

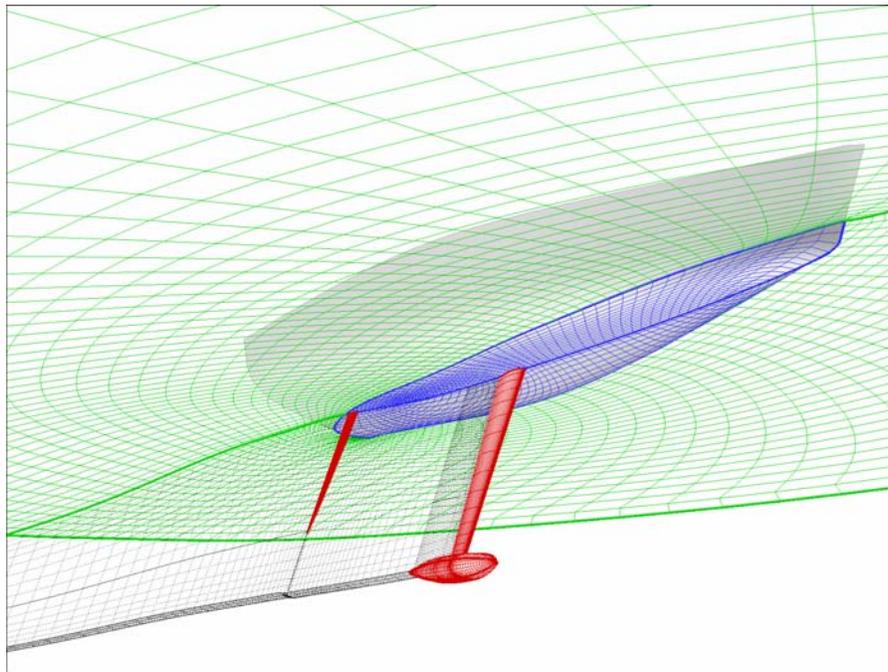
ACCPAN

Automated Geometry Package for SPLASH Free-Surface Code

Automated Panel Model Generation
with Free to Sink-and-Trim and Nonlinear Free-Surface
Hydrostatic and Hydrodynamic Capabilities

Version 5.1.0.05
Reference Manual

May 2, 2009



South Bay Simulations, Inc. • 44 Sumpwams Ave. • Babylon, NY 11702
(631) 587-3770 www.panix.com/~brosen brosen@panix.com

WARRANTY AND DISCLAIMER

South Bay Simulations, Inc. (SBS) makes no warranty as to the quality and performance of ACCPAN. While every effort is made to provide a bug-free and workable product, it is provided with no warranty that it is free from errors or that it will always work. This is the sole and exclusive warranty offered by SBS. There are no other warranties, express or implied, including but not limited to the implied warranties of design, merchantability and fitness for a particular purpose, or arising from a course of dealing, usage, or trade practice. No agent of SBS is authorized to alter or exceed the warranty obligations of SBS as set forth herein.

LIMITATION OF LIABILITY

In no event will SBS be liable for any lost revenues or profits, goodwill, or other special, indirect, consequential or punitive damages however caused by use of ACCPAN and regardless of theory of liability, even if SBS has been advised of the possibility of such damages. No SBS liability for damages resulting from use of ACCPAN shall exist.

COPYRIGHT

Copyright © 2008 by South Bay Simulations, Inc. All rights reserved worldwide. No part of ACCPAN software or documentation may be reproduced, transmitted, transcribed, stored in a retrieval system, or translated in any form without the express written permission of South Bay Simulations, Inc.

TRADEMARKS

Tecplot: Amtec Engineering, Inc.

ACCPAN Version 5.1.0.05 Reference Manual

Contents

Overview	1
Unit Dimensions.....	2
Database Mesh Descriptions	3
Hull	3
Keel.....	4
Keel-Mounted Bulb.....	5
Bulb-Mounted Wing	6
Keel/Bulb/Wing Combinations.....	7
Rudder.....	7
Final Location of Panel Model in SPLASH Global Coordinate System.....	8
Sail Pitching Moment and Vertical Force Models	9
Viscous Stripping Options.....	11
Overview of ACCPAN Input/Output Files	15
Figures.....	18
ACCPAN Standard-Input File Format	25
GENERAL Input Section.....	27
WEIGHTS Input Section	48
STRIPPING Input Section.....	50
NETWORK Input Section	51
ITERATION Input Section	56
DATASET Input Section	58
ACCPAN Standard-Output File.....	60
Force/Moment/Sink/Trim Iteration History File Format.....	61
Database Mesh File Format.....	69
External Sail Model File Format	70
Program Execution	72
Flotation-Only Operation (IFLOAT=-1).....	72
Stand-Alone Operation (IAUTO=0)	72
Fully Automated Operation (IAUTO =2)	73
Licensing Information	81
Suggested Reading	82

Overview

ACCPAN is a computer program for automated generation of SPLASH panel models (SPLASH is South Bay Simulations' aerohydrodynamic flow analysis panel code for steady flow with free-surface wave capabilities). ACCPAN can generate models using information from previous SPLASH analyses, thereby allowing the use of both programs together in an interactive fashion and providing more sophisticated nonlinear flow simulation capabilities. This interactive process enables calculations including free to sink-and-trim and nonlinear free-surface wave effects.

Providing treatment of fully appended yachts such as those in the IACC, IMS, TP 52, STP 65, and AC 90 classes, only conventional centerline-mounted appendages are permitted. Starting with Version 5.1 of ACCPAN, the centerline-mounted appendages may be canted (the canted appendages must be non-surface-piercing).

ACCPAN provides for easy modeling of several other yacht-related characteristics including simulation of keel-tab and rudder deflections, and the impact on sink and trim from sail, crew, gear and ballast weights, as well as from the sail/rig aerodynamic forces and moments.

ACCPAN provides user controls for primary panel model details and for selected SPLASH input parameters. With appropriate job control files, the two programs can be used in a relatively hands-off fashion to obtain predictions for a complete series of configurations and/or flow conditions. Such model tests can involve hundreds or thousands of individual panel models, flow solutions, and related files for keeping track of all the required information, especially when the free to sink-and-trim and nonlinear free-surface wave capabilities are employed. Together with auxiliary pre- and post-processing tools, the resulting ACCPAN/SPLASH software system can be viewed as a relatively automated numerical towing tank.

Configurations may consist of hull, keel, bulb (keel-mounted), wing (bulb-mounted), and rudder components. Two rudders are permitted, one forward and one aft. Each component is defined, in advance, as a single-surface database mesh. Surfaces must be meshed according to certain rules and mesh topologies. Conversion to the required mesh topologies and file formats, including the intersection and trimming of the keel, bulb and wing surfaces with each other, becomes a user pre-processing task to be completed just once for each configuration to be tested.

Auxiliary software tools available from South Bay Simulations can facilitate the database pre-processing task. Reliability is best achieved when pre-processing steps are automated (e.g., via UNIX/Linux shell scripts), starting with extraction of surface meshes from IGES NURBS files (output from CAD-type naval architecture or other design packages), and ending with generation of final component surface database meshes in the required mesh topologies and file formats.

For slightly different models at similar flow conditions, the ability to “restart” tests for a new model using the final results from a previous test for a different model greatly reduces the total computer time required to compute the nonlinear effects and the overall results.

Unit Dimensions

ACCPAN and SPLASH assume that all inputs are specified using a self-consistent set of unit dimensions. The following are examples of self-consistent unit dimensions:

Physical Quantity	English Units	Metric Units
length	foot (ft)	meter (m)
mass	slug	kilogram (kgm)
time	second (sec)	second (sec)
velocity	ft/sec	m/sec
acceleration	ft/sec ²	m/sec ²
force, weight, displacement	pound (lbf) = slug-ft/sec ²	Newton (N) = kgm-m/sec ²
density	slug/ft ³	kgm/m ³
viscosity	lbf-sec/ft ² = slug/(ft-sec)	N-sec/m ² = kgm/(m-sec)

All angles are input, and the vast majority are output, in degrees.

Database Mesh Descriptions

Configurations may consist of hull, keel, bulb (keel-mounted), wing (bulb-mounted), and rudder components. Two rudders are permitted, one forward and one aft. Each component is defined, in advance, as a single-surface database mesh. Surfaces must be meshed according to certain rules and mesh topologies.

The collection of database meshes for a typical configuration is shown in Figure 1. The database meshes should be defined for the upright condition (with appendages uncanted) at some orientation relative to the undisturbed free-surface. In ACCPAN this is referred to as the DWL (Design Water Line) flotation.

The SPLASH global coordinate system axes are also shown in Figure 1. The x-coordinate is positive aft. Locating the x-origin ($x=0$) at or near Station 5 is recommended, but not required. The y-coordinate is positive down, and is zero at the undisturbed free-surface. The z-coordinate increases to starboard.

Typically, one half of each component's surface mesh represents the starboard side, and the other half the port side. For symmetric designs the two sides of the model should meet at the centerplane, typically at $z=0.0$. This version of ACCPAN is also intended to handle slightly asymmetric models, with database mesh centerlines deviating somewhat from $z=0.0$, but these new capabilities are as yet untested.

The database meshes for the foils (keel and rudders) do not need to be exactly flush to the hull database mesh. And the hull database mesh should not be modified in any way on account of the foils. ACCPAN will perform these operations internally, trimming or extending the foils flush to the hull in the process. The foil leading and trailing edges should precisely intersect the hull database mesh along its centerline. If they do not, ACCPAN will translate the foil database mesh sideways, and rotate it about its hinge axis, to ensure that they do. Care is required, as such relocation may change the foil's position and incidence angle with respect to the flow.

Bulbs must be keel-mounted, and wings must be bulb-mounted. The intersection and trimming of the keel, bulb and wing database meshes with each other must be performed in advance of running ACCPAN. More details are provided in the sections to follow describing individual keel, bulb and wing database mesh requirements.

Linear interpolation schemes are generally used throughout the automated panel model generation process. Database meshes should be defined with sufficient resolution so that appropriate surface fidelity is maintained in the final panel model.

It can be convenient to place database mesh files in directories separate from those used for panel model and flow simulation files. This facilitates the use of common databases for different test matrices or minor configuration modifications.

Hull

A hull database surface mesh is illustrated in Figure 2.

Hull database meshes can be viewed topologically as a series of offsets. This interpretation is conceptual only, as it is not required that all points on an offset have the same x-value.

The first offset ($I=1$) is at the bow stem. This offset is folded back onto itself, and the points on the two sides should be coincident, thereby sealing the bow watertight. For best hull database mesh quality, the point at the bottom of this first bow stem offset should be located at the point of greatest curvature as the bow stem turns aft.

The last offset ($I=IMAX$) is at the transom edge.

Each offset I consists of $JMAX$ points, running from the starboard deck sheer line ($J=1$), down to the keel ($J=(JMAX+1)/2$), and back up to the port deck sheer line ($J=JMAX$). Each offset must start and end at, or preferably above, the waterline. Internally, ACCPAN will extend the ends of each offset upwards a small amount, to further avoid any offset ending below the (linear or nonlinear) waterline. This may allow calculations to proceed in lieu of the deck becoming submerged, for example, at the bow or amidships.

The deck and transom surfaces themselves should not be included in the hull database mesh.

Any transom immersion will be modeled by ACCPAN for SPLASH as a dry transom (free-surface panels are shed from the edge of the transom) plus special boundary conditions to approximate partially-wetted transom flows. This version of ACCPAN has no provision for generating a fully-wetted transom model (e.g., with free-surface panels at or near the undisturbed free-surface, base-type panels on the transom, and a separation-type wake streaming aft from the transom edge below the free-surface). There is also no provision for generating a model with a transom that has collapsed to a single vertical trailing edge (e.g., for a Wigley-type hull, with a lifting-type wake streaming aft from the hull trailing edge below the free-surface).

Experience to date has been limited to hull meshes with the edge of the transom defined by a single transverse plane (i.e., at some constant value of the x-coordinate). Alternate transom edge definitions, such as a cutback transom, may be possible, but are as yet untested.

This version of ACCPAN is intended for mildly immersed transoms only, and may fail to operate correctly should deeper immersion result in a wall-sided (nearly vertical) immersed transom edge.

Keel

Two typical types of keel database surface meshes are illustrated in Figure 3.

Keel database meshes can be viewed topologically as a series of airfoil sections. This interpretation is conceptual only, as it is not required that all points on a section have the same spanwise y-value, or that all sections employ the same airfoil x/c values.

Each airfoil section J consists of $IMAX$ points, running from the lower surface trailing edge ($I=1$), forward to the leading edge ($I=(IMAX+1)/2$), and back to the upper surface trailing edge ($I=IMAX$). Upper and lower trailing edge points should be coincident, thereby sealing the trailing edge watertight.

The first airfoil section ($J=1$) is at the root of the keel, and should be located close to the hull/keel intersection. It may be located slightly inside or outside the hull (for best results it should be located just inside the hull). ACCPAN will compute the final hull/keel intersection.

The last airfoil section ($J=JMAX$) is at the tip of the keel. If there is no bulb, then this section is folded back onto itself, and the points on the two sides should be coincident, thereby sealing the tip watertight. If there is a bulb, this section defines the intersection of the keel with the bulb. Bulb or not, the tip section should not collapse to zero chord.

Keel-Mounted Bulb

A database surface mesh for a bulb with a beavertail trailing edge is illustrated in Figure 4. A mesh for a bulb with a pointed/truncated tail, and wings, is illustrated in Figure 5.

Bulb database meshes can be viewed topologically as a series of axisymmetrically arranged upper surface airfoil sections, or, alternately, as a series of cross sections. These interpretations are conceptual only, as the bulb is not required to be axisymmetric, nor is it required that all points on a cross section have the same x -value or x/L_{bulb} value.

Each airfoil section J consists of $IMAX$ points, running from bulb nose to bulb tail. The first and last airfoil sections ($J=1$ and $J=JMAX$) are at the top centerline of the bulb, on the starboard and port sides, respectively. Points should be located along the actual keel/bulb intersection, including points precisely at the leading and trailing edges of the intersection.

Each cross section I consists of $JMAX$ points, running from the bulb top centerline starboard ($J=1$), down to the bulb bottom centerline ($J=(JMAX+1)/2$), and back up to the bulb top centerline port ($J=JMAX$). The first cross section ($I=1$) typically collapses to a point at the bulb nose. The last cross section ($I=IMAX$) defines the tail or trailing edge of the bulb.

The circumferential locations of the two bulb side airfoil sections ($J=(JMAX+3)/4$) and $J=(3*JMAX+1)/4$) are important, since panels will be distributed independently on the top and bottom portions of the bulb as defined by these sections. It is often the case that these sections are located at or close to the maximum breadth, circumferentially.

For bulb-mounted wings, these two bulb side airfoil sections should intersect the wing leading and trailing edges. These sections are then repeated twice in the database mesh, in order to define the intersection with both upper and lower wing surfaces. Points should be located along the actual bulb/wing intersection, including points precisely at the leading and trailing edges of the intersection. Forward and aft of the upper and lower bulb/wing intersection, the points on the repeated sections should be identical.

Some bulb tails may collapse to a point. However, pointed bulb tails are not recommended, since a strong potential flow singularity can result when the keel tip vortex emerges from the tail at a single point, with very adverse impact on flow solution quality. This problem does not arise for non-pointed bulb tails having an uncollapsed, finite perimeter trailing edge, as the keel tip vortex then emerges from the tail in a more distributed and less singular manner, along the finite perimeter of the bulb trailing edge.

The recommended approach for bulbs with pointed tails is to truncate the bulb (at 95% or more of its length is suggested), thereby creating the required finite perimeter at the bulb trailing edge, as well as a bulb open base region. Leaving the bulb tail open in this fashion will trigger the bulb separated base flow model. This provides a crude model for viscous boundary layer displacement thickness and flow separation effects which would otherwise occur at a pointed tail, but which are not directly included in the SPLASH potential flow formulation.

Leaving the bulb tail open will trigger the bulb separated base flow model, whereupon ACCPAN will generate appropriate bulb base panel networks, with separated flow boundary conditions, and corresponding separated flow wake panel networks streaming aft from the bulb trailing edge.

Some bulb tails may collapse to an approximately horizontal, or beavertail, trailing edge, with finite perimeter. The recommended approach for such beavertail trailing edges is simply to ensure that the trailing edge is closed and doubly collapsed, with identical points along the upper and lower bulb trailing edges, thereby sealing the trailing edge watertight. Whereupon ACCPAN will generate appropriate lifting-type wake panel networks streaming aft from the bulb trailing edge.

Other collapsed tail topologies, for example collapsed vertical or cruciform trailing edges, may be possible but are not specifically supported. In some cases such bulbs might be modeled using a reasonably small open base area. However, ACCPAN may fail to operate correctly for concave-polygon or other irregular bulb trailing edge and base shapes.

Bulb-Mounted Wing

A typical bulb-mounted wing database surface mesh is illustrated in Figure 6.

Wing database meshes can be viewed topologically as a series of airfoil sections. This interpretation is conceptual only, as it is not required that all points on a section have the same spanwise value, or that all sections employ the same airfoil x/c values.

Each airfoil section J consists of $IMAX$ points, running from the lower surface trailing edge ($I=1$), forward to the leading edge ($I=(IMAX+1)/2$), and back to the upper surface trailing edge ($I=IMAX$). Upper and lower trailing edge points should be coincident, thereby sealing the trailing edge watertight.

The first airfoil section ($J=1$) is at the tip of the port wing. From here the sections proceed inboard towards the root of the port wing. The first of two intermediate airfoil sections ($J=JMAX/2$) defines the port wing/bulb intersection. The second of the intermediate airfoil sections ($J=JMAX/2+1$) defines the starboard wing/bulb intersection. From here the sections move outboard towards the tip of the starboard wing. The last airfoil section ($J=JMAX$) is the tip of the starboard wing. The port and starboard tip sections are folded back onto themselves, and the points on the upper and lower surfaces coincident, thereby sealing the tips watertight.

Wing root geometry may be modified by ACCPAN so as to provide better alignment of closely opposing wing upper and lower surface panels. This outboard movement of points at the upper or lower bulb/wing intersection may lead to the appearance of a small fairing applied to the bulb in the final SPLASH panel model.

Keel/Bulb/Wing Combinations

Database surface meshes for typical keel/bulb/wing combinations are illustrated in Figure 7.

The bulb/keel and bulb/wing intersection must be accounted for as shown in the figure. The keel and wing have been trimmed to the bulb. The port and starboard sides of the wing are joined into a single surface mesh by a wing “center section” inside the bulb, between the port and starboard bulb/wing intersections. On the bulb, the bulb/keel intersection is open and unmeshed, whereas the bulb/wing intersections are covered by the mesh cells between the repeated bulb side airfoil sections.

Rudders

A typical rudder database surface mesh is illustrated in Figure 8.

Requirements for forward and aft rudder database meshes are the same as for keels without bulbs and with closed tips. The tip section should not collapse to zero chord.

Final Location of Panel Model in SPLASH Global Coordinate System

The database meshes are defined for the upright condition (with appendages uncanted) at some orientation relative to the undisturbed free-surface. In ACCPAN this is referred to as the DWL (Design Water Line) flotation. Sink and trim are defined to be zero at the DWL flotation.

A wide range of options are available to define alternate flotations. The MWL (Measurement Water Line) is another reference flotation, which may be the same as or different than the DWL flotation. The SWL (Sailing Water Line) reflects any further change in weight and/or center of gravity location due to crew, gear, sails, ballast, etc. Whilst the yacht is heeled and underway, additional hydrostatic and hydrodynamic forces and moments further affect the sink and trim, as do the aerodynamic forces and moments acting on the sails/rig.

A typical panel model, at heel, and with dynamic sink and trim underway, is shown in Figure 9. This also shows the model's orientation with respect to the SPLASH global coordinate system. The rotations, first for heel, and then for trim, occur about a reference point (r.p.) which is the model center of gravity prior to canting any appendages. A model-fixed point with starting DWL coordinates x_{DWL} , y_{DWL} , z_{DWL} , is therefore transformed to its final location in SPLASH global coordinates x_{global} , y_{global} , z_{global} according to:

$$\begin{aligned}
 x_{global} &= x_{r.p.} + (x_{DWL} - x_{r.p.})\cos(trim) - \left[(y_{DWL} - y_{r.p.})\cos(heel) - (z_{DWL} - z_{r.p.})\sin(heel) \right] \sin(trim) \\
 y_{global} &= y_{r.p.} + (x_{DWL} - x_{r.p.})\sin(trim) + \left[(y_{DWL} - y_{r.p.})\cos(heel) - (z_{DWL} - z_{r.p.})\sin(heel) \right] \cos(trim) + y_{sink,r.p.} \\
 z_{global} &= z_{r.p.} + (y_{DWL} - y_{r.p.})\sin(heel) + (z_{DWL} - z_{r.p.})\cos(heel)
 \end{aligned}$$

Since the steady flow yaw angle is also specified with respect to the SPLASH global coordinate system, it does not appear in or alter the above transformation.

The user may also specify the DWL coordinates for a model-fixed point, to be used as the datum point for the tabulated sinkage and moment values appearing in the final sink, trim, force and moment iteration history file used by both ACCPAN and SPLASH (the ***.fm** file). If no datum point is specified, the values in these files are referenced to the final center of gravity location after accounting for any canted appendages.

Sail Pitching Moment and Vertical Force Models

Once the user has specified the inputs to achieve some particular SWL flotation, the yacht may also be free to sink and trim underway, due to additional hydrodynamic and aerodynamic vertical forces and pitching moments. The hydrodynamic contributions include those due to hydrostatic pressure (computed over the wetted portions of the database meshes by ACCPAN), due to hydrodynamic pressure (computed over the wetted portions of the panel model by SPLASH), and due to viscous skin friction (approximated over the wetted portions of the database meshes by ACCPAN using viscous stripping). As the aerodynamic contributions from the sails are not as readily available, two sail force and moment models have been incorporated into ACCPAN so that the contributions may be included in the sink and trim calculations.

Once the pitching moment has been determined according to one of the two models, it is then assumed to act about an axis that is parallel to the SPLASH global coordinate system z-axis.

ISAIL=2, Internal Sail Force and Moment Model

This model is very easy to implement, as the user need only input the sail center of effort (x_{ce} , y_{ce} , and z_{ce}) at the SWL condition. The sail aerodynamic forces are deduced from their hydrodynamic counterparts, due to the steady forward speed and equilibrium sailing conditions, and a few other simplifying approximations.

The major components of the internal sail model are illustrated in Figure 10. The sail axial and side forces are assumed to be equal but opposite to the yacht axial and side forces. The sail side force is assumed to be the horizontal component of a force acting normal to the sail, so that the sail vertical force is then be related to the sail side force through the heel angle:

$$\begin{aligned} FXSL &= -FX_{YACHT} = -(FX_{ST} + FX_{CF} + FX_{DY}) \\ FZSL &= -FZ_{YACHT} = -(FZ_{ST} + FZ_{CF} + FZ_{DY}) \\ FYSL &= -FZSL * TAN(HEEL) \end{aligned}$$

To obtain the sail moments, the sail forces are first converted to the hydrodynamic wind (freestream) axes, and then multiplied by the appropriate moment arms from the sail center of effort to the yacht center of gravity:

$$\begin{aligned} DSL &= FXSL * COS(YAW) + FZSL * SIN(YAW) \\ LSL &= FZSL * COS(YAW) - FXSL * SIN(YAW) \\ MXSL &= (YCE - YCG)_{underway} * LSL - (ZCE - ZCG)_{underway} * FYSL \\ MYSL &= (ZCE - ZCG)_{underway} * DSL - (XCE - XCG)_{underway} * LSL \\ MZSL &= (XCE - XCG)_{underway} * FYSL - (YCE - YCG)_{underway} * DSL \end{aligned}$$

Further liberty is taken regarding the longitudinal separation of the sail center of effort and the yacht center of gravity: the value of XCE_{SWL} is set equal to XCG_{SWL} prior to transforming the sail center of effort location into to its final “underway” position (i.e., into the SPLASH global coordinate system), after which the value of $(XCE - XCG)_{underway}$ is set equal to zero.

The resulting values CFYSL and CMZSL are the sail vertical force and pitching moment used to sink and trim the yacht.

ISAIL=5, External Sail Force and Moment Model

A separate file is supplied tabulating the vertical force CFYSL and pitching moment CMZSL values as a function of boat speed, heel, yaw, rudder and tab settings. This allows completely independent control of sail vertical force and pitching moment at each test point.

Appropriate entries for each test point combination of speed, heel, yaw, rudder and tab setting must be present in the sail force and moment file. The model fails if there are no entries in the sail force file at the requested test point heel, yaw, rudder and tab settings and at, or bracketing, the requested test point boat speed (the force and moment at a bracketed speed will be found by linear interpolation). However, if the boat speed is zero and no appropriate entries are located, then the sail force and moment are set to zero.

