[#] [$] [K] Foil section | Setup

The **Setup** command allows you to edit the arrays of points of upper and lower sides of the profile.

Menu command:

- **Foil**
  - New - makes a new profile.
  - Open - opens a previously saved profile.
  - Save - saves a current profile.
  - Save as ...- saves a current profile with another filename.
  - Parameters - displays the following parameters of the profile form: chord, thickness, curvature, area and moment of inertia of area about the horizontal axes going through the center of gravity.
- **Table**
  - New - makes a new table for profile (X upper, Y upper, X lower, Y lower).
  - Edit - displays a currently edited profile in a tabular form (X upper, Y upper, X lower, Y lower).
  - Import - makes a table from external ASCII file.
- **Edit**
  - Reflect - reflects a currently edited profile with respect to the trailing edge and chord
  - Scale chord - multiplies all abscises of the current profile on a stretch factor.
  - Shift X (Y) – shifts all abscises (ordinates)
  - Set profile on 0-0 – sets leading and trailing edges of the profile on line Y=0.
  - Radius - sets (if need be) nose radius of profile.
  - Slat - sets slat for current profile. You need to set length of slat (in percent) and angle of slat (degrees).
  - Flap - sets flap for current profile. You need to set length of flap (in percent) and angle of flap (degrees).
- **Window -** contains Window related command such as Tile and Cascade
- **Help -** Help topic

Each profile window contains two lists of coordinates for the upper and lower sides of the profile, browser of the current profile and control buttons:

- **Add point** - adds a point to the end of the list.
- **Delete point** - deletes a selected point.
- **Insert point** - inserts a point into the list before selected.
- **Change point** - changes an abscissa and / or ordinate of a selected point.
- **Reflect on ...** - conversion of the form of the profile: all points of the current side are reflected on the opposite one. It is useful for design of symmetric profiles.
- **Stretch Y** - multiplies all ordinates of the current side on a stretch factor. This option allows to change thickness of the profile, and also obtain a plane side if stretch factor is equal to zero.

Maximal number of points on each side is equal to 100.

The selected points in lists of coordinates of the upper and lower sides are displayed in a browser by red color. The meanline (red) and thickness line(violet)are also displayed in a browser.

Note: All profile files must be placed into subdirectory ARF.

The comment: the meanline and the thickness line are drawn up with the spline - approximation, which can be not accurate near the profile corners. This spline - approximation is used then in calculations. For elimination of these errors, it is recommended to increase number of source points on the profile and to increase their concentration near the edges. To estimate the above mentioned error, please look at the gray line, which corresponds to the spline approximation.

[#] Airfoil_Change

[$] Foil section | Setup

[K] Foil section setup

$ K Configuration

The **Configuration** command allows you to create a wing configuration or to edit an existing wing configuration. The wing of finite span consist of one or several parts. Each part is set by root foil section and tip foil section located arbitrary in space. Their position and length of chord are defined by two points, the first point coincides with leading edge, and the second one coincides with trailing edge of the profile.

Menu commands:

- **Configuration**
  - **New** – creates a new configuration (lifting or planing).
  - **Open** – opens a previously saved configuration.
  - **Import** – import of ship hull configuration (planing) from external file format.
    - *Fast Ship* (*.dxf) - import of ship hull configuration (planing) from dxf-format. Number of planing parts sets by user. Planing parts must be a different colour.
  - **Save** – saves a current configuration.
  - **Save as ...** – saves a current configuration with another filename.
  - **Print** – prints currently edited configuration.
- **Edit**
  - **Copy configuration** – copies entire currently edited configuration into memory.
  - **Paste configuration** – inserts configuration stored in memory into the currently edited configuration.
- **Window -** contains Window related command such as Tile and Cascade
- **Help -** Help topic

The editor window contains the list of parts of wing configuration, set of browsers, where the current part is indicated by red colour, control buttons and switches:

- **Add part** - adds a new part in the given configuration.
- **Delete part** - deletes selected part.
- **Transform** - this command allows to shift a selected part along one of coordinate axes, and also to turn it around an axis determined by two points.
- **Area of the configuration** – this command calculates an area of the configuration and area of the selected part.
- **To memory** - copy the selected part to memory.
- **From memory** - restore previously saved part into the selected part.
- **Reflect** - reflect the selected part with respect to the plane of symmetry into a new part.

The browser contains 6 buttons for rotation of the configuration about coordinate axis and 3 buttons for zooming current configuration in or out.

PopUp Menu Command:

- **Rendering:** - changes view of the configuration. Default selection is “surface”.
- **Surface** - switches between “surface” / ”wireframes” displaying of a wing surface.
- **Lattice** - switches on/off displaying of a vortex lattice on configuration (only in “wireframe” mode).
- **View:**- changes a projection of configuration in a browser. This enables direct selection of the most common plot orientations.
- **Isometry:** - changes isometric projections of configuration in a browser.
- **Axonometry** – changes view to default axonometric projection.
- **Show triad** - switches on/off displaying of global system of coordinates.
- **Show grid lines** - switches on/off displaying of a grid lines in X-Z plane. The intervals between lines are equal 1.
- **Center on origin** – set origin of the global system of coordinates into screen center.

Maximal number of parts in configuration is equal to 200, maximal number of panels in configuration is equal to 50000. Total number of the panels is showed also in editor window.

Config_Setup
$ Config Setup
K Configuration setup

The recommendations for discretization of lifting surfaces:
All lifting elements are set in global right system of coordinates, the plane OXZ is parallel to the undisturbed free surface. The following requirements should be taken into account:

1) It is necessary to control, that the lifting elements do not lie in a vortex wake behind a foregoing lifting elements. The case shown in the Figure is incorrect:
{bmlt Auto0000.BMP}
If it is necessary to perform calculation of such configuration, the latter should be divided into lifting elements as shown:
{bmlt Auto0001.BMP}
The case shown below can arise, for example, for a wing with a flap:
{bml Auto0002.BMP}
Such configuration should be divided into lifting elements as follows:
{bmlt Auto0003.BMP}
Thus, the number M (Parameters of the vortex lattice) should be the same for the lifting elements, moving one behind another.

2) The lifting elements must be docked on chords. The such configuration is incorrect:
{bmlt Auto0004.BMP}
The vertical element should be truncated from below:
{bmlt Auto0005.BMP}

Comments:

- The strut will be automatically truncated from above, if its height is more than a wing submergence. It is recommended to set the strut height to be a little more, than the submergence of the wing.
- The plane Z=0 should be the symmetry plane for the case of every symmetric wing configuration. Set the wing configuration close to the plane Z=0, when the ship is unsymmetric. Hereby you will reduce costs of the wave surface computation.
- It is necessary to keep in mind, that the coordinates of planing parts are set in the global system of coordinates, in which coordinates of a submersed lifting wing are set.
- The rule of selection of M and N should be the following: It is advisable, that the vortex lattices are correlated at contact lines between different surfaces. The surfaces, adjacent along a span, should have the same M, surfaces, surface adjacent along a chord, should have the same N.
- For calculations of a viscous problem the M should be not less than 2, for an inviscid problem M can be arbitrary.
- It is necessary to set the planing part in position “Angle of pitch of ship is equal to zero”.
- The chords of a planing part should be parallel to the plane of symmetry.
- The trailing edge of a planing part should be below than the leading one.
- Please set the chord of every planing surface so long as it is in reality including part of the planing surface, located out of water.
- It is not important what chord is chosen as a tip chord, and what is the root one. The program will arrange chords automatically. The root chord will be chosen to be closer to the plane of symmetry, and the tip one is the farther chord. In case of the vertical strut the tip chord will be located above the root one. The mismatch with expected wing configuration caused by this automatic transformation is possible in some cases. Please advise yourself with the software developer or solve this problem yourself changing the root chord for the tip one.
- In the case of a wing with inverted profiles it is necessary to set inverted profiles in Foil section | Setup
- Setting a planing surface, please note that the planing surface can be consists of only two steps, each of each consists of different lifting elements. The number of these elements is not restricted. The first step is always the foregoing step, the second step (or group) lies in the wake of the first one. The leading edges of every lifting element of the second step should be lie behind the trailing edges of all lifting elements of the first step (see Figure below)

{bmlt Auto0006.BMP}

- Please, don’t forget, that the wetted area of a planing surface is calculated. The leading edge of a wetted surface is assumed to be rectilinear. If it is expected , that the wetted surface has a sufficiently curvilinear leading edge, please divide the planing surface in some longitudinal planing strips placed along the span.

- Every longitudinal strip can have a curvilinear profile set in the menu point Foil section | Setup. The profile should be thin. Please note, that software recognizes automatically what surface is the planing surface and what surface is the part of hydrofoil. The key of recognition is the submergence of the leading edge of the surface under consideration. Every planing surface should have the leading edge located out of water. It means that the Y-ordinates of the leading-edge points set in the menu point **Correct part** should be more than the submergence given in the **Calculation**.
- The interceptor function can only be applied to the simple (not stepped) planing hull. The interceptor is mounted at the trailing edge of the planing hull and its span is assumed to be equal to the total span of the hull.
- There are two possibilities for calculating wing configurations under a roll angle. First, one can rotate the wing configuration to a given roll angle using the commands of the Menu Configuration. Save the rotated configuration as a new configuration and then calculate it. Second, one can specify the roll angle in the Menu Calculate directly. **Note** that in both cases the forces and moments will be calculated in different coordinate systems in which the configurations are specified. They are shown in Figure below for a simple wing.

{bmlt Auto0021.BMP}

[#] [$] [+] [K] Calculate hydrofoil part | Single.

This command performs single calculation of a submersed lifting system (*.WIN). The input data are as follows:

- **Configuration file** - Name of file with wings geometry. The file should be created using the menu command **Configuration**. The file has the extension [.WIN]. Please use the button **Load** to load already existing wing configurations.
- **Output file** - Name of file with results of the calculations. Do not set the extension of this file! A directories will be created in this calculation. The name of the created directory is formed from the name of the wing configuration under investigation.
- **Symmetry of the wing system** - This parameter is only for the lateral motion. When the wing configuration is symmetric, please set up only the right half of the wing configuration. The left half of the wing configuration will be added automatically. It does not play any role if you set Symmetry for the case of longitudinal motion.
- **Longitudinal motion** - This parameter is only for the longitudinal motion
- **Characteristic size** - The reference size (usually averaged aerodynamic chord).
- **Characteristic area** - The reference area.
- **Submergence** - Depth of submergence measured above the origin of coordinates system.
- **Roughness** - Roughness of the wing system in meter.
- **Kinematic viscosity** - Coefficient of the kinematic viscosity.
- **Deflection** - Deflection angle of the wing configuration. This parameter is very convenient to set different angles of attack for the planing surface and hydrofoil.
- **Pitch** - Pitch angle of the wing configuration.
- **Drift** - Drift angle of the wing configuration.
- **Roll** - Roll angle of the wing configuration.
- **Yaw** - Yaw angular velocity of the wing configuration. Strictly speaking Yaw is the dimensionless angular velocity = Angular velocity/Speed*Characteristic Length
- **Vessel speed** - Vessel's speed.
- **Turbulence rate** - The turbulence rate of the upstream given in percent (between 0 and 2). This parameter is only for viscid/inviscid interaction.
- **Relaxation coef**. - The coefficient relaxing the iterative technique of the viscid/inviscid interaction. The value of parameters lies in the range from 0 to 0.5. This parameter is only for viscid/inviscid interaction.
- **Temperature** - Water temperature needed to indicate the cavities.
- **Wave parameters** - Set of the wave parameters

In a case of calculation of planing surface (stepped bottom) you need to set following parameters:
Schema parameters

- **Permissible relative error for lift R** - The wetted area and lift Y of planing surfaces are calculated iteratively. If Abs(Y_i-Y_i-1)/(Y_i+0.000001)*100. < R, the iteration process is complete. Here **i** is the number of iteration.
- **Minimum Number of Iterations** - You can select the minimum number of iterations needed for calculation of the wetted area and lift Y of the planing surfaces.
- **Permissible error for ordinate of the wetted area -** The error of calculations of the ordinates of the wetted area.
- **Permissible error for abscissa of the wetted area B -** If the span of a planing strip is less than B, the strip is eliminated. If the chord of a planing strip is less than B, the chord is set being equal to B. Increase this parameter when execution of the program Autowing failed !

