Bentley®

Advancing Infrastructure

CONNECT Edition

Key Capabilities

Modeling
- Dynamically trimmed NURB surfaces and curves
- Structured, triangular meshes
- Fast, intuitive modeling

Structure
- Shell plates
- Shell stringers
- Frames, decks, bulkheads
- Beam and plate FEA
- Shell expansion diagram

Stability
- Intact and damaged conditions
- Integrated loadcase editor
- Integrated compartment editor
- Comprehensive stability criteria
- Probabilistic damage

Resistance
- Planing, displacement, and sailing vessels
- Slender body potential flow
- Wake prediction

Motions
- Monohull and multihulls
- Strip theory and radiation-diffraction panel method
- RAOs and accelerations
- Crew and passenger response

Data Interoperability with
- MicroStation®
- Rhino
- AutoCAD
- Naval architecture software

MAXSURF®

Naval Architecture Applications for all Types of Vessels

MAXSURF offers comprehensive capabilities for the design of all types of marine vessels. MAXSURF includes capabilities for hull modeling, stability analysis, motions and resistance prediction, structural modeling, structural analysis, and export to vessel detailing. MAXSURF utilizes a single parametric 3D model that facilitates smooth communication and coordination among different team members and design activities.

Integrated Modeling and Documentation Workflows

With MAXSURF CONNECT Edition you have a personal portal to access learning, communities, and project information. You can also share personal files including iModels and PDFs directly from your desktop with other users, or stage them for easy access from a Bentley app, such as Structural Navigator. With the project portal your project teams can review project details and status, and gain visibility into project performance.

MAXSURF features data interchange, both import and export, with other industry standard file formats including offsets, CFD, CAD, and surface and mesh data.

MAXSURF Capabilities

Designed for professional naval architecture teams, MAXSURF offers a full range of tools for designing power, sail, commercial, and naval vessels made from steel, aluminum, wood, or composite material.

Create accurate, sophisticated models using dynamically trimmed 3D NURB (non-uniform rational B-spline) surfaces.

MAXSURF provides modeling tools to quickly generate the hull, appendages, and superstructure. It also includes interactive and numerical controls that enable systematic manipulation of the vessel's hull shape to achieve a fair and optimized hullform. Round-trip interoperability with MicroStation, Rhino, and other NURB modeling tools is provided. Alternatively, flexible data import, mesh modeling, and automated curve and surface fitting enable you to model existing vessels for analysis or modification.

Internal structure and layout is automatically constrained to the hull envelope facilitating the rapid creation of frames, bulkheads, decks, and other primary structures. They can be exported via DXF for nesting and cutting. In addition, MAXSURF's meshing tools assist in producing models suitable for analysis in CFD and FEA.

Verify the vessel's hydrostatic stability performance with a variety of tailored analyses and ensure compliance with stability criteria. Analyze the vessel in intact, damaged or partially damaged conditions; spilling from open-topped tanks and the effect of water-on-deck may also be included as well as the influence of quasi-static waveform and grounding.

MAXSURF

MAXSURF includes a comprehensive library of stability criteria, as well as the ability for users to define their own criteria. To assist with creating stability booklets, a template system allows you to define the report format using a Microsoft® Word template document. Tables, graphs, and images are then automatically sent to the report.

The ability to assess passenger comfort and vessel response to waves and estimate calm-water resistance and sailing performance enables naval architects to complete other routine design tasks within the MAXSURF worksuite.

