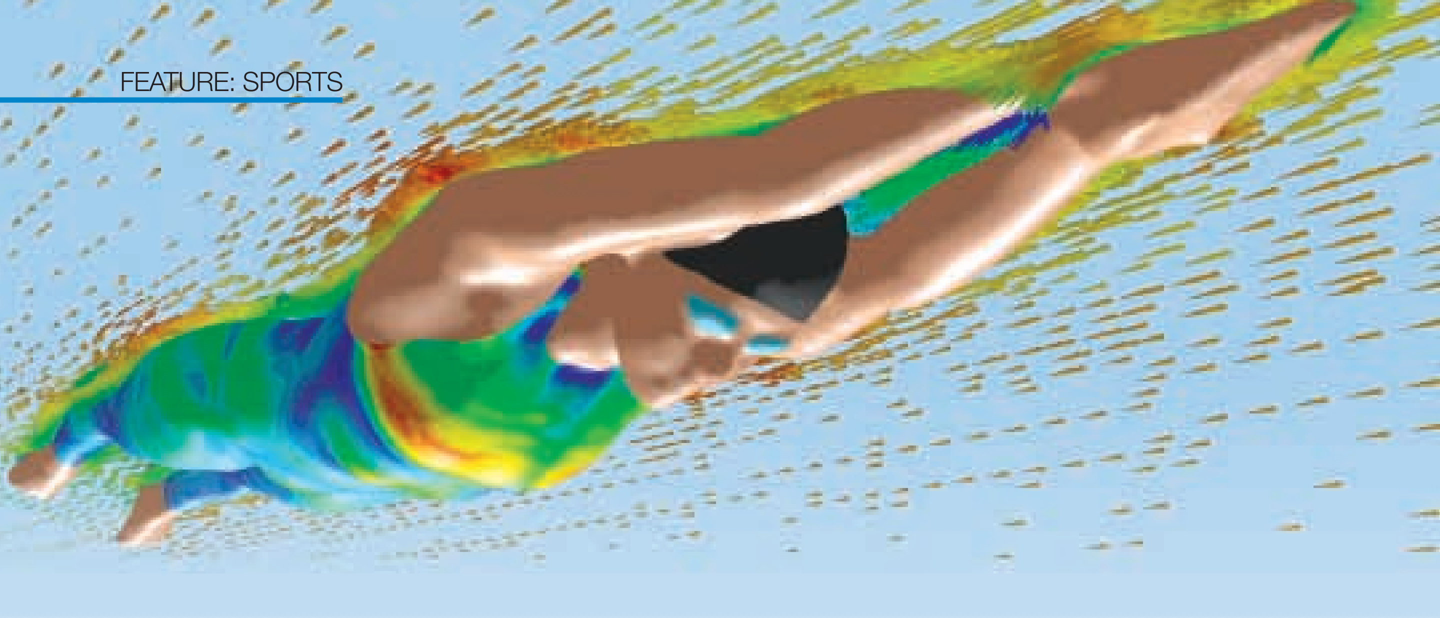


Simulating Swimwear for **Increased Speed**

Speedo's new full-body swimsuit takes advantage of simulation technology in pursuit of gold medals and world records.

By Leigh Bramall, PR Specialist, ANSYS, Inc.

Most of us are familiar by now with the use of simulation in sports such as Formula One racing, NASCAR® and, more recently, America's Cup yacht racing. The potential applications are obvious with aerodynamics on a racing car or hydrodynamics on a yacht. But the use of simulation technology is spreading far beyond these more obvious applications.

Swimwear designer and manufacturer Speedo® is a name synonymous with the pool and swimming competition. The company has an 80-year history of developing swimsuits for elite swimmers, all the while successfully maintaining its leading position in the industry. In the 1920s, Speedo made history with the Racerback — the world's first non-wool suit. More recently, the company introduced the full-body swimsuit to the competitive swimming arena with its FASTSKIN® suit, which was designed to reduce drag and optimize performance and was worn by the majority of competitors at the 2000 Sydney Olympics.