There are two variants of the calculation of a wing system with account for the free surface waves:

1. Inviscid flow - potential flow. The viscous drag (both the pressure drag and the friction drag) is calculated using recommendations from the paper K.L. Kirkman and J.W. Kloetzli, Scaling Problems of Model Appendages, Proc. of Nineteenth General Meeting of the American Towing Tank Conference, 1980, Vol. 1, pp. 129-154.

[#] Calculate
[$] Calculate
[+] Group0002:0000
[K] Calculate hydrofoil part. Single

2. Viscous flow - The viscosity is taken into account using the iterative procedure based on the viscid/inviscid flow interaction theory.

The menu command **Large Froude** provides the calculation of the hydrofoil at large Froude number (Fn>4.5). The deformation of the free surface is not considered. The input data are the same as in the case of the wing moving at arbitrary Froude numbers.

Designation of the angles of a wing system

{bmlt Auto0007.BMP}

[#] [$] [+] [K] Result | View result.

The **View result** command is intended to display results of calculation, including input data, time of calculation both of a lifting and a planing surfaces, pressure distribution on a lifting and planing systems, and also coefficients of hydrodynamic forces and moments on a lifting and planing surfaces and their parts. Forces on interceptor and hydrostatic forces are also presented. The hydrostatic forces and forces on interceptor are calculated by empirical methods of TSAHI .

The MSAR corrected pressure means the pressure corrected with use of Method of Matched Asymptotic Expansion (MAE). This correction is necessary to get a more accurate solution near the leading edge. According to the MAE method the full solution is divided into the outer solution (far from the leading edge) and the inner solution which is valid close to the leading edge. The flow around a parabola is applied as the inner solution. The outer solution is obtained using the Vortex Lattice Method. Both solutions are matched.

The printing of results and their export to a text file are possible.

Comment: all moment are calculated with respect to the origin of the global coordinates system.

[#] Result_View
[$] Result View
[+] Group0003:0000
[K] Text results

$ + K Result | Pressure distribution 3D.

This command is intended for displaying pressure coefficient distribution on a lifting and planing systems. The view of pressure consists of three windows: in the window *Preview,* the selected part of configuration is mapped. Six buttons are presented in the same window to rotate a symbol located at the lower left corner of the window. This symbol indicated a current position of coordinates system consists of three coordinate axes and a cube. In a window *Pressure distribution* the following control components are presented:

- **Configuration parts** - list of all calculated parts of configuration, including planing parts (if were), and also the full combination of parts both of a lifting system and planing system (if were). The keypress on a selected rotated part returns it in the initial position.
- **Detail** - selection of a detail level of pressure imaging. At *Low* level, the pressure distribution will be piecewise constant, as it is obtained in calculation. *High* level- corresponds to imaging with smoothing. The rotation of the image at the *High* level requires very large operating system resources.
- **Show cavities** - displays by white colour a zone, where the pressure coefficient is less than or equal to the cavitation number multiplied on a reserve coefficient.
- **Reserve coef.** - changes a reserve factor for calculation of zones of the cavitation (by default 0.85).
- **Set scale** - sets a number of colour gradation (by default 20) and limits of numerical values of displayed pressure coefficient (by default [min P, max P]).

The current correspondence between colours and values of the pressure coefficient is mapped in the window *Legend*.

The MSAR corrected pressure means the pressure corrected with use of Method of Matched Asymptotic Expansion (MAE). This correction is necessary to get a more accurate solution near the leading edge. According to the MAE method the full solution is divided into the outer solution (far from the leading edge) and the inner solution which is valid close to the leading edge. The flow around a parabola is applied as the inner solution. The outer solution is obtained using the Vortex Lattice Method. Both solutions are matched.

The distributions of the drag coefficient, thickness of the boundary layer and loading on a wing are shown similarly.

Result_Pressure
$Result Pressure
+Group0003:0001
K Pressure distribution 3D

[#] [$] [+] [K] Result | 2D result.

This command is intended for imaging results of calculation of a 2D problem. The results are mapped as the plot of pressure coefficient distribution. The digital data for pressure coefficient, the lift and moment coefficient are also shown.
The dependencies of the lift and moment coefficients versus serial parameter are mapped for the case of the serial calculations.
Note: Moment coefficients calculated about a trailing edge.

[#] Result_Pressure2D
[$] Result Pressure2D
[+] Group0003:0005
[K] Pressure distribution 2D

[#] [$] [+] [K]Result | Wave surface.

This command shows a perturbed wave surface behind a hydrofoil or behind a planing surface. It is possible to select a side view or rear view. The third coordinate is mapped by colour (see window *Legend*). The imaging of wing configuration can be switched on/off .

[#] Result_Wave
[$]Result Wave
[+]Group0003:0002
[K] Wave surface

[#] [$] [+] [K]Result | Vortex surface.

This command shows a vortex wake behind a wing. It is possible to select a side view or rear view. Each vortex is indicated by the colour. The imaging of wing configuration can be switched on/off .

[#] Result_Sled
[$]Result Sled
[+]Group0003:0004
[K] Vortex surface

[#] [$] [+] [K]Result | Vortex distribution.

This command shows the intensity of the trailing vortices shed from the trailing edge of the wing system. The positive intensity is marked by red colour, negative - by dark blue. The size of colour circles is proportional to the vortex intensity. The values of maximum and minimum vortices are presented.

[#] Result_Vortex
[$]Result Vortex
[+]Group0003:0003
[K] Vortex distribution

[#] [$] [+] [K]Roughness.

Setting of a mean square roughness (K, in meter).

The experimental data on the roughness for hydrofoils are absent. For practical application it is possible to use the following formulae:

$K = K_b / 5$

The data for ships:

K_b = 70 - 230 micron (fresh painted)
K_b =100 - 300 micron (at the beginning of maintenance)
K_b =300 - 400 micron (long maintenance)
6 months : K/K_0=1.2
12 months : K/K_0=1.5
14 months : K/K_0=2.0

If the data absent you can use the following value: K = Kfreshpaint = 40 micron

The data for propellers:

K = 30 microns (launch condition)
K = 0 microns (smooth), if the screw is made according to special advanced technology and launch had been made without delay.

The data for wings of planes(aircrafts):

K_b <5 micron(1 class)
K_b =5-15 micron (2 class)
K_b >15 micron (3 class, old planes(aeroplanes), chord up to 1.5 м)

The approximating formulae:

K_b =90+160*X+95*X*(X+1)+26.7*X*(X-1)*(X+1) (carbon steel)
K_b =2.7*X+3.5 (stainless steels)
X=t/6, t - time of maintenance in months

The data for models:

K_b =10-20 micron (polished metal)
K_b =3-8 micron (paraffin)
K_b =10-15 micron (painted wood)

[#] Roughness
[$]Roughness
[+]Group0002:0005
[K] Roughness

$ + K Calculate 2D | Single.

This command is intended to perform the calculation of potential flow around a profile. The calculation is made by the panel method with piecewise linear vortex distribution. The input data are as follows:

- **Output file** - Name of the file with results. The file has the [.PRF] extension and will be placed into [\2Dresult] dir.
- **Airfoil file** - Name of the file containing the information with profile geometry. The files, created in the Airfoil menu with the [.ARF] extension are suitable for calculation of 2D problems.
- **Surface type** - selection of type of calculation: unlimited flow, ground effect, the free surface at large Froude number.
- **Height** - Height of flight or depth of submergence measured from the trailing. It is nondimensionalized with respect to the chord. The value of the **Height** should be positive.
- **Angle of attack** - angle of attack of a profile.
- **Approximation function** - Selection of methods for profile approximation. If the total number of profile points is less than 40, it is recommended to use spline - approximation, otherwise, if this number is more than 40 use piecewise linear approximation.

In a case of Airfoil stability calculation you need to set a variation of pitch angle and height of flight and the position of the center of gravity measured from the trailing edge.

Calculate2d
$ Calculate2d
+ Group0002:0007
K Calculate 2D. Single

$ + K Wave parameters.

This command is intended to set parameters of calculation of the free wave surface. The input data are as follows:

- **Initial abscissa...** - Abscissa X of the free surface computational domain. It is recommended to set X to be equal to abscissa of the leading edge of hydrofoil plus two or more of hydrofoil’s averaged aerodynamic chords (AAC).
- **Size of wave panel** - Size of the wave panel on the free surface computational domain. It should be less than or equal to half of AAC.
- **Span of the wave panel system** -Lateral size (along the Z-axis) of the free surface computational domain. It should be not less than 2.5 of the maximum positive Z-coordinate of the wing configuration. Usually, the maximum positive Z-coordinate of the wing configuration is equal to its semi-span.
- **Length of the wave panel system** -Longitudinal size (along the X-axis) of the free surface computational domain. This positive value should be more than or equal to distance between leading edge of the hydrofoil and trailing edge of the planing surface plus five AAC.
- **Number of iterations** - Number of iterations needed for the calculation of the free surface. According to our experience it should be value lying between 50 and 70. This parameter should be chosen on the base of preliminary systematic comparative calculations for every wing configuration.
- **Number of first iteration** - This parameter is introduced to reduce the costs of calculations. You can use data of calculations you already performed for similar wing configuration with same wave parameters. For that you should set the number of first iteration not equal to 1 and name of file with prototype’s calculation. The full number of iteration will be equal to the Number of iterations minus this value. When the number of the first iteration is equal to 1, the undisturbed free surface will be chosen for the first iteration. This opportunity is provided only for the potential flow calculation.
- **Name of non-zero wave surface** - Name of file with prototype’s calculation (see the foregoing command). Please use the button **Load.**
- **Nonlinearity** - Choose of the nonlinear or linear theory for calculation of the free surface waves. When the nonlinear theory does not converge, please, use the linear theory.

Recommendations for the case of a planing wing:

- **Initial abscissa...** - For the case of a planing wing (both simple planing and stepped bottom) the value of the initial abscissa should be more than the maximum abscissa of the leading edge of the planing surface.
- **Size of wave panel** - For the case of a simple planing wing, this parameter is rather formal. You can take it as, say, the semi-span divided by 3 or 4. For the case of a planing wing with the stepped bottom, the size of wave panel is equal to the length of the wave panels on the computational domain which represents the wave surface behind the step. The parameter should be chosen from experience of calculations performed for your planing configuration. You can take it as, say, the semi-span divided by 4.
- **Length of the wave panel system** - For a planing wing (both simple planing and stepped bottom), the length should be a little more than the maximum length of the planing surface.
- **Number of iterations to calculate the wake behind the planing surface** - Number of iterations needed for the calculation of the free surface behind the step. According to our experience it should be value about 50. This parameter should be chosen on the base of preliminary systematic comparative calculations for each planing configuration.

Wave_parameters
$ Wave parameters
+ Group0002:0006
K Wave parameters

$ + K Calculate planing part / Calculate stepped bottom after hydrofoil

This command is intended to set parameters of calculation of a planing surface with stepped bottom. The parameters are as follows:

General

- **Configuration file** - File name with extension [.WIN] containing the name of the planing surface (with or without stepped bottom) moving behind the hydrofoil. Please use the button **Load.**
- **Output file** - File name with results of calculation of the wing configuration consisting of the characteristics for the foregoing hydrofoil and the planing surface.
- **Hydrofoil output file** - File name with results of calculation of the foregoing hydrofoil in which wake the planing surface moves. It is necessary to use the button **Load.**

Schema parameters

- **Permissible relative error for lift R** - The wetted area and lift Y of planing surfaces are calculated iteratively. If Abs(Y_i-Y_i-1)/(Y_i+0.000001)*100. < R, the iteration process is complete. Here **i** is the number of iteration.
- **Minimum Number of Iterations** - You can select the minimum number of iterations needed for calculation of the wetted area and lift Y of the planing surfaces.
- **Permissible error for ordinate of the wetted area -** The error of calculations of the ordinates of the wetted area.
- **Permissible error for abscissa of the wetted area B -** If the span of a planing strip is less than B, the strip is eliminated. If the chord of a planing strip is less than B, the chord is set being equal to B. Increase this parameter when execution of the program Autowing failed !