Viscous Stripping Options

Viscous stripping in ACCPAN is based on the use of estimates for average skin friction coefficients, cf , and form factors, ff . The drag force due to viscous effects is calculated as the summation of these effects over the computed wetted portions of the model database meshes:

$$C_{D,viscous} = \frac{1}{S_{REF}} \sum_{\text{wetted database mesh}} (cf_{panel} \times ff_{panel} \times A_{panel})$$

The moments due to viscous effects are also calculated by summation of each panel's viscous drag contribution (acting in the freestream direction) multiplied by appropriate moment arms:

$$C_{M,viscous} = \frac{1}{S_{REF} L} \sum_{\text{wetted database mesh}} (\bar{x}_{panel} - \bar{x}_{cg})_{underway} \times (cf_{panel} \times ff_{panel} \times A_{panel}) \times \bar{V}_{\infty} / \left| \bar{V}_{\infty} \right|$$

A variety of laminar, turbulent, and transitional formulations are available for estimating the required average skin friction coefficients and form factors. These formulations have been adopted following the work published by Teeters (Teeters, J.R., "Refinements in the Techniques of Tank Testing Sailing Yachts and the Processing of Test Data," 11th Chesapeake Sailing Yacht Symposium, Annapolis, Jan. 1993).

The skin friction estimates are all based on a relevant length scale and Reynolds number. For keels, rudders and wings, relevant length is local chord with respect to the freestream, and form factors are based on local thickness-to-chord ratio. For bulbs, relevant length is overall wetted length in x , and form factors are based on overall diameter-to-length ratio. For hulls, relevant length is overall wetted length at the waterline in x , and the user must specify a form factor.

The skin friction coefficient formulations are compared in Figures 11 and 12, along with total viscous drag estimates for airfoils of varying thickness-to-chord ratio, based on the transitional, combined skin friction and form factor models.

Average Skin Friction Formulations

Average skin friction estimates are user-controlled via ACCPAN parameters 'jcf' for which separate values are input for each of the hull, keel, bulb, wing and rudder components. For zero boat speed cases, cf is set to zero (unless a user-specified value of cf is to be supplied, via $jcf=0$).

User-Specified Average Skin Friction (jcf=0)

This indicates that the user-specified value of cf should be used for this component. Only one value of cf can be specified in each ACCPAN input file, and this one value will apply to all test points defined therein (regardless of forward speed).

Blasius Laminar Flat Plate Skin Friction (jcf=1)

$$cf = cflam = 1.328 / (Re^{*0.5})$$

Schlichting Turbulent Flat Plate Skin Friction (jcf=2)

$$c_f = c_{ftrb} = 0.455 / ((\log(Re))^{**2.58})$$

Prandtl-Schlichting Transitional Flat Plate Skin Friction (jcf=3)

$$Re_{crit} = 0.5e+06$$

$$A = Re_{crit} * (c_{ftrb}(Re_{crit}) - c_{flam}(Re_{crit}))$$

$$\text{If } (Re \bullet Re_{crit}) \text{ } c_f = c_{flam}$$

$$\text{If } (Re > Re_{crit}) \text{ } c_f = c_{ftrb} - A / Re$$

Simple Transitional Flat Plate Skin Friction (jcf=4)

$$c_f = \min (c_{ftrb}, \max (c_{flam}, 0.00293))$$

ITTC 1957 Ship-Correlation for Frictional Resistance (jcf=8)

$$c_f = 0.075 / (\log(Re) - 2)^{**2}$$

Form Factor Estimates

Form factor estimates are user-controlled via ACCPAN parameters 'jff' for which separate values are input for each of the hull, keel, bulb, wing and rudder components.

User-Specified Form Factor (jff=0)

This indicates that the user-specified value of ff should be used for this component.

Laminar Form Factor (jff=1)

Based on the premise that:

$$c_{dlam} = c_{flam} * (1 + (t/c)) + 1/2 * (t/c)^{**2}$$

the associated form factor, which consequently depends on the skin friction, is:

$$ff = f_{flam} = 1 + (t/c) + 1/2 * (t/c)^{**2} / c_{flam}$$

Turbulent Form Factor, Standard Airfoil (jff=2)

$$ff = f_{ftrb} = 1 + 2 * (t/c) + 60 * (t/c)^{**4}$$

Turbulent Form Factor, Laminar Flow Airfoil (jff=3)

$$ff = f_{ftrb} = 1 + 1.2 * (t/c) + 70 * (t/c)^{**4}$$

Bulb Form Factor (jff=4)

$$ff = f_{fblb} = 1 + 1.5 * (D/L)^{**1.5} + 7.0 * (D/L)^{**3.0}$$

Transitional, Combined Skin Friction and Form Factor Models

Denoted by the values jcf=5 and jcf=6, these viscous stripping models integrate several concepts underlying the previous laminar, turbulent and transitional skin friction formulations, as well as the laminar and turbulent form factor estimates, so as to provide more sophisticated, transitional, combined skin friction and form factor models.

When jcf=5, the standard airfoil turbulent form factor (jff=2) is used for the turbulent portion of the model. When jcf=6, the laminar flow airfoil turbulent form factor (jff=3) is used.

Transition from laminar to turbulent flow is assumed to occur over the Reynolds number range from Relam to Retrb. The values of Relam and Retrb are determined as functions of airfoil t/c by linear interpolation using the following tabulated values:

airfoil t/c	Relam	Retrb
0.00	10**4.6	10**5.5
0.06	10**4.7	10**5.6
0.12	10**4.8	10**5.7
0.20	10**4.9	10**5.7
0.25	10**5.0	10**5.7
0.37	10**5.1	10**5.7
0.50	10**5.2	10**5.7
0.66	10**5.3	10**5.7
1.00	10**5.5	10**5.8
2.00	10**5.75	10**5.9
∞	10**5.75	10**5.9

Table 1 Transitional Relam and Retrb Parameters as Functions of Airfoil t/c

The models then proceed as follows:

If (Re ≤ Relam)

$$c_{flam} = 1.328 / (Re^{0.5})$$

$$f_{flam} = 1 + t/c + 1/2 * ((t/c)^2) / c_{flam}$$

$$c_{dlam} = c_{flam} * f_{flam}$$

If (Re ≥ Retrb)

$$c_f = c_{ftrb} = 0.455 / ((\log(Re))^{2.58})$$

$$\text{If } (Re < 10^{7.5}) \text{ } c_f = c_{ftrb} = c_{ftrb}(Re) \text{ evaluated at } Re=10^{7.5}$$

For standard foils (jcf=5):

$$ff = fftrb = 1.0 + 2.0*(t/c) + 60*((t/c)**4)$$

For laminar profile foils, such as 64/65 series (jcf=6):

$$ff = fftrb = 1.0 + 1.2*(t/c) + 70*((t/c)**4)$$

$$cd = cdtrb = cftrb * fftrb$$

If (Relam < Re < Retrb)

Obtain cflam as above, but at Relam:

$$cflam = cflam(Relam)$$

Obtain cftrb as above, at Re:

$$cftrb = cftrb(Re)$$

Obtain ln(cf) and ln(cd) by linear interpolation as a function of ln(Re):

$$\begin{aligned} \ln(cf) = & \ln(cflam) + (\ln(cftrb) - \ln(cflam)) \\ & * (\ln(Re) - \ln(Relam)) / (\ln(Retrb) - \ln(Relam)) \end{aligned}$$

$$\begin{aligned} \ln(cd) = & \ln(cdlam) + (\ln(cdtrb) - \ln(cdlam)) \\ & * (\ln(Re) - \ln(Relam)) / (\ln(Retrb) - \ln(Relam)) \end{aligned}$$

The form factor is then:

$$ff = cd / cf$$

Overview of ACCPAN Input/Output Files

Figure 13 shows ACCPAN and SPLASH input and output file dependencies, and flowcharts the roles these various files play during automated ACCPAN/SPLASH interactive operations, so as to enable the free to sink and trim and nonlinear free-surface wave capabilities.

ACCPAN standard-input is read on Fortran Unit 5 which is pre-connected to the terminal command line by default. Shell commands to run ACCPAN can redirect standard-input to be read from an existing file. This file is referred to as the ACCPAN standard-input file.

ACCPAN standard-output is written on Fortran Unit 6 which is also pre-connected to the terminal command line by default. Shell commands to run ACCPAN can redirect standard-output (as well as error-output) to be written to a specified file. This file is referred to as the ACCPAN standard-output file.

The primary purpose of ACCPAN is to generate and update the SPLASH standard-input files containing the final panel model and boundary condition details for each individual test point. The SPLASH standard-input files are generated with a filename extension of **.gii* where *ii* is the ACCPAN/SPLASH iteration number. More information is given below, and in the section entitled “Program Execution”.

In the ACCPAN standard-input file, the user must specify pathnames and filenames for various files that will be read from and/or written to during normal ACCPAN execution. Pathnames specified may be full pathnames (e.g., ‘/home/user/model1’) or relative pathnames (e.g., ‘./model2’). For best results, do not use blank spaces in pathnames or filenames.

The user will specify the pathname to the directory containing the already pre-processed model component surface database mesh files. This directory is referred to as the database directory. The user will specify the individual filenames for the database surface mesh files for each of the hull, keel, bulb, wing and rudder components to be included in the current calculations.

If use of the external sail force model is selected, the user will also specify the pathname and filename of an existing external sail force and moment file.

Each ACCPAN standard-input file may contain information for a group of test points. Typically the points are for similar test conditions but at increasing forward speeds (this is not strictly required by ACCPAN or SPLASH, but it is the type of test-point grouping anticipated by the auxiliary test setup and test post-processing tools). The user will specify the pathname to an existing directory where the individual test point files for all test points in the group will be located. This directory is referred to as the dataset directory. The user will also specify a unique name for each individual test point, so as to identify which files in the dataset directory are associated with which test point. During ACCPAN execution, these unique names are combined with predetermined filename extensions to generate the final test point filenames.

For slightly different models at similar flow conditions, the ability to “restart” tests for a new model using the final results from a previous test for a different model greatly reduces the total computer time required to compute the nonlinear effects and the overall results. To implement, the user must specify a restart directory, and unique restart test point names (the defaults are the current test point names). Tests then proceed starting with the previous results for sink and trim, free-surface elevation, and hydrodynamic force and moment.

Depending on user inputs, ACCPAN may attempt to read existing SPLASH input and output test point files, using the information therein to generate new SPLASH input test point files with updated sink and trim and updated free-surface panel elevations. These files include:

- *.fm force/moment/sink/trim iteration history file (SPLASH output file *tfms*)
- *.t*ii* SPLASH flow solution file (SPLASH output file *tecout*)
- *.p*ii* SPLASH developing free-surface elevation file (SPLASH input file *pxxfs*)

Depending on user inputs, ACCPAN may attempt to update and/or create new SPLASH input test point files. These files include:

- *.fm force/moment/sink/trim iteration history file (SPLASH output file *tfms*)
- *.g*ii* SPLASH standard-input file
- *.p*ii* SPLASH developing free-surface elevation file (SPLASH input file *pxxfs*)

During automated SPLASH/ACCPAN operations, ACCPAN controls the organization and disposition of these and a number of other SPLASH input and output test point files, including:

- *.d*ii* SPLASH standard-output file
- *.l*ii* spanload file (SPLASH output file *spanload*)
- *.z*ii* doublet/source strengths from solving the zero-boat-speed, all panels solid and fixed, basis flow (SPLASH output file *dub1*)
- *.n*ii* doublet/source strengths from solving the non-zero-boat-speed, free-surface-wave flow (SPLASH output file *dub2*)
- *.x*ii* velocity scan input file (SPLASH input file *scninp*)
- *.v*ii* velocity scan output file (SPLASH input file *scnout*)

In the above, ‘*’ refers to the unique test point name. If the user has instructed ACCPAN to generate separate files for each ACCPAN/SPLASH iteration, then ‘*ii*’ is the current iteration number as determined from the number of records in the current force/moment/sink/trim iteration history file. If the user has instead instructed ACCPAN to overwrite these files during each ACCPAN/SPLASH iteration, then ‘*ii*’ is zero (‘00’).

Two additional files are required during automated SPLASH/ACCPAN operations. Both of these files are created in the directory pointed to by the shell environment variable \$TMPDIR. Refer to the section on automated SPLASH/ACCPAN operations for more information.

The first file is ‘accpan.data’, a list of the unique test point names in the current dataset/group for which interactive calculations have not yet converged. When this file no longer contains any

entries and is empty, or no longer exists, then automated operations for the current dataset/group terminate.

The second file is 'splash.exec', a shell script generated by ACCPAN and containing all the commands required to run SPLASH for the current iteration for each unconverged test point.

To simplify the specification of pathnames and filenames, one of several special starting character strings may be used:

<u>Starting Character String</u>	<u>Replaced by</u>
\$QSUB_WORKDIR	shell environment variable \$QSUB_WORKDIR
\$QSUB_HOME	shell environment variable \$QSUB_HOME
\$HOME	shell environment variable \$HOME
~	shell environment variable \$HOME
none	indicates that no pathname or filename is to be used

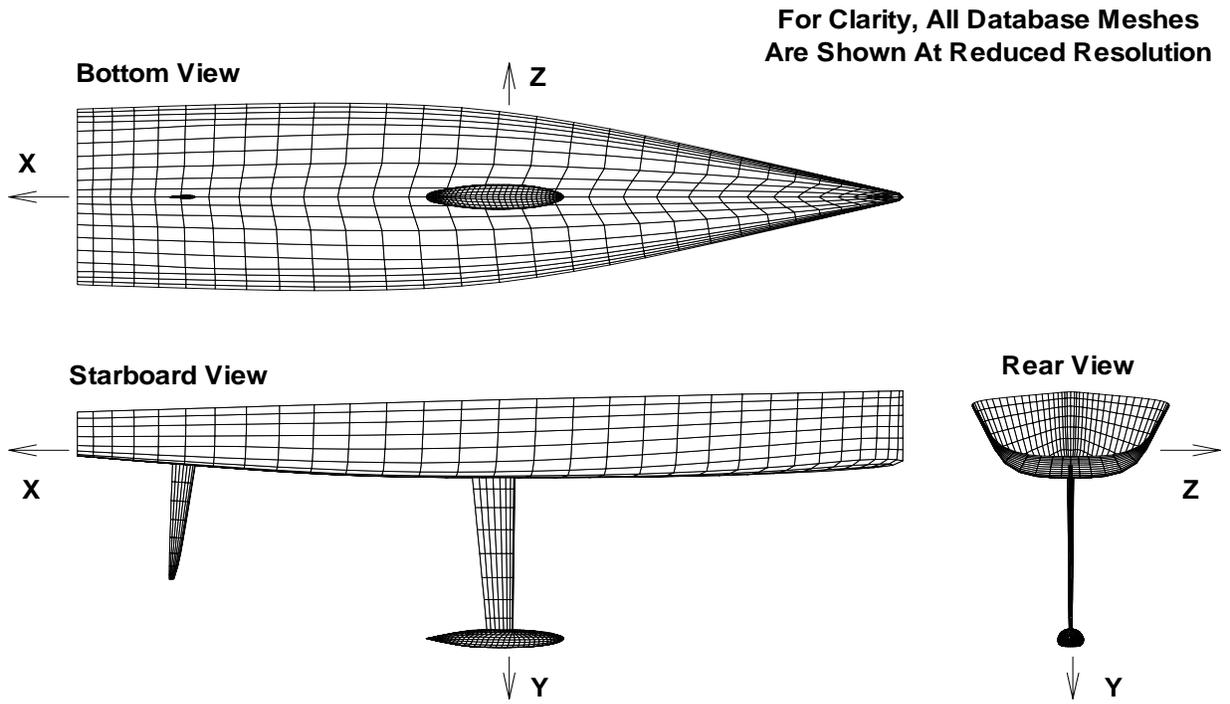


Figure 1 ACCPAN Database Network Surface Mesh Components for Yacht in SPLASH Global Coordinate System

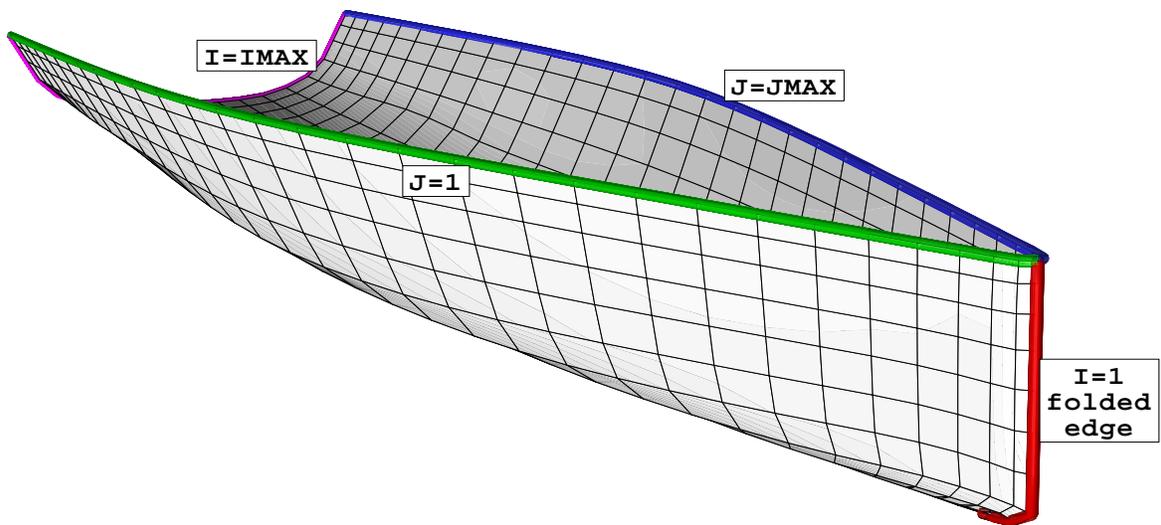


Figure 2 Hull Database Mesh for Input to ACCPAN

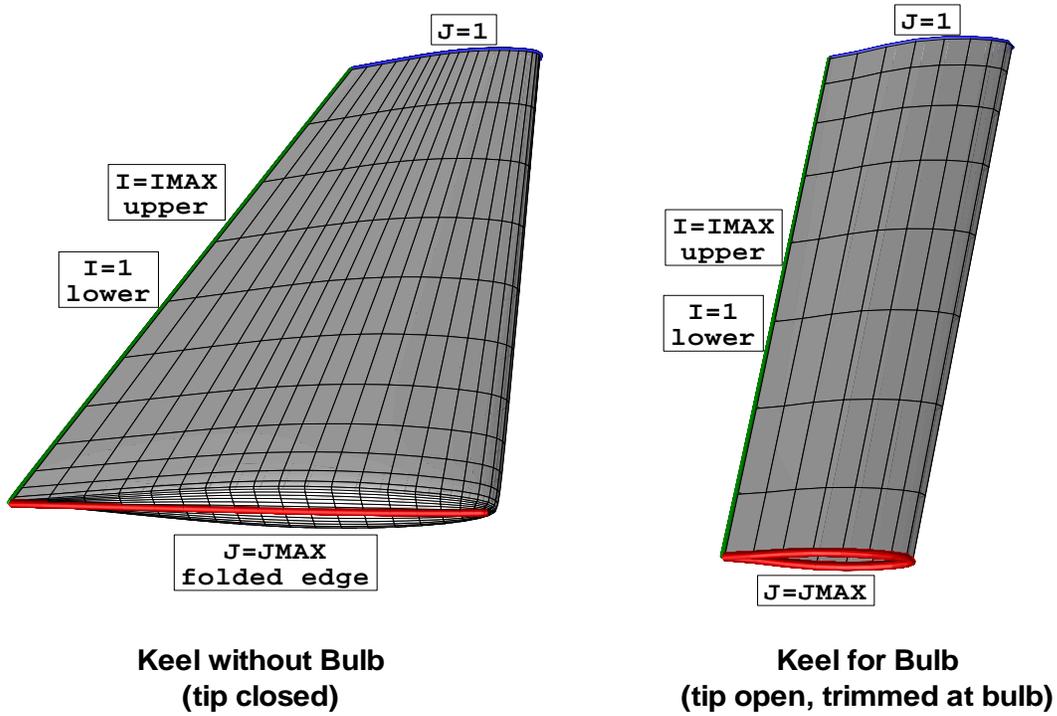
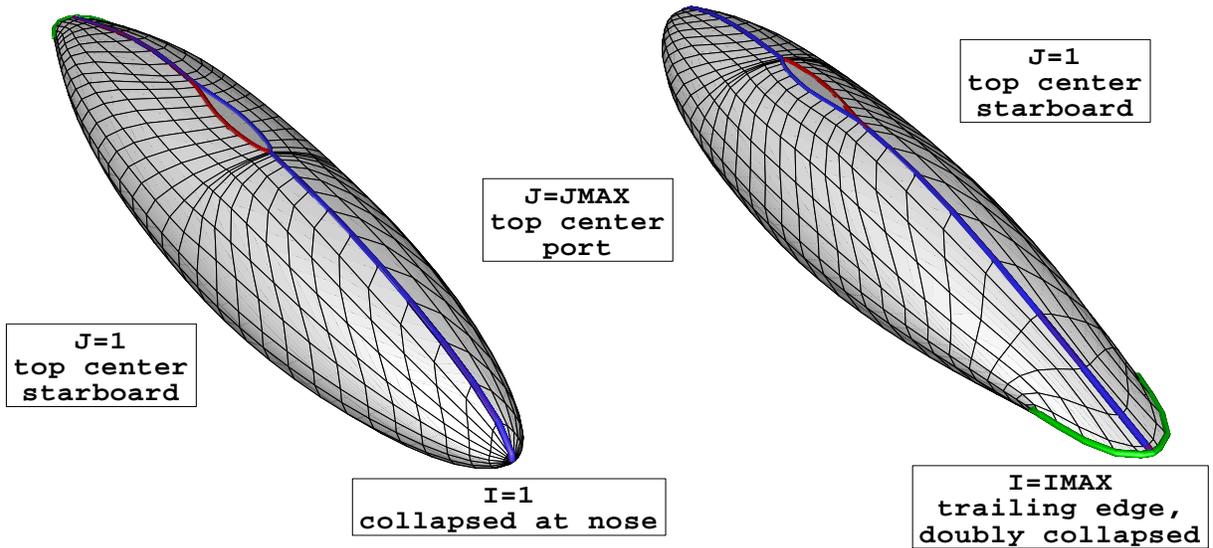
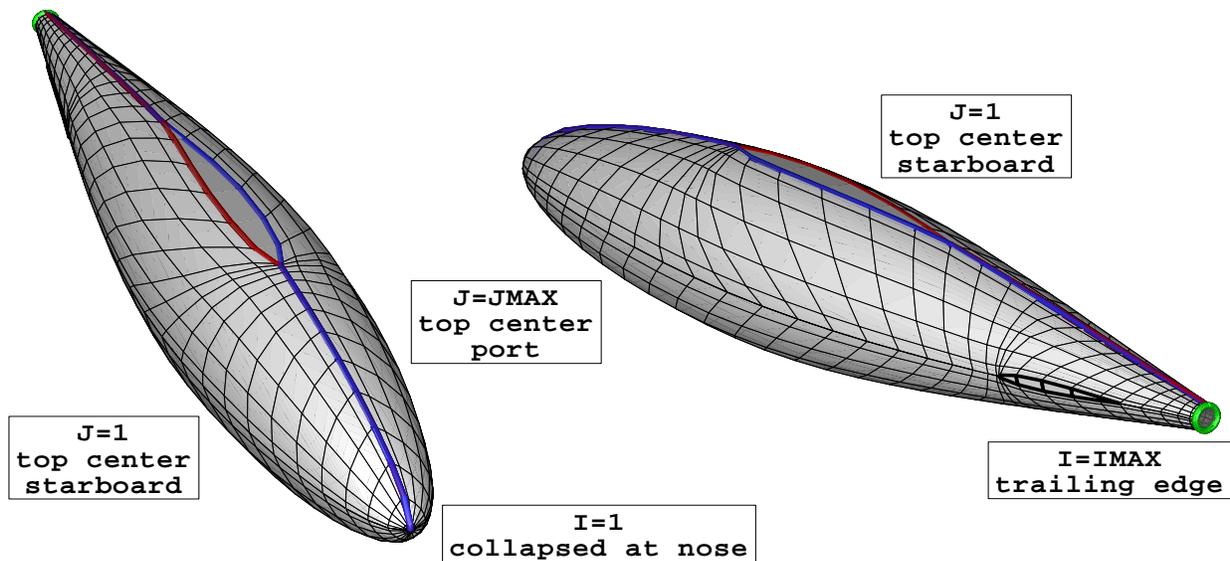


Figure 3 Keel Database Meshes for Input to ACCPAN



**Figure 4 Bulb Database Mesh for Input to ACCPAN:
Keel Mounted, Beavertail Trailing Edge**



**Figure 5 Bulb Database Mesh for Input to ACCPAN:
Keel Mounted, Pointed / Truncated Tail,
and Intersection with Bulb Mounted Wing (not shown)**

