Focal**Point** The Newsletter for Pointwise® Users

Volume 14 Issue 2 Winter 2010

Pointwise, Gridgen Streamline Ducted Fan, Stator Design

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Over the last few years, interest in unmanned air systems (UASs) has increased. Vehicles that require minimal ground support can offer troops at the squad or platoon levels an immediate reconnaissance capability. A configuration that provides such a capability is a ducted fan. Ducted fan configurations are highly efficient vertical takeoff and landing (VTOL) vehicles. Ducted fan configurations not only are proven to provide around 40 percent more thrust than an open rotor and around 70 percent more thrust than an equivalent weight helicopter, they have a protected fan and a simpler mechanical system requiring lower maintenance.

Since 2001, AVID LLC has been designing ducted fan vehicles, including designs for the DARPA OAV and DARPA OAV II vehicles, lead design for Honeywell T-Hawk™, and lead design and air-framer for the Brigade Combat Team Modernization (BCTM) Class I venicle, as well as several in-house research vehicles, Figure 1.

Figure 1: Ducted fan VTOL UAS

AVID incorporates computational fluid dynamics (CFD) early on for design evaluation and validation of ducted fan vehicles. Applications range from the aerodynamic database development, component aerodynamic force and moment predictions, wind tunnel wall effect analyses, to aerodynamic database development. AVID tightly integrates CFD in fan and stator design to maximize performance while achieving consistent cancellation of fan torque.

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Complex Grids for Fluid Flow Generated at RWTH Aachen

By Dipl.-Ing. Eric Borrmann, Chair for Computational Analysis of Technical Systems (CATS), RWTH Aachen University

At the Chair for Computational Analysis for Technical Systems (CATS) at the RWTH Aachen University, students use Gridgen and Pointwise to create meshes around complex geometries in the field of maritime applications. In the Voith meshing laboratory, the students prepare, as a part of their bachelor or diploma thesis, grids for fluid flow simulations around a Voith-Schneider propeller (VSP) propulsion system or ship hulls as shown in Figure 1.

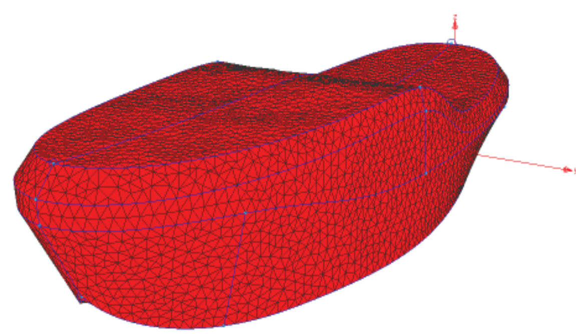

Figure 1: Pointwise surface mesh of a ship hull of a Voith-Water-Tractor (VWT)

The VSP is a combined propulsion and steering system which enables a vessel to adjust its thrust continuously in terms of magnitude and direction. This very unique propulsion characteristic is

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Accurate modeling of the lift fan is an integral part of the analysis for these hovering, ducted-fan vehicles since the fan-induced flow dominates the flow field. For these analyses, AVID uses NASA Langley's FUN3D Reynolds Averaged Navier-Stokes solver. This flow solver is coupled with an actuator disk module, using a blade-element loading model, to couple the effects of a rotor with the flow solver. Using the computed flow as inflow, the actuator disk equations are solved on an internally generated Cartesian mesh, with the effects interpolated back to the volume mesh, where the effects are incorporated into the momentum equations as source terms. Using FUN3D with the Spalart-Allmaras turbulence model and fans simulated by the blade-element loading actuator disk module, AVID has obtained results that compare very well with experimental data for several configurations.

The design of efficient stators is critical in the development of a ducted fan vehicle. These aerodynamic surfaces remove the fan generated swirl from the flow inside the duct. Having a consistent and smooth flow over the control vanes is critical for vehicle controllability. Since errors in interpolating the computed inflow and fan effects from the Cartesian mesh to the tetrahedral mesh will affect the flow field over the stator surfaces and the predicted stator performance, the effect of clustering in the rotor plane in the global mesh was investigated.