Very important

Please note, that

calculation of the planing surface with a stepped bottom is possible for the longitudinal motion only. Calculation of the simple planing surface (without any step) is possible both for the lateral and longitudinal motions.

Calculate_planning_part

$ Calculate planning part

+ Group0002:0004

K Calculate planning part

$ + K Calculate 2D | Serial.

This command is intended for the serial calculations of potential flow around wing profile near the ground , under the free surface at large Froude number and out of air-water interface influence. The panel method with piecewise distributed vorticity is applied. The following parameters should be given:

- **Variable** - The serial parameter which is changed in the serial calculations. It can be either angle of attack or depth of submergence (height of flight).
- **First** - Initial value of the serial parameter.
- **Step** - Step of parameter's variation.
- **Last** - Final value of the serial parameter.
- **Const** - The kinematic parameter which will be constant in the serial calculations.
- **Surface type** - Selection of the type of calculation. Three types of calculation are provided: calculation of a wing section near the ground, the calculation of a submersed wing section (large Froude numbers) and wing section located far from the water surface (under or above).
- **Approximation function** - Selection of the method of profile approximation. When the number of points described the profile contour is less than 40, please use the spline-approximation. Otherwise, please, use the method of piecewise linear approximation.
- **Output file** - Name of file with results of the calculations. Default extension is [.PRF]. Results will be placed into [\2Dresult] dir.
- **Airfoil file** - Name of file with profile geometry. The file should be created using the menu command **Foil Section**. The file has the extension [.ARF].

Calculate2ds
$ Calculate2ds
+ Group0002:0008
K Calculate 2D. Serial

[#] [$] [K] [+] Calculate airfoil part | Single.

This command provides a single calculation of a wing configuration in ground effect. The parameters of calculation are as follows:

- **Configuration file** - Name of file with wings geometry. The file should be created using the menu command **Configuration**. The file has the extension [.WIN]. Please use the button **Load** to load already existing wing configurations.
- **Output file** - Name of file with results of the calculations. Do not set the extension of this file ! A directories will be created in this calculation. The name of the created directory is formed from the name of the wing configuration under investigation.
- **Symmetry of the wing system** - This parameter is only for the lateral motion. When the wing configuration is symmetric, please set up only the right half of the wing configuration. The left half of the wing configuration will be added automatically. It does not play any role if you gave Symmetry for the case of longitudinal motion.
- **Longitudinal motion** - This parameter is only for the longitudinal motion
- **Characteristic size** - The reference size (usually averaged aerodynamic chord).
- **Characteristic area** - The reference area.
- **Height of flight** - Height of flight measured under the origin of coordinates system.
- **Roughness** - Roughness of the wing system in meter.
- **Kinematic viscosity** - Coefficient of the kinematic viscosity.
- **Deflection** - Deflection angle of the wing configuration. This parameter is very convenient to set different angles of attack for planing surfaces and hydrofoils.
- **Pitch** - Pitch angle of the wing configuration.
- **Drift** - Drift angle of the wing configuration.
- **Roll** - Roll angle of the wing configuration.
- **Yaw** - Yaw angular velocity of the wing configuration. Strictly speaking Yaw is the dimensionless angular velocity = Angular velocity/Speed*Characteristic Length
- **Vessel speed** - Vessel's speed.

The ground is taken into account by inverse image method. The potential flow is treated by the Vortex Lattice Method. The viscous drag (both the pressure drag and the friction drag) is calculated using recommendations from the paper K.L. Kirkman and J.W. Kloetzli, Scaling Problems of Model Appendages, Proc. of Nineteenth General Meeting of the American Towing Tank Conference, 1980, Vol. 1, pp. 129-154.

Static stability
In the case of the static stability calculation you have to set variations of pitch angle and height of flight.

Unsteady motion
In the case of the calculation of the unsteady motion you have to set kinds of desirables derivatives.
IMPORTANT: the first four letters of the name of the configuration intended for unsteady calculations should be not "tail". Exception: Calculation of the derivative of the pitching moment on vertical acceleration for the tail unit only.

[#] CalculateA

[$] alculateA

[K] Calculate airfoil part. Single

[+] Wig:000000

[#] [$] [+] [K]Frequently asked questions.

<u>Question</u>: How to calculate a wing configuration with strut located in the symmetry plane?

<u>Answer</u>: Both the left and right half of the wing configuration and strut should be given using the menu command **Configuration**. The wing configuration is to be asymmetric. The wing configuration is to calculate in lateral motion in spite of fact that the actual motion can be longitudinal. The options **Longitudinal motion** and **Symmetry of the wing system** are prohibited.
If you selected **Longitudinal motion** and a symmetric wing configuration the lifting elements will be doubled with respect to the plane of symmetry. The strut will be also doubled. It means that we will have two coinciding lifting elements. The calculation will be interrupted.

[#] FAQ
[$] FAQ
[+] Group0006:0005
[K] Frequently asked questions

$ + K Calculate hydrofoil part | Serial.

This command provides a serial calculation of a submersed wing system. The parameters are as follows:

Page **General**:

- **Configuration file** - Name of file with wings geometry. The file should be created using the menu command **Configuration**. The file has the extension [.WIN]. Please use the button **Load** to load already existing wing configurations.
- **Output file** - Name of file with results of the calculations. Do not set the extension of this file ! The number of directories will be created in the serial calculation. The names of the created directories are formed from the name of the output file and the number of current calculation.
- **Symmetry of the wing system** - This parameter is only for the lateral motion. When the wing configuration is symmetric, please set up only the right half of the wing configuration. The left half of the wing configuration will be added automatically. It does not play any role if you set Symmetry for the case of longitudinal motion.
- **Longitudinal motion** - This parameter is only for the longitudinal motion
- **Characteristic size** - The reference size (usually averaged aerodynamic chord).
- **Characteristic area** - The reference area.
- **Submergence** - Depth of submergence measured above the origin of coordinates system.
- **Roughness** - Roughness of the wing system in meter.
- **Kinematic viscosity** - Coefficient of the kinematic viscosity.
- **Deflection** - Deflection angle of the wing configuration. This parameter is very convenient to set different angles of attack for the planing surface and hydrofoil.
- **Pitch** - Pitch angle of the wing configuration.
- **Drift** - Drift angle of the wing configuration.
- **Roll** - Roll angle of the wing configuration.
- **Yaw** - Yaw angular velocity of the wing configuration. Strictly speaking Yaw is the dimensionless angular velocity = Angular velocity/Speed*Characteristic Length
- **Vessel speed** - Vessel's speed.
- **Turbulence rate** - The turbulence rate of the upstream given in percent (between 0 and 2). This parameter is only for viscid/inviscid interaction.
- **Relaxation coef**. - The coefficient relaxing the iterative procedure of the viscid/inviscid interaction. The value of parameters lies in the range from 0 to 0.5. This parameter is only for viscid/inviscid interaction.
- **Temperature** - Water temperature needed to indicate the cavities.
- **Wave parameters** - Set of the wave parameters
- **Database file name** - Name of the database in which will be write down the results of the serial calculations. You can use the button **Load**.
- **Action type** - Regime of record. If you will overwrite an existing database set **overwrite**. If you want to save existing results in database and to add new results set **append**.
- **Try calculate planing part** - Switches on / off the calculation of a planing surface moving in the wake of a foregoing hydrofoil.
- **Planing database file name** - Name of the database which will contain the results of the serial calculations for the combination hydrofoil +planing surfaces. You can use the button **Load**. The parameter **Action type** is also selected..
- **Constant pitch** - Switches on / off option of serial calculations performing only for planing surfaces behind a given hydrofoil calculated earlier. The name of file with results for hydrofoil is to be set. The **serial parameter** should be "pitch angle" only for this type of calculation.

Page **Parameters**: This page contains six boxes. Each of them sets one serial parameter.

- **Parameter N** - The serial parameter which will be changed in the series. The following eight parameter are possible: submergence, pitch, drift, deflection, yaw, roll, vessel speed, height of interceptor (spoiler).
- **Value** - Three values, described the range of series, namely the first value of the serial parameter (**First**), the final value of the serial parameter (**Last**), step of the variation of the serial parameter (**Step**).

CalculateS
$CalculateS
+Group0002:0001
K Calculate hydrofoil part. Serial

The database file contains of thirteen columns which are : Submergence, Pitch, Vessel speed, Deflection, Drift, Roll, Yaw, Cx, Cy, Cz, Mx, My,Mz.
There are two variants of the calculation of a wing system with account for the free surface waves:

1. Inviscid flow - Potential flow. The viscous drag (both the pressure drag and the friction drag) is calculated using recommendations from the paper K.L. Kirkman and J.W. Kloetzli, Scaling Problems of Model Appendages, Proc. of Nineteenth General Meeting of the American Towing Tank Conference, 1980, Vol. 1, pp. 129-154.
2. Viscous flow - The viscosity is taken into account using the iterative procedure based on the viscid/inviscid flow interaction theory.

The menu command **Large Froude** provides the calculation of the hydrofoil at large Froude number (Fn>4.5). The deformation of the free surface is not considered. The input data are the same as in the case of the wing moving at arbitrary Froude numbers.

Designation of the angles of a wing system

{bmlt Auto0007.BMP}

Very Important

When the surface-piercing hydrofoil (Command Hydrofoil) is calculated, please, pay attention to the following rules
1. Hydrofoil does not have any part which is entirely out of water. This rule is not valid for hydrofoils which are the parts of planing surfaces. In the latter case the parts of hydrofoil located above the free surface will be automatically eliminated.
2. The parameter Dx (Size of the wave panel on the free surface) should be so chosen that the Z-coordinate of the crossing of the hydrofoil and the free surface is approximately equal to Dx multiplied on an integer number

[#] [$] [K] [+] Calculate airfoil part | Serial.

This command provides a serial calculation of a submersed wing system. The parameters are as follows:
Page **General**:

- **Configuration file** - Name of file with wings geometry. The file should be created using the commands of the menu command **Configuration**. The file has the extension [.WIN]. Please use the button **Load** to load already existing wing configurations.
- **Output file** - Name of file with results of the calculations. Do not set the extension of this file ! The number of directories will be created in the serial calculation. The names of the created directories is formed from the name of the output file and the number of current calculation.
- **Symmetry of the wing system** - This parameter is only for the lateral motion. When the wing configuration is symmetric, please set up only the right half of the wing configuration. The left half of the wing configuration will be added automatically. It does not play any role if you set Symmetry for the case of longitudinal motion.
- **Longitudinal motion** - This parameter is only for the longitudinal motion
- **Characteristic size** - The reference size (usually averaged aerodynamic chord).
- **Characteristic area** - The reference area.
- **Height of flight** - Height of flight measured under the origin of coordinates system.
- **Roughness** - Roughness of the wing system in meter.
- **Kinematic viscosity** - Coefficient of the kinematic viscosity.
- **Deflection** - Deflection angle of the wing configuration. This parameter is very convenient to set different angles of attack for the planing surface and hydrofoil.
- **Pitch** - Pitch angle of the wing configuration.
- **Drift** - Drift angle of the wing configuration.
- **Roll** - Roll angle of the wing configuration.
- **Yaw** - Yaw angular velocity of the wing configuration. Strictly speaking Yaw is the dimensionless angular velocity = Angular velocity/Speed*Characteristic Length
- **Vessel speed** - Vessel’s speed.
- **Turbulence rate** - The turbulence rate of the upstream given in percent (between 0 and 2). This parameter is only for viscid/inviscid interaction.
- **Relaxation coef**. - The coefficient relaxing the iterative procedure of the viscid/inviscid interaction. The value of parameters lies in the range from 0 to 0.5. This parameter is only for viscid/inviscid interaction.
- **Temperature** - Water temperature needed to indicate the cavities.
- **Database file name** - Name of the database in which will be write down the results of the serial calculations. You can use the button **Load**.
- **Action type** - Regime of record. If you will overwrite an existing database set **overwrite**. If you want to save existing results in database and to add new results set **append**.
- **Try calculate planing part** - switches on / off for the calculation of a planing surface moving in the wake of hydrofoil.
- **Planing database file name** - Name of the database which will contain the results of the serial calculations for the combination (hydrofoil + planing surface). You can use the button **Load**. The parameter **Action type** is also selected..
- **Constant pitch** - Switches on / off option of serial calculations performing only for planing surfaces behind a given hydrofoil calculated earlier. The name of file with results for hydrofoil is to be set. The **serial parameter** should be only pitch angle for this type of calculation.