	Worksuite	
Capability feature: Modeling	**MAXSURF Advanced**	**MAXSURF Ultimate**
Hull geometry		
Trimmed NURB surfaces and NURB curves. Structured, triangular meshes and unstructured point data	✓	✓
Geometry exchange (including DGN, IGES, DXF, 3DM and industry-specific file formats)	✓	✓
Parametric transformation of NURB model. Fitting tools for NURB curves and surfaces	✓	✓
Automated modeling through COM	✓	✓
Hull structure		
Hull plates; development/expansion of single- and double-curved plates. Shell Expansion plan	✓	✓
Decks; transverse frames and bulkheads; longitudinal stiffeners, girders, and bulkheads	✓	✓
Capability feature: Hydrostatic analysis	**MAXSURF Advanced**	**MAXSURF Ultimate**
Probabilistic damage analysis: MSC.421(98); MSC.216(82) and MSC.19(58)		✓
Hydrostatics; GZ curve; equilibrium; specified condition, KN curves, KG limit, floodable length, longitudinal strength, tank calibration, MARPOL outflow, cross-flooding MSC.362(92)	✓	✓
Stability criteria compliance. User-customizable criteria	✓	✓
Intact stability. Damage stability with partial flooding. Spilling tanks. Fluid simulation in partially filled tanks	✓	✓
Multi-core solver. Batch analysis. Reporting. SQLite results database	✓	✓
Automated analysis through COM	✓	✓
Capability feature: Hydrodynamic analysis	**MAXSURF Advanced**	**MAXSURF Ultimate**
Radiation-diffraction panel method (6 DOF, zero speed)		✓
Strip theory (heave and pitch) with forward speed, simplified estimate of roll motion	✓	✓
Significant motions, MSI, MII, and SM for specified headings, speeds, and wave spectra	✓	✓
Automated analysis through COM	✓	✓
Hull Resistance and Sailing Performance prediction	**MAXSURF Advanced**	**MAXSURF Ultimate**
Hull resistance regression methods for monohull vessels. Velocity prediction for sailing monohull yachts	✓	✓
Slender body resistance algorithm including estimate of far-field wave pattern	✓	✓
Automated analysis through COM	✓	✓
Capability feature: Structural analysis	**MAXSURF Advanced**	**MAXSURF Ultimate**
Dynamic modal response and time history analysis		✓
Design codes: national (AS4100, AS4600, NZS3404) and international (AIJ, ASD, LRFD, AISI BS5950, EC3)		✓
Linear analysis of 3D structural frame and stiffened plate models	✓	✓
Nonlinear and buckling analysis of frame models	✓	✓
Beam cross-section modeler and properties calculator	✓	✓
Automated modeling and analysis through COM	✓	✓

MAXSURF KEY ADVANTAGES

SINGLE 3D HULL MODEL

MAXSURF applications work from a single geometry file, streamlining the design process by removing the need to create geometry files in different formats for downstream analysis programs. Changes in the hull surface flow through parametrically to compartmentation, resistance and motions hull meshes, and structural part definition.

HIGH-QUALITY SURFACING

MAXSURF is optimized to help naval architects create high-quality hull surfaces that are fair and can be used for all other analysis and CAD/CAM functions.

DYNAMIC TRIMMING

Surface trimming in MAXSURF is a simple point-and-click process. MAXSURF's trimming is fully dynamic, allowing you to modify trimmed surfaces and have the trimmed portions automatically update.

COMPREHENSIVE ANALYSIS

MAXSURF includes analysis capabilities such as intact and damage stability, longitudinal strength, structural analysis and design, resistance prediction, wake calculation, motions prediction, and a sailing VPP.

INTUITIVE INTERFACE

MAXSURF's consistent, graphical interface is easy to learn and use. Each model shares a common intuitive interface with high-quality rendering and animation to visualize analysis results.

