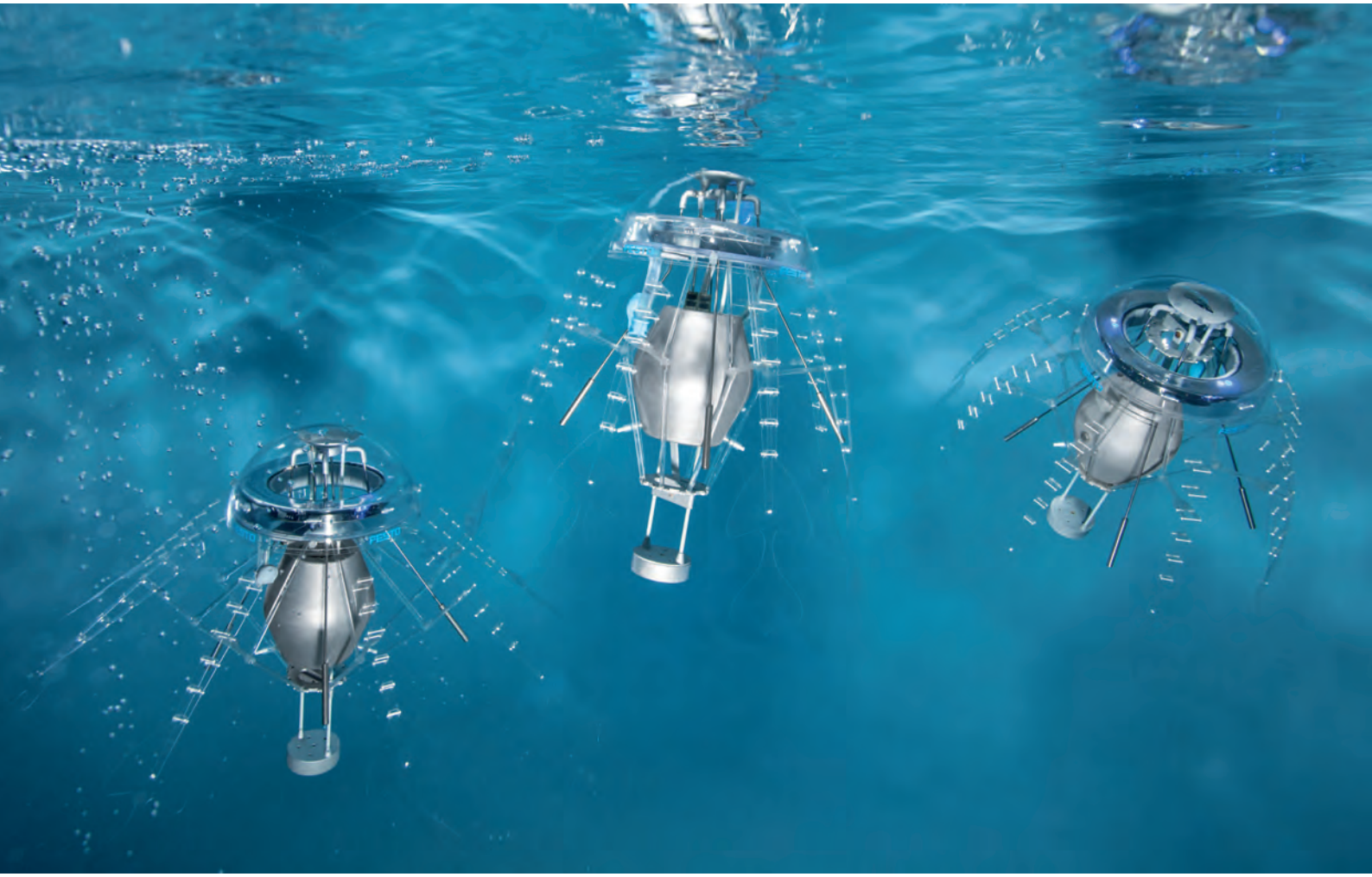
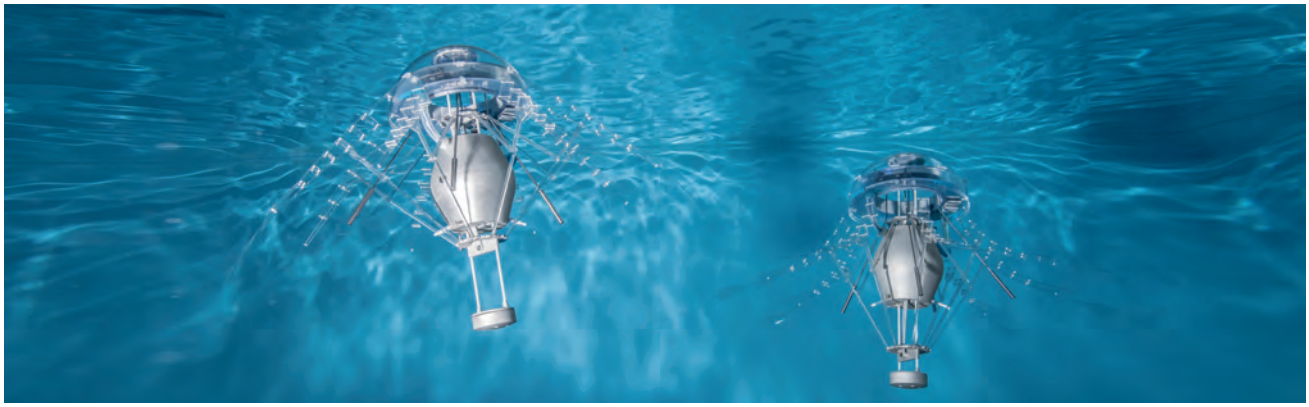
AquaJellies 2.0

