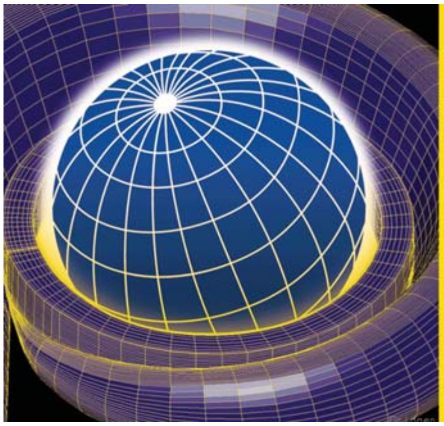

Focal Point

VOLUME 6, ISSUE 1
SPRING 2002
THE NEWSLETTER FOR GRIDGEN

Gridgen Helps Keep E-2C Flying High

From a Pointwise interview with Warren Davis, PhD.

The accuracy and flexibility of Gridgen grid generation and pre-processing CFD software combined with the robust, efficient capabilities of NASA's Overflow solvers provide optimum results for Northrop Grumman Integrated Systems' Warren H. Davis, Ph.D., the Aero CFD Principal Engineer who leads a team responding to continual updates, additions, and enhancements to his company's U.S. Navy electronics surveillance workhorse, the E-2C Hawkeye. The Hawkeye provided stellar success in Afghanistan missions earlier this year.

E-2C prop blade element model including swirl.

Dr. Davis is one of the people who answers the "will it fly right" question when confronted with next generation modifications. He helps assure that any modifications to aero/propulsion capabilities, airframe additions including antennas, and other changes maintain and enhance performance.

Dr. Davis and his team gauge adaptations on the computer, using two remarkable programs (among other tools): Gridgen and Overflow.

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Endangered Fish Benefit from CFD

Article by Cindy Rakowski and Marshall Richmond, Hydrology Group, Pacific Northwest National Laboratory, Richland, USA

Environmental applications of computational fluid dynamics (CFD) have become more common in recent years with the increased availability and ease of use of commercial grid generation software and CFD solvers. At Pacific Northwest National Laboratory, we have been supporting studies by the US Army Corps of Engineers, Portland District by creating and applying Reynolds-Averaged Navier Stokes (RANS) CFD models to the Columbia River and portions of the dam structures at several hydroelectric projects, including the tailrace of The Dalles Dam.

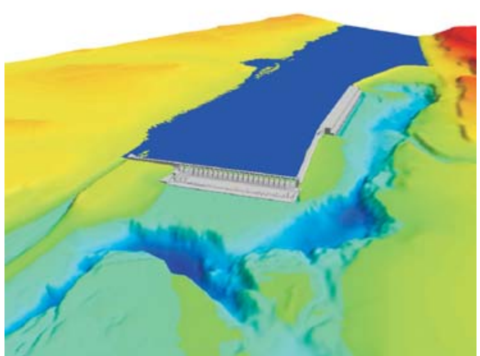

Figure 1. Bathymetry of the Dalles tailrace. The gray structures are the spillway in the center and the powerhouse in the upper right.

Numerical models in The Dalles tailrace are being used to support efforts to reduce fish mortality associated with fish passaging of the hydroelectric project. At The Dalles, several locations have been proposed for a high flow outfall that would move fish around the dam rather than through the turbines or over the spillway. The bathymetry downstream of the project is quite complex (Figure 1), and includes several islands and a shelf at about 68 ft. elevation

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Focal Point is a publication of Pointwise, Inc. It is for Gridgen users and people interested in learning more about Gridgen and numerical grid generation. It includes information about the latest release of Gridgen, future development plans, and tips on how to get the most out of Gridgen while saving time in grid generation.

Inside this issue:

Gridgen Helps Keep E-2C Flying High, cont.

