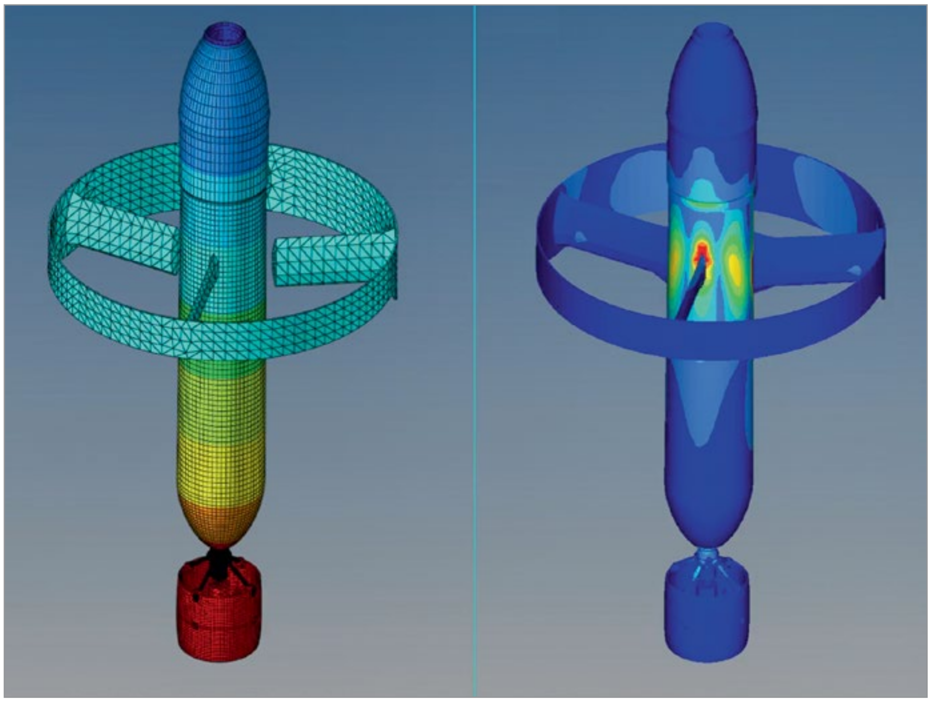
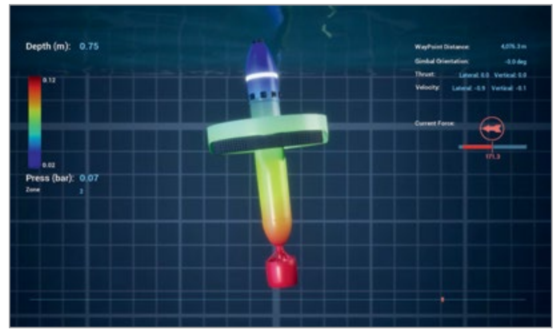
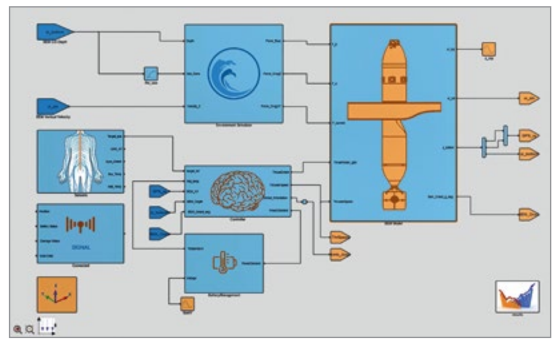
TEAMTAO Engineers the Future of Deep-Sea Exploration







About the Customer

At the end of 2015, the XPRIZE foundation launched the Shell Ocean Discovery competition, a three-year global challenge to advance deep-sea exploration using autonomous subsea drones. Teams competed to develop underwater robots that could fully map 500 km^2 of seafloor at a 4 km depth in less than 24 hours with no human intervention.

One of the competing teams was TEAMTAO, a collaboration of Newcastle University, SMD (Soil Machine Dynamics Ltd), and UK Research and Innovation. Altair joined the project as a technical design partner and provided the team with simulation expertise to virtually simulate, optimize, and test the devices. The Altair simulation specialists followed a simulation-driven design approach in order to save on development time and physical prototyping.

Their Challenge

TEAMTAO's goal was to change the way ocean data is collected by developing a low-cost platform using a 'CubeSat' like philosophy. The compact autonomous platform consisted of the BEMs (Bathypelagic Excursion Module), a swarm of vertically swimming AUVs and the surface vessel. It also had a 'vending machine' style autonomous surface catamaran that was responsible for the horizontal transit, data handling, communication, and recharging of the BEMs. At its core development, TEAMTAO strived for three main principles: minimal localized complexity, self-sustainability, and scalability.

