

ZOLLNER ELECTRONIK AG

INDUSTRIAL EQUIPMENT



Challenge:

Zollner Elektronik AG engineers were tasked with designing a fully functional, fire-breathing mechatronic dragon for the German Further Drachenstich festival.

Solution:

The team used SIMPACK multi-body simulation software from Dassault Systèmes' SIMULIA to generate and solve 3D models that predicted and visualized motion, coupling forces, and stresses on the entire flexible system.

Benefit:

SIMPACT allowed Zollner engineers to design the complex robot without running extensive field tests. The software helped them solve a wide range of challenges, improve the motion and stability of the machine, and be fully confident in their final design.

Medieval folklore stretches the imagination and sends us to a magical realm unlike any other. From orcs and trolls to elves and giants, human-like species make this unearthly world weirdly compelling. But the one creature of the genre that remains the most iconic—instilling fear, wonder and excitement into everyone—has to be the dragon.

Imagine an “animal” five stories tall, standing above you, its scales seemingly rock solid and teeth razor sharp. You look up at its beautiful 40-foot wingspan in amazement and back down at its enormous feet in terror—knowing this beast, weighing over 10 tons, can squish you like a bug. Its head rests at ground level so it can see your every move—close enough that you can feel the hot steam from every breath it takes. Then it steps forward, lifts its head high, opens its mouth, and unleashes bursts of flames across the sky.

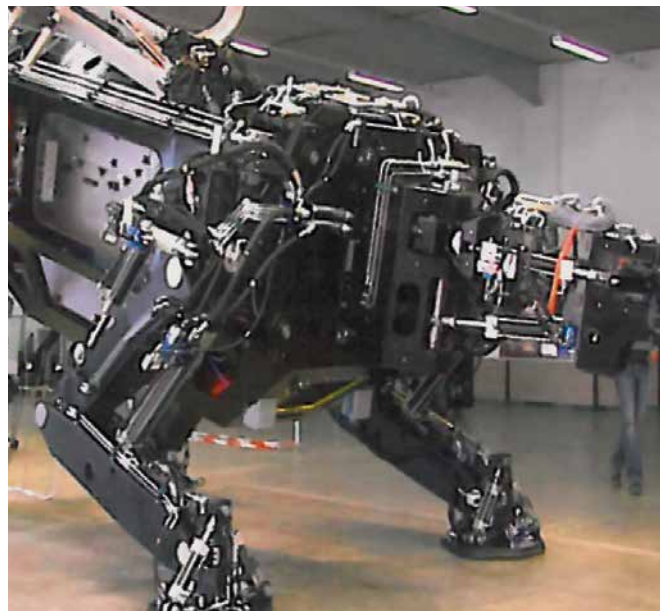
BRINGING FANTASY TO LIFE

Such an encounter is something most folklore fans can only dream of. Of course dragons don't exist, but can one be made? Zollner Elektronik AG engineers have proven it is possible by creating the world's largest, fully-functional mechatronic dragon—coming to life every year at the ancient German folk festival, Further Drachenstich. During the event, the 50-foot fire-breathing beast walks among people who come from all over who come to celebrate in the Bavarian Forest. Called Tradinno—an homage to both tradition and innovation—the 11-ton animatronic robot is scarily real.

Currently listed in the Guinness Book of World Records as the “world's largest robot” since 2014, Tradinno is powered by a 100kW Diesel engine—where 50 closed-loop controlled axes are moved by carbon fiber laminated (CFK) hydraulic cylinders.

At 15.5 m in length, 4.5 m in height and with a 12 m wingspan, Tradinno moves up to 0.5 km/hr and assumes several pre-programmed positions during the show.

Such an impressive machine was obviously extremely challenging to design. The biggest hurdle for the team at Zollner stemmed from Tradinno's large mass, paired with the



Zollner's Tradinno dragon robot (top) “showing off” for the people of the German town where the festival is held. The robotic “skeleton” (bottom) of Tradinno with all legs mounted and put into operation.

high number of degrees of freedom in individual components and the resulting play of varying dynamic forces on them.

To support the motion of each component and minimize their individual and combined effects on the entire robot, Simpack from Dassault Systèmes' SIMULIA was used throughout the design process. Simpack multi-body simulation software enabled the engineers at Zollner to generate and solve 3D models that successfully predicted and visualized motion, coupling forces, and stresses on a flexible mechatronic system.

“Simpack made us confident that our finished design would work,” says Frank Pfeffer, mechanical engineer at Zollner Elektronik AG. “Without the tool, it would be near impossible to ensure that the finished dragon would operate as flawlessly as it does.”

MAKING A DRAGON MOVE

Over 100 subassemblies (CAD geometries and mass properties) were imported into Simpack via ProSIM. Each component had different functions and subsequently different effects on the overall performance of the machine.

Because of the high number of moving parts and their combined overall weight, getting the robot to walk was an especially difficult task. Zollner engineers realized early on that evaluating contact and friction forces between the four feet and the ground was a priority. There were many variables that affected the stresses in the feet while walking, including the influence of wobbling masses such as the motor and hydraulic pumps or the weight of compressed oil within the cylinder.

To identify suitable stiffness and damping values, the team ran a variety of simulations to assess the range of flexibility of the leg subassemblies. They found that by optimizing the trajectory of each individual leg, the force from the impact of stepping on the ground could be reduced.

With the legs functioning as desired, walking and movement tests were then run on the robot as a whole—traversing a flat plane or a slope, moving in an arc, and turning on the spot. Simulating these stepping cycles provided information needed to strengthen the legs to prevent lateral buckling. The team then optimized the location of the components connected to the torso, and the motions of the neck and tail, by evaluating Tradinno's total center of mass while walking.

Additional tests were done on the wings to find the best possible balance between weight and stability. The engineers also found ways to stabilize the dragon in the rare event of a complete front-leg failure. "It was clearly important to eliminate any potential risk to festival attendees," says Pfeffer.

For smooth operation of the beast in action the Zollner team used MATLAB's SIMAT interface in conjunction with Simpack to run closed-loop control tests to ensure that when the

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—Frank Pfeffer, mechanical engineer,
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operator pressed a button on the controller, the robot would automatically perform the designated function. "Simpack was used to easily implement the geometry of the dragon to SIMAT and to connect it to MATLAB," explains Pfeffer. "With SIMAT we simulated the control processes to be as realistic as possible—for example the motion of a walking leg. Our aim was to observe the behavior of the dragon's hydraulics when it was walking and to determine whether or not the individual control circuits would interfere with one another."

SIMPACK SIMPLIFIES COMPLEXITY

Zollner engineers value the simplicity of using Simpack for such complex design projects, where their team needs to work with maximum efficiency to produce high-quality, high-performance mechatronic systems.

"Simpack allows us to easily identify and solve design challenges," says Pfeffer. "The software lets us know what works and what doesn't, without the need for extensive field testing. If a design flaw is found, it also shows us exactly where and why the problem is occurring, making it easier for us to fix."



The first walk in the yard (left). Zollner employed Simpack multibody simulation to optimize the robot's walking ability. The dragon's head (top-right) being put on its mechanical base for the first time. The Zollner developers (bottom-right) who brought Tradinno to life.



With the world's largest robot under their belt, there's no telling what project the engineers at Zollner will tackle next, but it's safe to say that Simpack will continue to play a key role in the design process of their next complex mechatronic assignment.

You can see their fire-breathing beast in action for yourself at the annual Further Drachenstich festival every August, or on the event's website at www.drachenstich.de/index.php/english.

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