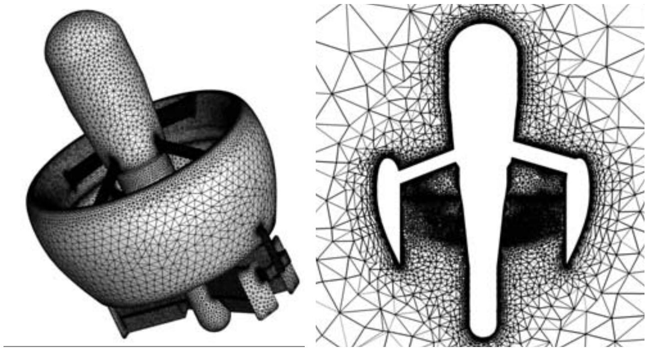

Figure 2: Surface and volume mesh about a generic ducted fan vehicle.

Using Pointwise for the surface mesh generation, an unstructured mesh was developed about a generic ducted-fan research configuration, Figure 2.

Volume meshes were generated using Gridgen's T-Rex technique and exported to FUN3D via a USM3D file. Using a Reynolds number of 660,000, based upon the fan-induced flow, anisotropic layers next to the surface were sized with an initial spacing of 2.07e-5 to result in a y+ at the first layer of approximately 1. The resulting baseline volume mesh consisted of 27.8 million cells.

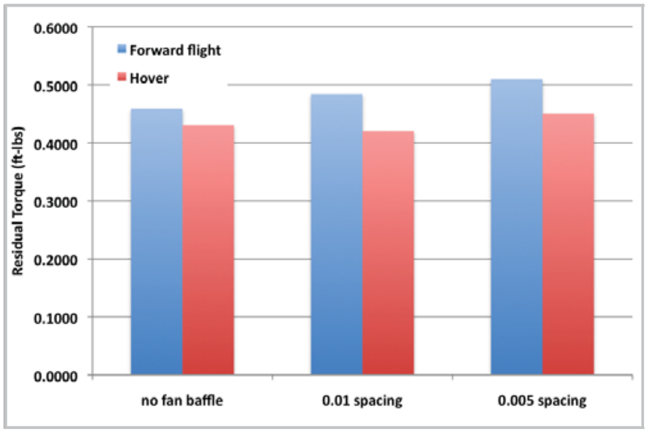

Figure 3: The effect of rotor plane clustering on predicted residual torque.

The clustering at the fan plane in the volume mesh was varied using a baffle surface. A donut-shaped baffle surface was placed inside the duct at the location of the lift-fan where clustering normal to the baffle surface was varied.

Residual torque, the difference between the fan-produced torque and the aerodynamic torque resulting from the stators, is a metric that can used to measure stator performance. Three cases were investigated: no clustering (baseline), $\Delta s = 0.005$, and $\Delta s = 0.010$. Figure 3 illustrates how increasing clustering on the baffle surface has little effect on residual torque for a hover condition with a non-optimized fan-stator design. Therefore, we concluded that the solution is independent of the rotor plane clustering.

However, in the forward flight case, the computed residual torque appears to be not yet mesh converged.

The use of the volumetric clustering capability within Gridgen and Pointwise has allowed for improved mesh generation that in turn results in improved flow predictions. The increased confidence and reduced total grid density greatly improve our CFD productivity and strengthen AVID LLC's position in the leading designers of ducted fan vehicles. See more on AVID LLC's vehicle design capabilities at www.avidaerospace.com. ■

Complex Grids for Fluid Flow Generated at RWTH Aachen

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achieved by a set of vertical blades with a typical hydrofoil profile fixed on a rotating base plate. The local angle of each blade to the trajectory of its moving axis of rotation can be adjusted independently according to the global position of the blade. A surface mesh for a VWT propulsion system including the Gridgen domains and connectors can be seen in Figure 2.