INTEROPERABILITY WITH MICROSTATION, RHINO, AND MICROSOFT OFFICE

MAXSURF is based on industry standard NURB surface modeling. It reads and writes DGN, 3DM, IGES, and DXF files, which facilitate a smooth data transfer with MicroStation, Rhino, AutoCAD, ShipConstructor, and SolidWorks. It also features copy and paste to and from Microsoft Excel, and a full automation interface, compatible with Microsoft Excel and Microsoft Word, that allows macros to be used to control MAXSURF for optimization studies or customized calculation and reporting.
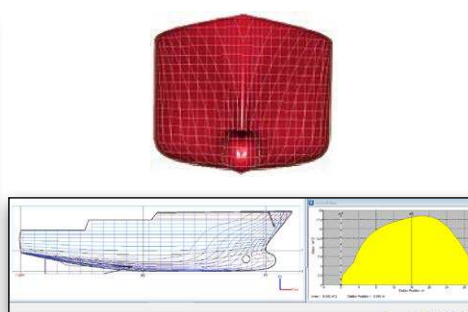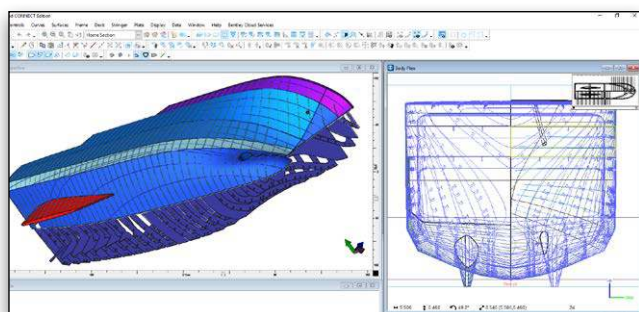
MAXSURF Modeler
NURB Hull Modeling

MAXSURF Modeler provides fast, flexible, and intuitive modeling of all types of hulls, superstructures, and appendages. Trimmed NURB surfaces can be used to model any vessel: from yachts to workboats to the largest ships.

The Modeler design module enables naval architects to create optimized hull forms quickly and accurately. Surfaces can be joined, trimmed, and manipulated to create a complete model ready for hydrostatic and performance analysis or construction detailing.

Modeler provides direct interactive manipulation of the surface shape by mouse or keyboard. Control points can be dragged with the mouse, adjusted numerically, or manipulated with a range of fairing commands. Modeler also provides capabilities to automatically transform hull shapes to match desired dimensions and hydrostatic properties.

Fair and accurate surfaces are critical for optimal vessel performance and ease of construction. Modeler's capabilities allow for evaluating curvature of the entire surface, as well as curvature along a particular surface contour, such as a waterline or diagonal. Curvature displays are automatically and interactively updated as the surface is modified.

The MAXSURF Modeler module facilitates modeling of all types of hulls and appendages.

All MAXSURF modules use a common design file containing the 3D geometry and other model data. Changes made to the hullform in Modeler automatically flow through to the other modules when the file is reopened. Design team collaboration is facilitated by the relatively small size of these files, which can be readily shared.

Modeler's interactive graphical environment allows you to quickly learn how to use the application. Multiple windows can be used to view and change the model and provide a tabular view of design data. Other windows provide on-the-fly checks of curve of areas, upright hydrostatic calculations, and tables of offsets.

Data exchange is a key requirement in the modern design office and Modeler supports many industry standard formats. Furthermore, you can copy and paste numerical tables to and from Microsoft Excel for custom calculations and formatting. Graphical views can be copied and pasted to other applications to help create presentation materials and reports.

| IMPORTING		EXPORTING	
MicroStation DGN	NURBS surfaces and curves	MicroStation DGN	NURBS surfaces and curves
IGES	NURBS surfaces (untrimmed)	IGES	NURBS surfaces
Rhino 3DM	NURBS surfaces and curves	Rhino 3DM	NURBS surfaces and curves
IMSA	NURBS surfaces	IMSA	NURBS surfaces
USNA / Fastship	NURBS surfaces	USNA / Fastship	NURBS surfaces
DXF	Curves & Markers Background	DXF	Polylines
GHS	Marker sections	BMT Microship	Sections
PIAS ascii	Marker sections	MHCP	Sections
Seaway	Marker sections	HYDROS	Sections
Wolfson LHF	Marker sections	IHI	Sections
nuShallo PAN	Trimesh surface	IMSA	Hull parameters
Polygon mesh PLY	Trimesh surface	GHS	Sections
Stereo Lithography mesh STL	Trimesh surface	nuShallo	Mesh
WAMIT med GDF	Trimesh surface	Parametric	Sections
Image PNG, JPEG, GIF	Background image	PD Strip	Sections
		PIAS ascii	Sections
		SHCP	Sections
		Shipflow	Sections & waerlines
		Stereo	
		Veres (MASHIMO)	Sections
		Wintech	Sections
		Wolfson LHF	Sections
		Polygon mesh PLY	Trimesh surface
		Stereo Lithography mesh STL	Trimesh surface
		WAMIT med GDF	Trimesh surface
		Direct X	Trimesh surface
		Wavefront	Trimesh surface
		Image BMP	Background image