Page **Parameters**: This page contains six boxes. Each of them sets one serial parameter.

- **Parameter N** - The serial parameter which will be changed in the series. The following eight parameter are possible: submergence, pitch, drift, deflection, yaw, roll, vessel speed, height of interceptor (spoiler).
- **Value** - Three values, described the range of series, namely the first value of the serial parameter (**First**), the final value of the serial parameter (**Last**), step of the variation of the serial parameter (**Step**).

[#] CalculateAS

[$] alculateAS

[K] Calculate airfoil part. Serial

[+] Wig:000001

The database file contains of thirteen columns which are : Submergence, Pitch, Vessel speed, Deflection, Drift, Roll, Yaw, Cx, Cy, Cz, Mx, My,Mz.

Unsteady motion

In the case of unsteady motion calculation, all derivatives can be calculated and saved in database file.

IMPORTANT: the first four letters of the name of the configuration intended for unsteady calculations should be not "tail".

Exception: Calculation of the derivative of the pitching moment on vertical acceleration for the tail unit only.

Don't forget: if you calculate the derivatives on drift, roll angles or yaw, you must specify the entire wing configuration (not only the half of configuration) and the motion must be lateral. The same rule must be satisfied, if you perform serial calculations. In the latter case the derivatives mentioned above will be calculated in any case.

[#] [$] [+] [K]Calculate attitude.

This command provides the calculation of a high-speed ship attitude versus speed of motion. It is assumed that the ship consists in general of hydrofoils (including planing surfaces) and wings in ground effect. Preliminarily, the databases with hydro- aerodynamical characteristics of the high-speed ship should be created to perform this calculation. The parameters of calculation are as follows:

- **Ship description**
  - **Velocity value** - Setting of the first (**First**) and last (**Last**) values of the vessel's speed, and the step (**Step**) of the speed variation.
  - **Vessel weight** - Weight of the ship.
  - **Center of gravity (hydro)** - Abscissa of the center of gravity given in the coordinates system used in the calculation of the hydrofoils.
  - **Center of gravity (air)** - Abscissa of the center of gravity given in the coordinates system used in the calculation of the wing in ground effect (of course this system can coincide with the hydrofoil's coordinates system mentioned above).
  - **Reserve coefficient** - See results of calculate attitude.
  - **Distance between origins of coordinates** - Distance between the origins of coordinates systems used in the calculation of hydrofoils and wings in ground effect. This parameter is only for combination of hydrofoil and wing in ground effect (further WIG). The distance is positive, if the center of gravity(air) is located above the center of gravity(hydro). . It is zero if you satisfy the recommendation from the Comment 6 Precomputing .
  - **Desirable submergence** - Switches on / off variant of calculation with desirable submergence.
  - **Height of center of gravity** - Height of the center of gravity, see comment.
  - **Setup angle** - The angle between the x-axes and the thrust vector. The setup angle is positive if the engine is tilted back.
  - **Arm of thrust** - Arm of thrust measured from the center of gravity.

- **Database**
  - **Velocity value in airfoil database file** - It shows how much values of the vessel's speed the WIG's database contains.
  - **Velocity value in hydrofoil database file** - It shows how much values of the vessel's speed the hydrofoil's database contains.
  - **Airfoil database file name** - Name of file with aerodynamic data for WIG. You can use the button **Load**.
  - **Hydrofoil database file name** - Name of file with hydrodynamic data for hydrofoil. You can use the button **Load**.
  - **Calculation type** - Type of calculation. There are three types: hydrofoil (including planing surfaces) (**only hydrofoil)**, WIG (**only airfoil)**, combination of hydrofoil (including planing surfaces) and WIG (**hydrofoil + airfoil)**.

Comments:

1. The height of the center of gravity is set in the hydrofoil's coordinates system when the high-speed ship consists of combination hydrofoil (including planing surfaces)+WIG or of a hydrofoil only . The height of the center of gravity is set in the WIG's coordinates system for the ship consisting of WIG only. It is zero if you satisfy the recommendation from the Comment 6 Precomputing . . When calculating a planing hull and /or hydrofoil, the submergence measured from the center of gravity is negative when the free surface lies below the CG and vice versa.
2. To calculate the ship attitude you must create data bases using Menu Commands "Serial Calculations". Please note, that the values of hight of flight/submergence and pitch angles must be the same for every speed of motion. Any holes in the series are prohibited. See comments 1, 2 and 5 from the Precomputing

---

[#] Trim
[$]Trim
[+]Group0004:0000
[K] Attitude calculation

3. Note For the case transition. As recommended the minimum height of flight corresponds to touchdown at zero pitch angle. To calculate the transition properly, we recommend to extend the data-base for airfoil as follows:
   - Edit the dbf file for airfoil
   - Copy entire data for the smallest height of flight into buffer
   - Paste copied data above the data for the smallest height
   - Set the height of flight in the pasted data corresponding to the lowest position of WIG used for calculation of the planing hull
   - Is it still not clear ? Ask the vendor
4. If the calculation does not succeed, please reduce the Reserve coefficient. If it is failed again, please see the file Info_pos.dat

Results of attitude calculation are written in the table.

[#] [$] [+] [K] Results of calculation of the attitude.

Results of attitude calculation are written in the table containing the following information:

- **Speed** - Vessel's speed,
- **Pitch** - Pitch angle of ship,
- **H** – Submergence or hight of flight. In fact, this parameter is the distance between the origin of system of coordinates used in serial calculations and undisturbed water surface. For the case of hydrofoil (or combination of hydrofoil and airfoil) the positive H means the origin is located under the free surface, negative H means the origin is located above the free surface. For the case of Airfoil only positive H means motion above the ground.
- **Error** - A scalar that has the value Sqrt(F(1)**2 + F(2)**2) , where F(1) is the residual in the equation of vertical equilibrium, F(2) is the residual in the equation of moment's equilibrium,
- **Note** - Comment.

The attitude is calculated using two procedures:

-direct solution of the system of nonlinear equilibrium equations using a modified Powell hybrid algorithm and a finite-difference approximation to the Jacobian, and

- method of simple enumeration. The computational space of pitch angles and submergence presented in database is divided in 1000 000 knots. We calculate Sqrt(F(1)**2 + F(2)**2) , where F(1) is the residual in the equation of vertical equilibrium , F(2) is the residual in the equation of moment's equilibrium, at every point and select the minimum Sqrt(F(1)**2 + F(2)**2).

Please, note that: The direct solution of the system of nonlinear equilibrium equations using a modified Powell hybrid algorithm and a finite-difference approximation to the Jacobian is based on routines of the library IMSL. If the initial estimate of the root is chosen not appropriately, the IMSL program can be interrupted internally. The result for this case is an empty table. If this situation is realised, please decrease the **Reserve coefficient.** Only the second method of solution is used for the case Reserve coefficient=0. In this case you will never have an empty table, but the first method is more accurate.

The Code 01 in the column **Note** means that the scalar Sqrt(F(1)**2 + F(2)**2) , where F(1) is the residual in the equation of vertical equilibrium, F(2) is the residual in the equation of moment's equilibrium, is more than **Reserve coefficient**, multiplied on the ship weight and divided by 100. Only the result obtained with use of full enumeration method is presented in this case. To eliminate the internal interruption of the IMSL routines the calculation using the first procedure is not performed. The reason is that the equilibrium point lies far from the range of vessel's speed, pitch angles and submergence represented in database.

The Code 00 in the column **Note** means that the calculation of the attitude is successfully completed.

To get the solution with Code 00, that can be more accurate than the solution with Code 01, please, use the following strategy:
- calculate the attitude at small **Reserve coefficient** (say 10),
- if you got the Code 01 again, increase the **Reserve coefficient** and calculate the attitude again, and so on until the Code becomes 00.

If you failed at large **Reserve coefficient** 150, there are two possibilities. Perhaps, the equilibrium is not possible at given speed. Calculate approximately with calculator. If it is not so, enlarge the range of pitch angles and submergence in the database.

At the end of calculations you get the map, which displays the function Sqrt(F(1)**2 + F(2)**2) , where F(1) is the residual from the equation of vertical equilibrium , F(2) is the residual from the equation of moment's equilibrium. The color distribution corresponds to that used in the geographic maps. You can control the solution. The proper solution should be in the dark blue area.

[#] AfterTrim
[$] AfterTrim
[+] Group0004:0001
[K] Results of attitude calculation

$ + K Calculate dynamics.

This command provides the calculation of ship longitudinal motion. The input data are as follows:

- **General**
  - **Directory with precomputing data** - Directory with precomputed files.
  - **Configuration file** - File with configuration
  - **Additional parameters** - Jz- moment of inertia with respect to the Z-axes (the moment of inertia must be determined about the Z-axes originating from the center of gravity), Vessel weight, Arm of thrust measured from the center of gravity, Setup angle- the angle between the x-axes and the thrust vector, Derivative of the thrust on speed
  - **Planing configuration** - File with planing ship configuration
  - **Center of gravity (wat)** - Abscissa of the center of gravity specified in the coordinates system used in the calculation of hydrofoils. See Comment 6 from Precomputing
  - **Height of c.g. (wat)** - The height of the center of gravity specified in the coordinates system of used in the calculations of planing hull and/or hydrofoil. It is zero if you satisfy the recommendation from the Comment 6 Precomputing
  - **Center of gravity (air)** - abscissa of the center of gravity specified in the coordinates system used in the calculation of the wing in ground effect (of course, this coordinates system can coincide with the hydrofoil's coordinates system mentioned above). . See Comment 6 from Precomputing
  - **Height of c.g. (air)** - . The height of the center of gravity specified in the coordinates system used in the calculation of the wing in ground effect. It is zero if you satisfy the recommendation from the Comment 6 Precomputing
  - **Max Z of the endplate** – Transversal coordinate used to indicate touchdown due to rolling.
  - **Min Y of the endplate** – Vertical coordinate used to indicate touchdown due to rolling.
  - **Min Y of the transom** – Vertical coordinate used to indicate touchdown due to pitching.
  - **X of the transom** - Longitudinal coordinate used to indicate touchdown due to pitching.
- **Initial conditions**
  - **Initial pitch** – The pitch angle at time t=0. Please calculate the initial pitch angle using the menu command **Calculate attitude** for the given **Speed of planing** (minimum speed of skimming corresponding the Froude number =3.0).
  - **Initial height** – The height of flight at time t=0 above the free surface. Please calculate the initial height using the menu command **Calculate attitude** for the given **Speed of planing** (flight)**.** The initial height is the height obtained from the Attitude plus the Height of the c.g. specified in the coordinate system used for the calculation of aerodynamics and hydrodynamics (see the Comment 6 of Precomputing).