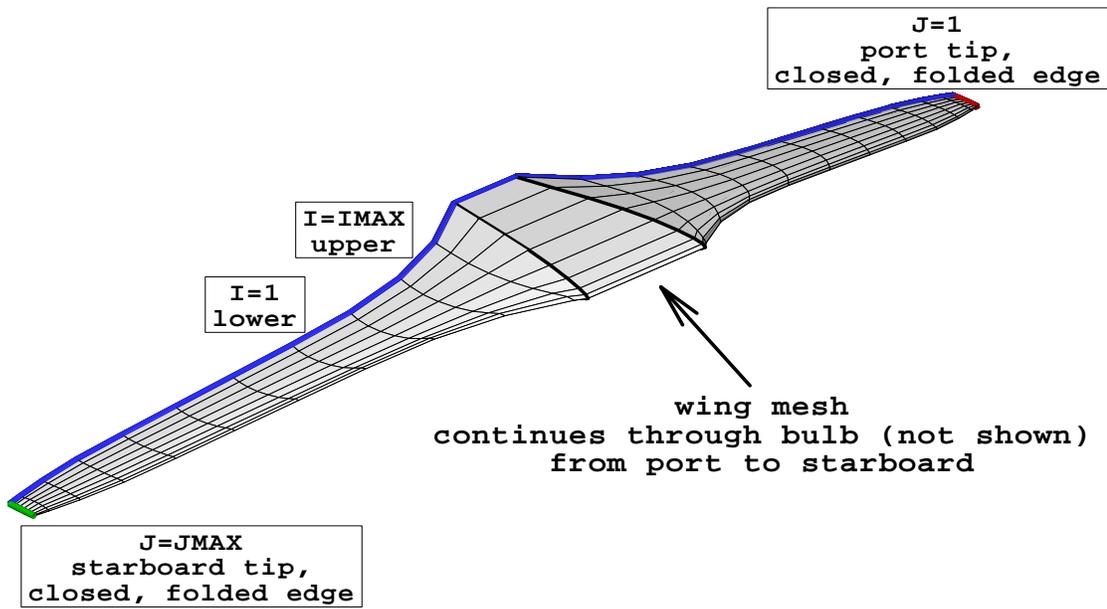


Figure 6 Bulb Mounted Wing Database Mesh for Input to ACCPAN

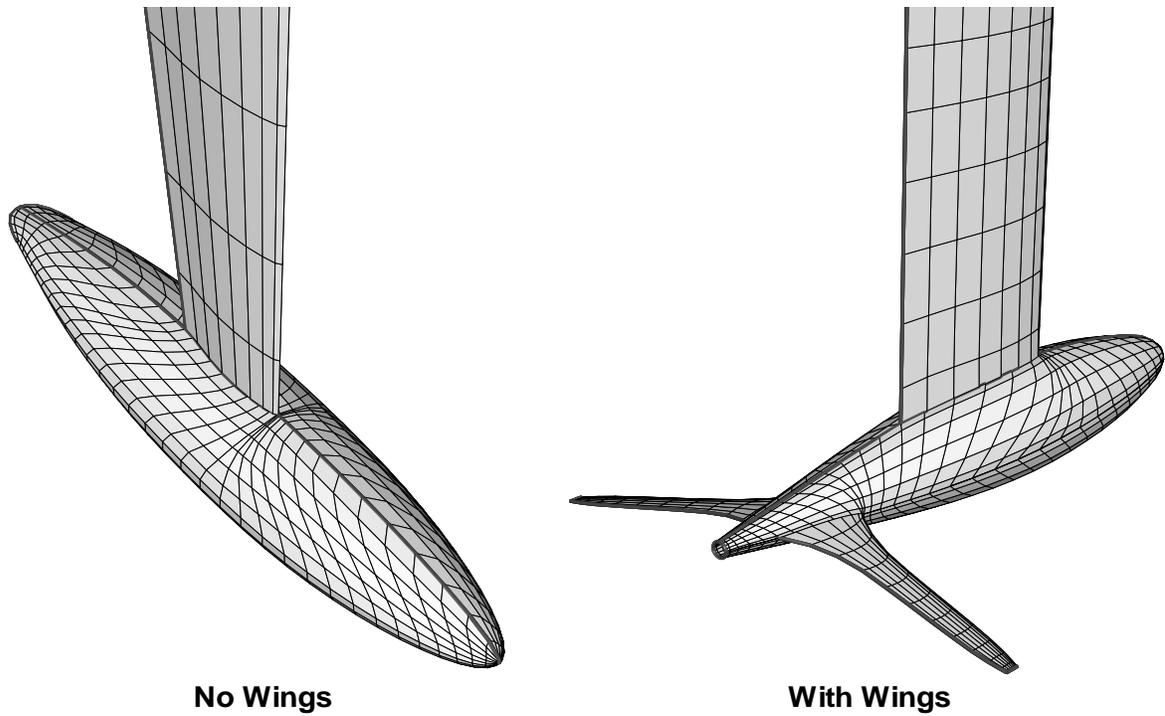


Figure 7 Typical Keel Appendage Database Meshes

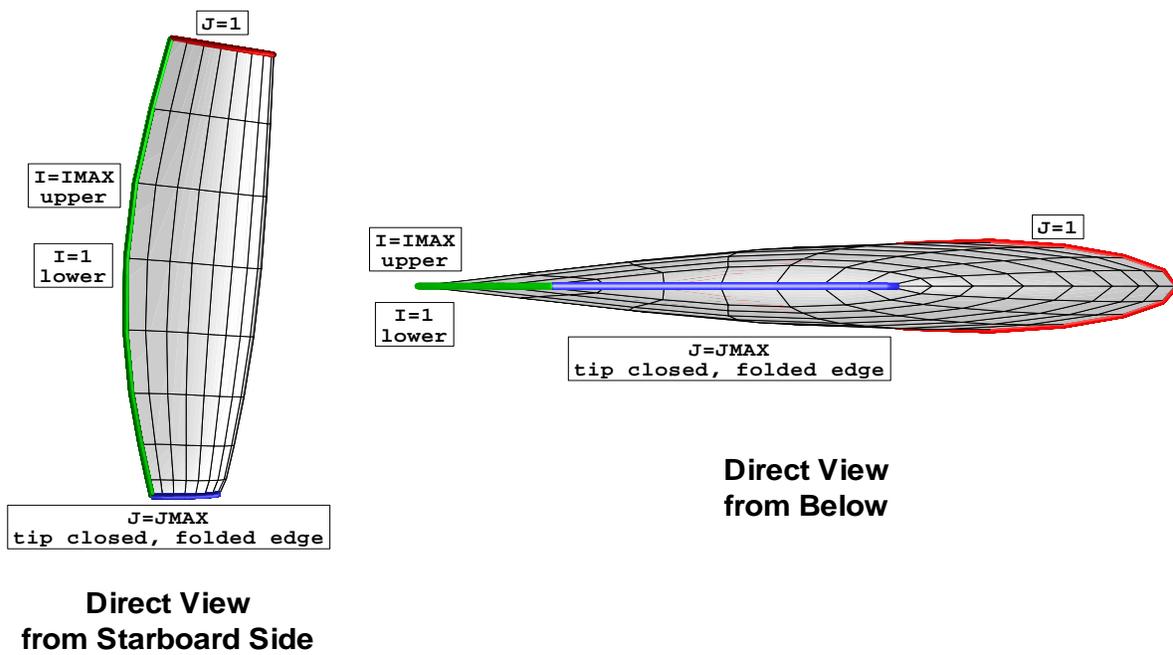


Figure 8 Rudder Database Mesh for Input to ACCPAN

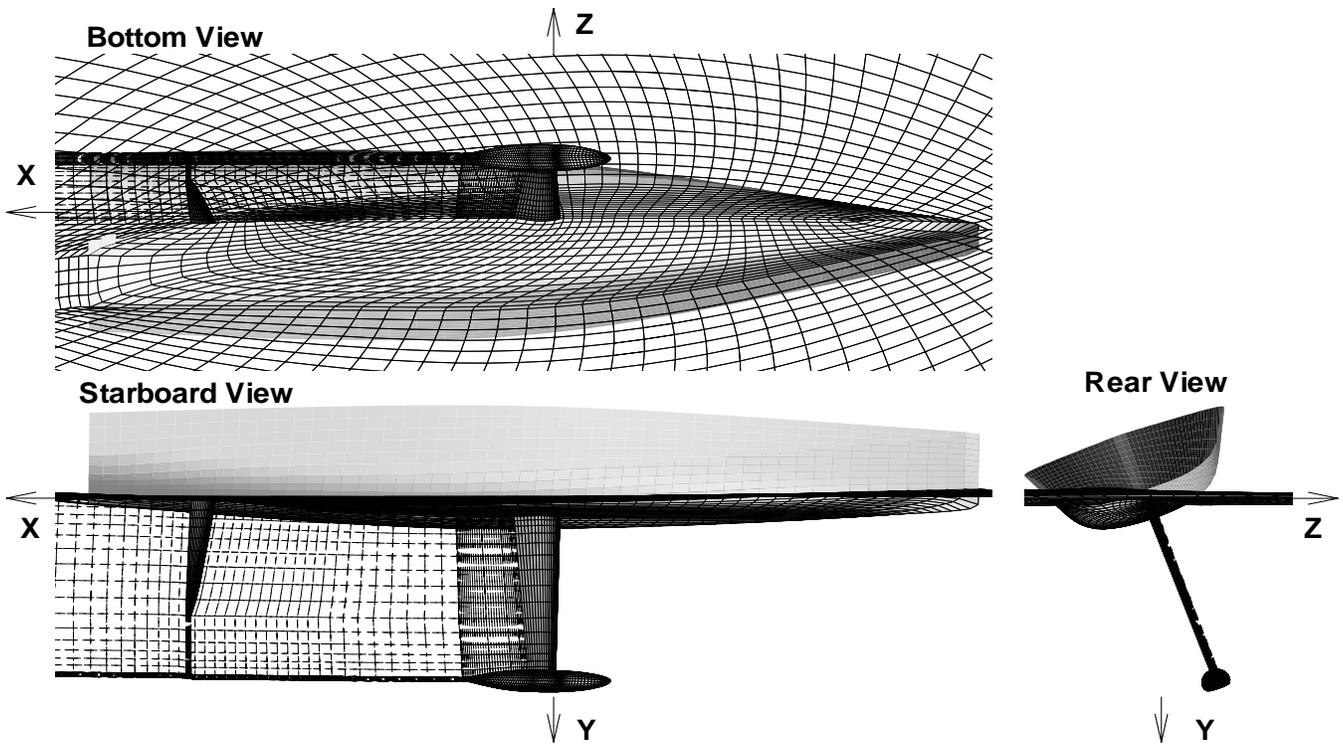


Figure 9 ACCPAN-Generated Panel Model for Heeled Yacht in SPLASH Global Coordinate System

sail driving force = yacht drag force
 sail pitching moment = - sail driving force x vertical arm
 = + yacht drag force x $(y_{ce} - y_{cg})_{\text{underway}}$

sail side force = yacht side force
 sail vertical force = sail side force x $\tan(\text{heel})$
 = yacht side force x $\tan(\text{heel})$

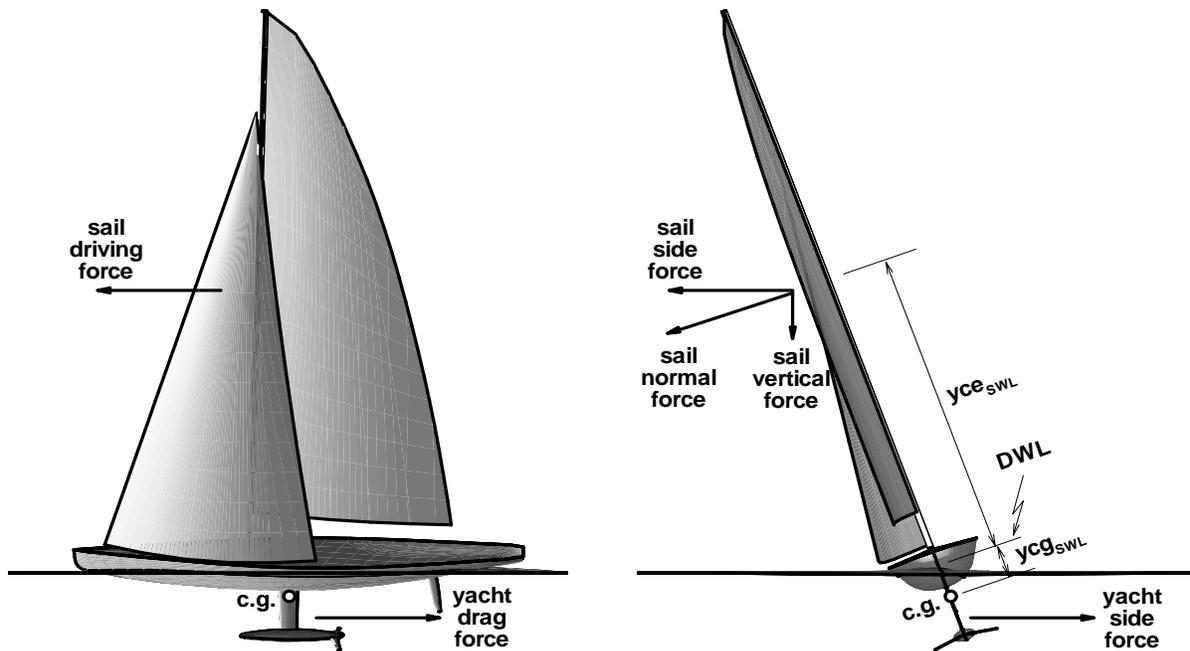


Figure 10 Sail Pitching Moment and Vertical Force Model (ISAIL=2)

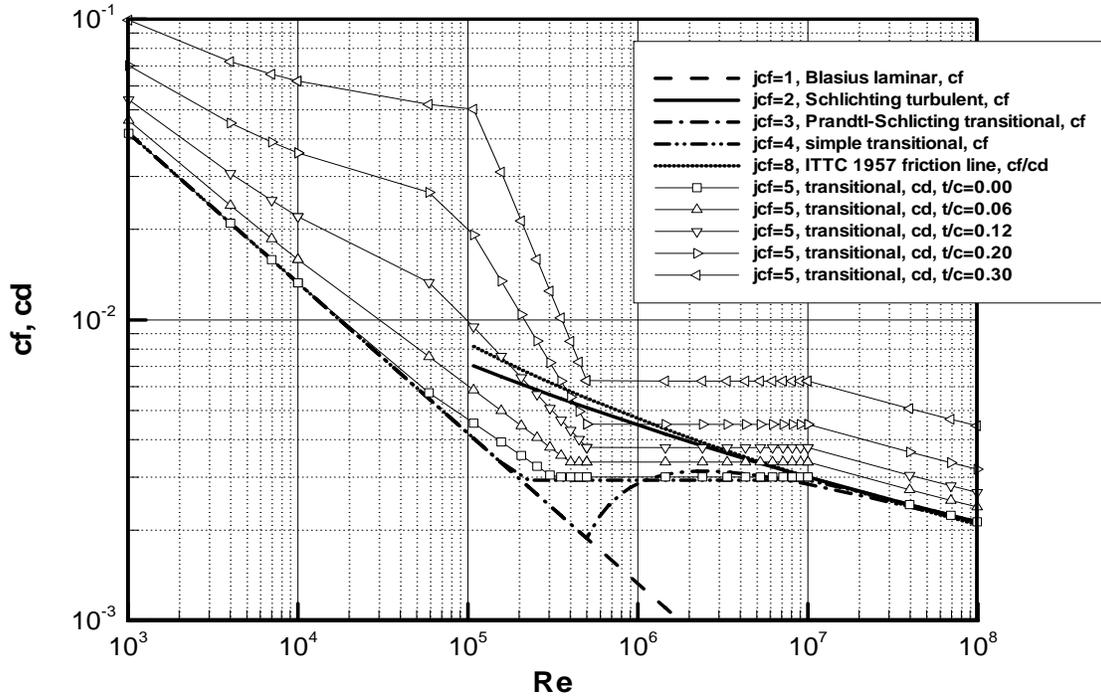


Figure 11 Viscous Stripping Formula for SPLASH with Laminar and Standard-Airfoil Turbulent Form Factor

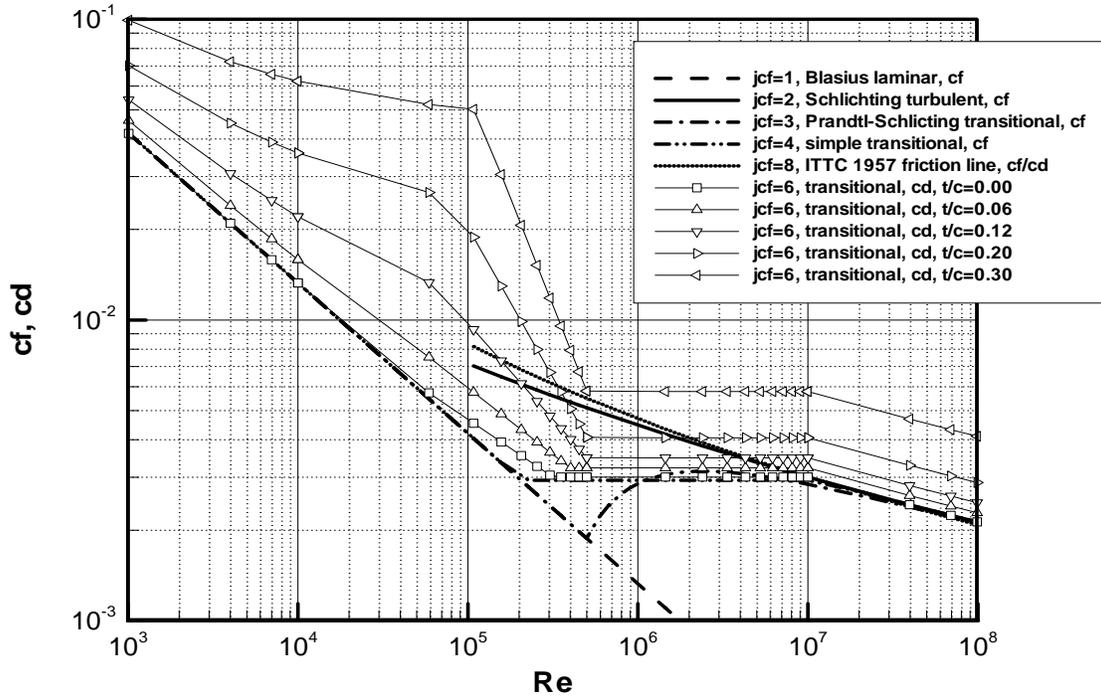


Figure 12 Viscous Stripping Formula for SPLASH with Laminar and Laminar-Flow-Airfoil Turbulent Form Factor

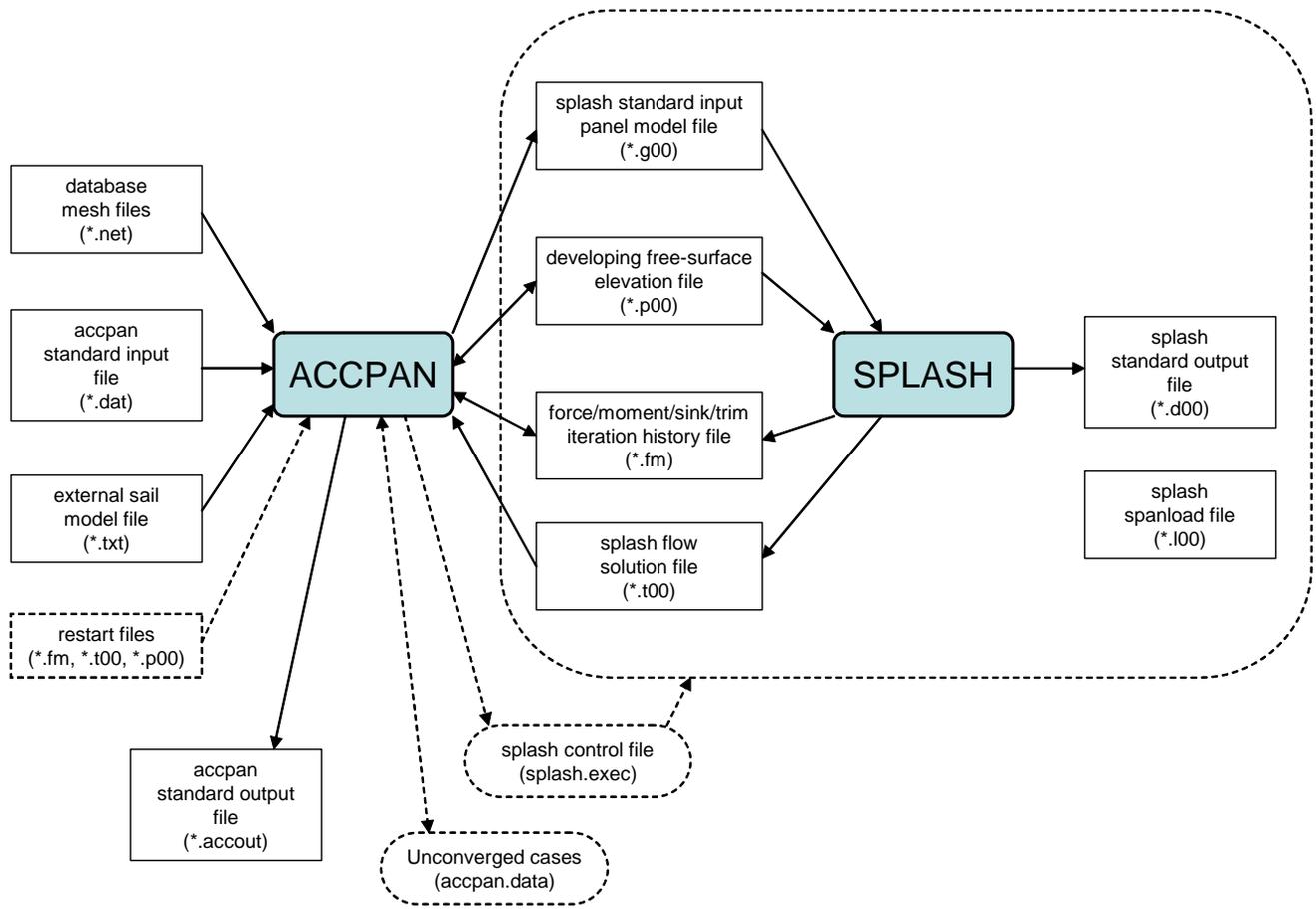


Figure 13 ACCPAN and SPLASH Input and Output File Dependencies

ACCPAN Standard-Input File Format

A sample ACCPAN standard-input file is included below, followed by a detailed description of the input format and parameters:

```

GENERAL INPUT DATA FOR NONLINEAR ACCPAN
case title
mx12-5.1.0.00-5.1.0.00
  nside      ixzfs      ileak      ivisc      intbt      idryn      iauto
  2          1          0          -1         1          0          -2
  isavg      isavf      isavt      isavd      iwlint     itrint
  1          4          1          1          1          1
  isavz      isavn      isavv      isavv
  0          0          0          0
  xcg        ycg          zcg          sref        cref        bref        xlboat
  0.00000    0.00000    0.00000    67.2000    17.2000    0.0000    0.0000
  xdatum     ydatum     zdatum
  0.00000    0.00000    0.00000
  xfrnt      xback      zside      grav        dens        visc        disp
  -1.50      1.75      1.15      9.80665    1025.0     1218.e-06  0.0
  xftab1     yftab1     zftab1     xftab2     yftab2     zftab2     itabf
  -8.8500    0.0000    0.0000    -8.6000    2.6300     0.0000     1
  xktab1     yktab1     zktab1     xktab2     yktab2     zktab2     itabk
  0.7000     0.0000    0.0000    0.7000     4.0000     0.0000     1
  xrtab1     yrtab1     zrtab1     xrtab2     yrtab2     zrtab2     itabr
  8.6500     0.0000    0.0000    8.9000     2.6300     0.0000     1
  jumpfr     fracfr     jumpkl     fracfl     jumprd     fracrd
  2          0.50000    0          0.50000    2          0.50000
  iedgpts    iedgcps    iedgcpv
  0          0          0
  idm1       idm2       idm3       islv1       islv2
  0          0          0          0          0
  imeth1     icond1     iperm1     iblsz1     nblok1     itrmx1     resid1
  6          0          0          0          0          0          0.000E+00
  imeth2     icond2     iperm2     iblsz2     nblok2     itrmx2     resid2
  6          0          0          0          0          0          0.000E+00
  ivfshl     ivhfls     ipfshl     ipfswk     iwkskd     iwkjmp
  1          1          0          0          0          0
  iwdiff     iupvwl     iradbc     limup1     limup2
  1          1          1          0          0
  iupvbc     ilagbc     xautowl     iordst     iordwl
  0          0          1.00000    0          0
  inrmzero   inrmfrsq   cnorm      iedgzero   iedgfrsq   cedge     inotopp
  2          3          4.0000E+0  2          3          4.0000E+0  1
  nonlin     ityyfs     ityymx     nfilty
  1          2          1          18
  tolyfs     tolymx     omegay     ffilty     xlamfs     xlammx     slopmx
  0.005000   0.010000   1.000     0.5        2.00      2.00      0.00000
  ifloat     itysnk     itytrm     icrew      isail
  1          1          0          2          2
  tolsnk     toltrm     omegas     omegat     xlams      xlamt
  0.000100   0.005000   1.000     1.000     1.00      1.00
  xcsail     ycsail     zcsail     wcrew     crewmn     crewmx
  0.0000     -13.6255   0.0000    0.00      0.0000    0.0000
sail force model filename
none
WEIGHTS INPUT DATA
imwldsp imwlcg imwlycg imwlzcg iswldsp iswlcg iswlycg iswlzcg icrew
  0          0          2          0          1          1          1          1          2
comp      wght      xwght      ywght      zwght      xmin      xmax
mwlt      0.0       0.0000    0.0100    0.0000
crew      19500.0   0.8125    0.0100    0.0000    0.8125    0.8125
sail      0.0       0.0000    0.0000    0.0000
ball      0.0       0.0000    0.0000    0.0000
STRIPPING INPUT DATA
comp      jcf      jff      cf      ff      tonc
hull      3        0        0.00000  1.04000  0.00000
keel      6        3        0.00000  0.00000  0.00000
rudr      6        3        0.00000  0.00000  0.00000