Computational fluid dynamics (CFD) first entered the sport of competitive swimming in a significant way with the development of Speedo's FASTSKIN FSII swimsuit, developed for use at the 2004 Athens Olympics. February 2008 saw the further development of Speedo's CFD program with the global launch of its LZR RACER® suit ahead of the Beijing games. Using FLUENT technology from ANSYS, Inc., Speedo used CFD analysis to guide, test and refine the final design of the suit, bringing together a range of research with the goal of improving performance.

The LZR RACER suit is the result of three years of work conducted by Aqualab, Speedo's own in-house R&D group. Headed by Jason Rance, the Aqualab® group oversaw a research program that employed multiple partners — the University of Otago in New Zealand, the University of Nottingham in the United Kingdom, the Australian Institute of Sport, Optimal Solutions in the United States, NASA in the United States and ANSYS. The outcome is a swimsuit that has 10 percent less passive drag than the FASTSKIN FSII suit and 38 percent less passive drag than an ordinary LYCRA® suit.

To begin the research, the team attempted to identify the fabric with the least possible drag. They started by taking body scans of more than 400 elite swimmers to provide geometries for testing more than 100 different fabrics and suit designs. Work focused on developing two different fabrics: LZR Pulse®, an ultra-lightweight, powerful, lowdrag, water repellent, fast-drying fabric to be used as the base woven material for the suit; and LZR panels made of a low-drag, ultra-powerful polyurethane membrane to be bonded onto the base woven material to reduce drag at specific high-drag locations.

To test the fabrics and create a suit with the lowest drag, the Speedo researchers used one of the world's most advanced water flumes at the University of Otago. NASA also was employed, with the space agency evaluating the surface friction of fabric candidates in its low-speed wind tunnel. The wind tunnel was operated at 28 meters per second to simulate a swimmer moving at 2 meters per second in water. NASA used a smooth aluminium plate as a benchmark for the fabric tests. Results showed that the smoothest fabric had the lowest drag, with the final fabric chosen for the LZR panel producing test results comparable to the drag results for the aluminium plate.

Following the water flume and wind tunnel tests, the Speedo team put the results into practice in the real world at the Australian Institute of Sport, conducting time-trials with swimmers wearing the new suit and standard training wear. The drag reductions identified in the water flume and wind tunnel translated to a 4 percent increase in speed for swimmers when wearing the new suit as opposed to wearing training swimwear. The new suit also delivered a 5 percent improvement in the swimmers' oxygen utilization when compared to trials performed in the training wear. These efficiencies are significant in a sport in which success or failure can be measured in hundredths of a second.

The Speedo team took further steps to reduce drag at every opportunity. They designed the suit to achieve a compression effect through the tensile properties of the materials — powerful fabrics that compress key body areas. Effectively, these features help to mold the swimmer's body into a more streamlined shape, reducing the hydrodynamic profile and minimizing oscillations in muscles that might disturb flow. The team also used ultrasonic welding to bind the material sections of the suit together, eliminating all seams that could disturb flow and induce drag.

For further analysis, ANSYS performed CFD studies in association with Dr. Herve Morvan of the University of Nottingham. The focus was on passive drag, which occurs when the body is in the glide position with arms outstretched in front and legs outstretched behind. Swimmers maintain this position for up to 15 meters immediately after diving and for a similar period after kicking off under water following each turn. For this reason, this position is critically important in a competitive race situation. Testing focused on this position, providing indications of overall performance of the suit during racing conditions.

The researchers used CFD analyses to identify areas in which both skin- and form-drag occur. Skin-drag is inherent in swimsuit material properties, since fluid flows over the fabric, and in local flow conditions, speed in particular. It is induced by the local velocity gradients that create a shear force due to the viscous properties of the fluid. Form-drag, on the other hand, is a result of the swimmer's body traveling through the fluid; the goal is to make the flow path as smooth and undisturbed as possible, thereby decreasing the drag. The CFD simulations involved precise boundary layer meshing techniques using software from ANSYS and resolved fine fluid flow details using the precision scanned geometries of elite swimmers. Speedo carried out all of these CFD studies as part of ongoing research conducted since the 2004 Olympics in Athens.