  - **Initial speed** – The vessel's speed at time t=0.
  - **Time step** - Time step.
  - **End time** - End time of simulation
  - **Transfer coefficient** - Coefficient of the System of stabilization and damping. The system actuates the flap by using proportional P and differential D coefficients as follows: *deflection_of flap = P*pitch_angle+D*pitching_velocity* (Eq.1). Transfer coefficient is the coefficient P from Eq. 1. (say, 114.6)
  - **Differential transfer coefficient** – the coefficient D from Eq. 1 (say, also 114.6)
- **Perturbation**
  - **Start time of perturbations** – the time of beginning the simulation of motion with perturbations
  - **End time of perturbations** - the time when the perturbations are cancelled
  - **Control devices**
    - **Deflection of rudder** – Angle of rudder deflection, degrees
    - **Deflection of flap** - Angle of flap deflection, degrees
    - **Deflection of tail flap** – Angle of deflection of the flap on the tail unit (height rudder), degrees
  - **Wind gust perturbation**

Calc_Dyn
$ Calc Dyn
+ Group0005:0000
K Calculate dynamics

    - **Amplitudes (Wx, Wy, Wz)** – Amplitudes of the wind gust, m/sec
    - **Wind gust type** – sinusoidal or step-wise
    - **Period** – Period of the sinusoidal wind gust perturbations, sec
  - **Wave perturbation**
    - **Amplitude** – Amplitude of waves
    - **Course angle** – Course angle of waves
    - **Length of wave** - Length of waves
    - **Speed of propagation** – Speed of wave propagation
- **Tail unit**
  - **Derivative of drag coefficient** – Derivative of the drag coefficient on the angle of the flap deflection on the tail unit (height rudder);
  - **Derivative of lift coefficient** - Derivative of the lift coefficient on the angle of the flap deflection on the tail unit
  - **Derivative of pitching moment** - Derivative of the pitching moment coefficient on the angle of the flap deflection on the tail unit. To calculate this characteristics of a WIG configuration with a deflected flaps or rudder do it as follows
    - Use the Menu Geometry. Select the original WIG configuration. You can specify the deflection of flap or rudder by changing the corresponding profile. Look at the WIG configurations and remember, what profiles should be changed.
    - Use the Menu Foil Section. Select the profile to be changed. Select Set a flap. Specify the flap. Afterwards, save the new profile.
    - Use the Menu Geometry again. Correct profiles names for the wing elements provided with flaps.
    - Perform calculations for the wing system with flaps deflection.
    - Perform calculations for the wing system without flaps deflection,

Calculate the derivatives by numerical differentiating of results obtained for deflected and non-deflected flaps. The dimensions of derivatives obtained are 1/deg

  - **Derivative of pitching moment on vertical acceleration** – Derivative of the pitching moment on vertical acceleration for the tail unit. To calculate this characteristics of a WIG configuration please do it as follows

  – Using the Menu Geometry eliminate all wing elements from the original WIG configurations excepting only the tail unit. Save the configuration with tail unit. IMPORTANT: the name of the configuration should be: tail_*.win (small letters)

  – Calculate the unsteady derivatives on pitch angle for tail unit (path : Calculation-WIG-Unsteady-Single). You have to calculate only the derivative on pitch angle. The sought derivative is equal to the derivative of the pitching moment on the pitching velocity, but with opposite sign.

  - **Engine**
    - **A1** – The dependence of the thrust on speed is written in the form:

    Thrust=A1+A2*Speed   Eq 2. A1is the coefficient in the Eq.2
    - **A2** – the coefficient in the Eq.2
  - **Ist die Anfahrensphase zu vermeiden ?** (only for the version “licensed for the **Wismar University**”) If **y** or **Y,** the Anfahrensphase will be ommited. See Comment 3 below.

Comments.

1. To calculate the ship dynamics you must create data bases using Menu Commands "Serial Calculations". Please note, that the values of height of flight/submergence and pitch angles must be the same for every speed of motion. Any holes in the series are prohibited.
2. The Comment for the version “licensed for the **Wismar University”**. Liebe Kollegen,es ist so schwer , ein universelles Gesetz für die Schubänderung , das sowohl für die Transition als auch für Flug gültig wäre, auszudenken. Der Nutzer kann die Schubänderung in Abhängigkeit von der Zeit selbst bestimmen. Dafür gibt es File schubbi.for im Verzeichniss c:\Msdev\Projects\Aprel\. Die Beschreibung, was in diesem File steht, finden Sie im File. Klicken zweimal file aprel.mdp. The Microsoft Developer Studio wird geladen. Dann machen File-Open-Shubbi.for. Ändern Sie file Schubbi.for. Danach Build-Build Aprel.exe. Schließen Sie Microsoft Developer Studio. Kopieren Sie das File aprel.exe aus dem Verzeichniss c:\Msdev\Projects\Aprel\Release ins

Verzeichniss, wo sich autowing.exe befindet. Jetzt kann man die Bewegungssimulation für Ihren Gesetz der Schubänderung durchführen

3. The Comment for the version “licensed for the **Wismar University”**. Die Transitionphase wird in zwei Unterphasen gegliedert: Fr < 3.0(Anfahrensphase) und Fr ≥3.0(skimming). Die erste Unterphase wird mit Hilfe der empirischen Daten für die inverse Gleitzahl= Widerstand/Gewicht berechnet. Die inverse Gleitzahl wird in der Abhaengigkeit von der Froudezahl im File C:\msdev\Projects\Aprel\metodik.for. Die Beschreibung, was in diesem File steht, finden Sie im File.dargestellt. Der Nutzer kann die Abhängigkeit von der Froudezahl selbst bestimmen. Dafür muss man folgendes machen Klicken zweimal file aprel.mdp. The Microsoft Developer Studio wird geladen. Dann machen File-Open-Metodik.for. Ändern Sie file Metodik.for. Danach Build-Build Aprel.exe. Schließen Sie Microsoft Developer Studio. Kopieren Sie das File aprel.exe aus dem Verzeichniss c:\Msdev\Projects\Aprel\Release ins Verzeichniss, wo sich autowing.exe befindet. Jetzt kann man die Bewegungssimulation für andere Abhängigkeit der inversen Gleitzahl von der Froudezahl durchführen

[#] [$] [+] [K] View results of calculate dynamics.

You can see kinematic parameters :
coordinate of the center of gravity, pitch, course and roll angles, horizontal speed, vertical speed, transversial speed referred to the horizontal speed, rolling angular velocity, yawing velocity, pitching velocity versus time. Both graphic and digital information are presented.

[#] View_Dyn
[$] View Dyn
[+] Group0005:0003
[K] Results of dynamics calculations

$ + K General information.

The Software package Autowing 2.4 has been developed by Prof., Dr. N. Kornev and Mr. A. Taranov at the Department of Hydromechanics of the State Marine Technical University St.Petersburg. The code for calculations of boundary-layer was written by Dr. K. Mazaev.

Autowing is the powerful and efficient software for doing aerodynamic and hydrodynamic design of the WIG Crafts and hydrofoils. The numeric tool is directed at solving the following technical problems:

- design of wing configuration of wingships,
- design of wing configuration of hydrofoils,
- design of wing configuration consisting of hydrofoils and planing surfaces, for example, planing hull,
- design of planing surface with a stepped bottom,
- calculation of wingship and hydrofoil dynamics,
- calculation of the ship attitude,
- design of a hydrofoil and an airfoil for given pressure distribution (only in Autofoil extension).

Autowing also provides visualization and document preparation capabilities. The Code can free you from expensive experiments, at least at the stage of the preliminary design so you can solve problems faster and cheaper. It enables designers to solve problems with less effort. For experimentalists, the Autowing is a tool for estimating reliability and accuracy of measurements. Especially it relates to the unsteady characteristics. For educators and students, the Autowing is invaluable educational tool for exploring hydro- and aerodynamics.

The hydro-and aerodynamic module of the Code can be used on a wide range of computer platforms and systems. The module uses memory only as needed. Autowing is equipped with an user-friendly interface. This is 32-bit application for Windows 95 and NT with 32-bit speed and precision. The interface of the Autowing displays and prints the pressure distribution, the distribution of the boundary-layer thickness and the local drag coefficient. In the case of the hydrofoil you can see also the wave pattern and vortex wake of the hydrofoils. Autowing's 2D and 3D graphics quickly lend an intuitive understanding of hydro-and aerodynamic processes through visualization of results and input data. The foil design can be done using Autowing's built-in abilities.

Autowing's Help system acts as a comprehensive on-line reference manual. You can view Help pages in a separate window and easily copy the examples or explanations into your document.

Autowing's codes are thoroughly tested and provide accurate, verifiable results. We can help you to use Autowing effectively- from installation to tackling your most difficult problems.

The advantage of the Autowing is that it permits to investigate not only the simplified model problems but also the real wing configurations of the WIG Crafts and Hydrofoils.

The Codes Autowing have been refined and updated over many years by scientists and engineers, giving them a high degree of computational accuracy and efficiency. Results of calculations and comparison with measurements were given in our papers [1],[2] for the well-known soviet ekranoplans Orlyonok, Lun, SKB, MPE, Ela01 and for the wing configuration developed by the Krylov Institute. Aerodynamic characteristics obtained by Autowing were used for the development of the Flight Simulator WIGSim [3]. Results for the free-surface problems (hydrodynamics of hydrofoils) were tested using the measurements of the Krylov Institute and the Central Aero Hydrodynamic Institute [18,34,35].

In the file *math.doc* you can find a short information about underlying mathematical methods applied in the Autowing. Further information you can find in publications listed below.

References

1. N.V Kornev., Method of calculation of the second generation of ekranoplans, *Ph.D. dissertation*, Leningrad Shipbuilding Institute, Department of Hydromechanics, Leningrad, 1988.
2. N.V. Kornev and V.K. Treshkov, Numerical Investigation of Nonlinear Unsteady Aerodynamics of the WIG Vehicle, *Proceedings of the Intersociety High Performance Marine Vehicle Conference*, Arlington, VA, USA, 1992, pp. ws38-ws48.
3. N.V Kornev. and G. Reichert, Three-Dimensional Instability of a Pair of Trailing Vortices Near the Ground, *AIAA Journal*, Vol. 35, No.10 (1997), 1667-1669.