```

```

bulb          3   4   0.00000   0.00000   0.00000
wing          6   3   0.00000   0.00000   0.00000
NETWORK      INPUT DATA FOR NONLINEAR ACCPAN
network database directory
~/mx12-sample-080723/nets/mx12
network database filename and ..
comp          imax jmax  (auxilliary inputs)
hull.net
hull          0  46  16   3.00000   1.00000   0.62500   0.62500   1.10000   1.10000
klbl.net
keel         -1  25  16
blwg.net
bulb          0  19  16   19    8    8
rudr.net
rudr         -1  25  16   0.50000   1.50000
wgb1.net
wing         -1  21  11
surf.net
surf          0  46  31
ITERATION INPUT DATA FOR NONLINEAR ACCPAN
iterates  iforce   tolyfs   omegay   tolsnk   omegas   toltrm   omegat
1          1      0.005000  1.000000  0.000100  1.000000  0.005000  1.000000
19         0      0.005000  1.000000  0.000100  1.000000  0.005000  1.000000
10         0      0.005000  0.500000  0.000100  0.500000  0.005000  0.500000
20         0      0.005000  0.250000  0.000100  0.250000  0.005000  0.250000
40         0      0.005000  0.125000  0.000100  0.125000  0.005000  0.125000
DATASET     INPUT DATA FOR NONLINEAR ACCPAN
splash dataset directory
../r20r03
splash restart directory
~/mx12-sample-080723/runs/mx12-5.1.0.00-5.1.0.00-previous-test/r20r03
splash dataset filename and splash restart filename and ..
speed      heel      yaw      dkeel      drudr      sink      trim
r20000r03
0.00000  20.00000  4.00000  5.00000  4.00000  0.00000  0.00000
r20080r03
4.11553  20.00000  4.00000  5.00000  4.00000  0.00000  0.00000
r20090r03
4.62997  20.00000  4.00000  5.00000  4.00000  0.00000  0.00000
r20100r03
5.14441  20.00000  4.00000  5.00000  4.00000  0.00000  0.00000
r20120r03
6.17329  20.00000  4.00000  5.00000  4.00000  0.00000  0.00000

```

Nomenclature:

$$Fr = UBOAT / \sqrt{GRAV * XLBOAT}$$

Standard FORTRAN Formatted Input Conventions:

Each input value must appear in its designated column range.

Values for integer variables (those beginning with I-N) must not contain a decimal point.

Values for real variables (those beginning with A-H and O-Z) must contain a decimal point.

Input for character string variables (those expressly identified as such) should be left-justified.

Standard FORTRAN Format-Free Input Conventions:

Similar to formatted input, but inputs may appear in any column, as long as multiple inputs are each separated by one or more blank spaces and/or a comma.

Comment lines appear throughout the ACCPAN standard input. They are typically used to describe the inputs on the line(s) to follow. In fact they may contain any valid character string, in columns 1-80. During program execution, the actual comment line character strings are ignored.

ACCPAN standard input is divided into six main sections. The start of these sections are indicated by the appearance of the following 10-character strings at the beginning of a line:

<u>Section Start String</u>	<u>Section Description</u>
<code>`GENERAL`</code>	this section is required and contains the majority of the input data to control the tests
<code>`WEIGHTS`</code>	this optional section allows input of data to control the hydrostatic calculations affecting the DWL, MWL, and SWL flotations (how to calculate or input of weight and/or center of gravity for each of: total model, individual model component, crew, sails and gear, ballast, etc.)
<code>`STRIPPING`</code>	this optional section allows input of data to control the viscous stripping options
<code>`NETWORK`</code>	this section is required and contains the specific details for each panel model component (hull, keel, bulb, wing, rudder(s), and free-surface): number of panels, cluster and other component-specific panelization parameters, foil cant angle, and nominal tab and rudder deflection angles
<code>`ITERATION`</code>	this section is optional, although strongly recommended for automated operations, and allows input of data to control the number of maximum iterations to be run, and to control solution tolerances and solution under-relaxation factors on an iteration-by-iteration basis.
<code>`DATASET`</code>	this section is required and contains unique test point information: unique test point name, heel, speed, yaw angle, tab angle, aft rudder angle, and nominal sink and trim values

GENERAL Input Section

The first line of this section is indicated by the appearance of the 10-character string ``GENERAL`` at the beginning of a line (columns 1-10). The remainder of the line (through column 80) is for comment only and is otherwise ignored.

The next line, which is preceded by a comment line, specifies a case title:

`titlds` (columns 1-60) A character string for identification purposes, such as to identify the model, test details, test points, etc.

The next line, which is preceded by a comment line, specifies overall parameters regarding the panel models and flow solutions to be generated, and the overall mode of operation:

`nside` (columns 1-10) Half-plane or full-plane panel model option:

		<p>nside=1 SPLASH symmetric (i.e., upright) half-models to be generated.</p> <p>nside=2 SPLASH asymmetric (e.g., heeled and/or yawed) full-models to be generated.</p>
ixzfs	(columns 11-20)	<p>Controls the interpretation of the free-surface outer boundary placement parameters xfrnt, xback, and zside:</p> <p>ixzfs=0 Interpret as actual coordinates in global coordinate system.</p> <p>ixzfs=1 Interpret as boat lengths (xlboat) away from configuration center of gravity (xcg and zcg).</p>
ileak	(columns 21-30)	<p>SPLASH input parameter, passed through to SPLASH input data set. Normally set to zero, except for special "leakage" or "surfing rudder" correction cases.</p>
ivisc	(columns 31-40)	<p>Controls the viscous stripping options. Also a SPLASH input parameter, passed through to SPLASH input data set.</p> <p>ivisc=0 No ACCPAN viscous stripping requested.</p> <p>ivisc=+1 Requests ACCPAN viscous stripping.</p> <p>ivisc=-1 Requests ACCPAN viscous stripping. The resulting viscous force and moment coefficients are also recorded by ACCPAN in the force/moment/sink/trim iteration history file (without this option, these coefficients are instead zero-filled in the file by SPLASH).</p>
intbt	(columns 41-50)	<p>Controls the panel model network-abutment checking option:</p> <p>intbt=0 No network-abutment checking is performed.</p> <p>intbt≠0 Network-abutment checking is performed. Requested panel distributions (number of panels and distribution functions) are checked for consistency at hull/free-surface abutment (no other network abutments are checked).</p> <p>intbt=1 is recommended</p>
idryn	(columns 51-60)	<p>Controls creation of mesh files for unwetted portion of yacht components (typically, for just the hull and the rudder). These are for user convenience only, such as for use in visualizations:</p> <p>idryn=0 Unwetted database mesh files are not created.</p> <p>idryn≠0 Unwetted database mesh files are created.</p> <p>This option is currently inactive. Use idryn=0.</p>
iauto	(columns 61-70)	<p>ACCPAN and SPLASH automation option:</p>

- iauto=0 No automated operation. ACCPAN runs as stand-alone program.
- |iauto|=1 Semi-automated operation (this option is obsolete).
- |iauto|=2 Fully automated operation of SPLASH and ACCPAN (requires additional, external job control and job execution files).

If iauto>0, the current SPLASH iteration count number *ii* is combined with unique test point names to determine unique test point filenames. As a result, separate SPLASH input and output files are created and saved for each SPLASH iteration.

If iauto≤0, the SPLASH iteration count number *ii* is temporarily set to zero ('00') before being appended to the appropriate filenames. As a result, corresponding SPLASH input and output files are overwritten during each SPLASH iteration.

Please refer to the section regarding automated program operations for a complete description of requirements for automated program operations.

The next line, which is preceded by a comment line, specifies file update and disposition information, as well as some SPLASH waterline integral options:

- isavg** (columns 1-10) Controls disposition of **.gii* files (SPLASH standard-input files) during fully automated operation:
 - isavg=0 After each SPLASH iteration, the files are erased by appropriate commands in the "splash.exec" shell script.
 - isavg≠0 The files are not erased.
- isavf** (columns 11-20) Controls usage and update of **.fm* force/moment/sink/trim iteration history files (SPLASH file *tfms*). The value of isavf is also used as the SPLASH standard-input parameter ifmst:
 - isavf=0 The files are not used.
 - isavf≠0 The files are used. Values of sink and trim in the files override those in the ACCPAN standard input. The files are also updated by ACCPAN and SPLASH during automated operation.

isavf≠0 is required for free to sink and trim and nonlinear free-surface calculations.

Different values of isavf result in different forms of the **.fm* force/moment/sink/trim iteration history file:

isavf	reference point for moments and sinkage	component viscous forces and moments	separate waterline forces and moments
1	center of gravity	no	no
2	datum point	no	no
3	center of gravity	yes	no
4	datum point	yes	no
101	center of gravity	no	yes
102	datum point	no	yes
103	center of gravity	yes	yes
104	datum point	yes	yes

If the moments and sinkage in the iteration history file are to be referenced to a datum point, the user is required to specify the coordinates *xdatum,ydatum,zdatum* later in the input sequence.

isavt (columns 21-30) Controls disposition of **.tii* files (SPLASH flow solution file *tecout*) during automated operation (the value of *isavt* is also used as the SPLASH standard-input parameter *itec*):

isavt=0 The files are not saved.

isavt≠0 The files are saved.

***isavt*≠0 is required for nonlinear free-surface calculations.**

isavd (columns 31-40) Controls disposition of **.dii* files (SPLASH standard-output file) during automated operation:

isavd=0 The files are not saved.

isavd≠0 The files are saved.

iwlint (columns 41-50) Controls SPLASH standard waterline integral calculations and their inclusion in total model forces and moments.

Waterline integrals, common to many linearized free-surface methods, account for the difference along the waterline between the panel corner point elevation based on final panel geometry, and the free-surface elevation based on computed dynamic pressure. The difference in elevation is interpreted as acting on a small vertical increase or decrease in extent of the hull panel at the waterline.

Even with SPLASH nonlinear free-surface calculations, small differences may still arise, due to smoothing of the computed free-surface pressures by ACCPAN just prior to generating the panel model for the next SPLASH nonlinear iteration.

iwlint=0 No SPLASH standard waterline integrals calculations.

iwlint=+1 Triggers both the calculations (with printout in the SPLASH standard output) and their inclusion in the overall forces and

moments. Causes the SPLASH standard-input file to specify `nwln=1` and `nwltyp=+1`. **Recommended.**

`iwlint=-1` Triggers only the calculations (with printout in the SPLASH standard output) but not their inclusion in the overall forces and moments. Causes the SPLASH input file to specify `nwln=1` and `nwltyp=-1`.

itrint (columns 51-60) Controls SPLASH transom waterline integral calculations and their inclusion in total model forces and moments.

SPLASH transom waterline integrals are the same as standard waterline integrals, except that the difference in hull and free-surface elevation is interpreted as acting on a partially wetted transom. This may be important whenever there is an immersed transom that is partially wetted and not completely dry.

`itrint=0` No SPLASH transom waterline integrals calculations.

`itrint=+1` Triggers both the calculations (with printout in the SPLASH standard output) and their inclusion in the overall forces and moments. Causes the SPLASH standard-input file to specify `nwln=1` and `nwltyp=+2`. **Recommended.**

`itrint=-1` Triggers only the calculations (with printout in the SPLASH standard output) but not their inclusion in the overall forces and moments. Causes the SPLASH input file to specify `nwln=1` and `nwltyp=-2`.

The next line, which is preceded by a comment line, specifies additional file update and disposition information:

isavz (columns 1-10) Controls disposition of `*.zii` files (SPLASH basis flow doublet and source solution file **dub1**) during fully automated operation:

`isavz=0` The files are not saved.

`isavz≠0` The files are saved.

isavn (columns 11-20) Controls disposition of `*.nii` files (SPLASH free-surface flow doublet and source solution file **dub2**) during fully automated operation:

`isavn=0` The files are not saved.

`isavn≠0` The files are saved.

isavx (columns 21-30) Controls disposition of `*.xii` files (SPLASH velocity scan input file **scinip**) during automated operation:

`isavx=0` The files are not saved.

`isavx≠0` The files are saved.

This is currently not operational, and the **.xii* files are never removed.

isavv (columns 31-40) Controls disposition of **.vii* files (SPLASH velocity scan output file *scnout*) during automated operation (the value of isavv is also used as the SPLASH standard-input parameter iscan):

isavv=0 The files are not saved.

isavv≠0 The files are saved.

isavv≠0 is required for velocity scans during fully automated operations.

The next line, which is preceded by a comment line, specifies various reference parameters:

xcg (columns 1-10) Nominal DWL center of gravity x-coordinate (LCG).

Under certain conditions, ACCPAN will calculate an alternate value for xcg. This occurs if the input displacement disp is zero and the model is free to sink and trim, or if the input displacement disp is zero and the model includes a free-surface.

The WEIGHTS input section of the ACCPAN standard input also allows specification of xcg, or an alternate calculation for xcg. If so, the specifications in the WEIGHTS input section override the value of xcg input here.

Regardless of the final method to set xcg, a value should always be specified here, nominally locating it close to amidships (e.g., at x=0.0, or at Station 5).

ycg (columns 11-20) Nominal SWL center of gravity y-coordinate (VCG)

The WEIGHTS input section of the ACCPAN standard input also allows specification of ycg, or of an alternate calculation for ycg. If so, the specifications in the WEIGHTS input section override the value of ycg input here.

zcg (columns 21-30) Nominal SWL center of gravity z-coordinate (TCG)

The WEIGHTS input section of the ACCPAN standard input also allows specification of zcg, or of an alternate calculation for zcg. If so, the specifications in the WEIGHTS input section override the value of zcg input here.

Regardless of the final method to set zcg, a value should always be specified here, nominally locating it close to centerline (e.g., at z=0.0).

sref (columns 31-40) Reference area for force and moment coefficients.

If sref=0.0, ACCPAN sets sref=1.0.

cref (columns 41-50) Reference length for pitch moment coefficient (e.g., boat length, or reference chord).

If cref=0.0 and xlboat>0.0, ACCPAN sets cref=xlboat.
 If cref=0.0 and xlboat=0.0 and bref>0.0, ACCPAN sets cref=bref.
 If cref=0.0 and xlboat=0.0 and bref=0.0, ACCPAN sets cref=1.0.

- bref** (columns 51-60) Reference length for roll and yaw moment coefficients (e.g., boat length, or reference span).
 If bref=0.0, ACCPAN sets bref=cref (after cref is determined as described above).
- xlboat** (columns 61-70) Configuration free-surface reference length (e.g., boat length). Also used throughout ACCPAN as the order-of-magnitude for testing for small quantities, and to control the number of decimal places used in output files.
 If xlboat=0.0, ACCPAN sets xlboat=cref (after cref is determined as described above).

After setting cref, bref, and xlboat as described above, ACCPAN finally sets cref=xlboat and cref=xlboat.

It is recommended to set each of cref, bref and xlboat to the same nominal/actual reference waterline length, or, that to set only one of them to this value and to set all the others equal to aero. Doing so eliminates any ambiguity as to the final values.

The next line, which is preceded by a comment line, specifies the datum point coordinates. These lines are input only if the use of a datum point is indicated by the specified value of input parameter isavf:

- xdatum** (columns 1-10) Model-fixed datum point DWL x-coordinate.
ydatum (columns 11-20) Model-fixed datum point DWL y-coordinate.
zdatum (columns 21-30) Model-fixed datum point DWL z-coordinate.

The next line, which is preceded by a comment line, specifies panel model extent, fluid properties, and DWL displacement:

- xfrnt** (columns 1-10) Upstream extent of free-surface outer boundary.
 If ixzfs=0, then xfrnt is the distance, in x, from the central reference point to the upstream boundary, i.e., $x_{up} - x_{rp} + x_{frnt}$
 If ixzfs≠0, then xfrnt is the distance, in boat lengths, from the central reference point to the upstream boundary, i.e., $x_{up} - x_{rp} + x_{frnt} * xlboat$
- xback** (columns 11-20) Downstream extent of free-surface outer boundary.
 If ixzfs=0, then xback is the distance, in x, from the central reference point to the downstream boundary, i.e., $x_{dn} - x_{rp} + x_{back}$
 If ixzfs≠0, then xback is the distance, in boat lengths, from the central reference point to the downstream boundary, i.e., $x_{dn} - x_{rp} + x_{back} * xlboat$

zside	(columns 21-30)	<p>Lateral extent of free-surface outer boundaries.</p> <p>If $ixzfs \neq 0$, then +/- zside is the distance, in z, from the central reference point to the lateral boundaries, i.e., $zlat \sim zrp \pm zside$</p> <p>If $ixzfs \neq 0$, then +/- zside is the distance, in boat lengths, from the central reference point to the lateral boundaries, i.e., $zlat \sim zrp \pm zside * xlboat$</p>
grav	(columns 31-40)	Gravitational constant (e.g., 32.1740 feet/second ² or 9.80665 meters/second ²). Also a SPLASH input parameter, passed through to SPLASH input data set.
dens	(columns 41-50)	Fluid density (e.g., 1.9905 slugs/foot ³ or 1025.0 kilograms/meter ³). Also a SPLASH input parameter, passed through to SPLASH input data set.
visc	(columns 51-60)	Fluid viscosity for use in ACCPAN viscous stripping methodology for viscous force and moment estimates. Also a SPLASH input parameter, passed through to the SPLASH standard-input file (although not used for any internal or flow calculations by the current version of SPLASH).
disp	(columns 61-70)	<p>Nominal DWL displacement. Specified as a force, with dimensions such as pound-force or Newton.</p> <p>If the model is free to sink and trim, ACCPAN will float the model at this displacement, and with input values of xcg and zcg, and interpret the resulting flotation (sink and trim) as the DWL condition.</p> <p>However, if disp is zero and the model is free to sink and trim, or if disp is zero and the model includes a free-surface, then ACCPAN will calculate a DWL displacement, xcg and zcg as required for the model to float on its lines as specified in the database surface mesh files.</p> <p>The WEIGHTS input section of the ACCPAN standard input also allows specification of displacement, or an alternate calculation for disp. If so, the specifications in the WEIGHTS input section override the value of disp input here.</p>

The next line, which is preceded by a comment line, specifies the forward rudder hinge line (location and type). These are required inputs, although they are used by ACCPAN only if calculations are for models with a forward rudder:

xftab1	(columns 1-10)	DWL x-coordinate of a first point on the hinge line.
yftab1	(columns 11-20)	DWL y-coordinate of a first point on the hinge line.
zftab1	(columns 21-30)	DWL z-coordinate of a first point on the hinge line.
xftab2	(columns 31-40)	DWL x-coordinate of a second point on the hinge line.
yftab2	(columns 41-50)	DWL y-coordinate of a second point on the hinge line.
zftab2	(columns 51-60)	DWL z-coordinate of a second point on the hinge line.
itabf	(columns 61-70)	Denotes the type of surface deflection model.

- itabf=0 Surface deflection is modeled by specifying a non-zero panel normal velocity, with magnitude equal to the deflection angle times the sine of the angle between the hinge line and vertical.
- |itabf|=1 The zero normal velocity boundary condition takes the 3-D rotation of the surface normal into account. **Recommended.**
- |itabf|=2 The zero normal velocity boundary condition takes the 3-D rotation of the surface normal, and a first order approximation of the 3-D surface displacement, into account.
- itabf<0 An explicit zero normal velocity boundary condition is implemented.
- itabf>0 An implicit zero normal velocity boundary condition is implemented. **Recommended.**

The deflection by default is for the entire surface. The deflection may be explicitly specified as all moving, by adding 10 to the magnitude of itabf (-2 becomes -12, -1 becomes -11, 0 becomes 10, +1 becomes +11, and +2 becomes +12). The deflection may be explicitly restricted to the surface aft of the hinge line, by adding 20 to the magnitude of itabf (-2 becomes -22, -1 becomes -21, 0 becomes 20, +1 becomes +21, and +2 becomes +22).

The next line, which is preceded by a comment line, specifies the keel hinge line (location and type). These are required inputs, although they are used by ACCPAN only if calculations are for models with a keel:

- xktab1** (columns 1-10) DWL x-coordinate of a first point on the hinge line.
- yktab1** (columns 11-20) DWL y-coordinate of a first point on the hinge line.
- zktab1** (columns 21-30) DWL z-coordinate of a first point on the hinge line.
- xktab2** (columns 31-40) DWL x-coordinate of a second point on the hinge line.
- yktab2** (columns 41-50) DWL y-coordinate of a second point on the hinge line.
- zktab2** (columns 51-60) DWL z-coordinate of a second point on the hinge line.
-
- itabk** (columns 61-70) Denotes the type of surface deflection model.
-
- itabk=0 Surface deflection is modeled by specifying a non-zero panel normal velocity, with magnitude equal to the deflection angle times the sine of the angle between the hinge line and vertical.
- |itabk|=1 The zero normal velocity boundary condition takes the 3-D rotation of the surface normal into account. **Recommended.**
- |itabk|=2 The zero normal velocity boundary condition takes the 3-D rotation of the surface normal, and a first order approximation of the 3-D surface displacement, into account.
- itabk<0 An explicit zero normal velocity boundary condition is implemented.
- itabk>0 An implicit zero normal velocity boundary condition is implemented. **Recommended.**

The deflection by default is for the surface aft of the hinge line. The deflection may be explicitly specified as all moving, by adding 10 to the magnitude of itabk (-2 becomes -12, -1 becomes -11, 0 becomes 10, +1 becomes +11, and +2 becomes +12). The deflection may be explicitly restricted to the surface aft of the hinge line, by adding 20 to the magnitude of itabk (-2 becomes -22, -1 becomes -21, 0 becomes 20, +1 becomes +21, and +2 becomes +22).

The next line, which is preceded by a comment line, specifies the aft rudder hinge line (location and type). These are required inputs, although they are used by ACCPAN only if calculations are for models with an aft rudder:

xrtab1	(columns 1-10)	DWL x-coordinate of a first point on the hinge line.
yrtab1	(columns 11-20)	DWL y-coordinate of a first point on the hinge line.
zrtab1	(columns 21-30)	DWL z-coordinate of a first point on the hinge line.
xrtab2	(columns 31-40)	DWL x-coordinate of a second point on the hinge line.
yrtab2	(columns 41-50)	DWL y-coordinate of a second point on the hinge line.
zrtab2	(columns 51-60)	DWL z-coordinate of a second point on the hinge line.
itabr	(columns 61-70)	Denotes the type of surface deflection model.
	itabr=0	Surface deflection is modeled by specifying a non-zero panel normal velocity, with magnitude equal to the deflection angle times the sine of the angle between the hinge line and vertical.
	itabr =1	The zero normal velocity boundary condition takes the 3-D rotation of the surface normal into account. Recommended.
	itabr =2	The zero normal velocity boundary condition takes the 3-D rotation of the surface normal, and a first order approximation of the 3-D surface displacement, into account.
	itabr<0	An explicit zero normal velocity boundary condition is implemented.
	itabr>0	An implicit zero normal velocity boundary condition is implemented. Recommended.

The deflection by default is for the entire surface. The deflection may be explicitly specified as all moving, by adding 10 to the magnitude of itabr (-2 becomes -12, -1 becomes -11, 0 becomes 10, +1 becomes +11, and +2 becomes +12). The deflection may be explicitly restricted to the surface aft of the hinge line, by adding 20 to the magnitude of itabr (-2 becomes -22, -1 becomes -21, 0 becomes 20, +1 becomes +21, and +2 becomes +22).