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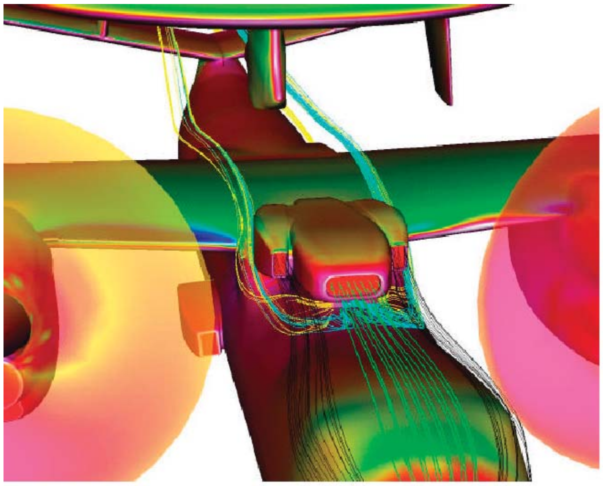
Gridgen is Pointwise Inc.'s grid generation and pre-processing CFD enabling bridge connecting computer aided design (CAD) software and CFD solvers such as Overflow, Fluent, STAR-CD, and CFX. The program generates hexahedral, tetrahedral, and hybrid (prisms and pyramids) meshes, reads geometry from CAD systems, and includes meshing tools and direct solver interfaces. Overflow is a Navier-Stokes flow solver that uses single block grids or Chimera overset (structured) grid systems. Chimera overset grids are body-fitted hexahedral grids around each component. They can overlap each other instead of requiring exact point-to-point interface matching like traditional structured grids. This makes the engineer's grid generation task faster and easier while maintaining accuracy.

"Applied engineers and vehicle designers need solid answers. These are the mechanisms by which we can model handling and performance testing and respond very quickly," he explains. "Working together, Gridgen and Overflow are the best available tools for over-the-top response and absolutely reliable results."

Now able to overcome formerly limited abilities to handle complex geometries, Davis and his team mesh, measure, and test scoops, props, the dome, inlets, and other complex configuration components.

On his plate: gauge and analyze prop blade variations, swirl effects, vortices, and incoming flow properties. Also, how would proposed changes to the propellers—changing the four-blade configuration to eight-blade on the E-2C's co-rotating propellers—affect handling and performance? What would be the wing and tail surface effects? Also, with increased power requirements for an advanced radar installation, the need for alternate radar liquid cooling scoops required designing new, larger scoops to provide cooling via clean airflow. The original inlets were positioned just behind swirling flow from the propellers, engine nacelle and fuselage surfaces. How would additions or modifications to the scoops impact performance? Would a repositioning be advantageous for the larger scoops?



Radar liquid cooling scoops side mounted on vapor cycle inlet.

Rather than change the whole wind tunnel model to test these changes, Dr. Davis uses Gridgen's high quality mesh cells to provide accurate simulations. "Our team can do the CFD calculations before the tunnel, with reliable, verifiable results," he stressed.

Gridgen's high accuracy was, is, and will be invaluable as the E-2C undergoes these major upgrades when combined with Overflow and ever-increasing computing power.

"Gridgen provides excellence both in initial surface grid generation and in its flexibility to fix any problems that arise at any stage of the process," Davis emphasized. He credits Gridgen's well-organized and intuitive interface and exceptional functionality. "We have the freedom to concentrate on producing the highest-quality grids in the shortest possible time."

Flexibility is joined by time savings as far as Gridgen's unique contribution to the process. At Pointwise, based in Fort Worth, Texas, developers recognized that one of the problems in the old days of CFD was that a detailed simulation like Davis' could actually take longer than building and testing wind tunnel models. Gridgen's unique ability is that it allows creation of millions of grid points in a relatively short period of time. Davis used 8.1 million grid points in his model. Just a few years ago, building a grid that large would have taken several months. Davis first began working with the early NASA version of Gridgen in 1991. The E-2C work began in 1997 with the early grid generation effort spread over a two-month effort.