GenInf
$ GenInf
+ Group0006:0001
K General information

4. N.V. Kornev, V.K. Treshkov and G. Reichert, Dynamics of the Trailing Vortices near the Ground, *IUTAM-Symposium on Dynamics of Slender Vortices*, 31.August- 03.September 1997, Aachen, Germany, Kluwer Academic Publishers, pp. 425-434.
5. N.V. Kornev and G. Reichert, Vortex Decay of the Ekranoplans, *German Aerospace Congress, DGLR-Jahrbuch* , Dresden, Vol.2, 1996, s. 1043-1052.
6. N.V. Kornev, A. Kudryavtsev, and A. Zakharov, Wing-In-Ground-Effect Vehicle Flight Simulation, *Proceedings of the Second International Conference on Fast Sea Transportation FAST-93*, Yokohama, Japan, 13-16 Dezember 1993, pp.1555-1559.
7. N.V. Kornev, Investigation of the Aerodynamic Characteristics of Ekranoplans, Parts I-III, Report of the Korea Research Institute of Ships and Ocean Engineering, South Korea, 1995, 105 pp.
8. N.V.Kornev and G. Reichert, Two-Dimensional Vortex Interaction with Wall in a Viscous Flow, The paper has been accepted for publication in Fluid Dynamics, 1998.
9. N.V.Kornev, Instability and Nonlinear Dynamics of Trailing Vortices in an Inviscid Fluid Over a Solid Surface, Fluid Dynamics, Vol.32, No.2, 1997, pp.239-244.
10. G.M.Fridman, N.V.Kornev, Matched Asymptotics for Three-Dimensional Planing Problems, 27th Israel Mechanical Engineering Conference, 19-20th of May, 1998, Technion Haifa, Israel, pp.668-670.
11. M.A. Basin und N.V. Kornev, Beruecksichtigung der Reibung in der Wirbelmethode, Zeitschrift fuer angewandte Mathematik und Mechanik, 78, issue 5, 1998, 335-344.
12. M.A. Basin, N.V. Kornev, Approximation of the vorticity field in an unbounded medium, Sov. Tech. Phys , 39, 1994, 1184-1187.
13. M.A. Basin and N.V. Kornev, Vortex Methods in Hydrodynamics, Proceedings of the International Symposium on Ship Hydrodynamics, St. Petersburg, Russia, 1995, pp. 431-449
14. N.V. Kornev and M.A. Basin, A Way to Split the Navier-Stokes Equations in the Context of Vortex Method, Commun. Numer. Meth. in Eng. , 1998, vol.14, pp. 313-319.
15. Besyadovsky, N.V. Kornev, and V.K. Treshkov, Numerical Method for calculations of aerodynamic characteristics of the WIG Vehicles, In Proceedings of the First International Conference on Ekranoplans, St.Petersburg, Russia, 3-5 May 1993,s. 48-65.(in Russian).
16. Kornev N.V., Review of works of the Center for Mathematical Modelling of the Marine Technical University St. Petersburg in field of the WIG aerodynamics, In Proceedings of the First International Conference on Ekranoplans, St.Petersburg, Russia, 3-5 May 1993, s.73-75 (in Russian).
17. Kornev N.V. and Taranov A.E., Computational Vortex Method for the Viscose Flow Simulation, In Proceedings of the Conf. devoted to the 200th Anniversary of the Dzerginsky Navy School, Part 1, 1998, pp.111-113 (in Russian).
18. Kornev N.V. and Taranov A.E., Nonlinear hydrodynamic characteristics of the hydrofoils at the arbitrary Froude numbers, In Proceedings of the Conf. devoted to the 200th Anniversary of the Dzerginsky Navy School, Part 1, 1998, pp.74-76 (in Russian).
19. N.V. Kornev, A.E. Taranov, V.K. Treshkov, Efficient software for numerical calculation of ekranoplans (WIG crafts) and hydrofoils, Workshop proceedings of WISE up to ekranoplan GEMs, 15th-16th June 1998, The University of New South Wales, Sydney, Australia, pp. 263 266.
20. Basin, N.V. Kornev N.V., A.B. Zakharov, Approximation of the three dimensional vortex fields, Proceedings of the Central Institute of Marine Fleet, 1993, pp. 184-196 (in Russian).
21. Kornev N.V., The method of regularization for problem of vortex sheet dynamics, Proceedings of the Leningrad Shipbuilding Institute, Improvement of ships seaworthiness, 1989, pp.97-100 (in Russian).
22. Kornev N.V., V.K. Treshkov, Numerical calculation of unsteady aerodynamic characteristics of a lifting surface in a lateral motion, Proceedings of the Leningrad Shipbuilding Institute, Problems of ship hydrodynamics, 1985, pp. 87-92 (in Russian).
23. Kornev N.V., V.K. Treshkov, Unsteady aerodynamic characteristics of a lifting surface near the ground, Proceedings of the Shipbuilding Scientific Society, Improvement of ships seaworthiness, issue 414,1985, pp.4-12 (in Russian).
24. V.K. Treshkov, N.V. Kornev, L.D. Volkov, Investigation of the interaction between two wings near the ground, Proceedings of the Leningrad Shipbuilding Institute, Ships seaworthiness, 1986, pp. 31-36 (in Russian).
25. N.V. Kornev, V.K. Treshkov, Numerical simulation of the unsteady wing aerodynamics near the ground with account for main factors of nonlinearity, Proceedings of the Leningrad Shipbuilding Institute, Problems of ships hydrodynamics and safety, 1988, pp. 69-74 (in Russian).
26. N.V. Kornev, V.A. Ryzhov, Inviscid separated flow around a profile, Proceedings of the Leningrad Shipbuilding Institute, Mathematical methods and automation in shipbuilding, 1988, pp. 88-94.

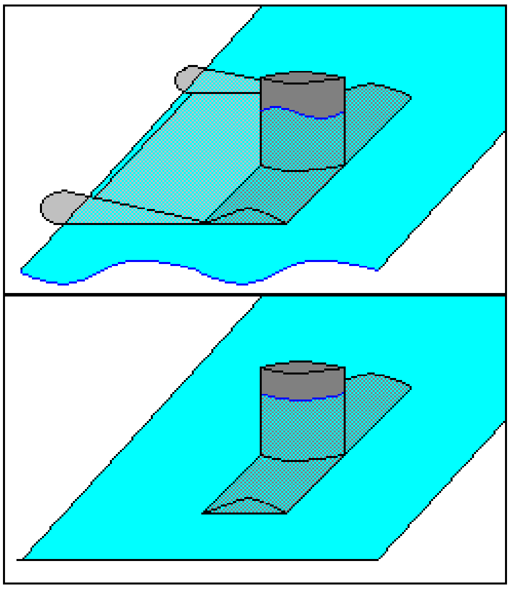
27. N.V. Kornev, A.L.Kudryavtsev, N.B. Plisov, Hydrodynamic characteristics of wings in a non-uniform potential flow near the ground. Proceedings of the Leningrad Shipbuilding Institute, Improvement of ships seaworthiness, 1989,pp.105-110 (in Russian).
28. Ju.V. Guriev, N.V. Kornev, L.A. Patrasheva, Splitting of hydrodynamic forces acting on a slender body at high angles of attack, Proceedings of the Leningrad Shipbuilding Institute, Improvement of ships seaworthiness, 1989,pp.72-76 (in Russian).
29. N.V. Kornev, V.K. Treshkov, Software for numerical investigations of nonlinear unsteady aerodynamics of ekranoplans, Exhibition Shipbuilding-89: Advanced scientific and design works in shipbuilding, Part 2, Bulletin, 1989(in Russian).
30. N.V. Kornev, V.K. Treshkov, D.A. Tchernyshov, Numerical calculation of wings with harmonically oscillating wetted area, Proceedings of the conference on ship theory, Part 2, Krylov Institute, Leningrad, 1990, pp. 46-53(in Russian).
31. N.V. Kornev, N.R. Lanina, K.V. Rozhdestvensky, D.A. Tchernyshev, Asymptotic and numerical methods in hydrodynamics of ships in a shallow water, Proceedings of the Conference "Krylov Readings", Shipbuilding publishers, Leningrad, 1991(in Russian).
32. Ju.V. Guriev, N.V. Kornev, Calculation of the lifting properties of wings with fuselage, Proceedings of the Conference "Krylov Readings", Shipbuilding publishers, Leningrad, 1991(in Russian).
33. N.V. Kornev, A.L.Kudryavtsev, N.B. Plisov, Hydrodynamic characteristics of wings in a shallow water, Proceedings of the Conference on fast ships, Gorky, 1991(in Russian).
34. Kornev N.V., and Taranov A.E., Investigations of the Vortex-Wave Wake behind a Hydrofoil, "Ship Technology Research", vol.46, no.1, Feb. 1999.
35. Kornev N.V., The Computational Method of Vortex Elements and its Application to Problems of Hydro-Aerodynamics, The second doctor thesis (Doctor of Science), St.Petersburg Marine Technical University, Department of Hydromechanics, 1998.

[#] [$] [+] [K] System of coordinates.

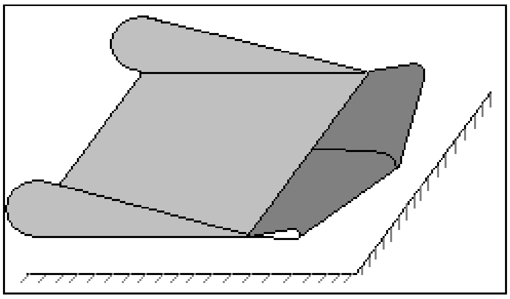
{bmlt Auto0008.BMP}
The plane OXZ of the coordinates system is parallel to the undisturbed free surface. The X-axis of the system fixed with the ship points to the direction of the direction of the ship forward velocity, and Y-axis is positive upward. The Z-axis is positive toward the starboard.

[#] System
[$]System
[+]Group0006:0002
[K] System of coordinates

[#] [$] [+] [K]Hydrodynamic and Aerodynamic Problems solving with the Autowing.

Problem	Menu Command	Comment
{bmct Auto0009.BMP}	Calculate 2D	Two-dimensional problem
{bmct Auto0010.BMP}	Calculate 2D	Two-dimensional problem
{bmct Auto0011.BMP}	Calculate 2D	Two-dimensional problem Large Froude Number
	Hydrofoil | Potential flow	
	Hydrofoil | Large Froude	

[#] Ability
[$]Ability
[+]Group0006:0003
[K] Abilities



{bmct Auto0013.BMP}

Calculate | WIG

{bmct Auto0014.BMP}

Hydrofoil | Viscid / Inviscid Interaction

With account for viscosity

{bmct Auto0015.BMP}

Step 1. Hydrofoil | Potential flow **or** Hydrofoil | Viscid / Inviscid Interaction
Step 2. Planing surface

{bmct Auto0016.BMP}

Step 1. Hydrofoil | Potential flow **or** Hydrofoil | Viscid / Inviscid Interaction
Step 2. Stepped bottom

{bmct Auto0017.BMP}

Step 1. Hydrofoil | Potential flow **or** Hydrofoil | Viscid / Inviscid Interaction
Step 2. Stepped bottom

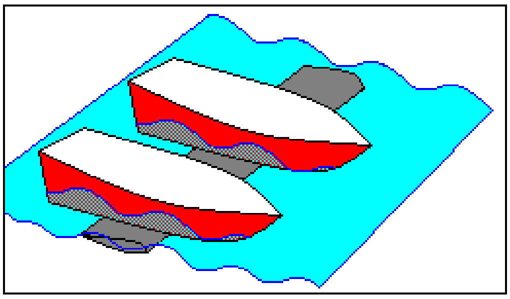
{bmct Auto0018.BMP}

Step 1. Hydrofoil | Potential flow **or** Hydrofoil | Viscid / Inviscid Interaction
Step 2. Stepped bottom

{bmct Auto0019.BMP}

Step 1. Hydrofoil | Potential flow **or** Hydrofoil | Viscid / Inviscid Interaction
Step 2. Stepped bottom

{bmct Auto0020.BMP}



Step 1. Creation of database with use of the serial calculation **Step 2**. Attitude	Calculation of attitude
Step 1. Creation of database with use of the serial calculation **Step 2**. Dynamics	Calculation of dynamics
Calculate | HyAssCat	Hydrofoil-Assisted Catamarans

[#] [$] [+] [K] Dynamic (static) stability: manual settings.

There are three possibilities in the Autowing allowing one to calculate the dynamic stability of the WIG:

1. Full calculation of the dynamic stability. In this case the full set of the aerodynamic characteristics is calculated
2. The calculation of the dynamic stability using the data base files pre-computed for the WIG configuration
3. Calculations of the dynamic stability for data set manually

This dialog panel describes calculation of dynamic stability, using aerodynamic coefficients set manually. You need to set following parameters:

- **Characteristic size -** The reference size (usually averaged aerodynamic chord).
- **Characteristic area -** The reference area.
- **Vessel speed** - Vessel's speed
- **Vessel weight -** Weight of the vessel.
- **Moments of inertia Jz –** moment of inertia with respect to the transversal Z-axes. The moment of inertia must be determined about the Z-axes originating from the center of gravity
- **Arm of thrust -** Arm of thrust measured from the center of gravity
- **Setup angle -** the angle between the x-axes and the thrust vector
- **Derivative of the thrust on speed –** This derivative takes into account decrease of the thrust due to increase of speed. The derivative is negative.

You need also set a table with steady coefficients (Cx, Cy, Mz) and unsteady derivatives.

