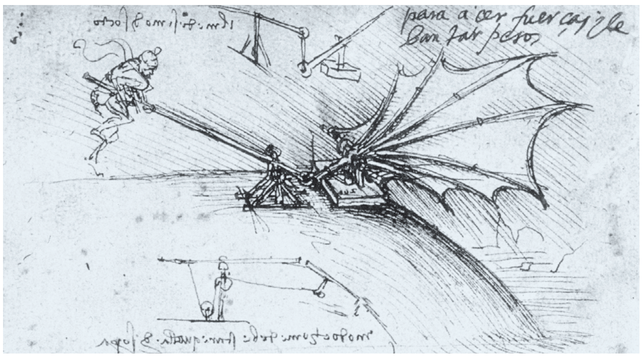
Air_ray

A remote-controlled hybrid construction with flapping-wing mechanism

Info

Bird flight as a model



Sketches by Leonardo da Vinci

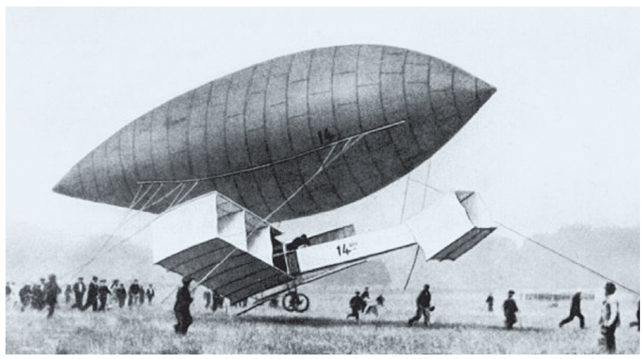
Etienne-Jules Marey's cinematographic recording of a bird in flight

Being able to fly like a bird is an age-old dream of mankind. Whether it be Icarus and Daedalus from Greek mythology, Leonardo da Vinci in the Renaissance era or Otto and Gustav Lilienthal around 1900: the desire to be able to fly is a vision that has constantly motivated many people to intensively investigate avian flight. These research and development processes have repeatedly given rise to flying machines that imitate the flight of a bird. In our times, some projects, such as the Ornithopter of Professor Dr. James DeLaurier from the University of Toronto, set out to realise a flapping-wing drive mechanism capable of bearing a man aloft. For Festo, fascination with moving air is a driving force for the future – not only in pneumatics, its core competence field, but also far beyond.

Leonardo da Vinci constructed the first flapping-wing models in 1490 to come a step closer to realising this ancient dream of mankind.

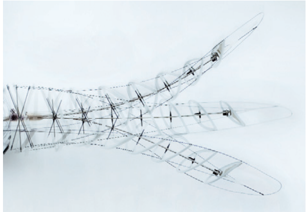
Etienne-Jules Marey, who lived from 1830 to 1904, carried out the first scientific investigations into the movement of living creatures. It was his cinematographic films that first made possible the study of individual motion sequences.

In 1889, Otto Lilienthal published the book "Bird flight as the foundation of the art of flying; a contribution to the systematics of flight technology". Countless tests and analyses carried out by Otto Lilienthal together with his brother Gustav Lilienthal gave rise to a large number of hang-gliders, flapping-wing models and the first scientific measurements in the field of aeronautics. In the chapter "The bird as a model" Otto Lilienthal describes in detail the flight of seagulls.



An airship in combination with an aircraft, by Santos-Dumont

In 1906, Alberto Santos-Dumont combined lighter-than-air balloon flight and aviation in France. In balloon flight, buoyancy is provided by a carrier gas, e.g. hydrogen, helium, superheated steam or hot air, in an enclosed space. Aviation makes use of the dynamic lifting force generated by air flowing at different speeds across the underside and the curved upper surface of a wing. Alberto Santos-Dumont mounted an aircraft named "14-bis" beneath his dirigible Airship No. 14. In the early days of aviation, such hybrid constructions had the advantage that the lifting force produced by the flowing air was only required to bear a portion of the overall load; the remaining load was borne by the dirigible airship. These hybrid constructions were susceptible to variations in wind conditions and proved difficult to steer.



The flapping wing in motion

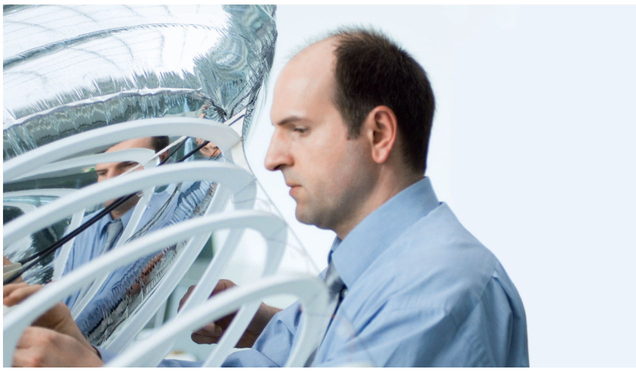
Air_ray is modelled on the manta ray, which with its flanks akin to flapping wings has been plying the oceans for thousands of years. The contours of the manta ray have undergone continuous refinement over the course of many stages of evolution.

Air_ray is a remote-controlled hybrid construction comprising a helium-filled ballonett and a flapping-wing drive mechanism. The ballonett is a gastight bladder of aluminium-vaporised “PET foil” with a specific mass of 22 g/qm; it can be filled with up to 1.6 cbm of helium. Since 1 cbm of helium generates approx. 1 kg weight of buoyant force, Air_ray’s overall mass must not exceed 1.6 kg.

Air has a density of 0.0012 kg/m^3 at 20° Celsius at sea level; by comparison, the density of water is about 1 kg/dcm^3. In the design of Air_ray, the difference in density between these two media necessitates an extremely light construction. This enables Air_ray to almost hover in the air by means of the buoyant force of the helium ballonet, floating through a sea of air just as the Manta_ray does in water.

The propulsion is effected by a flapping-wing mechanism. The wing module, which can be moved up and down by a servo drive unit, has a structure like that of the tail fins of many fish. This structure consists of two alternating pressure and tension flanks flexibly connected by ribs. When one flank is subjected to pressure, the geometrical structure automatically bends in the direction opposed to the force applied. This concept, named Fin Ray Effect®, was developed by Leif Kniese. In Air_ray it serves as an active structure. A servo drive unit pulls on the two flanks longitudinally in alternation, thus moving the wing module up and down.
What at first sounds complicated is in fact a simple principle, which in this case enables Air_ray to deploy the full power of its flapping wing. The structure is supplemented by a torsionally resistant central spar developed by Rainer Mugrauer. Mounted to its exterior end is a servo drive unit that enables the flapping wing to rotate about its transverse axis, so that Air_ray can fly backwards. The pitch elevator is also designed as a Fin Ray structure driven by a servo unit.

With this project, Festo demonstrates how nature can serve as a model to inspire new technical solutions. Air_ray’s movements already closely approach those of the biological model, and it can even execute birdlike light manoeuvres. Camera images can be transmitted live from Air_ray, and diagnosis of its operating parameters can be carried out online. The application of structures modelled on nature can also give rise to new solutions in automation.



Technical data

Span:	4.20 m
Length:	2.80 m
Height:	0.68 m
Total weight:	1.60 kg
Skin material:	aluminium-vaporised PET foil
Propulsion:	flapping-wing drive mechanism
Power supply:	2x LiPo accumulator cells, 8V, 1500 mAh

Project partners

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