Six-time Olympic gold medalist and American swimming sensation Michael Phelps in the glide position


Pressure contours around an elite male swimmer wearing a LZR RACER suit in the glide position

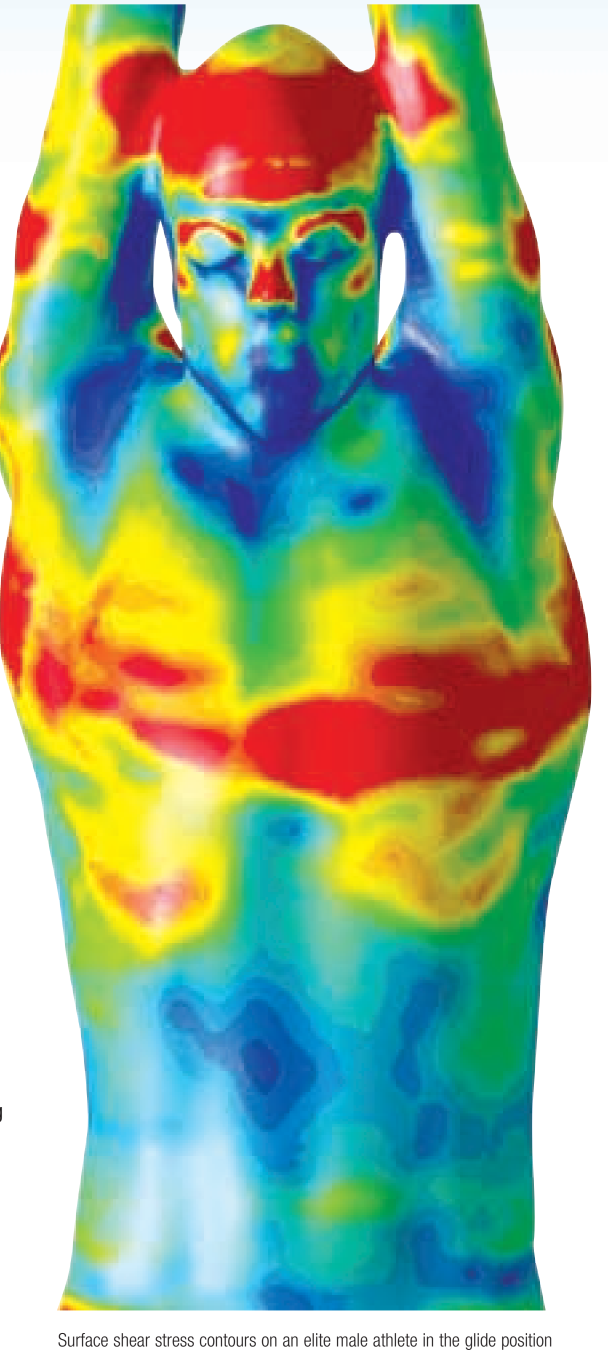
Flow pathlines colored by local flow velocity around an elite male swimmer wearing a LZR RACER suit in the glide position

Using the wealth of detailed fluid dynamics data from the CFD studies generated with software from ANSYS, Speedo researchers were able to guide the final design of the new suit — in particular, the precise location of the ultra-low-drag LZR panels, which were bonded onto the LZR RACER suit. In the end, the strategically placed LZR panels were found to reduce skin drag by a startling 24 percent in comparison to Speedo's previous FASTSKIN fabric.

Dr. Keith Hanna of ANSYS, who lectures on the application of CFD technology in sport, believes the scope for the application of CFD and simulation in general will only increase in the future. Hanna stated, "CFD is a powerful technology, and the accuracy of the results from this study have given Speedo confidence in the benefits of applying CFD in the design of future swimsuits. However, the big development in years to come could be the use of comprehensive multiphysics technology for elite swimsuit development — that is, the use of CFD with other physics such as structural simulation to actually simulate every aspect of real-world physics found in a competitive swimming scenario.

"The physics involved in simulating a moving swimmer are extremely complex, but the potential is there. Industries such as aerospace and automotive are increasingly turning to a multiphysics simulation solution as the only way of ensuring that all parameters are accounted for in their design process. In the instance of simulating performance in competitive swimming, a multiphysics approach would mean not only that CFD be used to analyze hydrodynamic flow and drag around a swimmer, but also that structural software be used to simulate how the suit itself may deform during a swimming stroke, for example, and how this affects drag." ■

In the first ten weeks following its launch in February, swimmers wearing the Speedo LZR RACER swimsuit set 35 world records.



Surface shear stress contours on an elite male athlete in the glide position