FESTO



Autonomous behaviour in a collective

Bionic technology bearers for the water technology sector



Jellyfish are fascinating creatures that consist of around 99 per cent water. Over the course of millions of years, they have efficiently adapted to the most varied of environments in both salt and fresh water.

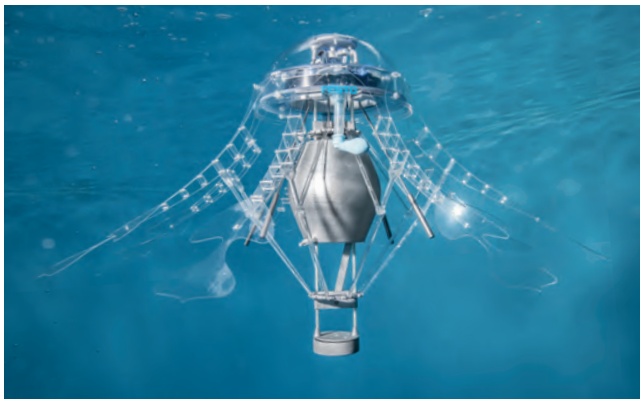
Artificial jellyfish based on biological role model
So that the movements of the AquaJellies come as close as possible to their natural role model, the artificial jellyfish have an intelligent, adaptive mechanism and are equipped with an electric drive unit. The integrated communication and sensor technology plus the real-time diagnostics enable a coordinated, collective behaviour even in a limited space.

The AquaJellies were developed as part of the Bionic Learning Network. In association with reputable universities, institutes and development firms, Festo is intensively occupied with transferring natural basic principles to the technical world of automation. The construction and further development of the artificial jellyfish is an attempt to get nearer to these fascinating creatures and to learn from them.

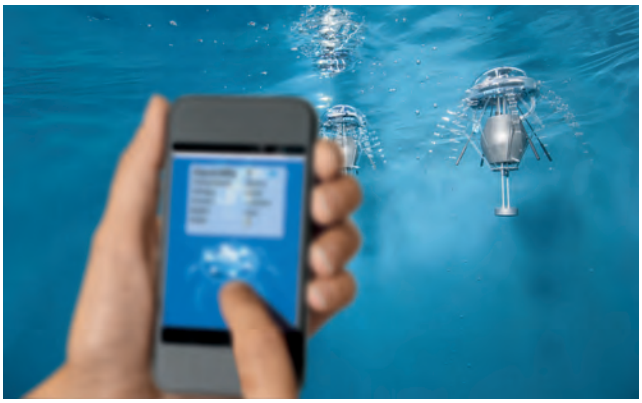
Continuous development
Festo presented the AquaJellies for the first time at the Hanover Fair in 2008. Since then the developers have been constantly working on improved communications technology and on the condition monitoring of the individual jellyfish on a smartphone.