Supported file formats and objects.

Modeler's unique surface trimming capabilities allow you to model complex surface edges while maintaining fairness throughout the rest of the hull. An interactive display of trimming intersections lets you create the shapes you require even with complex configurations such as curved transoms, stepped sheerlines, and appendages or bow thrusters. Surface trimming is automatically updated as the surfaces in the design are adjusted. Modeler provides all the required capabilities for hull, appendage, and superstructure modeling.

Structural Parts and Plate Development

Modeler provides tools for the definition of the primary structural parts, which must conform to the 3D hull shape. These include: hull plates; transverse frames and bulkheads; decks and longitudinal structure. Interactive graphical tools facilitate the definition of complex part layouts; particularly the fairing of longitudinal stiffener layouts on the hull plating surfaces. Parts may be also edited numerically when this is more convenient. All parts are defined parametrically in relation to the NURB surfaces making up the hull model, ensuring that the parts not only exactly match the hull surface, but that they adapt to any change in the

hull geometry. This means that the part shapes can be quickly recalculated (without any need to redefine the parts) to reflect any changes in the hull geometry arising from, for example, fairing or optimization. The ease with which parts can be updated to reflect changes in hull geometry enables concurrent engineering, allowing design, analysis and construction detailing to proceed in parallel; increasing scope for weight optimization and time saving.

The parts may be exported to industry-standard file formats in both 3D and 2D for further detailing in generic CAD packages. As well as the part geometry, other part properties including: areas, weights, centers of gravity, and cutting lengths are calculated and tabulated. The parts list database can be sorted by any criteria and each part can be renamed to suit your part naming conventions. All parts' lists can be exported to spreadsheets or databases for further processing.
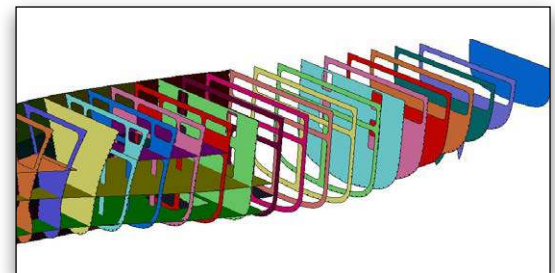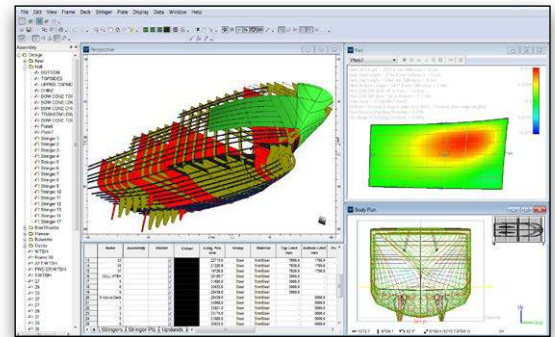
Define the vessel's primary structure in MAXSURF Modeler

Hull plates are defined directly from the precise NURB surface hull model enabling accurate calculation of the unrolled 2D plate shapes. Several plate-forming methods are supported (e.g. line heating and rolling) and precise data is computed to facilitate the plate forming process. In addition, the strain required to form the plate is estimated, which provides a very reliable guide to the amount of double-curvature in the plate and hence its developability.