TEAMTAO's unique concept was to develop a swarm of these devices all communicating with each other and sharing information. Originally, the swarm included about 20 subsea devices but could easily be scaled to higher numbers depending on the site being scanned.

Industry
Marine Research

Challenge
System development of a subsea swarm drone to autonomously capture sea floor data.

Altair Solution
Virtual testing of full system including structural, control, and mechatronic subsystems using Altair HyperWorks™.

Benefits
- Shorter development cycles
- Fewer prototypes
- Less physical testing
- Cost saving
- Virtual commissioning of the control system

Our Solution

To virtually test the devices upfront and to predict what would happen in a range of different scenarios at deep depths without risking the prototype, TEAMTAO turned to Altair. For example, the team tested how the structure would deal with extremely high pressures. The simulation also provided insights on how efficiently the device might move from the surface to its target, whether the power requirements are sufficient to get it from the start to the end position, and whether there might be any overheating during that process.

Altair deployed computer aided engineering (CAE) tools from the Altair HyperWorks™ suite such as the nonlinear finite element solver Altair Radioss™, to understand the stressing of the mechanical components. Altair Activate® was used for electro-mechanical system development and Altair Compose® was used to study the custom loading routines. Altair OptiStruct™ was used for static stressing of components and structural topology optimization.

While the team used a test tank to physically assess single components, they studied larger assemblies by simulating their functions to learn if the structure would or would not suffer any damage at depth. In addition to reaching structural efficiency, the system model gave high-level insights on the control system for different scenarios like frequently changing deep-sea currents at depths up to 4 km. The device still needed to be able to find its way to the target position even though there was no constant data stream and the passing of signals from the device to the surface was on a low frequency with big gaps of time in-between. A digital twin was used to collect data from the physical system in order to inform the digital model and control system how to further improve the capability and efficiency of the physical devices. Due to the multitude of difficult scenarios that can push the device off target, the ability to make the device dive more efficiently is a key feature of the digital twin.

"Using Altair solutions, TEAMTAO was able to test the control system and the system behavior with the digital twin prior to the field test. This virtual commissioning allowed a rapid project progress and is also a promising approach for the further development of the SMD offering."

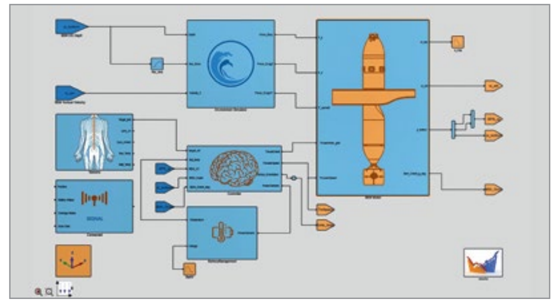
Chris Wilkinson
Chief technology officer at SMD

Results

TEAMTAO was the only UK team and one of the smallest teams to reach the grand final of the XPRIZE. During the final round of testing, TEAMTAO successfully demonstrated their autonomous swarm system technology and competed against seven other teams from around the world to map an area the size of Paris in deep waters off the coast of Greece near the port of Kalamata. TEAMTAO was honored for their exceptional accomplishments and in recognition of their highly innovative approach with the $200,000 Moonshot Award.

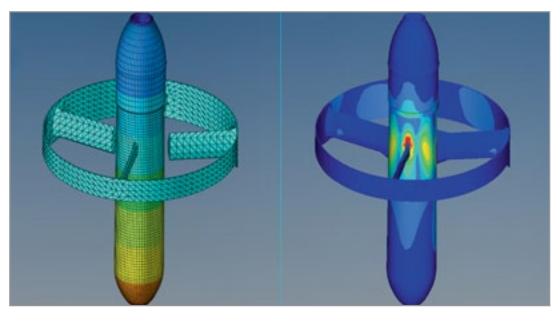
Using simulation to predict how the devices behave makes them more robust for scenarios that can't be predicted. By simulating and optimizing models of single components as well as assemblies and entire systems, the team was able to develop a swarm system that can bear high pressure in deep-sea while fully autonomously reaching its target position to scan the sea floor. The full model also provided a parallel digital twin of the system, so any new aspect is able to be quickly considered and built into the system. In combination with the structural simulation, this allowed for fast and focused design-to-prototype iterations.

Visualization of the BEM - depth, current force, pressure, and gimbal orientation.



The model in Altair Activate® was used for electro-mechanical system development and is accessible to a wide audience.

The system model gives insights on the control system for different operation scenarios.



Testing of the key body parts using digital twins.

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