The next line, which is preceded by a comment line, specifies parameters indicating how to treat the interruptions in transverse panel-to-panel neighbor relationships across the hull and free-surface centerline due to the presence of a foil (a keel or rudder):

jumpfr	(columns 1-10)	Controls how to treat interruptions due to the forward rudder.
---------------	----------------	--

- jumpfr=0** The interruptions are treated using transverse surface boundary condition specifications.
- jumpfr=1** The interruptions are treated using partial wake jump specifications. Panel-to-panel neighbor relationships are maintained across the hull and free-surface centerline, taking into account the fraction of lift generated by the foil upstream of, and along, the hull or free-surface panel edge. The fraction is found by assuming a thin flat plate chordwise lift distribution, and is accounted for by specifying a corresponding fractional jump across the foil wake.
- jumpfr=2** The interruptions are treated using a blended combination of the two approaches described for **jumpfr=0** and **jumpfr=1**. The blend is obtained based on the ratio of the hull or free-surface panel size to the foil root chord length. As this ratio varies, from zero to the input value of parameter **fracfr**, the treatment varies, from pure **jumpfr=0** to pure **jumpfr=1**. Thus hull or free-surface panels that are relatively small compared to the foil chord get more transverse surface boundary condition treatment, while relatively large panels get more partial wake jump treatment.
- fracfr** (columns 11-20) Forward rudder blending parameter. If **jumpfr=2**, then **fracfr** must be greater than zero. **jumpfr=2 and fracfr=0.5 are recommended.**
- jumpkl** (columns 21-30) Controls how to treat interruptions due to the keel.
- jumpkl=0** The interruptions are treated using transverse surface boundary condition specifications.
- jumpkl=1** The interruptions are treated using partial wake jump specifications. Panel-to-panel neighbor relationships are maintained across the hull and free-surface centerline, taking into account the fraction of lift generated by the foil upstream of, and along, the hull or free-surface panel edge. The fraction is found by assuming a thin flat plate chordwise lift distribution, and is accounted for by specifying a corresponding fractional jump across the foil wake.
- jumpkl=2** The interruptions are treated using a blended combination of the two approaches described for **jumpkl=0** and **jumpkl=1**. The blend is obtained based on the ratio of the hull or free-surface panel size to the foil root chord length. As this ratio varies, from zero to the input value of parameter **frackl**, the treatment varies, from pure **jumpkl=0** to pure **jumpkl=1**. Thus hull or free-surface panels that are relatively small compared to the chord get more transverse surface boundary condition treatment, while relatively large panels get more partial wake jump treatment.
- frackl** (columns 31-40) Keel blending parameter. If **jumpkl=2**, then **frackl** must be greater than zero. **jumpkl=2 and frackl=0.5 are recommended.**
- jumprd** (columns 41-50) Controls how to treat interruptions due to the aft rudder.

- jumprd=0 The interruptions are treated using transverse surface boundary condition specifications.
- jumprd=1 The interruptions are treated using partial wake jump specifications. Panel-to-panel neighbor relationships are maintained across the hull and free-surface centerline, taking into account the fraction of lift generated by the foil upstream of, and along, the hull or free-surface panel edge. The fraction is found by assuming a thin flat plate chordwise lift distribution, and is accounted for by specifying a corresponding fractional jump across the foil wake.
- jumprd=2 The interruptions are treated using a blended combination of the two approaches described for jumprd=0 and jumprd=1. The blend is obtained based on the ratio of the hull or free-surface panel size to the foil root chord length. As this ratio varies, from zero to the input value of parameter fracrd, the treatment varies, from pure jumprd=0 to pure jumprd=1. Thus hull or free-surface panels that are relatively small compared to the chord get more transverse surface boundary condition treatment, while relatively large panels get more partial wake jump treatment.

fracrd (columns 51-60) Aft rudder blending parameter. If jumprd=2, then fracrd must be greater than zero. **jumprd=2 and fracrd=0.5 are recommended.**

The next line, which is preceded by a comment line, specifies SPLASH input parameters controlling the methodology used to implement the transverse boundary conditions that will be specified for hull and free-surface panels whose edges abut an adjacent keel or rudder network:

- iedgpts** (columns 1-10) iedgpts=0 Transverse panel edge boundary condition specifications are used only to determine how much of the panel edge abuts the adjacent surface. SPLASH panel-to-panel velocity calculations will use a one-sided difference stencil, away from the adjacent surface, for the corresponding contribution. **Recommended.**
- iedgpts≠0 Transverse panel edge boundary condition specifications are used to provide a formula for the value of the velocity potential at the panel edge midpoint based on values from the adjacent surface. SPLASH panel-to-panel velocity calculations will use this edge midpoint value to construct central difference stencils for the corresponding contribution.
- iedgcps** (columns 11-20) iedgcps=0 Transverse panel edge boundary condition specifications are used only to determine how much of the panel edge abuts the adjacent surface. SPLASH panel-to-panel free-surface wave pressure gradient calculations will use a one-sided difference stencil, away from the adjacent surface, for the corresponding contribution (or, if inotopp≠0, set it to zero). **Recommended.**
- iedgcps≠0 Transverse panel edge boundary condition specifications are used to provide a formula for the value of the free-surface wave pressure at the panel edge midpoint based on values from the adjacent surface. SPLASH panel-to-panel pressure gradient

calculations will use this edge midpoint value as required to construct upwind difference stencils for the corresponding contribution. This option is not activate unless `iedgpts≠0`.

`iedgcpv` (columns 21-30) `iedgcpv=0` Transverse panel edge boundary condition specifications are used only to determine how much of the panel edge abuts the adjacent surface. Final SPLASH panel corner point velocities and pressures will be calculated using a one-sided difference stencil, away from the adjacent surface, for the corresponding contribution. **Recommended.**

`iedgcpv≠0` Transverse panel edge boundary condition specifications are used to provide a formula for the value of the velocity at the panel edge midpoint based on values from the adjacent surface. Final SPLASH panel corner point velocities and pressures will be calculated using this edge midpoint value as required to construct central difference stencils for the corresponding contribution. This option is not activate unless `iedgpts≠0`.

The next line, which is preceded by a comment line, specifies SPLASH input parameters controlling the flow solution algorithms. These parameters are either inactive, or reserved for internal use only:

`idm1` (columns 1-10) Currently inactive. Use `idm1=0`.
`idm2` (columns 11-20) Currently inactive. Use `idm2=0`.
`idm3` (columns 21-30) Currently inactive. Use `idm3=0`.
`islv1` (columns 31-40) Reserved for internal use only. **islv1=0 is required.**
`islv2` (columns 41-50) Reserved for internal use only. **islv2=0 is required.**

The next line, which is preceded by a comment line, specifies SPLASH input parameters controlling the algorithms used to solve the first (basis flow) solution matrix:

`imeth1` (columns 1-10) `imeth1=3` Direct matrix solution.
`imeth1=6` Block-iterative matrix solution with GMRES acceleration.
imeth1=6 is recommended, unless there is some reason to expect that the iterative solver will fail.

`icond1` (columns 11-20) Matrix preconditioning flag. Reserved for future use. **icond1=0 is required.**

`iperm1` (columns 21-30) Matrix permutation flag (sources and doublets arranged by increasing downstream position). Reserved for future use. **iperm1=0 is recommended.**

`iblsz1` (columns 31-40) Sets maximum block size (i.e., panels per block) used during iterative solve of the solution matrix. If `iblsz1=0`, an internal default maximum is used.

iblsz1=0 is recommended, unless the user specifically wishes to override the default value.

- nblok1** (columns 41-50) If nblok1>0, overrides the number of blocks to be used during iterative solve of the solution matrix. Blocks will be roughly equal in size. **nblok1=0 is recommended.**
- itrmx1** (columns 51-60) Sets the maximum number of iterations allowed during iterative solve of the solution matrix. If itrmx1=0, an internal default maximum is used. **itrmx1=0 is recommended, unless the user specifically wishes to override the default value.**
- resid1** (columns 61-70) During iterative solve of the solution matrix, the residual convergence criteria, expressed as a fraction of the maximum of the absolute values of the equation right-hand-sides. If resid1=0.0 an internal default value is used (typically 1.0×10^{-5}). Appears in the SPLASH standard-input file as parameter solres1. **resid1=0.0 is recommended, unless the user specifically wishes to override the default value.**

The next line, which is preceded by a comment line, specifies SPLASH input parameters controlling the algorithms used to solve the second (free-surface flow) solution matrix:

- imeth2** (columns 1-10) imeth2=3 Direct matrix solution.
imeth2=6 Block-iterative matrix solution with GMRES acceleration. **imeth2=6 is recommended, unless there is some reason to expect that the iterative solver will fail.**
- icond2** (columns 11-20) Matrix preconditioning flag. Reserved for future use. **icond2=0 is required.**
- iperm2** (columns 21-30) Matrix permutation flag (sources and doublets arranged by increasing downstream position). Reserved for future use. **iperm2=0 is recommended.**
- iblsz2** (columns 31-40) Sets maximum block size (i.e., panels per block) used during iterative solve of the solution matrix. If iblsz2=0, an internal default maximum is used. **iblsz2=0 is recommended, unless the user specifically wishes to override the default value.**
- nblok2** (columns 41-50) If nblok2>0, overrides the number of blocks to be used during iterative solve of the solution matrix. Blocks will be roughly equal in size. **nblok2=0 is recommended.**
- itrmx2** (columns 51-60) Sets the maximum number of iterations allowed during iterative solve of the solution matrix. If itrmx2=0, an internal default maximum is used. **itrmx2=0 is recommended, unless the user specifically wishes to override the default value.**
- resid2** (columns 61-70) During iterative solve of the solution matrix, the residual convergence criteria, expressed as a fraction of the maximum of the absolute values of the equation right-hand-sides. If resid2=0.0 an internal default value is used (typically 1.0×10^{-5}). Appears in the SPLASH standard-input file as

parameter `solres2`. **`resid2=0.0` is recommended, unless the user specifically wishes to override the default value.**

The next line, which is preceded by a comment line, primarily specifies SPLASH input parameters controlling the automated wake shedding and automated wake jump options:

`ivfsh1` (columns 1-10) Obsolete SPLASH input parameter.
`ivh1fs` (columns 11-20) Obsolete SPLASH input parameter.
`ipfsh1` (columns 21-30) Obsolete SPLASH input parameter.
`ipfswk` (columns 31-40) Obsolete SPLASH input parameter.
`iwkshd` (columns 41-50) A SPLASH input parameter controlling the automatic detection of wake shedding panels.

`iwkshd=0` No automatic detection of wake shedding panels in SPLASH.

`iwkshd≠0` Automatic detection of wake shedding panels in SPLASH.

`iwkshd=0` is recommended, as all wake shedding panels will be directly specified in the SPLASH standard-input files generated by ACCPAN.

`iwkjmp` (columns 51-60) A SPLASH input parameter controlling the automatic detection of wake jumps that need to be included in the panel-to-panel finite difference formulae used for calculating panel surface velocities.

`iwkjmp=0` No automatic detection of wake jumps in SPLASH.

`iwkjmp≠0` Automatic detection of wake jumps in SPLASH.

`iwkjmp=0` is recommended, as all wake jumps will be directly specified in the SPLASH standard-input files generated by ACCPAN.

The next line, which is preceded by a comment line, specifies additional SPLASH input parameters which control the implementation of the free-surface wave boundary conditions:

`iwdiff` (columns 1-10) Obsolete SPLASH input parameter.
`iupvw1` (columns 11-20) A SPLASH input parameter. **`iupvw1=1` is recommended.**
`iradbc` (columns 21-30) A SPLASH input parameter. Also used in ACCPAN to determine associated free-surface far field boundary condition details at outer boundary. **`iradbc=1` is recommended.**
`limup1` (columns 31-40) A SPLASH input parameter. **`limup1=0` is recommended.**
`limup2` (columns 41-50) A SPLASH input parameter. **`limup2=0` is recommended.**

The next line, which is preceded by a comment line, specifies additional SPLASH input parameters which control the implementation of the free-surface wave boundary conditions:

iupvbc (columns 1-10) A SPLASH input parameter. **iupvbc=0 is recommended.**

ilagbc (columns 11-20) A SPLASH input parameter. **ilagbc=0 is recommended.**

xautowl (columns 21-30) A SPLASH input parameter **xautowl=1.0 is recommended.**

iordst (columns 31-40) A SPLASH input parameter. **iordst=0 is recommended.**

iordwl (columns 41-50) A SPLASH input parameter. **iordwl=0 is recommended.**

The next line, which is preceded by a comment line, specifies additional SPLASH input parameters controlling the implementation of the free-surface wave boundary conditions. These include some very important parameters influencing the basis flow and free-surface flow solutions in the immediate downstream vicinity of a dry, or partially wetted, immersed transom:

inrmzero (columns 1-10) A SPLASH input parameter. **inrmzero=2 is recommended.**

inrmfrsq (columns 11-20) A SPLASH input parameter. **inrmfrsq=3 is recommended.**

cnorm (columns 21-30) A SPLASH input parameter. **cnorm=4.0 is recommended to start. The user may further adjust this value, for semi-empirical calibration of drag at lower speeds with partially wetted immersed transoms.**

iedgzero (columns 31-40) A SPLASH input parameter. **iedgzero=2 is recommended.**

iedgfrsq (columns 41-50) A SPLASH input parameter. **iedgfrsq=3 is recommended.**

cedge (columns 51-60) A SPLASH input parameter. **cedge=4.0 is recommended to start. The user may further adjust this value, for semi-empirical calibration of drag at lower speeds with partially wetted immersed transoms.**

inotopp (columns 61-70) A SPLASH input parameter. **inotopp=1 is recommended.**

The next line, which is preceded by a comment line, specifies primary nonlinear free-surface update control parameters:

nonlin (columns 1-10) Controls the selection of linear or non-linear free-surface panel models.

nonlin=0 Linear (flat, at $y=0.0$) free-surface panel models to be generated.

nonlin>0 Nonlinear free-surface panel models to be generated.

ityyfs (columns 11-20) Controls the interpretation of the free-surface convergence parameter, tolyfs.

ityyfs=0 The free-surface convergence parameter, tolyfs, is interpreted as an absolute, dimensional value.

ityyfs=1 The free-surface convergence parameter, tolyfs, is interpreted as a fraction of boat length, xlboat.

ityyfs=2 The free-surface convergence parameter, tolyfs, is interpreted as a fraction of boat length, xlboat, times $0.5 Fr^2$.

ityyfs=2 is recommended.

ityymx (columns 21-30) Controls the interpretation of the free-surface maximum allowable change parameter, tolymx.

ityymx=0 The free-surface maximum allowable change parameter, tolymx, is interpreted as an absolute, dimensional value.

ityymx=1 The free-surface maximum allowable change parameter, tolymx, is interpreted as a fraction of boat length, xlboat.

ityymx=2 The free-surface maximum allowable change parameter, tolymx, is interpreted as a fraction of boat length, xlboat, times $0.5 Fr^2$.

ityymx=1 is recommended.

nfilty (columns 31-40) |nfilty| is the number of smoothings applied to the free-surface shape from the latest SPLASH solution, prior to updating the free-surface panelization.

nfilty>0 Starting with a previous SPLASH solution, the change in free-surface shape during each smoothing is under-relaxed by the factor $6\pi Fr^4 / (1 + 6\pi Fr^4)$. **Recommended.**

nfilty<0 Starting with a previous SPLASH solution, the change in free-surface shape during each smoothing is under-relaxed by the specified under-relaxation factor, ffilty.

Optimal smoothing parameters may depend upon particular project applications and flow conditions.

The next line, which is preceded by a comment line, specifies additional primary nonlinear free-surface update control parameters:

tolyfs (columns 1-10) |tolyfs| specifies the convergence criteria for change in nonlinear free-surface elevations.

tolyfs>0 For all points on the free-surface, the maximum change in elevation is compared to the convergence criteria.

tolyfs<0 For all points on the free-surface, the RMS change in elevation is compared to the convergence criteria.

If ityyfs>0, then tolyfs=0.005 is recommended.

The ITERATION section of the ACCPAN standard input also requires specification of tolyfs. If present, the specifications in the ITERATION section override the value of tolyfs input here.

tolymx (columns 11-20) Specifies a nominal value for the maximum allowable change in nonlinear free-surface elevation during each panel model update.

If ityymx>0, then tolymx=0.01 is recommended.

omegay (columns 21-30) Specifies a nominal under-relaxation parameter applied to calculated changes in free-surface elevation.

Larger values (up to 1.0) may allow the final free-surface elevations to be reached using fewer ACCPAN/SPLASH iterations.

Smaller values (but greater than 0.0) may be required to achieve stability and convergence for the ACCPAN/SPLASH iterative process.

The ITERATION section of the ACCPAN standard input also requires specification of omegay. If present, the specifications in the ITERATION section override the value of omegay input here.

ffilty (columns 31-40) If nfilty<0, smoothing of the free-surface shape is reduced by factor ffilty.

If nfilty<0, then ffilty=0.5 is recommended.

xlamfs (columns 41-50) Applies an additional reduction to omegay, based on Froude number:

If nside=1: $\text{omegay} \approx \text{omegay} / (1 + \text{xlamfs} * (\tanh(\text{Fr}))^4)$

If nside=2: $\text{omegay} \approx \text{omegay} / (1 + \text{xlamfs} * (\tanh(\text{Fr}))^2)$

xlamfs=2.0 is suggested.

xlammx (columns 51-60) Applies an additional reduction to tolymx, based on Froude number:

If nside=1: $\text{tolymx} \approx \text{tolymx} / (1 + \text{xlammx} * (\tanh(\text{Fr}))^4)$

If nside=2: $\text{tolymx} \approx \text{tolymx} / (1 + \text{xlammx} * (\tanh(\text{Fr}))^2)$

xlammx=2.0 is suggested.

slopmx (columns 61-70) ACCPAN attempts to generate a free-surface shape with slope everywhere limited by the specified value of slopmx. If slopmx=0.0 is input, the default value $\text{slopmx} = \tan(12.5^\circ) = 0.221695$ is used.

If slopmx<0.0, the wave slope limiting algorithm is deactivated.

slopmx=0.0 is suggested.

The next line, which is preceded by a comment line, specifies primary sink and trim update control parameters:

ifloat (columns 1-10) Provides overall control of the sink and trim update process:

ifloat=0 Model is fixed in sink and trim, at values specified in ACCPAN standard-input data file, or in restart **.fm* iteration history file.

ifloat=1 Model is free to sink and trim. Calculations proceed in normal fashion.

ifloat=-1 Model is free to sink and trim, but ACCPAN halts execution after computing DWL, MWL and SWL conditions. Calculations otherwise do not proceed in normal fashion (no SPLASH panel models are generated). This option is useful for a quick check that flotation inputs have been correctly specified by the user.

itysnk (columns 11-20) Controls the interpretation of the sink convergence parameter, tolsnk.

itysnk=0 The sink convergence parameter, tolsnk, is interpreted as an absolute, dimensional value.

itysnk=1 The sink convergence parameter, tolsnk, is interpreted as a fraction of boat length, xlboat.

itysnk=2 The sink convergence parameter, tolsnk, is interpreted as a fraction of boat length, xlboat, times $0.5 Fr^2$.

itysnk=1 is recommended.

itytrm (columns 21-30) Controls the interpretation of the trim convergence parameter, toltrm.

itytrm=0 The trim convergence parameter, toltrm, is interpreted as an absolute, dimensional value, in degrees.

itytrm=0 is recommended.

icrew (columns 31-40) Selects between the various crew weight models available in ACCPAN.

icrew=0 The crew weight, wcrew, is located so as to create a target SWL condition with level (zero) trim. While underway, crew weight moves fore and aft within limits, crewmn and crewmx, in a further attempt to keep the model at a target trim of zero. Values of crewmn and crewmx are input as absolute x-coordinates.

icrew=1 Operates similar to icrew=0, except values of crewmn and crewmx are input as absolute x-coordinates divided by xlboat.

icrew=2 Currently the same as icrew=0.

icrew=3 Currently the same as icrew=1.

Adding 10 to the above values of icrew modifies the corresponding model, so that the target trim angle underway is no longer zero. Instead, the target value is the trim angle specified in the ACCPAN standard-input data file for each case or, if, there is an existing (or restart) **.fm* force/moment/sink/trim

iteration history file, then the last trim value contained therein becomes the target trim angle.

If the input value of `icrew` is negative, rather than positive, then `crewmn` and `crewmx` limits are ignored, and the crew moves fore and aft without restriction so as to keep the boat level (or at an otherwise specified target trim angle) whilst underway.

`icrew=2` is the recommended crew weight model.

`isail` (columns 41-50) Selects between the various sail force and moment models available in ACCPAN.

`isail=0` No sail force and moment model is used.

`isail=1` Obsolete external sail force and moment model.

`isail=2` An internal sail force and moment model is used, based on the computed drag and side force, and a user specified sail center of effort height. NOTE: computed drag includes viscous drag only if ACCPAN viscous stripping calculations have also been requested (`ivisc`≠0).

`isail=3` Obsolete external sail force and moment model.

`isail=4` Obsolete external sail force and moment model.

`isail=5` An external, user-supplied sail force and moment model is used. The inputs are trim moments and vertical forces, tabulated as a function of boat speed, and as a function of heel, yaw, rudder and tab settings. This model allows independent control of sail vertical force and pitching moment for each test point within a single sail force file.

However, entries for each test point combination of heel, yaw, rudder and tab setting must be present in the sail force file. If more than one boat speed is identified for such settings, the software attempts to bracket the test point boat speed for subsequent linear interpolation. The model fails if there are no entries in the sail force file at the requested heel, yaw, rudder and tab settings and at, or bracketing, the requested boat speed. Except if no entry is found, and the boat speed is zero, then the sail forces are set to zero.

`isail=2` or `isail=5` are the recommended sail force and moment models.

The next line, which is preceded by a comment line, specifies additional sink and trim update control parameters:

`tolsnk` (columns 1-10) Specifies the sink convergence criteria for free to sink-and-trim cases. The specific interpretation of `tolsnk` (absolute, fraction of boat length, etc.) is controlled by the previously input value of `itysnk`.

tolsnk=0.0001 is recommended.

The ITERATION section of the ACCPAN standard input also requires specification of tolsnk. If present, the specifications in the ITERATION section override the value of tolsnk input here.

toltrm (columns 11-20) Specifies the trim convergence criteria, in degrees, for free to sink-and-trim cases.

toltrm=0.005 is recommended.

The ITERATION section of the ACCPAN standard input also requires specification of toltrm. If present, the specifications in the ITERATION section override the value of toltrm input here.

omegas (columns 21-30) Under-relaxation parameter applied to predicted change in sink.

The ITERATION section of the ACCPAN standard input also requires specification of omegas. If present, the specifications in the ITERATION section override the value of omegas input here.

omegat (columns 31-40) Under-relaxation parameter applied to predicted change in trim.

The ITERATION section of the ACCPAN standard input also requires specification of omegat. If present, the specifications in the ITERATION section override the value of omegat input here.

xlams (columns 41-50) Applies an additional reduction to omegas, based on Froude number:

If nside=1: $\text{omegas} \approx \text{omegas} / (1 + \text{xlams} * (\tanh(\text{Fr}))^4)$

If nside=2: $\text{omegas} \approx \text{omegas} / (1 + \text{xlams} * (\tanh(\text{Fr}))^2)$

xlams=1.0 is suggested.

xlamt (columns 41-50) Applies an additional reduction to omegat, based on Froude number:

If nside=1: $\text{omegat} \approx \text{omegat} / (1 + \text{xlamt} * (\tanh(\text{Fr}))^4)$

If nside=2: $\text{omegat} \approx \text{omegat} / (1 + \text{xlamt} * (\tanh(\text{Fr}))^2)$

xlamt=1.0 is suggested.

The next line, which is preceded by a comment line, specifies parameters for the sail force and moment model and for the crew weight model. These are parts of the ACCPAN sink and trim update algorithm. Use of the input sail model parameters in ACCPAN depends upon the user-specified value of isail. Use of the input crew model parameters in ACCPAN depends upon the user-specified value of icrew.

xcsail (columns 1-10) With the model at DWL orientation, specifies the x-coordinate of the sail center of effort.

ycsail (columns 11-20) With the model at DWL orientation, specifies the y-coordinate of the sail center of effort.

- zcsail** (columns 21-30) With the model at DWL orientation, specifies the z-coordinate of the sail center of effort.
- wcrew** (columns 31-40) With the model at DWL orientation, specifies the crew+gear+sails weight to include to determine sink and trim at SWL conditions and whilst underway. Specified as a force, with dimensions such as pound-force or Newton.
- The WEIGHTS input section of the ACCPAN standard input also allows specification of wcrew. If so, the specification in the WEIGHTS input section overrides the value of wcrew input here.
- crewmn** (columns 41-50) With the model at DWL orientation, specifies the x-coordinate of the most forward allowable location of the center of gravity of the crew+gear+sails weight.
- The WEIGHTS input section of the ACCPAN standard input also allows specification of crewmn (as xmin). If so, the specification of xmin in the WEIGHTS input section overrides the value of crewmn input here.
- crewmx** (columns 51-60) With the model at DWL orientation, specifies the x-coordinate of the most aft allowable location of the center of gravity of the crew+gear+sails weight.
- The WEIGHTS input section of the ACCPAN standard input also allows specification of crewmx (as xmax). If so, the specification of xmax in the WEIGHTS input section overrides the value of crewmx input here.

