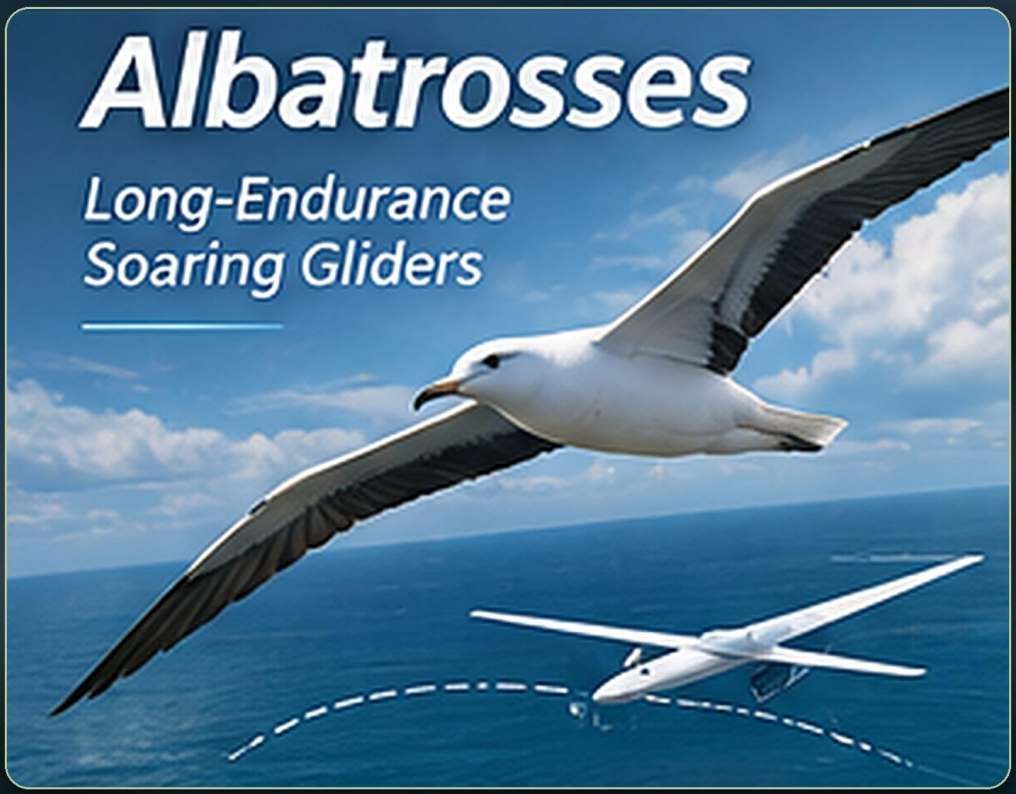
NATURE-INSPIRED INVENTIONS

FLIGHT · VOLUME 006 / 255



From living designs to working machines

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Albatrosses

Long-Endurance Soaring Gliders

Nature-Inspired Inventions

Volume 006 of 255

WealthSphere Labs

Albatrosses: Long-Endurance Soaring Gliders

Nature-Inspired Inventions, Volume 006

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About this book. This is an educational guide to biologically inspired engineering. The invention concepts in it are design ideas for study and experimentation, not tested or certified products. Worked numbers illustrate methods unless a source is named. Nothing here is engineering certification, legal advice on patents, or a substitute for qualified professional review of anything that will carry people, loads or risk.

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Contents

Introduction: Flying Without Flapping 5
Chapter 1: How Albatrosses Fly 6
Chapter 2: Anatomy of an Endurance Flyer 8
Chapter 3: Glide Performance and Dynamic Soaring 10
Chapter 4: A History of Soaring Flight 13
Chapter 5: Translating Albatross Flight Into Engineering 15
Chapter 6: Structures for Long, Slender Wings 17
Chapter 7: Sensing and Control for Soaring 18
Chapter 8: Ten Albatross-Inspired Design Concepts 19
Chapter 9: Testing Endurance Designs 22
Chapter 10: Failure Modes and Limitations 24
Chapter 11: Approval, Intellectual Property and Market 25
Chapter 12: Design Workbook 26
Chapter 13: Case Study — An Ocean-Monitoring Soaring Drone 28
Appendix A: Formulas and Rules of Thumb 31
Appendix B: Questions Readers Ask 32
Glossary 33
Further Reading 34

Introduction: Flying Without Flapping

A wandering albatross has the longest wingspan of any living bird, commonly around three metres. It spends most of its life over the open Southern Ocean, travelling thousands of kilometres on foraging trips that can last days or weeks. For much of that time it barely flaps. It glides low over the waves in long, swooping arcs, climbing into the wind, turning, and diving downwind, extracting energy from the air itself.