Real-time monitoring on a smartphone
An app can be used to individually record and track the current condition of each AquaJelly. Thanks to real-time diagnostics, it is possible to make a parameter query about the current battery status, the temperature, the current power consumption and the depth of the jellyfish in the water. A movement profile also shows in which direction the jellyfish in question is swimming.

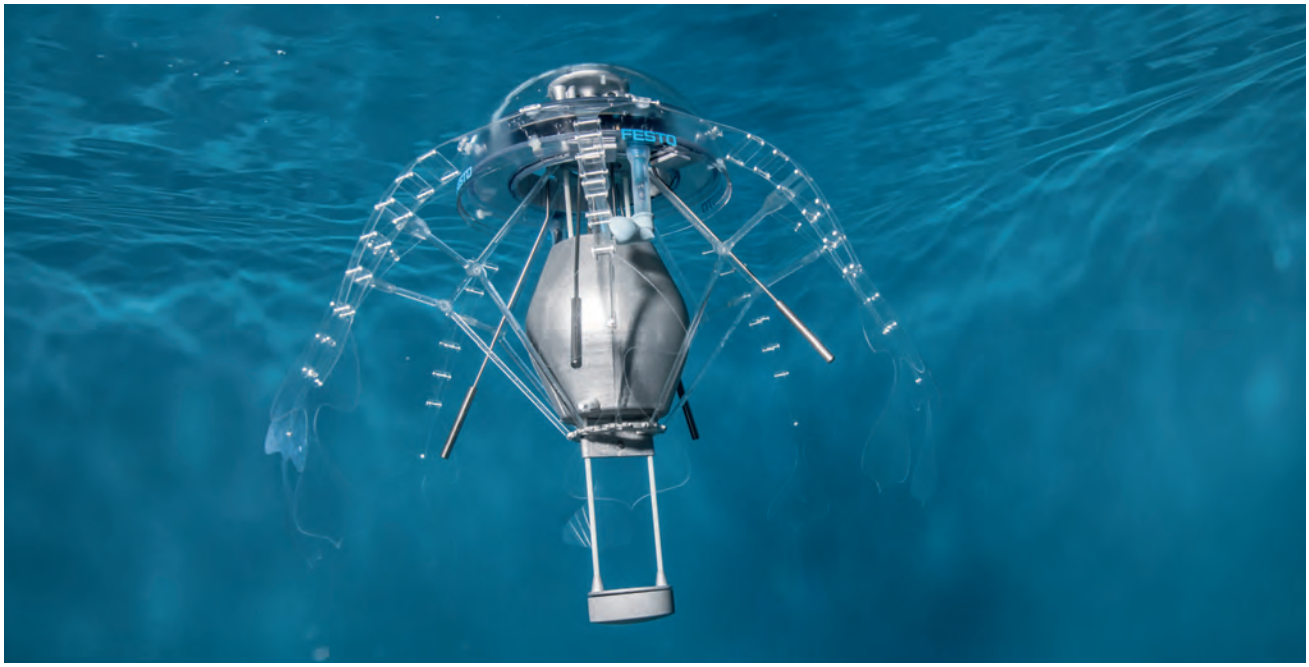
Festo is using these bionic technology bearers to visualise potential and ideas of how efficient systems in the field of water technology may look in the future. Process monitoring and condition monitoring are important topics in all equipment used in the process industry and hence also in the water technology sector.



Integrated platform: Model for lightweight construction, energy efficiency ...



... system capability and integrated communication technologies



Natural role model: The peristaltic thrust propulsion of the AquaJelly has a strong resemblance to the natural movements of the jellyfish.

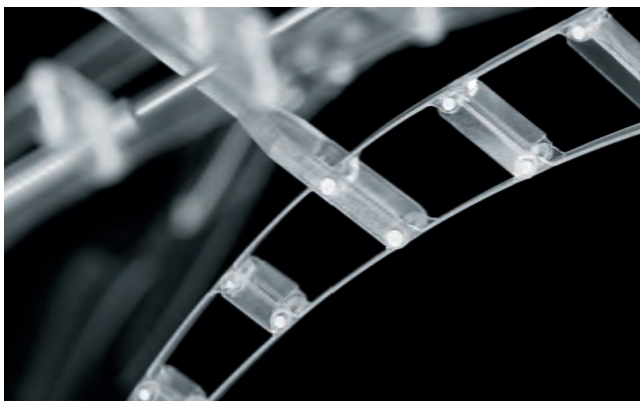
Highly integrated lightweight construction objects
The AquaJellies consist of a translucent hemisphere, a central pressurised body and eight tentacles for propulsion. The hemisphere is equipped with a ring-shaped control board with integrated infrared, pressure and radio sensors. A processor permanently monitors the position of the drive system. The watertight pressurised body in the centre of the jellyfish contains the central electrical drive unit, the two lithium ion polymer batteries and the servomotors for a swashplate. The electric drive unit moves two drive plates on the top and bottom of the pressurised body, which uses rhombus-shaped joints to set the jellyfish's eight tentacles in motion.