With his current full configuration E-2C model variation study, Davis estimates the grid generation portion of the task has taken only three weeks.

Davis says he is continually amazed at the ease of handling and at the ability to fix problems that arise when integrating with other tools (such as CAD, flow solvers, even other grid generators).

Pointwise's John Chawner sums it up: "We like to think Gridgen's capabilities render many of the old empirical processes in the design cycle obsolete."

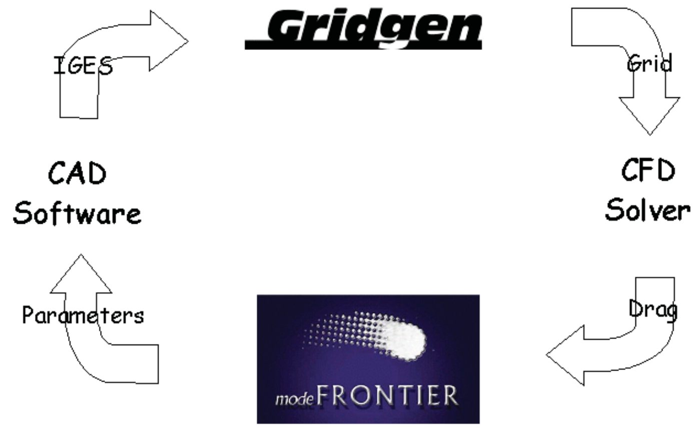
An expanded article on this subject will appear later in the year in *Mechanical Engineering Magazine*.

Create mirror images of complete grids using the new Mirror command.

Sirehna's Use of Gridgen for Optimization

Article by Yves-Marie Lefebvre, SIREHNA, Nantes, France

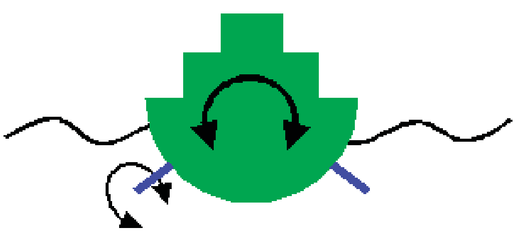
Sirehna has been developing and promoting optimal design approaches, especially involving CFD, for a long time. Our current policy is to combine the advantages of the most efficient flow pre and post-processors tools (Gridgen and Fieldview) together with Frontier, an advanced tool for design space investigation and optimization. The process is kept independent from the flow solver. Fluent is used in the two following applications. Others have been developed using ICARE, a dedicated solver for free surface flows in viscous fluid around a ship hull.



The first application is a simple case; the aim being to set up the whole optimization chain on a 2D case. The second one is 3D shape optimization of a ship hull.

1st study: SHIP STABILIZING FIN

We chose a very simple case since our interest was not in the parametric modelling or in the solver calculation but in the validation of the optimization chain.



The case of study was the optimization of the profile of a fin. This kind of fin is used to stabilize ships by inducing a moment opposite to roll, as shown above.

The objectives of this optimization process were to:

- maximize lift
- minimize drag
- minimize risk of cavitation

For each design, the process consisted of three parts taking place on different computers and different systems. All computers and systems were running in batch mode and controlled by Frontier:

Frontier sends the four shape control parameters to Gridgen, which then creates a mesh around the new profile. Gridgen Version 14 runs in batch mode using its new Glyph scripting language to control operation. The mesh is created by extrusion from the profile. Gridgen, running on a PC, then exports the mesh in the CFD solver format.

The second step was the flow calculation made on a UNIX station. The solution was then exported in Fieldview format.

Finally, Fieldview was used to integrate to find forces on the profile and to calculate the minimum pressure value.

A typical optimization process starts with an initial population of 70 designs. The results obtained for these designs are used by Frontier to set up response surfaces using neural networks, which are used by a multi-objective genetic algorithm to mix real calculations and virtual calculations in order to accelerate the process. Then we use the multi-criteria decision-making tools provided by Frontier to detect the Pareto frontier and to sort solutions.