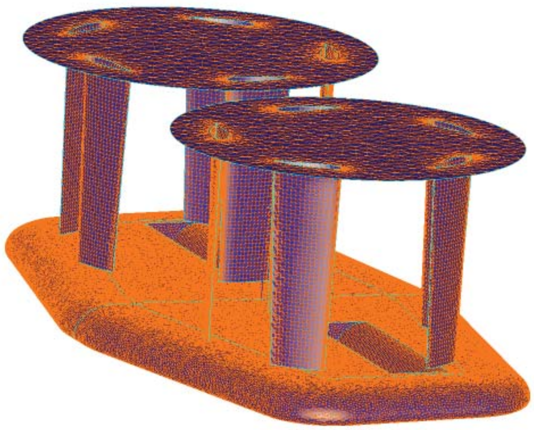


Figure 2: Surface grid for a Voith-Schneider propulsion system

The broad range of Gridgen tools enables students to create very accurate meshes, including the option to create structured domains on the sharply-rounded vents of the protection plate below the VSP propellers. Students use the Glyph scripting language to automate the meshing so that meshes with different resolutions can be generated by just entering in a Tk GUI window the desired mesh resolution parameters, as shown in Figure 3.

This is not only helpful when performing refinement studies but also when looking for the best mesh deforming algorithm in the zone between the bottom tips of the VSP blades and the protection plate. As the blades have to turn up to 50 degrees, the elements in this small gap have to undergo a very large de-

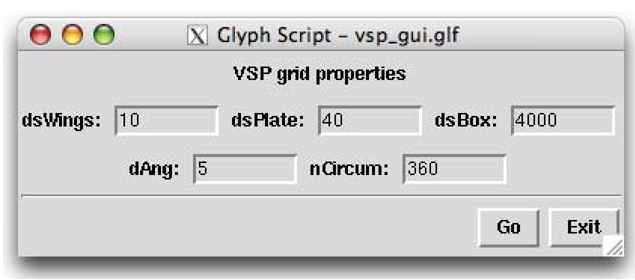


Figure 3: GUI of a Glyph script

formation, which can lead to tangling elements. With the use of our elastic mesh deformation approach, we can prevent tangling

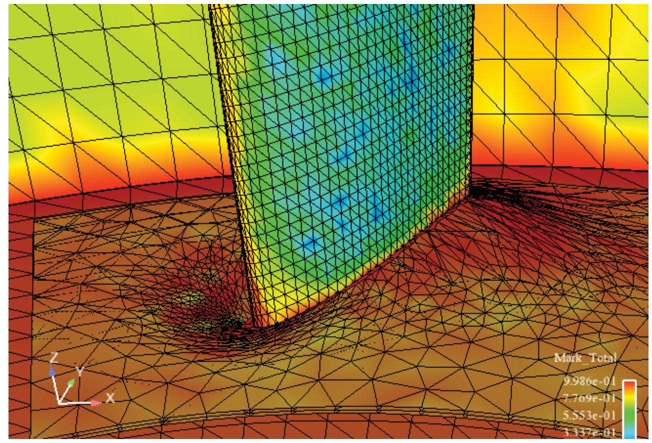


Figure 4: Baffle faces enabling elastic mesh deformation

only when element nodes are situated on just two planes parallel to the moving directions of the element nodes. This special mesh requirement can be fulfilled by using the Gridgen baffle faces concept, which enables the creation of single non-attached domains in order to prescribe certain mesh node positions in the interior of a volume mesh. In Figure 4, three baffle faces are shown below a turned blade. As the mesh deformation algorithm only allows node motion on a baffle face, element tangling can be prevented.

Based on an initial, successful refinement study with one turning blade, the more expensive, unsteady simulations are being performed currently at CATS, including the full propulsion system

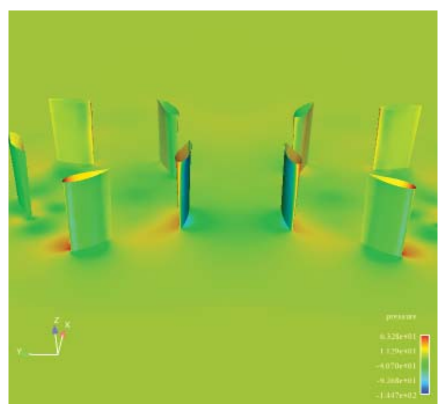


Figure 5: Fluid flow simulation around a VSP propulsion system.

geometry with ten blades. The pressure distribution around the VSP propulsion system, after almost two rotations at a propeller rotation speed of 80.2 rpm, is shown in Figure 5.

