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Albatross Flight: Dynamic Soaring

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ABSTRACT

This article presents the flight of an albatross, and more precisely the survey of the dynamic soaring. It is the flying technique used by the bird to save energy.

1 Introduction

With its 10 kilograms and its 3-meter-wide wings, the wandering albatross can spend weeks at sea without ever returning to land (Fig. 1). It allows the bird to fly for long distances without using a lot of energy and moving its wings, it is an unflapping flight. The albatross can fly in each direction, even against the wind easily. It operates in the shear wind field, an area of 10 to 20 meters above the surface of the ocean where the wind speed changes dramatically. Close to the water, the wind speed is dramatically reduced by friction.

Fig. 1 Albatross in flight [5]

2 Dynamic soaring

The flight technique used by the bird is known as dynamic soaring which allows it to extract energy from the shear wind [2]. Albatross use the wind lift as a propulsive force. This propulsive energy is just enough to overcome the winds drag. To improve the notion of dynamic soaring, scientists are using GPS tracking to analyse albatross flight and wind speed data [1]. The albatross flight cycle can be separated in four phases (Fig. 2).

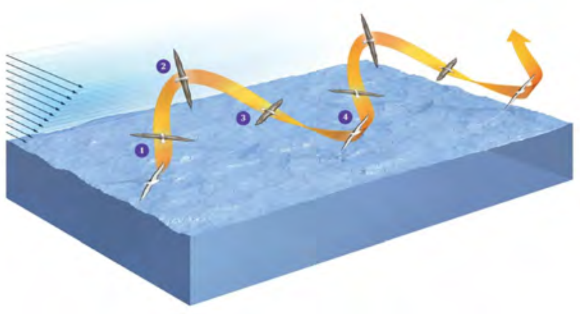

Fig. 2 The Albatross flight cycle [2]

The mechanism is simple, it is based on a cycle that it repeats again and again to gain energy and travel laterally to the wind direction. Each time it does the cycle, it starts with more ground speed and airspeed. The albatross can use this technique because a phenomenon appears close to relief and close to the water surface. Near the surface, there are two air masses with different velocities called wind gradient zones. (1) The first phase is the windward climb. The bird goes through the boundary between the two layers to gain energy. Facing the wind, the albatross gains a bit of altitude. (2) The second phase begins at peak altitude, after crossing the boundary between the two air masses. The bird describes a curve from upwind to downwind, it turns. (3) Then, the third phase is descending in wind direction, gaining speed and crossing once again the two gradient zones. (4) Finally, the last phase of the albatross flight cycle is close to the water. The albatross turns in the reverse direction to face the wind and start the cycle again.

When it is performing dynamic soaring, the albatross does a series of 180° turns so its path looks like a S-shaped maneuver. Moreover, the albatross can use these techniques because it has a specific shape and the ability to lock its wings when it is soaring in order to avoid muscle tension. This technique is used by gliders, but they fly in circles and not two rotations of 180° in opposite directions. Wind gradients are more important when the glider performs it than when the albatross turns close to the surface.

A research made by Philip L. Richardson, Ewan D. Wakefield and Richard A. Philips on the subject "Flight speed and performance of the wandering albatross with respect to wind" has provided interesting results [1]. During this research, the Leeway model, the airspeed model, the ground speed model and other relations have been found and defined. These seabirds regulate their velocities in relation to wind speed and relative wind direction. When the wind blows below 7 m/s, the optimal range speed of albatrosses is much higher when they fly upwind than for tailwind flights.

3 Biomimetics

Biomimetics is used by designers to help in solving human problems by creating nature-inspired solutions. In addition to this mechanism, albatrosses have the ability to lock their wings at the shoulder for long-distances soaring and unlock them when turbulence or gusts arise or when they need to maneuver. This trick allows the bird to reduce the drag and the effects of turbulence drastically. In that way, albatrosses can fly many kilometres without spending much energy [3]. It has inspired airlines companies such as Airbus which have the ambition to develop new wings with movable tips called "freely-flapping wing-tips". Currently as a model, the AlbatrossOne project would permit to cut down the drag forces, and thereby, induce lower loads transmission in the fuselage. The wing would not need to be heavily strengthened anymore. Therefore, it would be possible to decrease the aircraft weight and reach better fuel efficiencies.

Fig. 3 The Albatross UAV [4]

Albatross shape and dynamic soaring are not only used to design wings of different airplanes. A drone completely inspired from the albatross flight has been designed and commercialized since 2015: The Albatross UAV by Applied Aeronautics (Fig. 3). With its three-meter-wings and its ten-kilogram-MTOW, the electrical drone looks like the seabird. Every component is designed in order to reduce the drag and improve the efficiency of the cruise. The drone can take-off, fly and land autonomously for 4 hours. The Biomimetics is very present in this innovation.

4 Conclusion

To conclude, the dynamic soaring could be an interesting technique for airplane because it uses the wind energy to rise in the air. Whereas, it can not be used by civil or military airplane because the travel time would be too long.

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