To pin the crew at a specific location, set crewmn=crewmx.

The next line, which is preceded by a comment line, specifies the pathname and filename of a file containing external sail force and moment model parameters.

- sailfn** (columns 1-256) A character string comprising the pathname/filename of the external, user-supplied sail force and moment model file. If, due to the input value of isail, no external sail model file is required, input the 4-character string 'none'.

WEIGHTS Input Section

The first line of this section is indicated by the appearance of the 10-character string '**WEIGHTS**' at the beginning of a line (columns 1-10). The remainder of the line (through column 80) is for comment only and is otherwise ignored.

This optional but highly recommended section allows input of data to control the hydrostatic calculations affecting the DWL, MWL, and SWL flotations (how to calculate, or input of, weight and/or center of gravity for each of: total model, individual model component, crew, sails and gear, ballast, etc.). This data overrides any flotation data specified previously in the GENERAL input section.

The next line, which is preceded by a comment line, specifies the various flotation options selected.

- imwldsp** (columns 1-8) Controls the measurement waterline displacement calculations:
- imwldsp=0 MWL displacement equals DWL displacement.
 - imwldsp=1 MWL displacement by input weights for model components (hull, keel, bulb, wings and rudders).
 - imwldsp=2 MWL displacement by input weight for complete model.
- imwlcg** (columns 9-16) Controls the measurement waterline xcg calculations:
- imwlcg=0 MWL xcg by hydrostatics.
 - imwlcg=1 MWL xcg by input xcg's for model components.
 - imwlcg=2 MWL xcg by input for complete model.
- imwlycg** (columns 17-24) Controls the measurement waterline ycg calculations:
- imwlycg=1 MWL ycg by input ycg's for model components.
 - imwlycg=2 MWL ycg by input for complete model.
- imwzcg** (columns 25-32) Controls the measurement waterline zcg calculations:
- imwzcg=0 MWL zcg by hydrostatics.
 - imwzcg=1 MWL zcg by input zcg's for model components.
 - imwzcg=2 MWL zcg by input for complete model.
- iswldsp** (columns 33-40) Controls the sailing waterline displacement calculations:
- iswldsp=1 SWL displacement equals MWL displacement plus additional user-specified input weights for crew, sails, ballast, and other.
 - iswldsp=2 SWL displacement by input weight for complete model.
- iswlcg** (columns 41-48) Controls the sailing waterline xcg calculations:
- iswlcg=0 SWL xcg by hydrostatics (zero heel, zero trim).
 - iswlcg=1 SWL xcg equals MWL xcg plus additional user-specified input xcg's for crew, sails, ballast, and other.
 - iswlcg=2 SWL xcg by input for complete model.
- iswlycg** (columns 49-56) Controls the sailing waterline ycg calculations:
- iswlycg=1 SWL ycg equals MWL ycg plus additional user-specified input ycg's for crew, sails, ballast, and other.
 - iswlycg=2 SWL ycg by input for complete model.
- iswzcg** (columns 57-64) Controls the sailing waterline zcg calculations:
- iswzcg=0 SWL zcg by hydrostatics (zero heel, zero trim).
 - iswzcg=1 SWL zcg equals MWL zcg plus additional user-specified input zcg's for crew, sails, ballast, and other.
 - iswzcg=2 SWL zcg by input for complete model.
- icrew** (columns 65-72) Specifies the crew weight model option. These options, and corresponding icrew values, are discussed in the GENERAL input section.

The next group of lines, which are preceded by a single comment line, constitute the remainder of the WEIGHTS input section, and specify various flotation parameters:

comp (columns 1-4) A 4-character string that identifies the flotation component to which a line applies. The available character strings, and corresponding flotation components, are:

hull	weight and center of gravity of hull
keel	weight and center of gravity of keel
bulb	weight and center of gravity of bulb
wing	weight and center of gravity of both wings
rudr	weight and center of gravity of aft rudder
frud	weight and center of gravity of forward rudder
mwlt	total weight and center of gravity for complete model at MWL
crew	crew weight and center of gravity at SWL
sail	weight and center of gravity of sails at SWL
ball	weight and center of gravity of ballast at SWL
othr	any additional weight and center of gravity at SWL
swlt	total weight and center of gravity for complete model at SWL

Only those lines containing the flotation parameters required to achieve a desired flotation, as per the flotations options selected on the line preceding this group, need be specified here. An input line, or a parameter on any input line, that is present here but that is not actually required, due to the selected flotation options, will otherwise be ignored by ACCPAN.

The remainder of the line (columns 5-80) contains the associated flotation parameters, in a format-free input:

wght	The weight associated with this flotation component.
xwght	DWL x-coordinate of the associated weight.
ywght	DWL y-coordinate of the associated weight.
zwght	DWL z-coordinate of the associated weight.
xmin	DWL x-coordinate of the most forward allowable location of the center of gravity of the associated weight (for crew weight only).
xmax	DWL x-coordinate of the most aft allowable location of the center of gravity of the associated weight (for crew weight only).

To pin the crew at a specific location, set $xmin=xmax=xwght$.

The WEIGHTS input section is terminated upon encountering an input line denoting the start of the next input section.

STRIPPING Input Section

The first line of this section is indicated by the appearance of the 10-character string `'STRIPPING '` at the beginning of a line (columns 1-10). The remainder of the line (through column 80) is for comment only and is otherwise ignored.

This optional section allows input of data to control the viscous stripping algorithms in ACCPAN.

The next group of lines, which are preceded by a single comment line, constitute the remainder of the STRIPPING input section, and specify various viscous stripping parameters:

comp (columns 1-4) A 4-character string that identifies the model component for which the viscous stripping parameters are to be specified. The available character strings are:

hull
keel
bulb
base bulb base
wing both wings
rudr aft rudder
frud forward rudder

Only those lines containing the viscous stripping parameters required to achieve a desired stripping need be specified here. An input line, or a parameter on any input line, that is present here but that is not actually required, will otherwise be ignored by ACCPAN.

The remainder of the line (columns 5-80) contains the associated viscous stripping parameters, in a format-free input.

jcf Skin friction option for this component. Refer to the section of this manual entitled "Viscous Stripping Options" for the values that may be input for jcf and the corresponding skin friction methodology.

jff Form factor option for this component. Refer to the section of this manual entitled "Viscous Stripping Options" for the values that may be input for jff and the corresponding form factor methodology.

cf If jcf=0, the input value of cf is used.

ff If jff=0, the input value of ff is used.

tonc Applies in conjunction with the bulb form factor option only (jff=4). If the input value of tonc>0.0, then the input value is used for bulb D/L in lieu of an internal ACCPAN calculation for D/L based on the bulb database surface mesh.

The STRIPPING input section is terminated upon encountering an input line denoting the start of the next input section.

NETWORK Input Section

The first line of this section is indicated by the appearance of the 10-character string `'NETWORK'` at the beginning of a line (columns 1-10). The remainder of the line (through column 80) is for comment only and is otherwise ignored.

This section is required and contains the specific details for each panel model component (hull, keel, bulb, wing, rudder(s), and free-surface), including: database mesh file, number of panels, cluster and other component-specific panelization parameters, foil cant angle, and nominal tab and rudder deflection angles.

The next line, which is preceded by a comment line, specifies the pathname of the database directory where the individual model component database mesh files are located. The files must already exist prior to ACCPAN execution.

`netdir` (columns 1-80) The pathname of the database directory.

The next group of lines, which are preceded by a single comment line, constitute the remainder of the NETWORK input section. These lines specify database mesh filenames for each included model component, as well as various panelization parameters. A series of lines are input for each included model component, as follows.

first line

`filnam` (columns 1-80) A character string containing the filename of a model component database mesh file. This file must reside in the database directory `netdir`.

second line

`comp` (columns 1-4) A 4-character string that identifies the model component for which the database filename and panel model parameters are specified. The available character strings are:

hull
keel
bulb
wing both wings
rudr aft rudder
frud forward rudder
surf free-surface

`ispn` (columns 6-10) Used to trigger the SPLASH spanload analysis for this model component. Typically used for the foil type components (keel, wings, rudders).

`ispn=0` No SPLASH spanload analysis for this model component.

`ispn<0` Requests the SPLASH spanload analysis for this model component.

`ispn>0` Requests the SPLASH spanload analysis for this model component. Also requests a yet-to-be-developed SPLASH viscous stripping analysis for this model component. **Not recommended.**

The remaining inputs on this second line vary, depending on the model component for which they are specified, as follows:

hull panel model parameters on second line

- | | | |
|---------------|-----------------|--|
| ioh1 | (columns 11-15) | Number of panel corner points in the I-direction, bow to stern. |
| joh1 | (columns 16-20) | Number of panel corner points in the J-direction, deck sheer line to bottom centerline. |
| ccurv1 | (columns 21-30) | A constant in the formula used to cluster the panel corner points lying along the waterline based on the curvature of the waterline. |
| ccurv2 | (columns 31-40) | A constant in the formula used to cluster the panel corner points lying along the waterline based on the curvature of the waterline. |

ccurv1=3.0 and ccurv2=1.0 are suggested.

Panel corner points lying along the waterline are imagined to be connected, one to the next, by springs. Initially, spring constants are adjusted so as to produce the nominal spacings between points (i.e., without any cluster to curvature). Spring constants are then adjusted based on the amount of curvature along the waterline at each spring location. The updated spring constants are used to arrive at a new waterline point distribution, and updated values of curvature at each point. The spring constants, point distribution, and curvature values are iteratively updated in this fashion, until convergence (i.e., no further changes are predicted). The degree of cluster to curvature is controlled via the adjustments to the spring constants, K:

$$k = k_{\text{nominal}} + (0.5 + 0.5 * s) * \text{ccurv1} * \tanh(\text{ccurv2} * \text{deltas} / \text{crvloc})$$

Here k_{nominal} is the spring constant required to achieve the nominally requested waterline spacing (assuming $k=1.0$ for even spacing), deltas is the local spacing between waterline points, and crvloc is the local waterline curvature. If the input value of ccurv1 and/or ccurv2 is equal to zero, the default value $\text{ccurv1}=1.0$ and/or $\text{ccurv2}=1.0$ is used instead. If the input value of ccurv1 and/or ccurv2 is less than zero, then the value $\text{ccurv1}=0.0$ and/or $\text{ccurv2}=0.0$ is used instead.

The cluster-to-curvature is biased towards the stern. Parameter s is proportional to arclength along the waterline; $s=0.0$ at the bow and $s=1.0$ at the stern.

- | | | |
|--------------|-----------------|--|
| xbfwd | (columns 41-50) | Specifies the distance along the hull mesh from $j=1$ to $j=joh1$ at the bow ($I=1$), expressed as a fraction of waterline beam. |
|--------------|-----------------|--|

The default is xbfwd=0.625

- | | | |
|--------------|-----------------|---|
| xbaft | (columns 51-60) | Specifies the distance along the hull mesh from $j=1$ to $j=joh1$ at the stern ($I=IMAX$), expressed as a fraction of waterline beam. |
|--------------|-----------------|---|

The default is xbaft=0.625

- | | | |
|-----------------|-----------------|---|
| hfactfte | (columns 61-70) | For configurations with a forward rudder, specifies a minimum distance along the hull mesh from $j=1$ to $j=joh1$ at the bow, expressed as a fraction of the distance along the hull mesh from $j=1$ at the bow to the forward rudder trailing edge. This can be used to ensure that the aft end of the hull stem mesh edge extends at least some amount behind the forward rudder trailing edge. |
|-----------------|-----------------|---|

The default is hfactfte=1.1

hfactrle (columns 71-80) For configurations with an aft rudder, specifies a minimum distance along the hull mesh from $j=1$ to $j=j_{ohl}$ at the stern, expressed as a fraction of the distance along the hull mesh from $j=1$ at the stern to the aft rudder leading edge. This can be used to ensure that the forward end of the hull stern mesh edge extends at least some amount in front of the aft rudder leading edge.

The default is hfactrle=1.1

keel panel model parameters on second line

io_{k1} (columns 11-15) Number of panel corner points in the I-direction, leading edge to trailing edge.

jo_{k1} (columns 16-20) Number of panel corner points in the J-direction, root to tip.

scal_{k1} (columns 21-30) A scale factor that can be used to adjust the thickness of the keel near the root. This should be used to thin near the root of a keel whose thickness is so large as to adversely impact the hull or free-surface panelizations. Default value (if input scal_{k1}=0.0 and chdskl=0.0) is scal_{k1}=1.0.

scal_{k1}=0.0 and chdskl=0.0 are recommended.

chdskl (columns 31-40) Thinning of the keel is restricted to the immediate vicinity of the keel root. Changes from the original keel surface to the thinned keel surface are smoothly introduced, starting some spanwise distance away from the root. The spanwise distance is equal to chdskl times the keel root chord. If chdskl=0.0 then the keel root thinning algorithm is deactivated.

scal_{k1}=0.0 and chdskl=0.0 are recommended.

cant_{k1} (columns 41-50) Keel cant angle underway.

dkeel (columns 51-60) Nominal keel or keel tab deflection angle about keel hinge axis. This value is always overridden, by values of dkeel to be specified for individual test points in the DATASET input section to follow.

bulb panel model parameters on second line

io_{bls1} (columns 11-15) Number of panel corner points in the I-direction, bulb nose to keel leading edge.

io_{bls2} (columns 16-20) Number of panel corner points in the I-direction, keel leading edge to keel trailing edge.

io_{bls3} (columns 21-25) Number of panel corner points in the I-direction, keel trailing edge to bulb tail.

jo_{bls1} (columns 26-30) Number of panel corner points in the J-direction, top centerline to maximum half breadth.

jo_{bls2} (columns 26-30) Number of panel corner points in the J-direction, maximum half breadth to bottom centerline.

wing panel model parameters on second line

iowg (columns 11-15) Number of panel corner points in the I-direction, leading edge to trailing edge.

jowg (columns 16-20) Number of panel corner points in the J-direction, root to tip.

aft rudder panel model parameters on second line

iord (columns 11-15) Number of panel corner points in the I-direction, leading edge to trailing edge.

jord (columns 16-20) Number of panel corner points in the J-direction, root to tip.

scalrd (columns 21-30) A scale factor that can be used to adjust the thickness of the rudder near the root. This should be used to thin near the root of a rudder whose thickness is so large as to adversely impact the hull or free-surface panelizations. Default value (if input scalrd=0.0 and chdsrd=0.0) is scalrd=1.0.

scalrd=0.5 and chdsrd=1.5 are suggested.

chdsrd (columns 31-40) Thinning of the rudder is restricted to the immediate vicinity of the rudder root. Changes from the original rudder surface to the thinned rudder surface are smoothly introduced, starting some spanwise distance away from the root. The spanwise distance is equal to chdsrd times the rudder root chord. If chdsrd=0.0 then the aft rudder root thinning algorithm is deactivated.

scalrd=0.5 and chdsrd=1.5 are suggested.

cantrd (columns 41-50) Aft rudder cant angle underway.

drudr (columns 51-60) Nominal aft rudder or rudder tab deflection angle about rudder hinge axis. This value is always overridden, by values of drudr to be specified for individual test points in the DATASET input section to follow.

forward rudder panel model parameters on second line

iofr (columns 11-15) Number of panel corner points in the I-direction, leading edge to trailing edge.

jofr (columns 16-20) Number of panel corner points in the J-direction, root to tip.

scalfr (columns 21-30) A scale factor that can be used to adjust the thickness of the rudder near the root. This should be used to thin near the root of a rudder whose thickness is so large as to adversely impact the hull or free-surface panelizations. Default value (if input scalfr=0.0 and chdsfr=0.0) is scalfr=1.0.

scalfr=0.5 and chdsfr=1.5 are suggested.

chdsfr (columns 31-40) Thinning of the rudder is restricted to the immediate vicinity of the rudder root. Changes from the original rudder surface to the thinned rudder surface are smoothly introduced, starting some spanwise distance away from the root. The spanwise distance is equal to chdsfr times the rudder

root chord. If `chdsfr=0.0` then the forward rudder root thinning algorithm is deactivated.

`scalfr=0.5` and `chdsfr=1.5` are suggested.

- `cantfr`** (columns 41-50) Forward rudder cant angle underway.
- `dfrud`** (columns 51-60) Nominal forward rudder or rudder tab deflection angle about rudder hinge axis. Unlike for the keel and aft rudder, deflection for the forward rudder is not specified in the DATASET input section, and so must be input here.

free-surface panel model parameters on second line

- `iofs`** (columns 11-15) Number of panel corner points in the I-direction, upstream to downstream.
- `jofs`** (columns 16-20) Number of panel corner points in the J-direction, waterline to outer boundary.

additional lines for user-specified panel cluster factors

For each input immediately above and defining the number of panel corner points in the I or J direction on a model component, the user may override the internal default cluster factors used to determine the nominal spacing in that direction on that component, by making the above input the negative of the number of points.

For each such negative value, the input of two additional lines is triggered. These additional lines specify the start cluster factors (columns 1-10) and end cluster factors (columns 11-20) in the I or J direction. The first line gives the cluster factors to apply at the start of the interval, and the second line gives the cluster factors to apply at the end of the interval. For example, consider the following keel-related portion of the NETWORK input section:

```
klbl.net
keel   -1   -2   16
        0.10  1.00
        0.15  0.95
```

Here the -2 indicates that cluster factors are to be specified for the keel component in the I-direction. The cluster factors at the keel root are 0.10 at the leading edge and 1.00 at the trailing edge, and at the keel tip they are 0.15 at the leading edge and 0.95 at the trailing edge.

If the second set of cluster factors, those on the second line, are all zero, ACCPAN will set them equal to the first set of cluster factors, those on the first line.

Cluster factors in effect during ACCPAN program execution are printed to ACCPAN standard output. This is useful for determining the default cluster factors used by ACCPAN. User-specified cluster factors should use the default values as a starting point.

The NETWORK input section is terminated upon encountering an input line denoting the start of the next input section.

ITERATION Input Section

The first line of this section is indicated by the appearance of the 10-character string `'ITERATION'` at the beginning of a line (columns 1-10). The remainder of the line (through column 80) is for comment only and is otherwise ignored.

This optional section controls the maximum number of ACCPAN/SPLASH iterations attempted during automated operations, as well as the values of various update and convergence parameters in effect during each ACCPAN/SPLASH iteration.

The next group of lines, which are preceded by a single comment line, constitute the remainder of the ITERATION input section, and specify various iteration update and convergence parameters. Each line specifies a number of iterations to attempt and the update and convergence parameters in effect during the iterations. On each line, input is format-free.

iterates	Number of iterations to attempt.
iforce	This specification for iforce replaces the value of the environment variable \$IFORCE otherwise used during automated ACCPAN/SPLASH operations. iforce=0 For each test point, ACCPAN/SPLASH iterations will terminate upon convergence of sink and trim and free-surface elevation. iforce=1 ACCPAN/SPLASH iterations continue regardless of convergence. Typically iforce=1 for the first iteration only.
tolyfs	Specifies the convergence criteria for change in nonlinear free-surface elevations. Overrides the value of tolyfs as specified in the GENERAL input section. Refer to the GENERAL input section description for more information.
omegay	Specifies the nominal under-relaxation parameter applied to calculated changes in free-surface elevation. Overrides the value of omegay as specified in the GENERAL input section. Refer to the GENERAL input section description for more information.
tolsnk	Specifies the sink convergence criteria for free to sink-and-trim cases. Overrides the value of tolsnk as specified in the GENERAL input section. Refer to the GENERAL input section description for more information.
omegas	Specifies under-relaxation parameter applied to predicted change in sink. Overrides the value of omegas as specified in the GENERAL input section. Refer to the GENERAL input section description for more information.
toltrm	Specifies the trim convergence criteria for free to sink-and-trim cases. Overrides the value of toltrm as specified in the GENERAL input section. Refer to the GENERAL input section description for more information.
omegat	Specifies under-relaxation parameter applied to predicted change in trim. Overrides the value of omegat as specified in the GENERAL input section. Refer to the GENERAL input section description for more information.

The ITERATION input section is terminated upon encountering an input line denoting the start of the next input section.

DATASET Input Section

The first line of this section is indicated by the appearance of the 10-character string `'DATASET'` at the beginning of a line (columns 1-10). The remainder of the line (through column 80) is for comment only and is otherwise ignored.

This section is required and specifies the dataset directory, and unique identifying names and test conditions for the individual test points. Information for restarting tests based on final results from a previous test for a similar model may also be specified.

The next line, which is preceded by a comment line, specifies the pathname of the dataset directory where the individual test point files for all test points defined in this dataset will be located. This directory must already exist prior to ACCPAN execution.

spldir (columns 1-256) Specifies the pathname to an existing directory where the individual test point files for all test points to be described in this ACCPAN standard-input file will be located.

The next line, which is preceded by a comment line, specifies the pathname of the restart directory where the individual test point files for all restart test points are located. For a successful restart, this directory and its individual test point foils must already exist prior to ACCPAN execution.

resdir (columns 1-256) Specifies the pathname to an existing directory where the restart test point files are located (typically, a spldir from a previous test).

The next group of lines, which are preceded by a single comment line, constitute the remainder of the DATASET input section. These lines specify unique filename identifiers and unique test conditions for each individual test point. Two lines are input for each individual test point, as follows.

first line for each individual test point

fileds (columns 1-256) Specifies a unique character string to identify each individual test point specified. These are combined with predetermined filename extensions to generate the final test point filenames.

resnam (columns 1-256) If making use of restart files, and the restart filename identifier is different than the current test point filename identifier, this specifies the character string identifying the corresponding restart files. The resnam character string should start just after the fileds character string, with the two strings separated by one or more blank spaces between them.

Tests proceed starting with the restart test point results for sink and trim, free-surface elevation, and hydrodynamic force and moment (thus requiring the existing restart test point *.t00, *.p00 and *.fm files)

second line for each individual test point

speed (columns 1-10) Model steady forward speed.

heel	(columns 11-20)	Model heel angle.
yaw	(columns 21-30)	Model yaw (sideslip) angle.
dkeel	(columns 31-40)	Keel or keel tab deflection angle about keel hinge axis. This overrides the value of dkeel specified in the NETWORK input section.
drudr	(columns 41-50)	Aft rudder or rudder tab deflection angle about rudder hinge axis. This overrides the value of drudr specified in the NETWORK input section.
sink	(columns 51-60)	Model sink at center of gravity. For each individual test point, a sink value read from an existing or restart <i>*.fm</i> force/moment/sink/trim iteration history file is used instead of the value specified here (accounting, if necessary, for the difference between sink at the datum point and sink at the center of gravity).
trim	(columns 61-70)	Model trim angle. For each individual test point, a trim value read from an existing or restart <i>*.fm</i> force/moment/sink/trim iteration history file is used instead of the value specified here.

ACCPAN Standard-Output File

The ACCPAN standard-output file includes printout of the following information:

Copyright information and case identifying string.

WEIGHTS section input summary.

STRIPPING section input summary.

Final panel cluster factors for each panel model component.

Component database mesh cell densities and related database characteristics.

Amount of foil (keel or rudder) rotation and translation required to align the foil leading and trailing edges with the hull mesh centerline. Foil root-thinning parameters.

Final computed DWL, MWL and SWL characteristics:

- location of center of gravity (in DWL coordinates)
- location of reference point (in DWL coordinates) for heel and trim transformations
- sink and trim iteration results, final sink and trim displacement
- crew weight and location (in DWL coordinates)
- wetted areas and wetted lengths
- forces and moments due to hydrostatic pressure integration
- change in center of gravity location due to canting of appendages.

Current ACCPAN/SPLASH iteration number and corresponding ITERATION section update parameters.

For each individual test point as specified in the current ACCPAN standard-input file:

- restart or previous iteration force/moment/sink/trim iteration history filename (*.fm)
- restart or previous iteration flow solution filename (*.t00)
- restart or previous iteration developing free-surface elevation filename (*.p00)
- sink and trim iteration results, final sink and trim
- forces and moments due to viscous stripping
- crew location (in DWL coordinates)
- residual results for component elliptic mesh generation algorithms
- residuals of change in free-surface panel and pressure elevations from previous iteration
- convergence results for sink and trim, and nonlinear free-surface shape, and action taken
- output from panel model generation and boundary condition specification algorithms
- new SPLASH input dataset filename
- summary of forces and moments due to sails, hydrostatic pressure, and viscous stripping
- updated force/moment/sink/trim iteration history filename.

Amount of memory storage and execution time required by various program segments, and total execution time.