Tentacles with Fin Ray® structure
Each tentacle is designed with a Fin Ray® structure, a construction derived from the functional anatomy of a fish's fin. The structure itself consists of an alternating traction and pressure flank connected by ribs. If a flank is put under pressure, the geometrical structure automatically bends against the direction of the applied force.

From the bionic floating object to the customer application
In the meantime Festo has put this effect into industrial practice. With the adaptive gripper DHDG, the structure locks its fingers around the object being gripped, thus enabling fragile and irregularly shaped objects to be handled safely without breaking them.

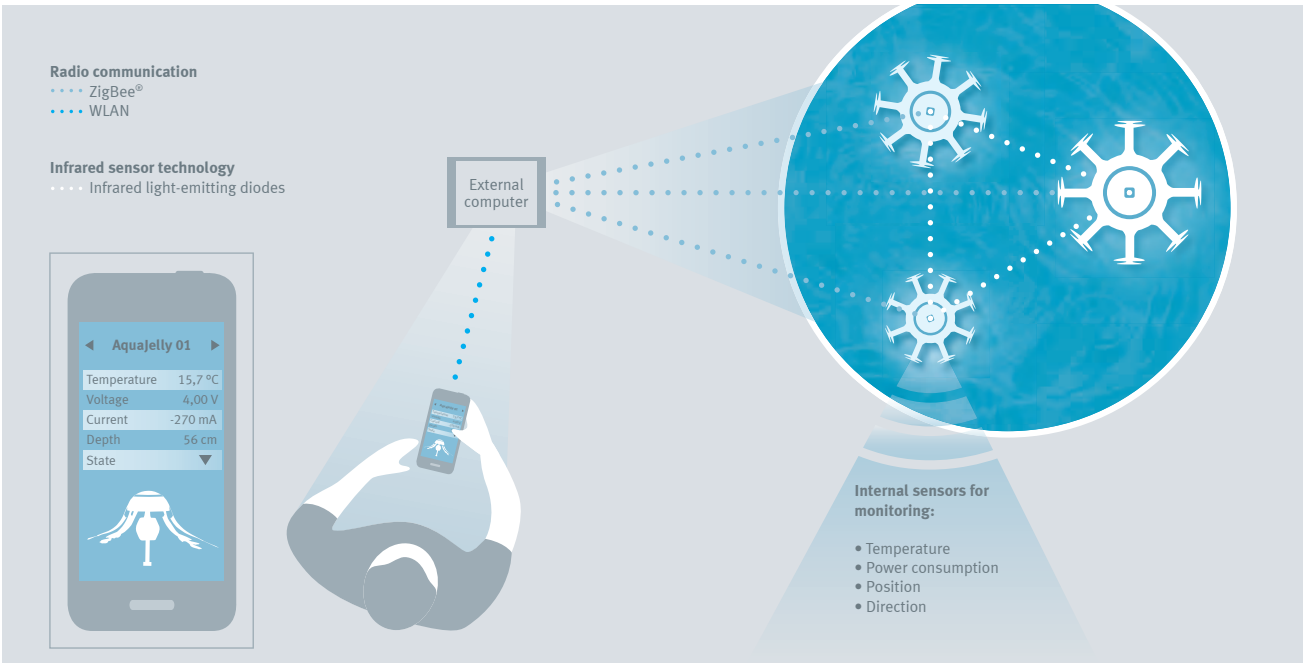
The AquaJellies' delayed activation of the individual tentacles and their bending action leads to all eight arms making a simultaneous wave motion. This produces a peristaltic forward motion similar to that of their biological role model.

Their motion in three-dimensional space is controlled by weight displacement. For this purpose, two servomotors integrated in the body control a swash plate. The plate operates a four-armed pendulum that can be deflected in four spatial directions.
When the pendulum tilts in a particular direction, the jellyfish's centre of gravity is displaced accordingly and it then swims in this direction. Combined with the peristaltic propulsion, the AquaJellies can therefore swim in any spatial direction.