During the last three years, 14 students have taken part in the VSP laboratory. Pointwise, Gridgen and Glyph let them complete many fluid simulations. ■

Partner Highlight

Founded in 1994, Metacomp Technologies is a leading provider of software tools for major aerospace, defense, and automobile manufacturers, many U.S. government labs and research organizations, as well as companies that require complex modeling during research and development.

Metacomp's flagship product CFD++ is based on unified grid, physics and computing methodology in an advanced numerical discretization and solution framework. CFD++ utilizes a multi-dimensional TVD polynomial reconstruction with up to fourth order accuracy in time in explicit mode and second order accuracy in time in implicit mode. CFD++ also uses a finite-volume framework with fast convergence to steady state and fast computation of unsteady flows, with enhanced speed using dual time stepping.

CFD++ application capabilities include

- High and low speed reacting/non-reacting flows
- Incompressible flows
- Conjugate heat transfer
- Multiphase flows
- Sliding and overset meshes for flow around and within bodies in relative motion
- 6-DOF applications

Metacomp Technologies

CFD++ is used in aerospace, appliances, automotive, biomedical, chemical, electronics cooling, wind energy, HVAC, mixing, pumps and turbomachinery.

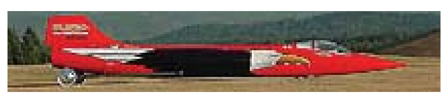
Pointwise provides the meshing technology needed for accurate CFD++ computations for aerospace configurations. Metacomp and Pointwise have worked together since the early 2000s, providing CFD and meshing technology for high fidelity models.

Metacomp, located in California, provides worldwide services in research and development, software development, dissemination and support and in fluid dynamics, structural analysis, numerical algorithms, turbulence and combustion modeling, acoustics, geometry modeling and mesh generation. For more information, see www.metacomptech.com.

Pointwise Sponsors Challengers of 763 MPH Land Speed Record

Pointwise has partnered with Team North American Eagle™ in its quest to break the 763 mph world land speed record set in 1997. This team of volunteers, headed by Edward J. Shadle and Keith Zanghi, is converting a former Lockheed F-104A-20 Starfighter into one of the most sophisticated vehicles on earth. Their goal is 800 mph (1,287 km/h).

The purpose of the NAE program is to test the capability of a land based vehicle to safely transition through supersonic speed. The team has conducted more than 25 test runs, with its fastest speed being approximately 400 mph in 2008.



The Eagle weighs 13,000 pounds and is 56 feet long.

Pointwise software will be used by the aerodynamics team to analyze airflow around the Eagle using computational fluid dynamics (CFD).

"Anyone who plans to strap wheels on an F-104 and drive 800 mph deserves our support," said John Chawner, Pointwise president.

Training Dates 2011

Pointwise Standard Course	25-27 January	Fort Worth, TX
Pointwise Standard Course	22-24 February	East Coast
Pointwise Standard Course	22-24 March	Fort Worth, TX
Pointwise Standard Course	24-26 May	Fort Worth, TX
Pointwise Standard Course	21-23 June	Midwest
Gridgen Standard Course	12-14 July	Fort Worth, TX

For more information, contact our training department at support@pointwise.com.

Product News

Pointwise 16.04 Capabilities Include Gridgen Features and Then Some

Leading the parade of Gridgen functionality migrated to Pointwise 16.04 is the surface meshing formulation of the T-Rex technique (anisotropic triangle extrusion) with which you can now generate 2D or surface-constrained meshes with layers of high aspect ratio, high quality triangles.

For isotropic tetrahedral meshes, any problematic cells that prevent a mesh from being generated now are highlighted graphically to help you identify and repair trouble spots. When examining structured grids, you now have the option to display and count cells of various Jacobian types (for example, negative and negative skew). A similar change was made to examination of Database Associativity to display counts of points on and off the database.