- **Derivative of the pitching ...** - derivative of the pitching moment on vertical acceleration for tail unit. This derivative is equal approximately to the unsteady part of the derivative of the pitching moment on the pitching velocity, but with opposite sign. To calculate this characteristics of a WIG configuration please do it as follows
  – Using the Menu Geometry eliminate all wing elements from the original WIG configurations excepting only the tail unit. Save the configuration with tail unit. IMPORTANT: the name of the configuration should be: tail_*.win (small letters)
  – Calculate the unsteady derivatives on pitch angle for tail unit (path : Calculation-WIG-Unsteady-Single). You have to calculate only the derivative on pitch angle. The sought derivative is equal to the derivative of the pitching moment on the pitching velocity, but with opposite sign.
- **The distance ...** - Distance between the center of gravity and the origin of the coordinate system used for calculation of aerodynamics.

Comments

1. The aerodynamic characteristics must be determined in the system of coordinates which origin either coincides with the center of gravity (in this case The distance between the center of gravity and the origin of the coordinate system is zero) or the coordinates of the CG must satisfy the following condition
   - the vertical coordinate of the CG is zero in the coordinate system used for calculations of aerodynamics
   - the transversal coordinate of the CG is zero in this coordinate system
   - the longitudinal coordinate is close to zero

The second case allows you to investigate the influence of the position of the CG on the stability.

Please note that the moment of inertia should be specified for the actual position of the CG

[#] Dynamic_stability_manual_settings
[$] Dynamic stability: manual settings
[+] **Wig**:000021
[K] Dynamic stability: manual settings

$ + K Dynamic (static) stability: from database.

There are three possibilities in the Autowing allowing one to calculate the dynamic stability of the WIG:

1. Full calculation of the dynamic stability. In this case the full set of the aerodynamic characteristics is calculated
2. The calculation of the dynamic stability using the data base files pre-computed for the WIG configuration
3. Calculations of the dynamic stability for data set manually

This dialog panel describes calculation of static or dynamic stability, using database files.

You need to set following parameters:

- **Database with steady coefficients** - name of file that contains steady forces and moments coefficients
- **Height of flight** - Height of flight measured under the origin of coordinates system.
- **Pitch** - Pitch angle of the wing configuration.
- **Vessel speed** - Vessel's speed.
- **The distance ...** - Distance of the center of gravity from the origin of the coordinate system used for calculation of aerodynamics.

In the case of dynamic stability calculation you need to set also following parameters:

- **Database with unsteady coefficients** - name of the set of files containing unsteady derivatives of forces and moments coefficients on vertical and pitching velocity.
- **Additional parameters of configuration** - – Jz- moment of inertia with respect to the Z-axes (the moment of inertia must be determined about the Z-axes originating from the center of gravity), Vessel weight, Arm of thrust measured from the center of gravity, Setup angle- the angle between the x-axes and the thrust vector, Derivative of the thrust on speed

- **Derivative of the pitching ...** - derivative of the pitching moment on vertical acceleration for the tail unit. . This derivative is equal approximately to the unsteady part of the derivative of the pitching moment on the pitching velocity, but with opposite sign. To calculate this characteristics of a WIG configuration please do it as follows

– Using the Menu Geometry eliminate all wing elements from the original WIG configurations excepting only the tail unit. Save the configuration with tail unit. IMPORTANT: the name of the configuration should be: tail_*.win (small letters)

– Calculate the unsteady derivatives on pitch angle for tail unit (path : Calculation-WIG-Unsteady-Single). You have to calculate only the derivative on pitch angle. The sought derivative is equal to the derivative of the pitching moment on the pitching velocity, but with opposite sign.

Comments

1. The wing configurations used for calculations of database had to be set in the system of coordinates which origin either coincides with the center of gravity (in this case The distance between the center of gravity and the origin of the coordinate system is zero) or the coordinates of the CG must satisfy the following conditions:
   - the vertical coordinate of the CG is zero in the coordinate system used for calculations of aerodynamics
   - the transversal coordinate of the CG is zero in this coordinate system
   - the longitudinal coordinate is close to zero

The second case allows you to investigate the influence of the position of the CG on the stability.

Dynamic_stability_from_database
$ Dynamic stability: from database
+**Wig**:000041
K Dynamic stability: from database

Please note that the moment of inertia should be specified for the actual position of the CG

$ + K Dynamic stability: full calculation.

There are three possibilities in the Autowing allowing one to calculate the dynamic stability of the WIG:

1. Full calculation of the dynamic stability. In this case the full set of the aerodynamic characteristics is calculated
2. The calculation of the dynamic stability using the data base files pre-computed for the WIG configuration
3. Calculations of the dynamic stability for data set manually

This dialog panel describes full calculation of the dynamic stability. You need to set a following parameters:

- **Configuration file for steady calculation** – the name of file with the wing configuration used for steady calculations. The wing configuration used for steady calculations can be as arbitrary as you want.
- **Symmetry of the wing system** - This parameter is only for the lateral motion. When the wing configuration is symmetric, please set up only the right half of the wing configuration. The left half of the wing configuration will be added automatically. It does not play any role if you set Symmetry for the case of longitudinal motion.
- **Longitudinal motion** - This parameter is only for the longitudinal motion
- **Configuration file for unsteady calculation** - the name of file with the wing configuration used for unsteady calculations. The wing configuration used for unsteady calculations must meet the following requirement : for each lifting elements, the projections of root chord and the end chord on the plane of the wing element must be parallel. Usually it concerns the end plates. Please set the lower tip of the end plate to be parallel to the upper tip. IMPORTANT: the first four letters of the name of the configuration should not be "tail" (why, see below)
- **Configuration file with tail unit only** –the name of file with the wing configuration consisting of the tail unit of your WIG configuration. IMPORTANT: the name of the configuration should be: tail_*.win (small letters)

IMPORTANT: All wing configurations mentioned above must be set in the same coordinate system.

- **Characteristic size -** The reference size (usually averaged aerodynamic chord).
- **Characteristic area -** The reference area.
- **Height of flight -** Height of flight measured under the origin of coordinates system.
- **Pitch -** Pitch angle of the wing configuration.
- **Kin. viscosity -** Coefficient of the kinematic viscosity.
- **Roughness -** Roughness of the wing system.
- **Vessel speed -** Vessel's speed.
- **Additional parameters of configuration** – Jz- moment of inertia with respect to the Z-axes (the moment of inertia must be determined about the Z-axes originating from the center of gravity), Vessel weight, Arm of thrust measured from the center of gravity, Setup angle- the angle between the x-axes and the thrust vector, Derivative of the thrust on speed
- **The distance ... -** Distance between the center of gravity and the origin of the coordinate system used for calculation of aerodynamics.

Comments

1. The wing configurations used for calculations must be set in the system of coordinates which origin either coincides with the center of gravity (in this case The distance between the center of gravity and the origin of the coordinate system is zero) or the coordinates of the CG must satisfy the following conditions:
   - the vertical coordinate of the CG is zero in the coordinate system used for calculations of aerodynamics
   - the transversal coordinate of the CG is zero in this coordinate system
   - the longitudinal coordinate is close to zero

The second case allows you to investigate the influence of the position of the CG on the stability.

Please note that the moment of inertia should be specified for the actual position of the CG

2. Full calculation consists of the following steps:

Dynamic_stability_full_calculation

$ Dynamic stability: full calculation

+ **Wig**:000061

K Dynamic stability: full calculation

Calculation of the steady characteristics for the specified height of flight (h) and pitch angle (theta)
Calculation of the steady characteristics for the h+Δh, theta
Calculation of the steady characteristics for the h-Δh, theta
Calculation of the steady characteristics for the h, theta+Δtheta
Calculation of the steady characteristics for the h, theta-Δtheta
Calculation of derivatives on h and theta by numerical differentiating
Calculation of unsteady derivatives on vertical speed and pitching angular velocity
Calculation of the damping of the tail unit (proportional to the vertical acceleration)
Calculation of the dynamic stability

$ K + Precomputing.

Comments

Before investigating the dynamics of your WIG you should create the Databases with aerodynamic characteristics. For that you have to use the path: Calculate -WIG- serial calculation Do it as follows:

1. Calculate the steady aerodynamic characteristics for your WIG configuration. Three parameters should be set as follows:
   - the minimum pitch angle, say -3, the maximum pitch angle, say +4, the step +1 or +2
   - the minimum height of flight corresponds to touchdown at zero pitch angle.
   - The maximum height of flight is arbitrary
   - If you calculate the transition regime (aerodynamics + hydrodynamics) the minimum speed should be less than the initial speed of skimming (corresponds to the Froude number 3.0).
   - The interval between the minimum speed and the maximum values of speed should cover the possible range of speed change in the calculation of dynamics

   The roll, drift angles, the yaw and deflections of flaps and rudders should be zero.
2. Set the height of flight as the Parameter 1 in the serial calculations. It allows to make the correction mentioned in the Comment 3 Calculate altitude easier
3. Perform then calculations of 5 Databases with steady characteristics in the order listed in the menu Precomputing. But now you have to perform serial calculations only for TWO parameters (not three as above): pitch angle and height of flight. The pitch angles and height of flight are changed in the range described in Comment 1. The speed should be specified being equal to the maximum speed used in calculations mentioned above in the comment 1. The roll and drift angles, the yaw you can specify in the General menu of Serial Calculations. To calculate the aerodynamic characteristics of a WIG configurations with a deflected flaps or rudder do it as follows
   - Use the Menu Geometry. Select the original WIG configuration. You can specify the deflection of flap or rudder by changing the corresponding profile. Look at the WIG configurations and remember, what profiles should be changed.
   - Use the Menu Foil Section. Select the profile to be changed. Select Set a flap. Specify the flap. Afterwards, save the new profile.
   - Use the Menu Geometry again. Correct profiles names for the wing elements provided with flaps.
   - Perform serial calculations for the wing system with deflected flaps.

4. Perform the serial calculations for the WIG configuration intended for unsteady calculations. The pitch angles and height of flight are changed in the range described in Comment 1. The speed should be equal the maximum speed used for steady calculations of the longitudinal motion without flap and rudder deflection. The wing configuration used for unsteady calculations must meet the following requirement : for each lifting elements, the projections of root chord and the end chord on the plane of the wing element must be parallel. Usually it concerns the end plates. Please set the lower tip of the end plate to be parallel to the upper tip. **Don't forget:** you must specify the entire wing configuration (not only the half of configuration).
5. If you want to calculate the transition regime, perform the serial calculations for the part of the WIG having contact with the water. For that you have to use the path: Calculation- Planing Surface (or Stepped Bottom)-Simple-Serial. The pitch angles are changed in the range described in Comment 1. The maximum submergence should be equal to the attitude of the WIG in the rest. The minimum submergence should be equal to the highest position of the WIG at which it still has contact with water. The minimum speed should be equal to the initial speed of skimming (corresponds to the Froude number 3.0). The maximum speed should be more than the speed of detachment. When

---

Precomputing

$ Precomputing

K Precomputing

+ Group0005:000023

calculating a planing hull and /or hydrofoil, the submergence measured from the center of gravity is negative when the free surface lies below the CG and vice versa.

6. **Important:** All wing configurations used for calculations mentioned in Comments must be set in the same system of coordinates which origin either coincides with the center of gravity or the coordinates of the CG must satisfy the following conditions:
   - the vertical coordinate of the CG is zero in the coordinate system used for calculations of aerodynamics
   - the transversal coordinate of the CG is zero in this coordinate system
   - the longitudinal coordinate is close to zero

The second case allows you to investigate the influence of the position of the CG on the stability.

Please note that the moment of inertia should be specified for the actual position of the CG

Afterwards, you read the Comments, it is easy to specify the input data for pre-computing. As angles of deflection you must specify those used for profile corrections (see Comment 2)

$ K + Calculation of Hydrofoil-Assisted Catamarans.