Bionic transfer: the Fin Ray® structure in the AquaJelly tentacles ...

... and in the fingers of the adaptive gripper DHDG



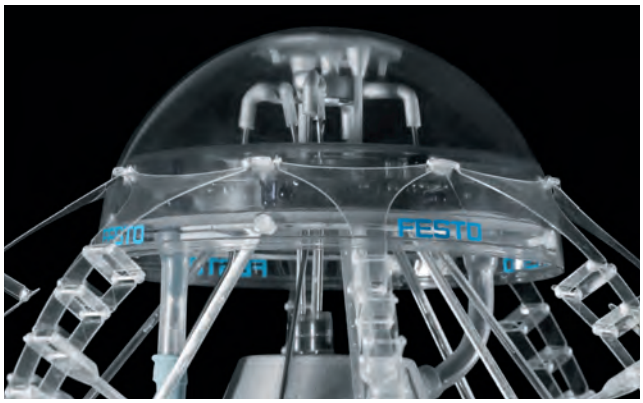
Digital networking: data collection and exchange in real time using pressure sensors, radio communication and infrared light

Intelligently combined sensor technology
The jellyfish's sensor technology resorts to three different media: pressure, radio and infrared. The main communication medium between the jellyfish is the infrared sensor system. Each AquaJelly has eleven infrared light-emitting diodes that are attached to a ring inside its dome. Six white and six blue LEDs on the circuit board allow the spectator to see the communication in action.

Avoiding collisions
By using pulsed infrared signals, the AquaJellies are able to communicate over a distance of up to 80 centimetres. In this way, for example, each jellyfish can take evasive action in time if it receives the position signal of an approaching jellyfish.

For communication with the user, the AquaJellies use the energy-saving ZigBee® short-range radio system. This forwards the information for the real-time diagnostics via an external computer, which exchanges the status data by WLAN using the associated app for androids. In addition to the sensors that monitor their surroundings, AquaJellies are also fitted with an internal sensor system that monitors its energy condition. A solenoid switch enables it to register the orientation of the propulsion system. A pressure sensor enables the jellyfish to determine their position in the basin to within a few millimetres and to position themselves within a specific pressure zone.

Collective behaviour
Each jellyfish decides autonomously what action to take next – depending on the state of the battery charge, on the orientation of the propulsion system, but also on the proximity of another jellyfish. The overall behaviour of the AquaJellies is emergent. This means the following, in other words: without predetermined control of the overall system, nevertheless, from the simple actions of the individual alone, a collective behaviour displayed by the overall group emerges. This makes the AquaJellies a starting point and inspiration for other developments; among other things, studies of collective behaviour patterns. If this principle is transferred to the field of automation, several autonomous, decentralised systems could be networked for a specific purpose and together solve a bigger task.



Integrated communication technology: the light-emitting diodes inside and ...

... the pressure sensor, protected in a sealed balloon

Collective behaviour: The AquaJellies show how the autonomous actions of individual systems can lead to an overall system.

Impulses for the automation of tomorrow
As a worldwide partner to the manufacturing and process industry, Festo's core competence is to look for new solutions for the production and working worlds of the future. The AquaJellies help developers by acting as technology bearers for the automation technology of tomorrow and beyond.

In the field of process automation, the range of solutions extends from simple components like valves and sensors, drive units and control systems through to ready-to-install systems and integrated automation concepts – in all project phases of engineering through to the operation and maintenance of plants.