Force/Moment/Sink/Trim Iteration History File Format

A sample ACCPAN/SPLASH force/moment/sink/trim iteration history file is included below, followed by a detailed description of the format and parameters:

speed	heel	yaw	dkeel	drudr	sink	trim	4
swethl	swetkl		swetbl	swetbb	swetrd		swetwg
xwethl	xxxxxx		xxxxxx	wcrew	xcrew		wxcrew
cfxsl	cfysl		cfzsl	cmxsl	cmysl		cmzsl
cfxst	cfyst		cfzst	cmxst	cmyst		cmzst
cfxvhl	cfyvhl		cfzvhl	cmxvhl	cmyvhl		cmzvhl
cfxvkl	cfyvkl		cfzvkl	cmxvkl	cmyvkl		cmzvkl
cfxvbl	cfyvbl		cfzvbl	cmxvbl	cmyvbl		cmzvbl
cfxvvg	cfyvvg		cfzvvg	cmxvvg	cmyvvg		cmzvvg
cfxvrd	cfyvrd		cfzvrd	cmxvrd	cmyvrd		cmzvrd
cfxvfr	cfyvfr		cfzvfr	cmxvfr	cmyvfr		cmzvfr
cfxcf	cfycf		cfzcf	cmxcf	cmycf		cmzcf
cfxdy	cfydy		cfzdy	cmxdy	cmydy		cmzdy
6.17329	20.00000	4.00000	5.00000	4.00000	-0.05524	-0.27315	4
5.24756E+01	6.99614E+00	6.48255E+00	4.34105E-03	3.35800E+00	1.33385E+00		
1.74690E+01	0.00000E+00	0.00000E+00	1.95000E+04	8.12500E-01	2.76552E+03		
-3.42347E+03	8.69173E+01	5.99670E-03	4.04975E+02	1.59540E+04	-4.37855E+04		
-1.06586E-01	-2.09480E+05	-1.34902E-02	-1.32780E+05	-1.34197E+00	-1.49857E+05		
1.73351E-03	0.00000E+00	1.21218E-04	3.16222E-06	-7.44565E-05	-4.52219E-05		
3.47403E-04	0.00000E+00	2.42928E-05	2.62157E-06	1.31538E-05	-3.74903E-05		
2.85896E-04	0.00000E+00	1.99918E-05	3.98645E-06	2.05107E-05	-5.70089E-05		
6.48209E-05	0.00000E+00	4.53271E-06	9.35721E-07	4.37733E-06	-1.33814E-05		
1.70477E-04	0.00000E+00	1.19210E-05	8.02965E-07	-1.86722E-06	-1.14830E-05		
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00		
2.60210E-03	0.00000E+00	1.81957E-04	1.15089E-05	-3.82819E-05	-1.64586E-04		
4.21862E-03	1.87295E-02	4.49112E-02	5.40128E-03	-3.16919E-03	9.94460E-03		
6.17329	20.00000	4.00000	5.00000	4.00000	0.00556	-0.18090	4
5.63898E+01	6.99614E+00	6.48255E+00	4.34105E-03	3.49831E+00	1.33385E+00		
1.88004E+01	0.00000E+00	0.00000E+00	1.95000E+04	8.12500E-01	2.76552E+03		
-1.31505E+04	2.15308E+04	-5.83802E+04	8.47945E+05	1.00440E+05	-1.53963E+05		
-6.09079E+01	-2.39576E+05	-3.99090E+01	-1.53345E+05	-5.44329E+02	-1.90272E+05		
1.84462E-03	0.00000E+00	1.28988E-04	3.13832E-06	-7.95484E-05	-4.48801E-05		
3.47405E-04	0.00000E+00	2.42929E-05	2.62239E-06	1.31581E-05	-3.75020E-05		
2.85896E-04	0.00000E+00	1.99918E-05	3.98684E-06	2.05172E-05	-5.70146E-05		
6.48208E-05	0.00000E+00	4.53271E-06	9.36529E-07	4.37883E-06	-1.33930E-05		
1.77369E-04	0.00000E+00	1.24028E-05	8.13724E-07	-2.10510E-06	-1.16368E-05		
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00		
2.72011E-03	0.00000E+00	1.90208E-04	1.14978E-05	-4.35994E-05	-1.64426E-04		
4.62374E-03	2.57582E-02	4.64246E-02	5.75681E-03	-2.99833E-03	1.10541E-02		
.
.
.
(intermediate iteration records)							
.
.
.
6.17329	20.00000	4.00000	5.00000	4.00000	0.06882	-0.08220	4
5.75827E+01	6.99614E+00	6.48255E+00	4.34104E-03	3.56618E+00	1.33385E+00		
2.03253E+01	0.00000E+00	0.00000E+00	1.95000E+04	8.12500E-01	2.76552E+03		
-1.42823E+04	2.25237E+04	-6.10359E+04	8.86513E+05	1.07495E+05	-1.67775E+05		
-3.30272E+02	-2.63885E+05	-6.94030E+02	-1.71425E+05	-9.67732E+03	-2.31030E+05		
1.86414E-03	0.00000E+00	1.30353E-04	2.95290E-06	-8.14808E-05	-4.22284E-05		
3.47407E-04	0.00000E+00	2.42931E-05	2.62326E-06	1.31627E-05	-3.75145E-05		
2.85897E-04	0.00000E+00	1.99919E-05	3.98726E-06	2.05241E-05	-5.70204E-05		
6.48207E-05	0.00000E+00	4.53271E-06	9.37393E-07	4.38042E-06	-1.34054E-05		
1.80694E-04	0.00000E+00	1.26353E-05	8.24669E-07	-2.22315E-06	-1.17933E-05		
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00		
2.74296E-03	0.00000E+00	1.91806E-04	1.13255E-05	-4.56368E-05	-1.61962E-04		
5.15666E-03	2.97914E-02	4.75344E-02	6.12098E-03	-2.64535E-03	1.18953E-02		
6.17329	20.00000	4.00000	5.00000	4.00000	0.06903	-0.07761	4

5.75471E+01	6.99614E+00	6.48255E+00	4.34105E-03	3.56624E+00	1.33385E+00
2.03314E+01	0.00000E+00	0.00000E+00	1.95000E+04	8.12500E-01	2.76552E+03
-1.43093E+04	2.25287E+04	-6.10478E+04	8.86685E+05	1.07628E+05	-1.68116E+05
-3.50621E+02	-2.63777E+05	-7.42912E+02	-1.71375E+05	-1.01637E+04	-2.32135E+05
1.86291E-03	0.00000E+00	1.30267E-04	2.94917E-06	-8.14065E-05	-4.21752E-05
3.47407E-04	0.00000E+00	2.42931E-05	2.62330E-06	1.31629E-05	-3.75150E-05
2.85897E-04	0.00000E+00	1.99919E-05	3.98728E-06	2.05244E-05	-5.70207E-05
6.48207E-05	0.00000E+00	4.53271E-06	9.37433E-07	4.38050E-06	-1.34059E-05
1.80697E-04	0.00000E+00	1.26356E-05	8.25197E-07	-2.22319E-06	-1.18009E-05
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
2.74173E-03	0.00000E+00	1.91720E-04	1.13224E-05	-4.55619E-05	-1.61918E-04
5.17664E-03	2.97458E-02	4.75320E-02	6.11952E-03	-2.61355E-03	1.19275E-02

The ACCPAN/SPLASH force/moment/sink/trim iteration history files are input and output by ACCPAN with a filename extension of *.fm. A unique *.fm file is created for each individual test point. The file is used to keep track of various configuration details and flow conditions: sink and trim; wetted areas and lengths; crew and sail weights, forces and moments; hydrostatic forces and moments; viscous forces and moments; and inviscid (wave plus lift-induced) forces and moments. The file consists of a repeating series of records, with a set of lines being appended to the file for each ACCPAN/SPLASH iteration undertaken.

For free-to-sink-and-trim and/or nonlinear free-surface solutions, these files are required for the automated operations to iteratively drive ACCPAN and SPLASH to final (converged) panel models and steady state flow solutions.

The supplied “tabtec” post-processing tool also uses these files: to collate test results; to make "leakage" and other corrections to the results; and to include stripping estimates (either ACCPAN’s viscous force and moment estimates, or the simpler “tabtec” post-processing viscous drag estimates which are based only on computed wetted areas and lengths).

ACCPAN will attempt to create a new *.fm file, including appropriate header lines, if the specified *.fm file does not already exist.

For slightly different models at similar flow conditions, the ability to “restart” tests for a new model using the final results from a previous test for a different model greatly reduces the total computer time required to compute the nonlinear effects and the overall results. This restart capability requires that the *.fm files from the previous test are available.

The number of lines recorded to a *.fm file during each ACCPAN/SPLASH iteration will vary depending on the user-specified value of parameter isavf. To facilitate the general reading and writing of *.fm files by ACCPAN, and by post-processing tools, the value of isavf in effect during each iteration is written to the *.fm file at the end of the first line of results for each iteration. This applies to the header line set as well.

Header Lines

Appropriate header lines will be included by ACCPAN upon creation on a new *.fm file.

In the sample *.fm file, the value of isavf on the first line is 4. The total number of header lines is therefore 13, i.e. the same as the total number of lines of data to be recorded during each ACCPAN/SPLASH iteration when isavf=4.

In general the header lines are counted but their contents are not examined, and so they may contain any character string. Except that the first header line must include the isavf value, to indicate the total number of header lines to be expected when reading the file:

isavf (columns 71-78) Controls usage and update of **.fm* force/moment/sink/trim iteration history files (SPLASH file *tfms*). The value of isavf is also used as the SPLASH standard-input parameter ifmst. Refer to the GENERAL input section of

the ACCPAN standard-input file for more information on isavf input options.

ACCPAN/SPLASH Iteration Data Record Lines

The following set of lines is recorded in the *.fm file during each ACCPAN/SPLASH iteration:

The following line of data is always recorded, by ACCPAN, regardless of the value of isavf:

speed	(columns 1-10)	Model steady forward speed.
heel	(columns 11-20)	Model heel angle.
yaw	(columns 21-30)	Model yaw (sideslip) angle.
dkeel	(columns 31-40)	Keel or keel tab deflection angle about keel hinge axis.
drudr	(columns 41-50)	Aft rudder or rudder tab deflection angle about rudder hinge axis.
sink	(columns 51-60)	Model sink at center of gravity or at datum point.
trim	(columns 61-70)	Model trim (pitch) angle.
isavf	(columns 71-78)	Value of isavf in effect during this ACCPAN/SPLASH iteration.

The following line of data is always recorded, by ACCPAN, regardless of the value of isavf:

swth1	(columns 1-13)	Wetted surface area of hull database (below the as-paneled free-surface).
swtk1	(columns 14-26)	Wetted surface area of keel database.
swtb1	(columns 27-39)	Wetted surface area of bulb database.
swtbb	(columns 40-52)	Wetted surface area of bulb base.
swtrd	(columns 53-65)	Wetted surface area of aft rudder database (below the as-paneled free-surface).
swtwg	(columns 66-78)	Wetted surface area of wing database.

The following line of data is always recorded, by ACCPAN, regardless of the value of isavf:

xweth1	(columns 1-13)	Wetted length of hull database (in x, at the as-paneled free-surface).
xxxxxx	(columns 14-26)	Reserved for future use.
xxxxxx	(columns 27-39)	Reserved for future use.
wcrew	(columns 40-52)	Crew weight.

xcrew (columns 53-65) Longitudinal location of crew weight.
wxcrew (columns 66-78) Pitching moment about the center of gravity due to crew weight.

The following line of data is always recorded, by ACCPAN, regardless of the value of isavf:

cfxs1 (columns 1-13) Sail force on model in x-direction (positive aft).
cfys1 (columns 14-26) Sail force on model in y-direction (positive down).
cfzs1 (columns 27-39) Sail force on model in z-direction (positive to starboard).
cmxs1 (columns 40-52) Moment about x-axis at model center of gravity due to sail forces (positive rolling deck to port).
cmys1 (columns 53-65) Moment about y-axis at model center of gravity due to sail forces (positive yawing bow to starboard).
cmzs1 (columns 66-78) Moment about z-axis at model center of gravity due to sail forces (positive pitching bow up).

The following line of data is always recorded, by ACCPAN, regardless of the value of isavf:

cfxst (columns 1-13) Hydrostatic force on wetted databases in x-direction (positive aft).
cfyst (columns 14-26) Hydrostatic force on wetted databases in y-direction (positive down).
cfzst (columns 27-39) Hydrostatic force on wetted databases in z-direction (positive to starboard).
cmxst (columns 40-52) Moment about x-axis at model center of gravity due to hydrostatic forces (positive rolling deck to port).
cmyst (columns 53-65) Moment about y-axis at model center of gravity due to hydrostatic forces (positive yawing bow to starboard).
cmzst (columns 66-78) Moment about z-axis at model center of gravity due to hydrostatic forces (positive pitching bow up).

The following line of data is recorded by ACCPAN when ivisc=-1 and the value of isavf is 3, 4, 103 or 104:

cfxvh1 (columns 1-13) Viscous force on wetted hull in x-direction (positive aft).
cfyvh1 (columns 14-26) Viscous force on wetted hull in y-direction (positive down).
cfzvh1 (columns 27-39) Viscous force on wetted hull in z-direction (positive to starboard).

- cmxvh1** (columns 40-52) Moment about x-axis at model center of gravity due to hull viscous forces (positive rolling deck to port).
- cmylvh1** (columns 53-65) Moment about y-axis at model center of gravity due to hull viscous forces (positive yawing bow to starboard).
- cmzvh1** (columns 66-78) Moment about z-axis at model center of gravity due to hull viscous forces (positive pitching bow up).

The following line of data is recorded by ACCPAN when ivisc=-1 and the value of isavf is 3, 4, 103 or 104:

- cfxvk1** (columns 1-13) Viscous force on keel in x-direction (positive aft).
- cfyvk1** (columns 14-26) Viscous force on keel in y-direction (positive down).
- cfzvk1** (columns 27-39) Viscous force on keel in z-direction (positive to starboard).
- cmxvk1** (columns 40-52) Moment about x-axis at model center of gravity due to keel viscous forces (positive rolling deck to port).
- cmylvk1** (columns 53-65) Moment about y-axis at model center of gravity due to keel viscous forces (positive yawing bow to starboard).
- cmzvk1** (columns 66-78) Moment about z-axis at model center of gravity due to keel viscous forces (positive pitching bow up).

The following line of data is recorded by ACCPAN when ivisc=-1 and the value of isavf is 3, 4, 103 or 104:

- cfxvb1** (columns 1-13) Viscous force on bulb in x-direction (positive aft).
- cfyvb1** (columns 14-26) Viscous force on bulb in y-direction (positive down).
- cfzvb1** (columns 27-39) Viscous force on bulb in z-direction (positive to starboard).
- cmxvb1** (columns 40-52) Moment about x-axis at model center of gravity due to bulb viscous forces (positive rolling deck to port).
- cmylvb1** (columns 53-65) Moment about y-axis at model center of gravity due to bulb viscous forces (positive yawing bow to starboard).
- cmzvb1** (columns 66-78) Moment about z-axis at model center of gravity due to bulb viscous forces (positive pitching bow up).

The following line of data is recorded by ACCPAN when ivisc=-1 and the value of isavf is 3, 4, 103 or 104:

- cfxvvg** (columns 1-13) Viscous force on wings in x-direction (positive aft).

cfyvvg	(columns 14-26)	Viscous force on wings in y-direction (positive down).
cfzvvg	(columns 27-39)	Viscous force on wings in z-direction (positive to starboard).
cmxvvg	(columns 40-52)	Moment about x-axis at model center of gravity due to wing viscous forces (positive rolling deck to port).
cmyvvg	(columns 53-65)	Moment about y-axis at model center of gravity due to wing viscous forces (positive yawing bow to starboard).
cmzvvg	(columns 66-78)	Moment about z-axis at model center of gravity due to wing viscous forces (positive pitching bow up).

The following line of data is recorded by ACCPAN when *ivisc*=-1 and the value of *isavf* is 3, 4, 103 or 104:

cfxvrd	(columns 1-13)	Viscous force on wetted aft rudder in x-direction (positive aft).
cfyvrd	(columns 14-26)	Viscous force on wetted aft rudder in y-direction (positive down).
cfzvrd	(columns 27-39)	Viscous force on wetted aft rudder in z-direction (positive to starboard).
cmxvrd	(columns 40-52)	Moment about x-axis at model center of gravity due to aft rudder viscous forces (positive rolling deck to port).
cmyvrd	(columns 53-65)	Moment about y-axis at model center of gravity due to aft rudder viscous forces (positive yawing bow to starboard).
cmzvrd	(columns 66-78)	Moment about z-axis at model center of gravity due to aft rudder viscous forces (positive pitching bow up).

The following line of data is recorded by ACCPAN when *ivisc*=-1 and the value of *isavf* is 3, 4, 103 or 104:

cfxvfr	(columns 1-13)	Viscous force on wetted forward rudder in x-direction (positive aft).
cfyvfr	(columns 14-26)	Viscous force on wetted forward rudder in y-direction (positive down).
cfzvfr	(columns 27-39)	Viscous force on wetted forward rudder in z-direction (positive to starboard).
cmxvfr	(columns 40-52)	Moment about x-axis at model center of gravity due to forward rudder viscous forces (positive rolling deck to port).
cmyvfr	(columns 53-65)	Moment about y-axis at model center of gravity due to forward rudder viscous forces (positive yawing bow to starboard).
cmzvfr	(columns 66-78)	Moment about z-axis at model center of gravity due to forward rudder viscous forces (positive pitching bow up).

The following line of data reports viscous forces and moments acting on the total model. If `ivisc=-1`, this line of data is recorded by ACCPAN based on ACCPAN's viscous stripping results. If `ivisc≠-1`, this line of data will instead be zero-filled by SPLASH. Refer to the GENERAL input section of the ACCPAN standard-input file for more information on `ivisc` input options.

- cfxcf** (columns 1-13) Viscous force on wetted databases in x-direction (positive aft).
- cfycf** (columns 14-26) Viscous force on wetted databases in y-direction (positive down).
- cfzcf** (columns 27-39) Viscous force on wetted databases in z-direction (positive to starboard).
- cmxcf** (columns 40-52) Moment about x-axis at model center of gravity due to viscous forces (positive rolling deck to port).
- cmycf** (columns 53-65) Moment about y-axis at model center of gravity due to viscous forces (positive yawing bow to starboard).
- cmzcf** (columns 66-78) Moment about z-axis at model center of gravity due to viscous forces (positive pitching bow up).

The following line of data is always recorded, by SPLASH, regardless of the value of `isavf`.

- cfxdy** (columns 1-13) Hydrodynamic force on paneled model in x-direction (positive aft).
- cfydy** (columns 14-26) Hydrodynamic force on paneled model in y-direction (positive down).
- cfzdy** (columns 27-39) Hydrodynamic force on paneled model in z-direction (positive to starboard).
- cmxdy** (columns 40-52) Moment about x-axis at model center of gravity due to hydrodynamic forces (positive rolling deck to port).
- cmydi** (columns 53-65) Moment about y-axis at model center of gravity due to hydrodynamic forces (positive yawing bow to starboard).
- cmzdy** (columns 66-78) Moment about z-axis at model center of gravity due to hydrodynamic forces (positive pitching bow up).

The following line of data is recorded, by SPLASH, when the value of `isavf` is 101, 102, 103 or 104.

- cfxwl** (columns 1-13) Hull waterline integral force in x-direction (positive aft).
- cfywl** (columns 14-26) Hull waterline integral force in y-direction (positive down).
- cfzwl** (columns 27-39) Hull waterline integral force in z-direction (positive to starboard).
- cmxwl** (columns 40-52) Moment about x-axis at model center of gravity due to hull waterline integral forces (positive rolling deck to port).

- cm_{ywl}** (columns 53-65) Moment about y-axis at model center of gravity due to hull waterline integral forces (positive yawing bow to starboard).
- cm_{zwl}** (columns 66-78) Moment about z-axis at model center of gravity due to hull waterline integral forces (positive pitching bow up).

Database Mesh File Format

The format of an ACCPAN database mesh file is similar to that for a SPLASH panel model network. The following is an example of the file format (annotated with mesh index values in parentheses):

```

  61    61          hull
-1.12965279E+01 -1.56499517E+00  0.00000000E+00      (i=1, j=1)
-1.11074696E+01 -1.55840492E+00  6.71336353E-02      (i=2, j=1)
-1.09009190E+01 -1.55119884E+00  1.40225664E-01      (i=3, j=1)
.
.
.
  1.07883759E+01 -1.21342444E+00  1.55561352E+00      (i=IMAX-2, j=1)
  1.10032635E+01 -1.21336198E+00  1.51222837E+00      (i=IMAX-1, j=1)
  1.11999998E+01 -1.21331334E+00  1.47239876E+00      (i=IMAX, j=1)
-1.12719765E+01 -1.51636553E+00  0.00000000E+00      (i=1, j=2)
-1.10828552E+01 -1.51046801E+00  6.65112957E-02      (i=2, j=2)
-1.08767958E+01 -1.50231051E+00  1.38413921E-01      (i=3, j=2)
.
.
.
  1.07874718E+01 -1.16361439E+00  1.51838064E+00      (i=IMAX-2, j=2)
  1.10023890E+01 -1.16532612E+00  1.47577167E+00      (i=IMAX-1, j=2)
  1.11999998E+01 -1.16720486E+00  1.43673158E+00      (i=IMAX, j=2)
-1.12472982E+01 -1.46780276E+00  0.00000000E+00      (i=1, j=3)
-1.10579147E+01 -1.46432364E+00  6.62729964E-02      (i=2, j=3)
-1.08516283E+01 -1.45511413E+00  1.37233689E-01      (i=3, j=3)
.
.
.
  1.07883759E+01 -1.21342444E+00 -1.55561352E+00      (i=IMAX-2, j=JMAX)
  1.10032635E+01 -1.21336198E+00 -1.51222837E+00      (i=IMAX-1, j=JMAX)
  1.11999998E+01 -1.21331334E+00 -1.47239876E+00      (i=IMAX, j=JMAX)

```

The first line of the database mesh file specifies the mesh size and an identifying character string:

```

imax    (columns 1-5)    Maximum value of mesh i-index.

jmax    (columns 6-10)   Maximum value of mesh j-index.

title   (columns 20-80)  Identifying character string.

```

The remainder of the file specifies the x-, y- and z-coordinates of each point on the mesh, one such set of coordinates per line. The points are ordered with i varying from 1 to IMAX, first at j=1, then at j=2, and so on, through to the end of the surface at j=JMAX. Coordinate values are specified using a format-free input:

```

x                Mesh point x-coordinate.

y                Mesh point y-coordinate.

z                Mesh point z-coordinate.