Comprehensive tools to layout and fair longitudinal structure in the hull surfaces (stingers) are provided. Stringer intersections with frame are automatically calculated and adjusted for the local surface normal. Inverse bending lines for the forming of the longitudinal structure may be computed. As with the NURB surface modeling tools, the structural layout tools work equally well for both monohull and multihull vessels. Shell expansion diagrams showing the schematic layout of all the primary structure may be generated and exported to CAD.

Hull Modeling Advantages

• Model complex hull geometry with trimmed NURB surfaces

• Visualize hull shape changes with dynamic updating of all views

• Match required hull parameters using parametric transformation

• Extract key design data via hull lines, tables of offsets, hydrostatic properties, or curve of areas

• Import NURB surfaces, meshes or point data

• Guided manual fitting of NURB surfaces to point data

Part Modeling Advantages

• Parametric structural parts respond instantly to design changes

• Interactive interface lets you define parts quickly and accurately

• Integrated parts list produces accurate weight information

• Automated stringer layout facilitates design process

• Rapid generation of frames and decks using common parametric attributes

• Integrates with downstream CAD systems via industry-standard 3DM, IGES, and DXF files

MAXSURF Stability

Intact and Damaged Hydrostatics and Stability

The MAXSURF Stability module provides fast, graphical, and interactive calculation of intact and damaged stability and strength for all types of MAXSURF designs.

Once a design is created using Modeler, its stability characteristics can be assessed using the Stability analysis module. The Stability analysis module provides a range of powerful analysis capabilities to handle all types of stability assessment and longitudinal hull girder bending calculations. Precise calculations are performed directly from the MAXSURF model without the need for offsets or batch file preparation.

All functions within Stability are performed using a graphical multi-window environment consistent with all other MAXSURF modules. Data is displayed simultaneously in graphical and tabular form and is automatically updated when changes are made and as the analysis progresses. An integrated load case editor makes setting up loading conditions simple and error free. Copying and pasting data to and from spreadsheets also makes it easy to prepare complex loading schedules in other programs and run them in Stability. Load cases can also be saved and reused with other design configurations.

Tank and compartment modeling are integrated within Stability, allowing you to quickly and easily define the vessel's tank and compartment layout. Complex compartment geometries can be defined using surfaces created in MAXSURF Modeler. Tanks are automatically included in the weight schedule and as parametric objects they are automatically updated if the hull shape is changed as the design progresses. A tank calibration option is provided to give detailed volume and CG characteristics of all tanks.

The Stability module includes intact and damaged options for analysis methods including upright hydrostatics, large angle

stability, equilibrium analysis, cross curves, limiting KG, and longitudinal strength analysis (MAXSURF Ultimate also includes probabilistic damage analysis). For each analysis method, Stability automatically highlights the required data to be entered and provides data entry dialogs to ensure data is entered correctly.

Stability provides commonly used standard criteria to ensure compliance with class requirements. Your own custom criteria for specific special requirements may also be defined.

After an analysis is completed, all results are presented in either tabular or graphical form. You can click on any graph and move the cursor to obtain precise values at any location. You can also choose how tables are displayed, which columns are visible, and sort results by any column.