Long endurance is one of the most valuable properties an aircraft can have. Weather monitoring, ocean surveillance, wildlife tracking, communications relays and search-and-rescue all benefit from aircraft that can stay aloft for hours, days or weeks. The albatross is nature's most extreme example of long-endurance flight, and it achieves it with two strategies engineers can learn from: an exceptionally efficient wing, and a flight technique that harvests energy from wind.

This volume explains how albatrosses fly so far for so little energy, the aerodynamics of efficient gliding and dynamic soaring, the history of soaring flight, and how designers can apply these principles to long-endurance gliders and drones.

How this book is organized

Chapters 1 and 2 cover albatross flight and anatomy. Chapter 3 explains glide performance and dynamic soaring. Chapter 4 surveys the history of soaring flight and autonomous soaring. Chapters 5 to 7 cover translation, structures and control. Chapter 8 presents ten design concepts. Chapters 9 to 12 cover testing, failure modes, approval and a design workbook.

> Figures for real birds and aircraft are rounded and typical. Worked numbers are illustrations unless a source is named.

Chapter 1: How Albatrosses Fly

The albatross family

There are about 20 species of albatross, most living in the Southern Ocean and some in the North Pacific. The great albatrosses, including the wandering and royal albatrosses, are the largest, with body masses of roughly 6 to 12 kilograms.

Ranging over the ocean

Albatrosses forage for squid, fish and other food over huge areas of ocean. Satellite and GPS tracking have shown remarkable journeys. A study led by John Croxall and published in *Science* in 2005 tracked grey-headed albatrosses that circled the entire Southern Ocean during their non-breeding period, with the fastest completing the circuit in about 46 days.

Energy cost

Despite these distances, albatross flight is very cheap in energy. Research by Henri Weimerskirch and colleagues, published in 2000, measured the heart rates of wandering albatrosses during flight and found that, when soaring in suitable winds, their heart rates were close to resting levels. The most expensive parts of flight were takeoff and landing, not the long glides between.

Dependence on wind

Albatrosses need wind. In calm conditions, they often sit on the water rather than fly, because flapping their long wings is costly. Their range and routes are shaped by the strong, persistent westerly winds of the Southern Ocean.

Chapter takeaways

- Albatrosses travel thousands of kilometres on cheap, wind-powered flight.

- Heart rates in soaring flight can be close to resting levels.
- Takeoff and landing are the most expensive phases; calm weather grounds them.

Chapter 2: Anatomy of an Endurance Flyer

Long, narrow wings

The albatross wing has a very high aspect ratio — long and narrow, like a sailplane wing. Much of the length comes from long forearm bones, unlike the hummingbird, whose wing is mostly hand. The long inner wing gives a large, efficient lifting surface.

The shoulder lock

Holding a three-metre wing extended for hours would be tiring if muscles had to do all the work. Albatrosses have an anatomical locking mechanism at the shoulder, involving a tendon arrangement and specialized muscle, that holds the wings extended with little sustained muscular effort. This is a natural example of a mechanism that holds a configuration without continuous power.

Wing stiffness and flexibility

The albatross wing is stiff enough to carry high loads during dynamic soaring turns, yet it can bend and twist somewhat under gusts. Its pointed tips have no slots, unlike those of eagles; at the high aspect ratio and speeds of ocean soaring, slots offer little benefit.

Body and drag

The albatross has a streamlined body. Its feet are tucked back under the tail in flight. Its tubular nostrils are linked to a salt gland that lets it drink seawater, and the tubes may also play a role in sensing airflow, an idea that has been studied but is not fully established.

Chapter takeaways

- High aspect ratio wings reduce induced drag.
- A shoulder lock holds the wings extended with little effort.