Configuration file – The filename containing the geometry data for the foils. The file, which has the extension [.WIN], should be created using the menu command: "Configuration ". Use the "Load" button to load an already existing wing configuration.
Output file – The filename containing results of calculations. Do not set the extension of this file! A directory will be created during the calculation. The name of which, is formed from the name of the wing configuration under investigation.
Characteristic size - The reference size (usually averaged aerodynamic chord).
Characteristic area - The reference area for of the force and moment coefficients.
Rise of the transom- the rise of the transom
Roughness - Roughness of the wing system.
Kinematic viscosity - Coefficient of the kinematic viscosity.
Deflection - Deflection angle of the wing configuration. This parameter is very convenient to set different angles of attack for the planing surface and hydrofoil.
Pitch - Pitch angle of the wing configuration.
Drift - Drift angle of the wing configuration.
Roll - Roll angle of the wing configuration.
Yaw - Yaw angular velocity of the wing configuration. Strictly speaking Yaw is the dimensionless angular velocity = Angular velocity/Speed*Characteristic Length
Vessel speed - Vessel's speed.
Relaxation coef. - The coefficient relaxing the iterative technique. The value of parameters lies in the range from 0 to 0.5.

Wave parameters (see the Fig. 1)

Acceptable error for wave elevation - The acceptable error for calculation of intersection points between the body and the free surface (FS).

Number of points on the FS to the left of the hull - Number of points on the FS to the left of the hull, which also equals the number of panels +1 located to the left of the hull on the FS N_l (5 in the Fig.1)

Number of points on FS to the right of the hull - Number of points on FS to the right of the hull, which also equals to the number of panels +1 located to the right of the hull on the FS N_r (5 in the Fig.1)

Number of panel nodes on the free surface along the x-axis -Number of panel nodes on the free surface along the x-axis (13 in the Fig.1).

Number of panel nodes along the x-axis in front of the ship - Number of panel nodes along the x-axis in front of the ship (3 in the Fig.1)

Number of panels across the hull - Number of panels across the hull (an even number) (4 in the Fig.1)

Number of panels along the hull - Number of panels along the hull (8 in the Fig.1)

Semi-width of the ship - Semi-width of the ship (see Fig. 3). This value is equal to the z-coordinate of the zero point of the hull coordinate system in the global coordinate system.

Configuration file of the hull – The filename containing the geometry data for the hull. The file, which has the extension [.dat], should be created using an usual text editor. Use the "Load" button to load an already existing hull configuration. The structure of the file is described below.

Size of vortex filament - The size of the filament section of the vortex wake

The width of the computational domain - The width of the computational domain

X of the Outlet, X of the Inlet x - coordinates of the computational domain

Payne correction - correction of hydrostatic forces proposed by Payne P. "Contributions to Planing Theory," Ocean Engineering 22(7) 699-729, 1995.

HyAssCat

$ HyAssCat

K HyAssCat

+ Group0002:000024

Number of iterations - Number of iterations needed for the calculation of the free surface. According to our experience it should be value lying between 50 and 70. This parameter should be chosen on the base of preliminary systematic comparative calculations for every wing configuration.

Nonlinearity – If nonlinearity is selected, the water rise is considered when the wetted area is calculated and nonlinear terms in the force calculations are taken into account. When the nonlinear theory does not converge, please, use the linear theory.

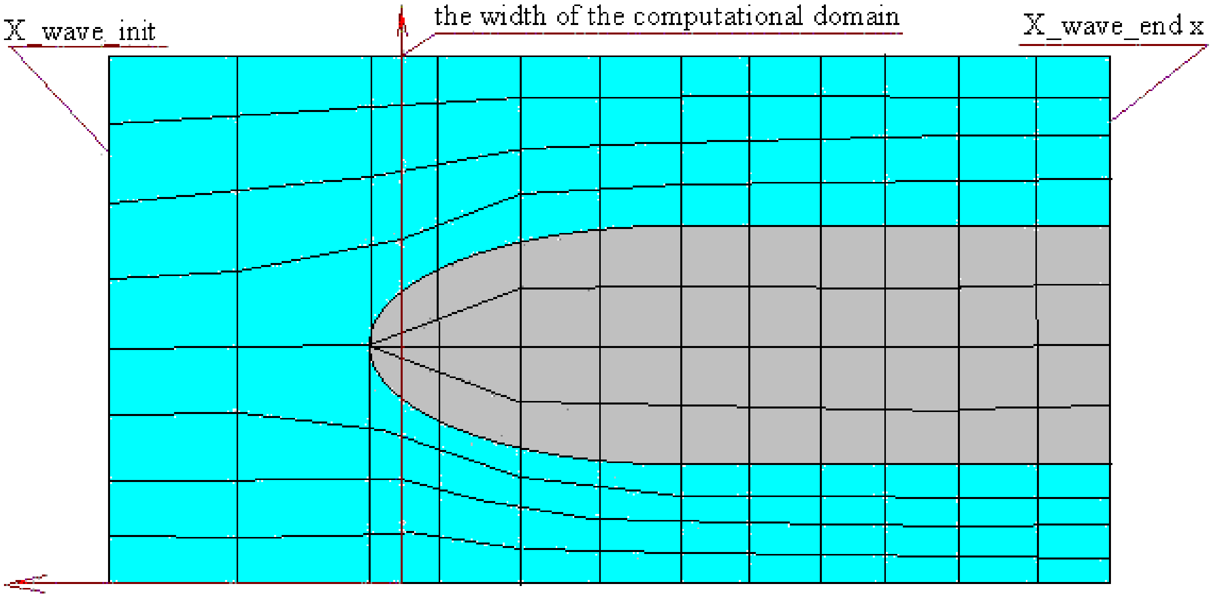


Fig.1

Specification of the geometry

The hull and foils are given in the connected coordinate system which axis $0X_0$ coincides with the undisturbed free surface (see Fig.2).

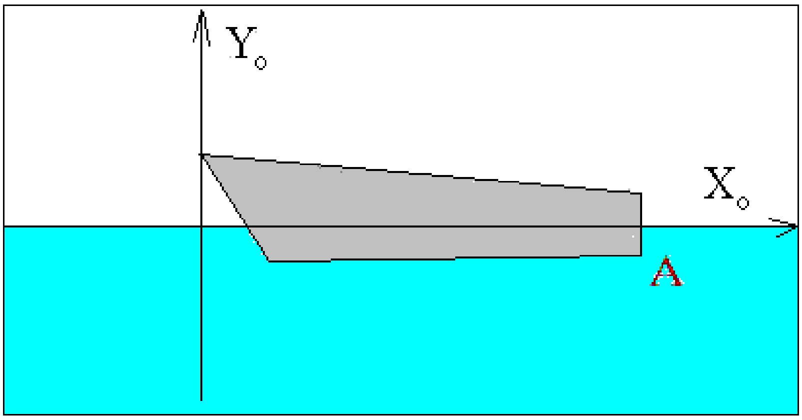


Fig. 2

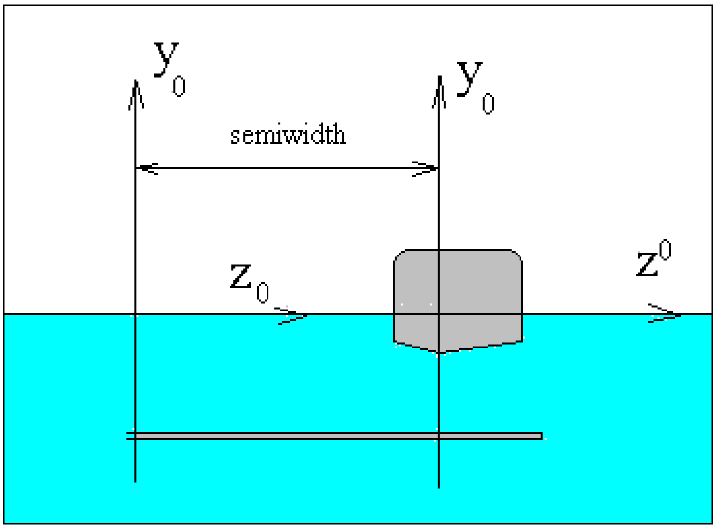


Fig. 3

The z-coordinates of the hull are given in the coordinate system (X_0Y_0 Z_0) whereas the coordinates of foils are given in the system (X_0Y_0 Z_0) (see Fig.3). The coordinates (x_2 y_2 z_2), used in calculations, are obtained from following transformations (see Fig.4):

$$x_2 = -(x_0 \cos\alpha + y_0 \sin\alpha)$$

$$y_2 = -x_0 \sin\alpha + y_0 \cos\alpha + \Delta$$

$$\begin{cases} z_2 = z^0 + S \qquad \textit{for} \quad \textit{the} \quad \textit{hull} \\ \qquad z_2 = z_0 \qquad \textit{else} \end{cases}$$

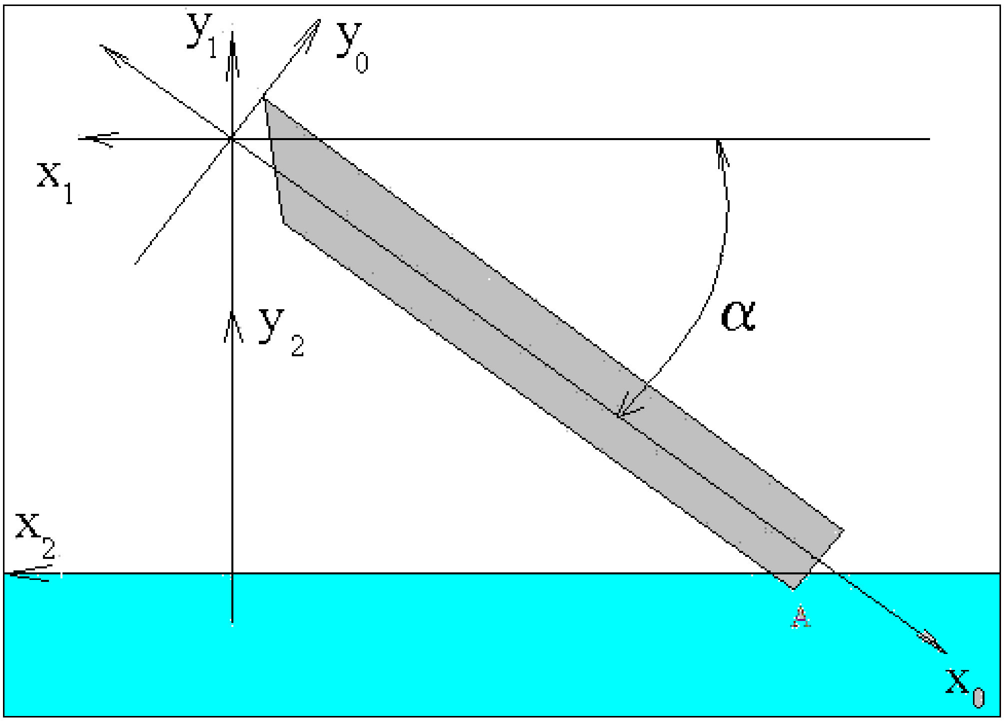


Fig. 4

Where S is the semiwidth of the catamaran.

The parameter Δ is found from the following formulae

$$\Delta = x_{A0} \sin \alpha + R$$

The geometry of the hull is to be given in an ASCII file whose name is specified from the Menu. Use the file name: sections.dat. The geometry of the hull is given as a number of sections along the hull. The abscissa (x coordinate) of each section is specified starting from the bow (x=0). Every section is specified only up to the dry chine. The section is specified starting from the port side.

The structure of the file SECTIONS.dat, Geometry of the hull

10	Number of sections
1 0.0	Number of geometric points in the specific section, abscissa of the section.
-1. 0.	z-coordinate of the point, y-ordinate of the point

The foil geometry is given in the Menu Option Geometry.

If however, the configuration consists of the hull only, the Autowing interface needs the name of the configuration file (WIN-file). Please specify it as null.win . The file null.win should be located in the same directory as the Autowing.exe file. For the file null.win you can use any simple WIN-file with, say, one wing. In other words, a copy of any available WIN-file renamed as null.win is suitable.