After each analysis, results can be stored in a database and sent to a Microsoft Word document (or the built-in report window) to help prepare a stability book for your vessel. Descriptions, tables, graphics, and graphs are automatically inserted and can be re-formatted or deleted at any time. You can also enter notes into the report and cut and paste graphics from the Stability module, other MAXSURF modules, or any other application. The entire report can be generated using a customizable Microsoft Word template. The results database can be used at any time to recreate a stability book using a new or modified report template.
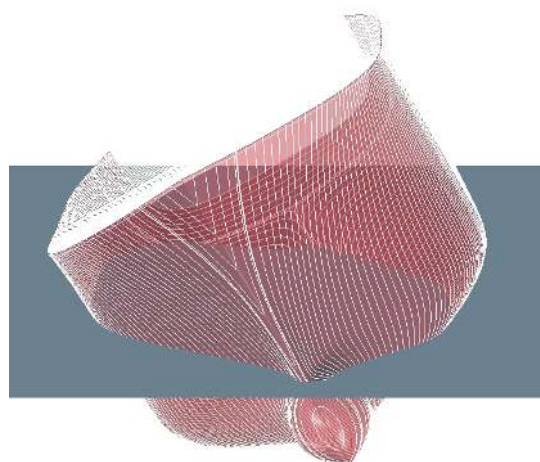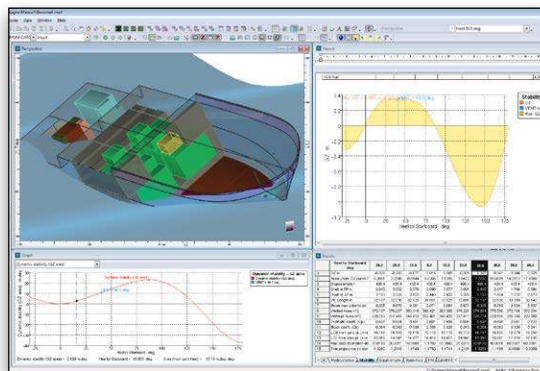
The MAXSURF Stability module integrated analysis environment

Stability Advantages

- Hull geometry read directly from the model file
- Visualize hydrostatic behavior during analysis
- Ensure accurate load cases with tanks automatically included
- Check standard or custom stability criteria from the criteria library
- Analyze any hydrostatic condition with comprehensive analysis capabilities
- Analyze intact, damaged and partially damaged conditions, including the effects of spilling from opened-topped tanks, fluid movement and water-on-deck

MAXSURF Motions
Vessel Motions Prediction

The MAXSURF hydrodynamic and seakeeping analysis module, Motions, provides fast, reliable calculation of the vessel's response and seakeeping characteristics in a variety of sea states for the many types of designs created with MAXSURF Modeler.

The Motions module allows designers to quickly predict the seakeeping performance of MAXSURF designs. The hull geometry required for the analysis is read directly from the MAXSURF model file.

Data is displayed simultaneously in graphical and tabular form and is automatically updated when changes are made. Data can be copied to spreadsheets and other applications for presentation purposes or further analysis, for example, to calculate the probability of slamming, propeller emergence, and more.

Ship motions are predicted for specified wave spectra and headings, vessel speeds, and other analysis parameters. RAOs and response spectra are computed, as well as the added resistance, significant absolute and relative motions, velocities, and accelerations of the vessel for each of the specified operating conditions and wave spectra. RMS and significant motion Motion, velocity, and acceleration data as well as crew performance measures including motion sickness incidence (MSI) and motion induced interruptions (MII) may also be computed for any position on the vessel.

Ship motions in the vertical plane (heave and pitch) are computed using traditional strip theory, with the 2D added-mass and damping calculated using conformal mapping techniques; roll response is estimated from a user-specified estimate of viscous roll damping. Strip theory is applicable to many hull shapes with length-beam ratio (L/B) greater than 4.0. MAXSURF Ultimate additionally provides a zero-speed, six degrees of freedom, 3D radiation-diffraction panel method suitable for more complex hull geometries.