```

External Sail Model File Format

The use of an external sail force and moment model file is requested by the user by setting the value of input parameter isail equal to 5. The following is an example of the file format:

```

PACT sail model 3 (ACCPAN sail model isail=5)
      xcg      ycg      zcg
0.66095  0.00000  0.00000
number of points
      54
speed, m/s  cmz, N-m  cyf, N  heel  yaw  rudder  tab
0.00000    0.        0.      0.00  0.00  0.00    0.00
2.05776   -9803.      0.      0.00  0.00  0.00    0.00
3.08665  -13558.      0.      0.00  0.00  0.00    0.00
4.11553  -25652.      0.      0.00  0.00  0.00    0.00
4.62997  -40872.      0.      0.00  0.00  0.00    0.00
5.14441  -63812.      0.      0.00  0.00  0.00    0.00
5.65885  -93844.      0.      0.00  0.00  0.00    0.00
6.17329 -129923.      0.      0.00  0.00  0.00    0.00
7.20217 -209586.      0.      0.00  0.00  0.00    0.00
8.23106 -271948.      0.      0.00  0.00  0.00    0.00
0.00000    0.        0.     10.00  0.00  0.00    0.00
2.05776   -9654.      0.     10.00  0.00  0.00    0.00
3.08665  -13352.      0.     10.00  0.00  0.00    0.00
4.11553  -25263.      0.     10.00  0.00  0.00    0.00
4.62997  -40251.      0.     10.00  0.00  0.00    0.00
5.14441  -62843.      0.     10.00  0.00  0.00    0.00
6.17329 -127949.      0.     10.00  0.00  0.00    0.00
0.00000    0.        0.     10.00  0.00  0.00    5.00
4.11553  -25263.      0.     10.00  0.00  0.00    5.00
4.62997  -40251.      0.     10.00  0.00  0.00    5.00
5.14441  -62843.      0.     10.00  0.00  0.00    5.00
6.17329 -127949.      0.     10.00  0.00  0.00    5.00
0.00000    0.        0.     10.00  2.00  2.00    5.00
4.11553  -26463.     1434.    10.00  2.00  2.00    5.00
4.62997  -41770.     1815.    10.00  2.00  2.00    5.00
5.14441  -64719.     2241.    10.00  2.00  2.00    5.00
6.17329 -130651.    3226.    10.00  2.00  2.00    5.00
0.00000    0.        0.     10.00  4.00  4.00    5.00
4.11553  -30065.     2868.    10.00  4.00  4.00    5.00
4.62997  -46329.     3630.    10.00  4.00  4.00    5.00
5.14441  -70347.     4481.    10.00  4.00  4.00    5.00
6.17329 -138755.    6453.    10.00  4.00  4.00    5.00
0.00000    0.        0.     20.00  0.00  0.00    0.00
2.05776   -9212.      0.     20.00  0.00  0.00    0.00
3.08665  -12741.      0.     20.00  0.00  0.00    0.00
4.11553  -24105.      0.     20.00  0.00  0.00    0.00
4.62997  -38407.      0.     20.00  0.00  0.00    0.00
5.14441  -59964.      0.     20.00  0.00  0.00    0.00
6.17329 -122088.      0.     20.00  0.00  0.00    0.00
0.00000    0.        0.     20.00  0.00  0.00    5.00
4.11553  -24105.      0.     20.00  0.00  0.00    5.00
4.62997  -38407.      0.     20.00  0.00  0.00    5.00
5.14441  -59964.      0.     20.00  0.00  0.00    5.00
6.17329 -122088.      0.     20.00  0.00  0.00    5.00
0.00000    0.        0.     20.00  2.00  2.00    5.00
4.11553  -25251.     2824.    20.00  2.00  2.00    5.00
4.62997  -39857.     3575.    20.00  2.00  2.00    5.00
5.14441  -61754.     4413.    20.00  2.00  2.00    5.00
6.17329 -124666.    6355.    20.00  2.00  2.00    5.00
0.00000    0.        0.     20.00  4.00  4.00    5.00
4.11553  -28688.     5649.    20.00  4.00  4.00    5.00
4.62997  -44207.     7149.    20.00  4.00  4.00    5.00
5.14441  -67125.     8826.    20.00  4.00  4.00    5.00
6.17329 -132399.   12710.    20.00  4.00  4.00    5.00

```

The first line contains any identifying character string:

The next line, which is preceded by a comment line, specifies the model center of gravity location (in DWL coordinates) about which the sail moments are to be specified. Currently these values are ignored, and instead the input sail moments are assumed to be specified about the current configuration center of gravity as determined by ACCPAN during final flotation. The values are specified using a format-free input:

xcgs1	Sail model file DWL x-coordinate of center of gravity.
ycgs1	Sail model file DWL y-coordinate of center of gravity
zcgs1	Sail model file DWL z-coordinate of center of gravity

The next line, which is preceded by a comment line, specifies the number of test point conditions at which sail forces and moments will be specified. The value is specified using a format-free input:

nsail	Number of test point conditions at which sail forces and moments will be specified.
--------------	---

The remainder of the file, which is preceded by a single comment line, specifies the test point conditions and corresponding sail vertical forces and pitching moments, one test point to each line. The values are specified using a format-free input:

usail	Test point forward speed.
cmzsfm	Pitching moment about model center of gravity due to sail forces.
cfysfm	Vertical force (in y-direction) on model due to sail forces.
sailh	Test point heel angle.
saily	Test point yaw or sideslip angle.
sailr	Test point aft rudder deflection angle.
sailt	Test point keel tab deflection angle.

This allows completely independent control of sail vertical force and pitching moment at each test point.

Appropriate entries for each test point combination of speed, heel, yaw, rudder and tab setting must be present in the sail force and moment file. The model fails if there are no entries in the sail force file at the requested test point heel, yaw, rudder and tab settings and at, or bracketing, the requested test point boat speed (the force and moment at a bracketed speed will be found by linear interpolation). However, if the boat speed is zero and no appropriate entries are located, then the sail force and moment are set to zero.

Program Execution

This section describes overall ACCPAN program execution on a UNIX or Linux operating system. All command lines and shell scripts use a csh shell syntax. The user's PATH environment variable should point to one or more directories containing the ACCPAN and SPLASH executables, and other supplied job control script files (so that just the executable or script filename can be used, without needing to specify a pathname).

Flotation-Only Operation (IFLOAT=-1)

If the user sets ifloat=-1 in the GENERAL input section, then ACCPAN will only compute the static flotations at the DWL, MWL and SWL conditions. The DATASET input section of the ACCPAN standard input file is not processed, and no SPLASH panel models are generated.

The following steps demonstrate how to run ACCPAN for flotation-only operation.

- 1) Change directory to the subdirectory containing the ACCPAN standard input files (the *.dat files). Separate input files are typically used for each test point speed sweep.
- 2) Copy one of the standard input files, giving it a new name such as "float.dat". Edit "float.dat" and set ifloat=-1.
- 3) Ensure that the database mesh directory and database mesh files, as specified in the ACCPAN standard-input files, are available.
- 4) Run ACCPAN using the following command at a csh command line input prompt:

```
accpan < float.dat >& float.accout
```

This may execute for several seconds, or minutes. Upon normal termination this will return the user to a new command line input prompt.

- 5) The resulting ACCPAN standard output file "float.accout" contains the output from ACCPAN, and this may be edited or viewed to examine the flotation-only results.

Stand-Alone Operation (IAUTO=0)

If the user sets iauto=0 in the GENERAL input section, then ACCPAN will operate in stand-alone mode. Do not set ifloat=-1.

The following steps demonstrate how to run ACCPAN for stand-alone operation.

- 1) Change directory to the subdirectory containing the ACCPAN standard input files (the *.dat files). Separate input files are typically used for each test point speed sweep.
- 2) Ensure that the database mesh directory and database mesh files, as specified in the ACCPAN standard-input files, are available.

- 3) Ensure that the external sail force and moment model file, if specified in the ACCPAN standard-input files, is available.
- 4) Ensure that the dataset directory, as specified in the ACCPAN standard-input file, exists. If appropriate, ensure that any iteration history files (*.fm), flow solution files (*.tii) and developing free-surface elevation files (*.pii) from a previous iteration are present in the dataset directory.
- 5) Ensure that the restart directory, if specified in the ACCPAN standard-input file, exists. Ensure that any iteration history files (*.fm), flow solution files (*.tii) and developing free-surface elevation files (*.pii) from a previous test for another model at the same test conditions, as specified in the ACCPAN standard-input file, are present in the restart directory.
- 6) Run ACCPAN using the following command at a csh command line input prompt:

```
accpan < r20r03.dat >& r20r03.accout
```

In the above, the string “r20r03” should be replaced so that it refers to the user’s intended standard input file (for example, accpan < userfile.dat >& userfile.accout).

Use “>>&” rather than “>&” to append output to an existing *.accout file rather than overwriting it.

This may execute for several seconds, or minutes. Upon normal termination this will return the user to a new command line input prompt.

- 7) The resulting ACCPAN standard output file “r20r03.accout” contains the output from ACCPAN, and this may be edited or viewed to examine the results.
- 8) ACCPAN will also have generated new SPLASH standard input files (*.gii), and new or updated iteration history files (*.fm) and developing free-surface elevation files (*.pii), for each individual test point specified in the standard input file. The individual test point files will all be located together in the specified dataset directory.

Depending on user options, and convergence levels for model sink and trim and nonlinear free-surface wave panel elevation, test point files for any individual test point may not be created or updated if an already converged solution is detected.

Fully Automated Operation (|IAUTO|=2)

If the user sets |iauto|=2 in the GENERAL input section, then ACCPAN will operate in fully automated mode. Do not set ifloat=-1.

Fully automated ACCPAN/SPLASH operations typically require the use of top-level job control csh script files designed specifically for this purpose. A standard set of job control files include **qsub_csh**, ***.qjob** and ***.exec** files. Some of these files are supplied as is. Others can be generated using our auxiliary test setup software. Some are generated by ACCPAN itself.

Using the aforementioned job control files, the fully automated ACCPAN/SPLASH operations proceed. ACCPAN standard input files are processed, one at a time from start to finish, through the iterative ACCPAN/SPLASH calculations. During each iteration, results for each test point specified in the input file are advanced one step (ACCPAN generates a new panel model, and SPLASH generates a new flow solution).

Execution of ACCPAN itself in fully automated mode ($|iauto|=2$) is very similar to that in stand-alone mode ($iauto=0$). Furthermore, using the aforementioned job control files, ACCPAN is able to:

- query the system for an existing temporary directory, **\$TMPDIR**, from which SPLASH can be executed (SPLASH input and output files for individual test points will be copied to and from this directory as required);
- determine the current ACCPAN/SPLASH iteration number, **\$ITERAC**;
- create or update the SPLASH panel model data for each test point;
- generate a script file with all the commands needed to run SPLASH for each test point;
- track the convergence status of the iterative calculations for each test point, and cease ACCPAN/SPLASH operations for those points for which calculations have converged (unless **\$IFORCE** is not zero).

The environment variables **\$TMPDIR**, **\$ITERAC** and **\$IFORCE** are set by the job control files. When $|iauto|=2$, ACCPAN will query the system for their values. If they are not defined, at all, or incorrectly, ACCPAN behavior during execution can be unpredictable. Using the standard set of job control files during fully automated ACCPAN/SPLASH operations ensures that these environment variables are properly defined. The value of **\$IFORCE** may be overridden by the user inputting values of “iforce” in the ITERATION section of the ACCPAN standard input file.

The **qsub_csh** batch job submittal script file provides the user a mechanism to submit a shell script command file to the standard UNIX/Linux queue system for batch job execution. The **qsub_csh** script sets additional environment variables in the batch job execution shell, including:

- **\$QSUB_WORKDIR**: the name of the directory from which the **qsub_csh** command is invoked. Since this is the directory from which ACCPAN will ultimately be executed, it should be the directory in which the ACCPAN standard input files are located.
- **\$TMPDIR**: the name of a unique temporary directory created automatically by **qsub_csh** for each batch job submission. The submitted shell script command file starts executing in this directory. This directory is erased at the end of job execution. This directory is the one from which SPLASH will ultimately be executed.

The **accpan-and-splash.exec** automated operations script file is the main driver script for the automated ACCPAN/SPLASH operations. This script processes the ACCPAN standard input files, one at a time from start to finish, through the iterative ACCPAN/SPLASH calculations.

The **accpan-and-splash.exec** script assumes that the ACCPAN standard input files are in directory **\$QSUB_WORKDIR** (from which it will execute ACCPAN), and that SPLASH should be run in directory **\$TMPDIR** (SPLASH input and output files for individual test points will be copied to and from this directory as required). These environment variables must be previously defined, which will be the case if the **qsub_csh** script is used to initiate operations.

The **accpan-and-splash.exec** script controls the ACCPAN/SPLASH iterative process. By setting additional environment variables, it is able to communicate to ACCPAN the current iteration number, **\$ITERAC**, and an option flag, **\$IFORCE**, indicating the action ACCPAN should take upon detecting convergence of the calculations for a specified test point (if **\$IFORCE** is zero, cease operations; otherwise, continue the calculations anyway). In **accpan-and-splash.exec**, defaults are set for the maximum number of iterations allowed (9999) and for **\$IFORCE** (zero, except during the first iteration). However these defaults are overridden by the user-specified iteration data in the **GENERAL** input section of the ACCPAN standard input file.

In fully automated mode, ACCPAN creates and updates two additional control files.

The first additional file, **accpan.data**, is a running list of the individual test points for which the calculations have not yet converged. It will normally be fully populated with all the test points during the first iteration. During subsequent iterations, if calculations at a test point have converged, that point is deleted from the list and no further processing for that point will occur (except if **\$IFORCE** is not zero, in which case the calculations continue despite convergence). If the list becomes empty, then calculations for all specified test points have converged.

The second additional file, **splash.exec**, is a script file with all the commands needed to run SPLASH once for each individual test point (in the ACCPAN standard input file) for which calculations have not yet converged. These commands include those needed to copy SPLASH input and output files for individual test points to and from the **\$TMPDIR** directory as required.

The additional files **accpan.data** and **splash.exec** are created in the **\$TMPDIR** directory. The files are updated by ACCPAN at the beginning of each ACCPAN/SPLASH iteration.

To implement fully automated ACCPAN/SPLASH operations using the standard job control files, create another script file, the model test control file (e.g., **sample.qjob**), which calls the **accpan-and-splash.exec** script once for each ACCPAN standard input file, and then submit the model test control file to the batch job submittal script file **qsub_csh** at the command line:

```
qsub_csh sample.qjob
```

Note that the only job control script file that the user must supply is the model test control file (e.g., **sample.qjob**).

It is possible to run ACCPAN with `|iauto|=2` and independent of the job control script files. It is still necessary to have the system environment variables properly defined in the shell in which ACCPAN itself will run. The following shows one possible way to set these environment variables, at the command line:

```
setenv ITERAC 1 ; setenv IFORCE 1 ; setenv TMPDIR .
```

It is then possible to run ACCPAN at the command line, similar to running it in stand-alone mode, but with ACCPAN operating in fully automated mode.

Sample Batch Job Submittal Script File (**qsub_csh**)

```
#!/bin/bash  
#
```

```

# set USEDIR environment variable to pathname of scratch directory
#
USEDIR=/home1/tmp
#
# set SHELL environment variable to pathname of scratch directory
#
SHELL=/bin/bash
#
export USEDIR
echo 'HOMDIR=`pwd`' > $USEDIR/$$tmp
echo 'export HOMDIR' >> $USEDIR/$$tmp
echo 'TMPDIR=$USEDIR/qsub$$' >> $USEDIR/$$tmp
echo 'export TMPDIR' >> $USEDIR/$$tmp
echo 'QSUB_HOME=$HOME' >> $USEDIR/$$tmp
echo 'export QSUB_HOME' >> $USEDIR/$$tmp
echo 'QSUB_SHELL=$SHELL' >> $USEDIR/$$tmp
echo 'export QSUB_SHELL' >> $USEDIR/$$tmp
echo 'QSUB_PATH=$PATH' >> $USEDIR/$$tmp
echo 'export QSUB_PATH' >> $USEDIR/$$tmp
echo 'QSUB_LOGNAME=$LOGNAME' >> $USEDIR/$$tmp
echo 'export QSUB_LOGNAME' >> $USEDIR/$$tmp
#echo 'QSUB_MAIL=$MAIL' >> $USEDIR/$$tmp
#echo 'export QSUB_MAIL' >> $USEDIR/$$tmp
#echo 'QSUB_TZ=$TZ' >> $USEDIR/$$tmp
#echo 'export QSUB_TZ' >> $USEDIR/$$tmp
echo 'QSUB_WORKDIR=`pwd`' >> $USEDIR/$$tmp
echo 'export QSUB_WORKDIR' >> $USEDIR/$$tmp
echo 'echo -----' >>
$USEDIR/$$tmp
echo 'date' >> $USEDIR/$$tmp
echo 'echo Job Submitted from $HOMDIR' >> $USEDIR/$$tmp
echo 'echo Job Started in $TMPDIR' >> $USEDIR/$$tmp
echo 'echo -----' >>
$USEDIR/$$tmp
echo 'mkdir $TMPDIR' >> $USEDIR/$$tmp
echo 'cd $TMPDIR' >> $USEDIR/$$tmp
cat $1 >> $USEDIR/$$tmp
echo 'cd $HOMDIR' >> $USEDIR/$$tmp
echo '/bin/rm -rf $TMPDIR' >> $USEDIR/$$tmp
echo 'echo -----' >>
$USEDIR/$$tmp
echo 'date' >> $USEDIR/$$tmp
echo 'echo -----' >>
$USEDIR/$$tmp

# use one of the following lines for batch command execution
#
#batch -s < $USEDIR/$$tmp
batch < $USEDIR/$$tmp
#batch -q Z < $USEDIR/$$tmp
#
# use the following two lines for interactive execution
#
#chmod gu+rx $USEDIR $USEDIR/$$tmp $TMPDIR
#$USEDIR/$$tmp

```

```
/bin/rm $USEDIR/$$tmp
```

```
#cd $HOME/nextcase/files      # uncomment to submit next job  
#qsub_csh sample.qjob         # when this one finishes
```

Sample ACCPAN/SPLASH Model Test Control File (e.g., **sample.qjob**)

```
#!/bin/csh  
#  
accpan-and-splash.exec r00a00  
accpan-and-splash.exec w00a00  
accpan-and-splash.exec r10a00  
accpan-and-splash.exec w10a00  
accpan-and-splash.exec r10r01  
accpan-and-splash.exec r10r02  
accpan-and-splash.exec r10r03  
accpan-and-splash.exec r20a00  
accpan-and-splash.exec w20a00  
accpan-and-splash.exec r20r01  
accpan-and-splash.exec r20r02  
accpan-and-splash.exec r20r03
```

Sample ACCPAN/SPLASH Automated Operations Script File (**accpan-and-splash.exec**)

```
#!/bin/csh  
#  
# *****  
#  
# Preliminary setup ...  
#  
# Batch job submittals should have $TMPDIR set to a  
# system-determined job-specific directory.  
#  
# If necessary, set $TMPDIR here.  
#  
#setenv TMPDIR=/usr/var/tmp  
#  
cd $TMPDIR  
#  
# Set YACHT to main subdirectory (eg $QSUB_WORKDIR)  
#  
set YACHT = "$QSUB_WORKDIR"  
#  
# Set CASE to prefix of accpan dataset filename (eg ku)  
#  
set CASE = "$*"   
#  
# Set itermx to maximum number of accpan/splash iterations  
#  
set itermx = 9999  
#  
# Set ifirst, value of iforce during first iteration (eg 1 or 0)  
# Set iafter, value of iforce after first iteration (eg 0 or 1)
```

```

#
set ifirst = 0
set iafter = 0
#
# *****
#
# Do each $YACHT/$CASE case of interest
#
foreach yacht ($YACHT)
  foreach case ($CASE)
#
# *****
#
# Top of accpan/splash iteration loop
#
    rm accpan.data
    rm splash.exec
    @ ITERAC = 0
    topiterac:
    @ ITERAC = $ITERAC + 1
    if ( $ITERAC == 1 ) then
      set IFORCE = $ifirst
    else
      set IFORCE = $iafter
    endif
    if ( $ITERAC <= $itermx ) then
      set ITERAC = $ITERAC
#
# *****
#
# Run ACCPAN
#
    cd $yacht
    setenv IFORCE $IFORCE
    setenv ITERAC $ITERAC
    accpan < $yacht/$case.dat >>& $yacht/$case.accout
    cd $TMPDIR
    if ( -e ./accpan.data == 0 || \
        -z ./accpan.data != 0 ) then
      goto enditerac
    endif
#
# Check for SPLASH executions
#
    if ( -e ./splash.exec == 0 || \
        -z ./splash.exec != 0 ) then
      goto enditerac
    endif
    chmod u+x ./splash.exec
#
# Run SPLASH
#
    ./splash.exec
#
    if ( -e ./splash.stop ) then
      rm ./splash.exec

```

```

        rm ./splash.stop
        goto enditerac
    endif
#
# *****
#
# Erase splash.exec and go to next iteration
#
        rm ./splash.exec
        goto topiterac
#
# *****
#
# This iteration finished
#
        endif
        enditerac:
        rm accpan.data
#
# *****
#
# All $YACHT/$CASE cases of interest finished
#
        end
end

```

Sample accpan.data file

```

r20000r03
r20080r03
r20120r03

```

Sample splash.exec file

```

#!/bin/csh

cd $QSUB_WORKDIR
if ( -e $TMPDIR/pxxfs ) then
    /bin/rm -rf $TMPDIR/pxxfs
endif
/bin/cp ../r20r03/r20000r03.fm $TMPDIR/tfms
/bin/cp ../r20r03/r20000r03.g00 $TMPDIR/input
if ( -f ../r20r03/r20000r03.p00 ) then
    /bin/cp ../r20r03/r20000r03.p00 $TMPDIR/pxxfs
endif
cd $TMPDIR
splash_cw < input >& output
cd $QSUB_WORKDIR
/bin/cp $TMPDIR/tfms ../r20r03/r20000r03.fm
if ( -e $TMPDIR/pxxfs ) then
    /bin/rm -rf $TMPDIR/pxxfs
endif
/bin/cp $TMPDIR/output ../r20r03/r20000r03.d00
/bin/cp $TMPDIR/tecout ../r20r03/r20000r03.t00
/bin/mv $TMPDIR/spanload ../r20r03/r20000r03.100

```

```

#! /bin/csh

cd $QSUB WORKDIR
if ( -e $TMPDIR/pxxfs ) then
  /bin/rm -rf $TMPDIR/pxxfs
endif
/bin/cp ../r20r03/r20080r03.fm $TMPDIR/tfms
/bin/cp ../r20r03/r20080r03.g00 $TMPDIR/input
if ( -f ../r20r03/r20080r03.p00 ) then
  /bin/cp ../r20r03/r20080r03.p00 $TMPDIR/pxxfs
endif
cd $TMPDIR
splash_cw < input >& output
cd $QSUB WORKDIR
/bin/cp $TMPDIR/tfms ../r20r03/r20080r03.fm
if ( -e $TMPDIR/pxxfs ) then
  /bin/rm -rf $TMPDIR/pxxfs
endif
/bin/cp $TMPDIR/output ../r20r03/r20080r03.d00
/bin/cp $TMPDIR/tecout ../r20r03/r20080r03.t00
/bin/mv $TMPDIR/spanload ../r20r03/r20080r03.100

#! /bin/csh

cd $QSUB WORKDIR
if ( -e $TMPDIR/pxxfs ) then
  /bin/rm -rf $TMPDIR/pxxfs
endif
/bin/cp ../r20r03/r20120r03.fm $TMPDIR/tfms
/bin/cp ../r20r03/r20120r03.g00 $TMPDIR/input
if ( -f ../r20r03/r20120r03.p00 ) then
  /bin/cp ../r20r03/r20120r03.p00 $TMPDIR/pxxfs
endif
cd $TMPDIR
splash_cw < input >& output
cd $QSUB WORKDIR
/bin/cp $TMPDIR/tfms ../r20r03/r20120r03.fm
if ( -e $TMPDIR/pxxfs ) then
  /bin/rm -rf $TMPDIR/pxxfs
endif
/bin/cp $TMPDIR/output ../r20r03/r20120r03.d00
/bin/cp $TMPDIR/tecout ../r20r03/r20120r03.t00
/bin/mv $TMPDIR/spanload ../r20r03/r20120r03.100

```

Licensing Information

ACCPAN software contains a UNIX workstation node-locked licensing feature. To obtain a valid license file password key, do the following.

1. On the workstation for which a license is to be supplied, run the "sbsinfo" program supplied by South Bay Simulations. This will output the required workstation information.
2. E-mail the output of the sbsinfo program to South Bay Simulations (brosen@panix.com), and a corresponding license file password key will be generated.
3. Enter the supplied license file password key on a separate line in the license file. The default license file is **\$HOME/sbs/license.sbs**. The user may override the default filename by assigning the desired filename to the environment variable **\$SBS_FILE** prior to running ACCPAN.

Suggested Reading

Rosen, B.S., Laiosa, J.P. and Davis, W.H., "CFD Design Studies for America's Cup 2000," AIAA Paper 2000-4339, Aug. 2000.

Rosen, B.S. and Laiosa, J.P., "SPLASH Nonlinear and Unsteady Free-Surface Analysis Code for Grand Prix Yacht Design," 13th Chesapeake Sailing Yacht Symposium, Annapolis, Jan. 1997.

Rosen, B.S., Laiosa, J.P., Davis, W.H. and Stavetski, D., "SPLASH Free-Surface Flow Code Methodology for Hydrodynamic Design and Analysis of IACC Yachts," 11th Chesapeake Sailing Yacht Symposium, Annapolis, Jan. 1993.

Boppe, C.W., Rosen, B.S., Laiosa, J.P. and Chance, B., Jr., "Stars and Stripes '87: Computational Flow Simulations for Hydrodynamic Design," 8th Chesapeake Sailing Yacht Symposium, Annapolis, Mar. 1987.

DeBord, F., Jr., Reichel, J., Rosen, B. and Fassardi, C., "Design Optimization for the International America's Cup Class," Transactions of the 2002 SNAME Annual Meeting, Boston, Sep. 2002.

Reichel, J., Pugh, J., Rosen, B. and DeBord, F., Jr., "Grand Prix Yacht Design with the Aid of Computational and Experimental Techniques," Yacht Vision '94 International Yacht Design Symposium, Auckland, Feb. 1994.

Maskew, B., "Program VSAERO: A Computer Program for Calculating the Non-linear Aerodynamic Characteristics of Arbitrary Configurations," NASA CR-166476, Dec. 1982.

Dawson, C.W., "A Practical Computer Method for Solving Ship-Wave Problems," The Proceedings, 2nd International Conference on Numerical Ship Hydrodynamics, Berkeley, Sep. 1977.

Teeters, J.R., "Refinements in the Techniques of Tank Testing Sailing Yachts and the Processing of Test Data," 11th Chesapeake Sailing Yacht Symposium, Annapolis, Jan. 1993.