2nd study: OPTIMIZATION OF A SHIP HULL FORM.

Once we validated the optimization chain during the first study, we wanted to test it on a 3D calculation; the integration of an appendage on a ship hull. For this case, the parameterization was not done in Gridgen, but in the CAD software. For each design, an IGES file was input as geometry for Gridgen. An IGES file from Pro/ENGINEER was input as geometry for Gridgen. A Glyph script, obtained by journaling, was used to automatically create a 3D structured multi-block mesh, comprising approximately 300,000 cells, around the hull of the vessel. Structured grids benefited from the grid quality improvement provided by the elliptic solver. More than 70 meshes of different designs were generated automatically thanks to this script.

In order to reduce the computation time in the flow solver, the calculation for each design was started with a flow field already converged on another design. Moreover, the flow field was restricted to a region around the appendage. Boundary conditions were deduced from a solution obtained on a larger flow field. Thanks to these two tricks, the computation time was decreased by 60%.

Response surfaces were used in conjunction with multi-objective genetic algorithm in order to get quick convergence. In less than 110 hours of computing, a minimum for drag was reached.

For more information on Frontier, visit Sirehna's web site at www.sirehna.com

If you have a Gridgen project and would like to share your successes, let us know. We welcome story ideas and accept articles. Please send your ideas to Heather McCoy at hlmccoy@pointwise.com

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Endangered Fish Benefit from CFD, cont.

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adjacent to deeply carved depressions (below –200 ft. elevation). Data sets for the computational domain included point measurements and contours of bathymetric data, shorelines extracted from orthophotos, and hard copies of drawings of the draft tubes and spillway structures. Three stereolithography (STL) files were created from these data (river, powerhouse draft tubes, and spillway stilling basin) and used as the underlying geometry for creating a 3D hybrid (tetrahedral and hexahedral) mesh for use with STAR-CD. In this case, these STLs were also needed for use with another CFD solver, so the STL files provided a common format from which to develop the computational meshes for both models. We were pleased to beta test Version 14 because of the new feature that allows us to use and project to STL's.

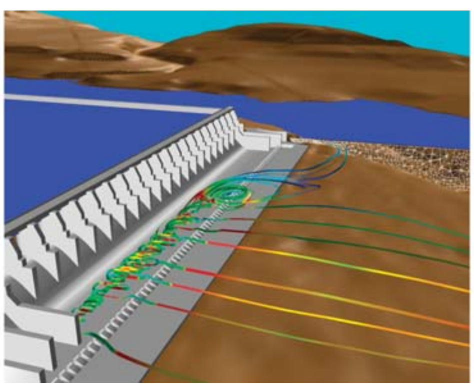

Figure 2. Example of particle tracks of neutrally buoyant particle in the spillway stilling basin.

The numerical model was a steady-state, rigid lid model, hence the computational mesh needed to have the option of removing or adjusting the top layers for flow scenarios with higher or lower tailwater elevations. This meshing approach increases the suite of flow scenarios for which the mesh can be used without the need to generate and validate a new computational mesh. Flow results (Figure 2) are validated to field-measured data, reduced-scale physical model data, and results from another CFD flow solver. In the future, free-surface simulation results from the high flow outfalls will be used to provide inflow conditions to the STAR-CD model. These results will be used to support high flow outfall location decisions.

Gridgen Version 14's ability to project to STLs made it possible for us to create complex 3D hybrid meshes of the river and engineered structures. The use of the STLs in Gridgen Version 14 also allowed us to use a common set of geometric and bathymetric base data for multiple CFD solvers with different geometry requirements.

Gridgen Training 2002
Jul 16-17-18
Sep 17-18-19
Nov 5-6-7
Additionally there will be a one day on demand Version 14 training class scheduled independently of the regularly scheduled training classes. Please check www.poinwise.com/support/ to register or for more information.