Results have been validated against a variety of data from various independent sources including model tests, full scale trials, and other numerical methods.
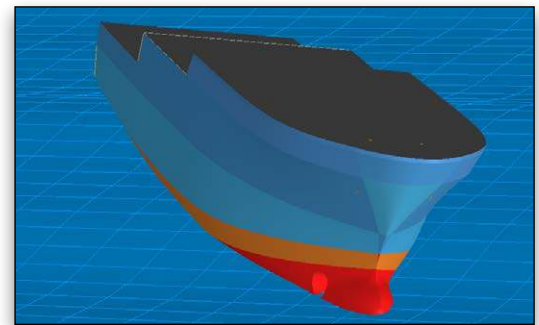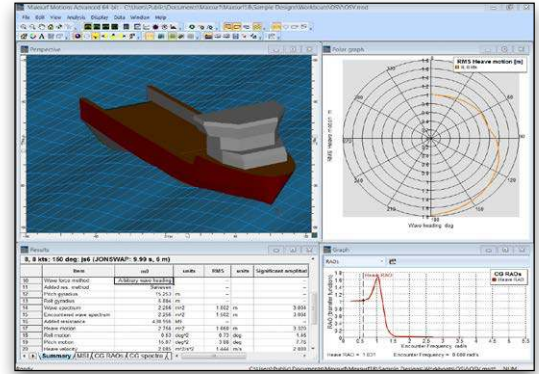
The MAXSURF Motions module calculates RAOs and accelerations in various headings and sea states.

Motions Advantages

- Analysis geometry at specified draft and trim automatically generated from the model design file
- Quickly calculate response amplitude operators, added resistance, and crew performance measures
- Determine response at vessel center of gravity or at remote locations
- View results in both graphical and numerical displays
- Animate seakeeping response in specified sea state

MAXSURF Resistance
Resistance and Power Prediction

The MAXSURF Resistance module estimates the calm water resistance for a broad range of monohull vessels using industry standard regression methods. The resistance and wavemaking of slender monohull and multihull vessels (with symmetrical hulls) can be estimated using a simplified potential flow method. The ease with which the resistance can be quickly estimated directly from the common design file can be particularly useful during concept and initial design stages.

The appropriate regression methods can be selected based on the type and form of the vessel being designed. Calculation methods include Savitsky pre-planing and planing, Lahtiharju for planing vessels, Blount & Fox for planing vessels, Holtrop and Compton for fast displacement hulls, Fung and Series 60 for ships, van Oortmerssen for full form hulls such as tugs and trawlers, and Delft systematic yacht series for sailing yachts. It is also possible to directly analyze the resistance of a MAXSURF hull using a slender-body method, which uses a potential flow approach.

The Resistance module reads the design file and automatically measures the required input parameters. You can override these automatically calculated values to fine tune the calculations to match requirements.

Output is provided in both tabular and graphical format and is automatically recalculated as changes are made to input parameters.

Resistance Advantages

- Directly measure the 3D model
- Predict vessel performance in minutes
- Override measured parameters to test design variants
- Compare analytical resistance with tank test methods
- Add wind and appendage resistance
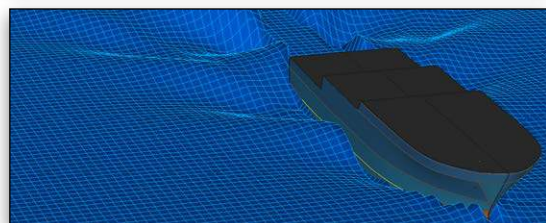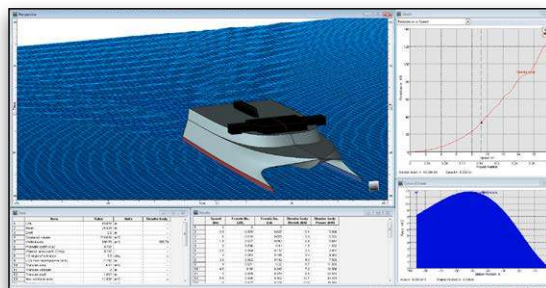
The MAXSURF Resistance module can compute the wavemaking of slender hull shapes.

MAXSURF Multiframe
Structural Analysis and Design

MAXSURF Multiframe helps structural experts determine the stresses in their vessel to comply with class requirements and optimize it for strength and weight.