The order of blocks for CAE export now can be customized using the Sort feature. You can sort by dragging and dropping in the list, sequentially by any of the data columns, and by moving each individual block. While we're on the topic of blocks, interblock connections now can be overwritten with a flow solver boundary condition to model thin surfaces. You also can annotate your project with note entities imported from CAD files or created in Pointwise.

Using Print to File, you can capture the Display window screen and save it to a PNG, BMP, or TIFF file. Optional capabilities can be applied to save high-resolution images that are better suited for print publication. Your file import and export options have been expanded greatly in V16.04, with CAE export now available for GASP, INCA, NSAERO,

Three new features in Pointwise V16.04 are illustrated in this image: T-Rex 2D, Tweak and Notes.

This faceted geometry model (shell) of the Statue of Liberty was imported from an STL file and split using the new split command for shells.

Exodus II, TASCflow, Tecplot, WIND, and WIND-US. New grid import was added for UGRID files and new grid export was added for CFL3D. The CAE plugin API, with which you can customize Pointwise with your own CAE export format, was extended to support structured grid data and file types.

Pointwise's capabilities continue to grow beyond Gridgen's feature set. One of the most powerful new features is Tweak, the ability to move individual grid points in surface and volume grids, providing the ultimate in fine control to make the grid just the way you want it.

If you work with shells (faceted database entities), you're now able to split them with planes and join them. Pointwise now remembers two separate last-used file path preferences: one for file import, export, open, and save and a second for executing and journaling scripts. For easy recall of scripts, a list of your most recently executed scripts was added to the Script menu.

Pointwise now has a Mac OS X universal binary that includes native 64-bit (x86) support for 10.6 "Snow Leopard". Other enhancements to the user interface include the display of a second set of coordinate axes at the origin of the X-Y-Z coordinate system, and the ability to save (in HTML or plain text), copy, and clear the contents of the Message window.

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

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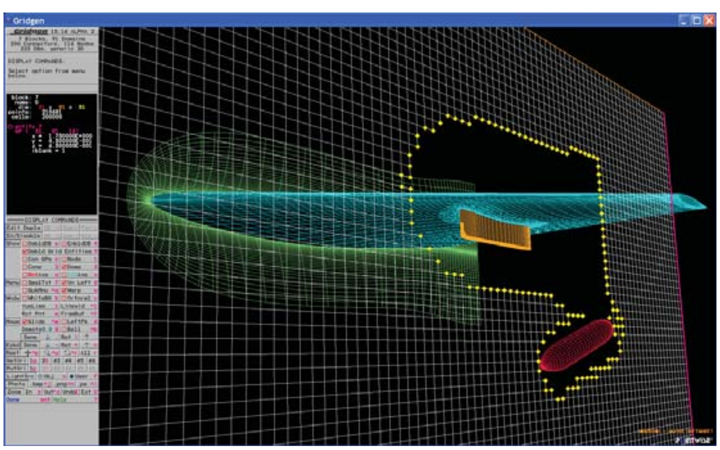
Gridgen Integrates Overset Grid Tools

Beginning with V15.16, Gridgen includes integration with third-party overset grid assembly tools and provides diagnostics for resolving problems with overset grids.

In a new Overset Attributes panel, you can select which overset grid assembly software to use and set assembly attributes like body, grid, and boundary names, case names, and any other global and custom attributes. Gridgen V15.16 supports PEGASUS5 (from NASA) and SUGGAR (from Pennsylvania State University) grid assembly tools.

Once the input attributes are set, the assembly software can be launched from Gridgen with the results returned for display and diagnosis using Gridgen's Examine command. IBLANK data in PLOT3D files is now supported. You can display hole, orphan, and fringe points and contours of IBLANK scalar function to identify problems and guide grid editing.

PLOT3D import has been generalized to include single/multiple block, IBLANK, big/little endian, and 2D/3D options, all of which are detected automatically on import. ■



Gridgen V15.16 provides easy access to overset grid assembly tools. For more information, see www.pointwise.com/overset/.