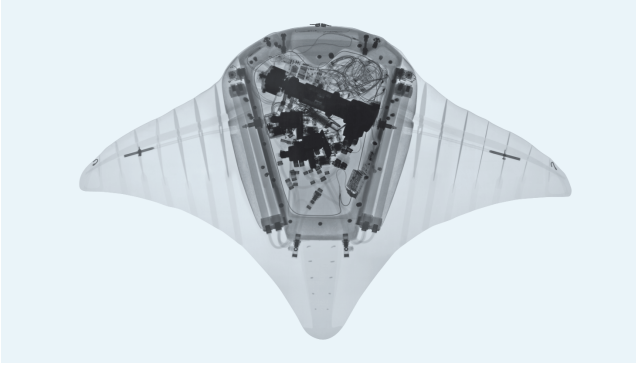
Aqua_ray

FESTO

Water-hydraulic
manta ray
with flapping-wing drive

Info

A remote-controlled fish



X-ray image of the Aqua_ray

Aqua_ray without skin

Analysis of various types of movement through water has established that rays are perfectionists in submarine “flight” and gliding. The up-and-down motion of their flanks in water closely resembles the flapping of a bird’s wings in the air. This wavelike movement perfectly combines maximum propulsion with minimum energy consumption. The streamlined form lends graceful movement to the manta ray, in particular, and makes it a veritable submarine acrobat.

Aqua_ray is a remote-controlled fish with a water-hydraulic drive unit; its form and kinematics are modelled on the movement patterns of the manta ray.

Bionic fluidic muscles from Festo serve as actuators. These largely consist of hollow elastomer tubes with integrated woven aramide fibres. When the fluidic muscle is filled with air or water, its diameter increases and it contracts longitudinally, giving rise to smoothly flowing elastic movement.

The fluidic muscle from Festo, in combination with the Fin Ray Effect®, constitutes Aqua_ray’s central propulsion and control unit. The Fin Ray Effect® is a construction that is derived from the functional anatomy of a fish’s fin and imitates almost perfectly the mode of propulsion executed by the natural model. It is entirely due to the mechanics of the fin ray’s-bony rods that constitute the fin’s supporting structure – that the wing can be arched to ensure even distribution of forces; this makes for a highly efficient drive mechanism.

Like a heart, Aqua_ray’s water-driven central vane cell pump generates the propulsion energy, which is conveyed in the form of pressure via specially developed valves to three antagonistically acting pairs of muscles. Their force of contraction is transferred by artificial tendons of high-strength Dyneema® cord via spools and sheaths to the wings and the tail, which in turn transform the tendon travel of 55 mm into a vertical wing amplitude of more than 550 mm.

Through the use of new elastic materials for all moving components and for the 3D-deformable skin, and by matching the elasticity and self-adaptive characteristics of the internal wing and tail structures to the hydrodynamic forces, it has been possible to reproduce the kinematics of nature’s marine model. Water is essential to Aqua_ray’s function, since entirely authentic movement can only be attained in combination with this medium and its special characteristics.

The change in direction of force effected by the tendons makes it possible to relocate the dorsal and thoracic muscles to the side, thus providing more room for energy storage and transformation components along with the control and sensory units. The requirements regarding technology and performance efficiency, e.g. payload, could thus be reconciled with the biological advantages of aquatic movement.

Aqua_ray can be excellently manoeuvred and can be operated either as a hydrostatic glider or with actively flapping wings. This makes for considerable energy savings.

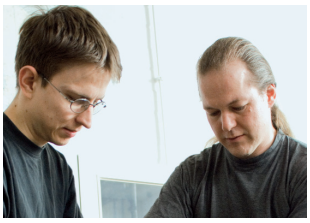
Thanks to its form and its mode of propulsion, Aqua_ray is suitable for application in diverse fields of marine research without disturbance to the natural environment.

Aqua_ray's closed contour and lack of rotating parts such as propellers allow it to be used even in sensitive areas; it is particularly suited to the inspection of pipelines, cables or the sea floor itself.

Despite its small frontal area for low flow resistance, its body shape yields a large horizontal surface; Aqua_ray thus makes an ideal bionic carrier module for sonar systems and other test probes.

The bionic Aqua_ray with Fin Ray Effect® combines research projects with the products and "patents" of nature into an elegant underwater flying machine characterised by striking manoeuvrability and natural gracefulness.

With Aqua_ray, Festo is demonstrating the opportunities that lie in mimicking biological principles. Smoothly flowing muscular movements are transformed into the dynamic flapping of a wing, which propels the artificial manta ray though the water.



Technical data

Overall length:	61.5 cm
Dry chamber:	41.0 cm
Overall width:	96.0 cm
Dry chamber:	31.0 cm
Height:	14.5 cm
Weight:	approx. 10 kg
Materials	
Torso:	fibreglass-reinforced plastic
Wings and tail:	CURV®, water-jet carved
Skin:	polyamide with elastan content
Drive / control units:	A Torcman brushless motor powers a 400 l pump, which drives fluidic muscles from Festo, and two servo drive units for orientation of the wings
Power rating:	24 V, 10 Ah
Maximum speed:	approx. 1.8 km / h
Minimum flight duration under full load:	30 min.
Sensors, diagnosis:	5 angular sensors, 2 force sensors, 1 potentiometer
Control:	wireless digitally addressable 2-way communication
Computing power:	2 units with 10 MIPS at 40 MHz

Trademarks:
Fin Ray Effect® is a trademark of Evologics GmbH, Berlin, Germany
CURV® is a trademark of Propex Fabrics GmbH, Gronau, Germany

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