When designing a steel or aluminum vessel, there are a variety of structural analysis approaches that can be used to assess the ship's structural capacity and compliance with class requirements. Multiframe is a general-purpose beam and plate element-based system that allows you to very quickly model and analyze ship structures and carry out static or dynamic analyses of their structural behavior. Multiframe complements the more time-consuming full finite element analysis and less-accurate spreadsheet calculations.

With Multiframe, you can open geometry files from MAXSURF Structure or most other structural modeling systems and apply structural properties such as restraints, materials, and section shapes. You can create a family of load cases and then perform a static or dynamic analysis and review results in terms of

displays of actions, stresses, and deflections. Dynamic results include natural frequencies and mode shapes or more detailed time history results for time varying loads.
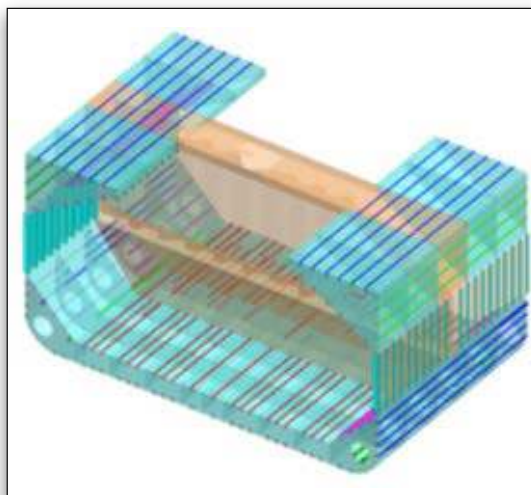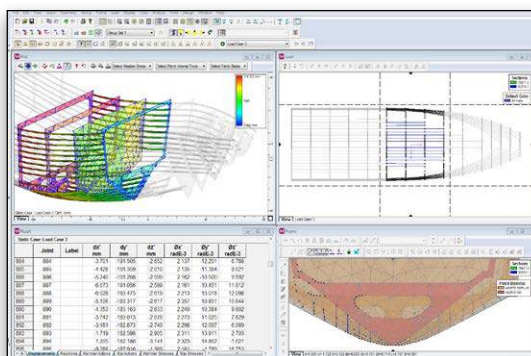
Multiframe's automation interface with Excel enables optimization of structural behavior using custom calculations, as well as built-in searching, sorting, and checking functions. Automation is particularly useful for post-processing of analysis data as well as pre-processing including generation of hydrostatic or wave loads.

Multiframe easily manages the complex geometry that results from a detailed structural analysis model. Rendering and animation can be combined with clipping, searching, and sorting functions. This makes it easy to narrow your focus to critical areas.

Multiframe also includes the Shape Editor, a section properties calculator, and a comprehensive library of common structural shapes.

Multiframe Advantages

- Graphically model beam and plate structures
- Automatically adjust mesh density and hot spots
- Apply loads using self weight, buoyancy, inertial and current load cases
- Check results numerically and graphically
- Animate structural response with rendering

The MAXSURF Multiframe module provides structural analysis of beam and plate models.

MAXSURF VPP – Sailing Yacht Velocity Performance Prediction

The MAXSURF VPP estimates sailing performance for monohull yachts in a variety of sailing conditions and produces polar curves to show predicted yacht speed for each wind speed.

Using calculation methods similar to the original IMS Velocity Performance Prediction program, VPP solves the equations for lift and drag for hull and rig and finds an equilibrium velocity and angle of heel. Calculations are made for a specified range of true wind angles and speeds, with spinnaker both up and down.

Integrated into VPP is a hull measuring capability that automatically measures the MAXSURF design to extract the required input measurements and parameters. Alternatively, a small number of key values can be entered directly from an IMS certificate.

Output from VPP is provided in both tabular and graphical format for each wind strength and direction. Results include apparent wind strength, hull velocity, Vmg, heel angle and the various lift-and-drag forces involved. The family of polar performance curves produced can be selected to find key values for any setting.