500 meters. These types of thermals are hard to detect because once they seperate from the ground, a thermal detector (streamer or thermometer on a pole) may not respond to their passing. One may be located by watching the area for soaring birds or a swarm of insects that seam to be caught in a rising thermal.



The next soaring method is slope soaring. This is where a bird is lifted by air currents as it approaches a large object. Such an object may be a hill or cliff, a clump of trees, a large building, or even a large wave on the ocean. The extra lift is caused by the prevailing wind that must rise to go around the large blocking object. This carries the bird up with it, giving it extra altitude. I've personally seen pelicans use this method when flying along the high-rises in Daytona Beach. They purposely fly toward one of the large hotels that line the beach, and are lifted up over the top, and then they glide on toward the next one down the beach. They have really mastered this method of soaring because they rarely have to flap their wings.

This slope soaring method lends itself to radio-controlled gliders because you have to purposely aim for a large object.



Slope soaring can be done on the upwind side of a building.

If is also wise to note that you have to avoid the downwash of air immediately beyond the large object, or the glider will lose the altitude that was just gained. The way to do this is to turn off to the side when the lift appears to have ceased. For more instructions on how to do this, go watch the birds.

The last method of static soaring is closely associated with slope soaring as it occurs when the wind is deflected upward by some method. This one is called gust soaring because it happens randomly. The easiest way to visualize this is by thinking of the wind entering downward into a gully and then shooting upward as it flows out the backside. So you need a lot of rough terrain to use this method, which doesn't lend itself easily to the places that rocketeers usually use for ranges. Gusts of wind also occur when cold and warm air fronts converge. Again, blustery days usually keep space-modelers away from the range.

Dynamic Soaring

Dynamic soaring is a method of extracting energy out of a steady flow of wind. Only one species of birds has really mastered this technique, the wandering albatross. This method requires a steady wind over a large flat area, like a good sized rocket range, or over a large body of water. When the wind blows across the surface, it sets up a velocity gradient where the velocity is near zero at the surface and it increases very rapidly with increasing height (up to about 12 meters).

The process begins with the bird descending and flying with the direction of the prevailing wind (down wind). As it descends it gains speed, hence kinetic energy. When it is very close to the surface, it turns and heads into the wind and be-

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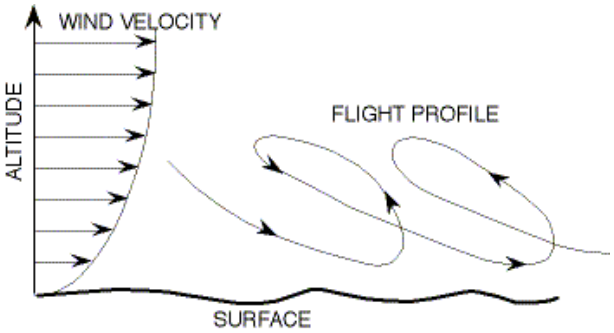

Dynamic Soaring takes complex flight manuevers that requires a RC airplane.

gins a climb. As it rises, the velocity of the bird falls off rapidly; but due to the wind velocity gradient, the air is flowing faster over the wings. This gives the bird extra lift, hence it is extracting energy from the wind. As it continues to climb, the wind speed reaches a constant value (remember the wind velocity gradient), and the bird must now trade some of its own kinetic energy for potential energy to keep increasing its own height. At its highest altitude, its forward velocity is approaches zero, so the bird changes direction again and heads downwind again - starting the whole process over again.

To the observer on the ground, the flight looks like a series of zig-zags, but according to the wandering albatross, it can be kept up for a long time, and even combined with slope soaring (over waves). This method could be used near the end of a RC glider flight, but it wouldn't be recommended in events that require precision landings, because there might not be enough altitude to maneuver for a final approach.

From these methods of soaring as taught to us by birds comes a flying strategy for model rocket gliding flights where duration is the key element in taking first place. The process would go something like this: on clam days - hunt for thermals (pay attention to soaring birds, and to other thermal detectors). On breezy days (which is more common), begin by looking for thermals, and maybe you might get lucky and get caught in a vortex-ring. If you are flying RC gliders, try setting up the glider to be in a position to take advantage of slope soaring off any large objects near the range (after you have exhausted all the good thermals). After your glider has lost more altitude, get into a large clear area and switch to dynamic soaring. You may not keep your glider in the air for hours, but you may just eek out a few more precious seconds (which might be all you need for first place).

About the Author:

Tim Van Milligan is the owner of Apogee Components (http://www.apogeerockets.com) and the curator of the rocketry education web site: http://www.apogeerockets.com/education. He is also the author of the books: "*Model Rocket Design and Construction*," "*69 Simple Science Fair Projects with Model Rockets: Aeronautics*" and publisher of the FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site, or sending an email to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.

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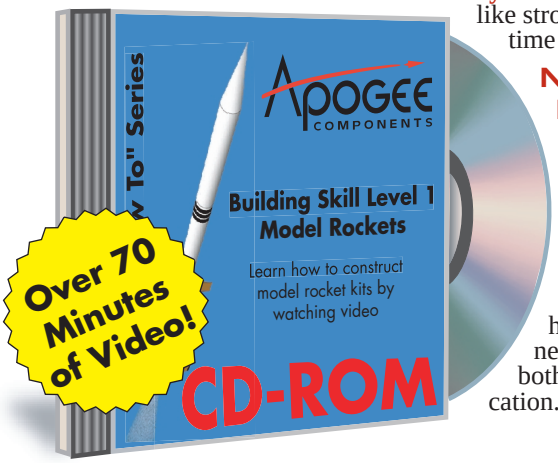

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