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I like to move it...move it...

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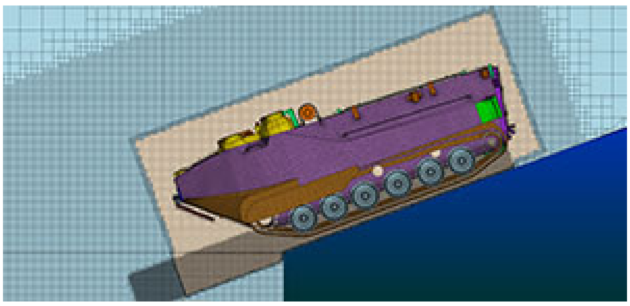
We've all been mesmerized for years by that thing of beauty rising out of the water majestically in that James Bond movie... If you're thinking Ursula Andress or Halle Berry or Daniel Craig, think again. I'm an Engineer and to me, the submarining Lotus Espirit from*The Spy who Loved Me* is my equivalence of a teenager's infatuation with water entry of matinee idols. In my fantasy world, my car would run on road, swim in water, fly in air and even brew me a nice, cold beer while I watch football. The Lotus Espirit ticked off two of those boxes quite handsomely.

When I was tasked with showing off new application areas with STAR-CCM+?s Overset Mesh feature, I scoured the internet for a model of the Lotus Espirit. In the end, I had to settle for a worthy substitute, the Assault Amphibious Vehicle (AAV7A1) used by the United States Marine Corps. The engineering design challenges for an amphibious vehicle are primarily the reason they are few and far between. In the case of vehicles like the AAV7A1, requirements of dual capability of speed in water and land in extreme conditions combined with a light armor to keep the weight down result in working within a tight design space. One of the major concerns when designing such a vehicle is the crossing from land to water or vice versa. Safety of the crew and the vehicle as a whole is of paramount importance when crossing into a different environment.



Numerous parameters play a role in the vehicle?s behavior when entering water or land: vehicle speed, direction relative to water and slope of the beach being the most important. Key factors in assessing the safety of the beach ingress are the maximum pitch and roll angles as the vehicle enters water, maximum accelerations on the vehicle and flooding of engine and passenger compartment. The body shape, weight distribution and size of the vehicle are already defined based on the mission requirements to achieve proper performance for land or sea. Safety tests are usually done on a prototype in a test basin using varying angles of ground slope and speed for entry into the water.

Simulation of water entry is currently being used in analysing the vehicle body shape; correcting for proper trim, body accelerations and flooding behavior before testing a prototype. Amphibious vehicles are well known for ballooning design times and project costs stemming from extensive testing for adequate safety. Simulation can reduce both time and cost, while giving insight on vehicle behavior.

Here?s an Example:

Using theOverset Mesh[1] feature of STAR-CCM+, the slope of the beach is set at 20° and the initial speed of the vehicle is approximately 22 mph. Free entry of the vehicle into the water is assumed. The overset region is meshed with polyhedral elements and the background mesh consists of trimmed hexahedral elements for easier capture of the free surface of the water. Adequate refinement of the interface between water and air and around the vehicle is provided to capture the water splash correctly and there are a total of 18M volume cells. The Volume of Fluid (VOF) capability is used to prescribe a flat wave for the water. One-DOF translating motion is prescribed initially until the vehicle wheels touched the water surface. Other degrees of freedom are then turned on to calculate the accelerations encountered and trim angles. The animation shows the vehicle?s water ingress at 20°. As expected at this higher slope angle, there is heavy flooding of the vehicle as it enters the water. The time taken from CAD to solution is a little under two days.

A simple use ofOptimate[2] with this simulation will help designers analyze instantaneous trim angles, accelerations and flooding of the vehicle for various slopes, waves and corrections to the body shape to properly optimize the vehicle for a safe water entry. This helps designers quickly analyze numerous design corrections and build a final prototype with confidence of meeting the project requirements. Of course, there is no style without substance (Mr. Bond will testify to that) and the Overset Mesh capability has already been well validated for various industrial applications. Easy, accurate simulations at your fingertips!

So start up a session of STAR-CCM+, put all the previous assumptions you used to simulate moving bodies in a little box, bring in that Overset Mesh and just move it. As for me, I?ll ask the bartender to pour me a well-deservedmartini[3]. Maybe I can simulate the pouring using Overset Mesh?.

P.S. The picture below clearly describes my feelings about Overset Mesh.

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