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Gridgen Reliable CFD Meshing

Computing High-Speed Flows Using IMPNS and Gridgen

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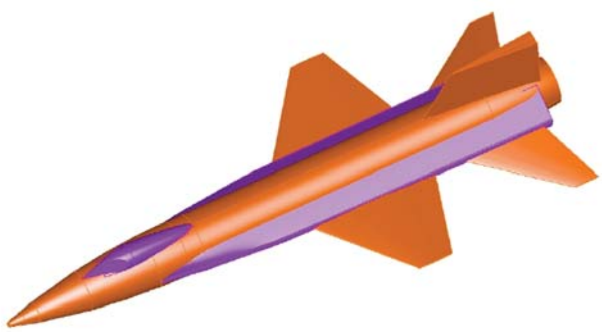

Surface model of the X-15 aircraft vehicle.

The ability of computational analyses to inform the aerodynamic design process at an early stage in the design cycle requires rapid, robust and credible productivity oriented analysis tools. At Cranfield University, we have sought to meet this challenge for the United Kingdom weapon aerodynamics community through the development and demonstration of four key competencies; a computationally efficient high-fidelity flow solver based upon the solution of the parabolized Navier-Stokes equations; a detailed appreciation of error and uncertainty obtained from a continuous and rigorous verification and validation regime; effective use of analysis data through reduced order modelling; and robust, reliable and efficient mesh generation. The latter is provided by Pointwise's Gridgen software.

To demonstrate the efficacy of this approach to our industrial partners for a complex geometry, Cranfield University has recently undertaken computations of the X-15 aircraft. The X-15 was the world's first manned hypersonic research aircraft setting a series of speed records in the Mach 4-6 range between 1959 and 1967. Uniquely, the aircraft was extensively instrumented providing a wealth of data on supersonic and hypersonic air flows, aerodynamic heating and stability and control. The geometric complexity of the aircraft coupled with the availability of extensive flight and wind tunnel test data provide an ideal opportunity to demonstrate credible, rapid CFD.

To construct the grids used in the project extensive use was made of the tools available within Gridgen to manipulate CAD databases for the individual aircraft elements (nose, fuselage, wings and fins) into a watertight surface model of the X-15 aircraft.

The IMPNS solver employs an efficient space marching solution algorithm that requires that grid points should lie in a sequence of planes normal to the marching (flow) direction. Fortunately, the flexibility of the structured multi-block grid generation tools within Gridgen mean that such constraints posed no significant challenge for the experienced analyst. The final grids around the complete configuration contained 20 blocks and between 2-3 million grid cells. In addition to the full aircraft, 12 supporting configurations exhibiting a range of geometric and physical complexity were also considered in the final study requiring the generation of more than 60 high-quality grids and analyses within a 13 week period.

Initial comparisons of computations with flight test data are favorable demonstrating the credibility of Cranfield's approach to the prediction of aerodynamic flows involving complex geometry and physics. The ability of Gridgen to provide reliable, robust mesh generation in a timely fashion lies at the heart of this success and work has now begun on a more extensive programme of work to evaluate the IMPNS software for the prediction of stability and control derivatives using a CAD model provided by NASA's Geolab.