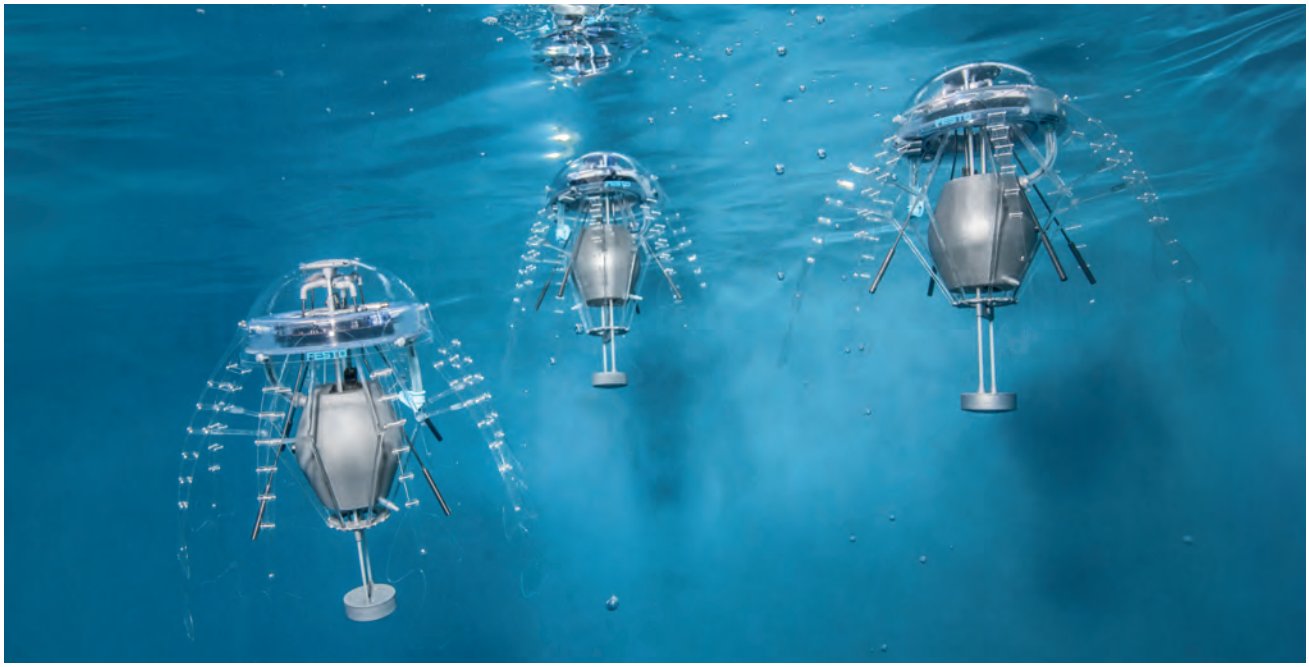
Autonomous systems in the water technology sector
The task of self-organisation can already be found in wastewater technology today, for example when it comes to channelling collected rainwater from several decentralised rain overflow basins into a central sewage treatment plant. At the same time, condition monitoring allows efficient operations management, servicing and maintenance.

With the aid of permanent real-time data transmission and diagnostics, the whole plant can be controlled and monitored from the sewage works' remote control centre. If you transfer the principle of the information structures present in the AquaJellies to the control system for the rain overflow basins, the communication including permanent calibration of the condition monitoring of the decentralised units would be conceivable. Energy self-sufficient automation concepts of decentralised water reservoirs in the water management field are already picking up on these ideas to some extent.

Intelligent components in the factory of the future
In the factory of the future it will be increasingly common for decentralised systems or components to organise themselves and thus take on orders at a superordinate control level. The foundation of these future production systems are intelligent components – self-contained, autonomously functioning mechatronic modules. Information and communication technologies are expected to merge with classic industrial processes. The AquaJellies are already helping to illustrate these kinds of networked overall systems.

Permanent real-time diagnostics: whether it is for monitoring the AquaJellies ...

... or for the process reliability at a waterworks.



Technical data per AquaJelly

- 1 Microprocessor for communication by light
- 1 Microprocessor for motor control unit
- 1 Microprocessor with ZigBee® module for radio communication
  Communication of the microprocessors with each other via I2C-bus operation of the electronics at 3.7 V

- 1 pressure and temperature sensor, accuracy: ‹ 1mm water depth
- 14 Infrared transmitting LEDs, total transmitting power: approx. 250 mW
- 11 Infrared reception units
- 1 Hot Swap® controller for automatically monitoring the rechargeable battery with integrated safety shut-off

- 2 Servomotors for directional control, controlled directly by microprocessor
- 1 digital 3-axis acceleration sensor for 3D tilt control
- Rechargeable battery: Lithium ion polymer, 3.7 Volt; capacity: 3000 mA/h
- Motor: coreless motor, 3 Volt
- Gears: upstream planetary gears, transmission ratio 1:180
- Main processor: Microcontroller, 20 MHz

Brands: Fin Ray Effect® is a brand of Evologics GmbH

Project participants

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→ Film AquaJelly (2008)

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50036 en 10/2013