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Introduction

The GHS software is primarily for ship stability and strength in view of regulatory standards. But it is also well-suited to simulating the behavior of any body, floating or not, where ground reactions and other forces may be present. It is often used in simulation-oriented settings such as salvage, crane ships and heavy-lift operations, to name a few. It also has an on-board configuration, known as GHS Load Monitor, GHS-LM or simply GLM, where it becomes an efficient “electronic stability book” that naval architects provide for their clients, augmenting the traditional paper T & S books.

GHS derives nearly all of its results directly from 3-dimensional geometry models of the ship hull and its interior arrangements. This is unlike some competing software that use intermediate tables for the sake of efficiency. Because GHS has a highly-efficient calculating engine, it performs the essential volume integrations very quickly, and so is able to provide both speed and the accuracy inherent in using the “first principles” approach.

The Purpose of this Document

This document serves as text for the standard 3-day introductory GHS training course. It assumes no initial familiarity with GHS. It does assume familiarity with personal computers under the Windows operating system.

The important concepts and principles upon which GHS is built are presented in some detail, but in other respects this is not a complete user's guide to the program. The GHS User's Manual is the complete reference document. Most of the User's Manual is conveniently accessible through the Help menu in the GHS program.

Topics are presented in a particular order that builds on material presented previously. Sometimes the explanation of a program feature is split to provide necessary prerequisite information only where it is needed while avoiding information overload before it is needed. Therefore this should be read in its natural order, not at random.

By the time you finish going through this document you will know how to get useful work done with GHS, and you will be oriented well enough to make good use of the User's Manual to extend your knowledge.

No attempt is being made here to cover every detail of GHS. The emphasis is on simplicity. It is left to the user to build on this foundation as needed, with the User's Manual as the main source of information, possibly augmented with advice from the GHS technical support team. or the online help.

GHSport.com/support contains all the latest:

- Training Guides, Tutorials & Wizards
- Bulletins, Questions & Answers, Did You Know articles, and sample Run Files

First, the Geometry File

GHS uses a convenient and compact geometry model of the ship, that includes all of its internal tank and compartment arrangements, and all of its superstructure windage elements. This model is contained in a single computer file we call the Geometry File (typically using the file-name extension .GF). Since all calculations are based on geometry, the first stage of any project is building the geometric model; and the first sessions of this training course will teach you how to create Geometry Files.

The Rest of the Model: Fixed Weights vs. Tank Loads

The Geometry File, with its tank models, provides for weights and centers of liquid loads, but it does not provide weights of structure and other non-liquid loads. Consider that all of the buoyancy and weight forces derived from the geometry are variable – subject to change – when the vessel changes its draft, heel and trim. On the other side of the equation you have the fixed forces from the weight of structure and loads that have fixed magnitudes and positions on the ship. Therefore we divide the weight items into "Fixed" weights and "Tank" weights (meaning the weights and centers of tank contents), which implies that Tank weights are variable at least in the locations of their centers. Here is the issue: Fixed weights, including light ship weight and its center, are represented in "Commands" that reside in "Run Files". So we have two kinds of files: Geometry Files and Run Files.

Talking to GHS: Commands, Run Files and Reports

GHS is a command-oriented program. All of the input data – all of the information you provide that is not in the Geometry File – is in the form of commands. A command, as we have already noted, can provide such things as Fixed-weight items. Commands also instruct the program about what you want to do with the model.

A fundamental and important concept is that commands are processed as sequential steps, and the order in which commands are given can be very significant. The program processes commands one at a time. Every time a command is processed, the program takes some action, and in many cases the state of the program is changed as a result. This is actually a very familiar paradigm that we see all around us: everything and everyone reacts to sequential inputs and at any given moment is the result of the history of those inputs.

Many people today have trouble understanding sequential processing because of their familiarity with spreadsheets, The spreadsheet appears to process its inputs simultaneously; the position of an item on the page does not necessarily imply a sequence. If not warned about this in advance, they will look at a GHS Run File as a if they were looking at a spreadsheet. They will not realize that command A must precede command B if the program is to have the benefit of command A when it processes command B.

A Run File is simply the text file where you write your commands. The preferred file-name extension for Run Files is `.RF`, and they can be created and edited using the text editor that is available within the GHS program. You could type your commands directly into the program, but using a Run File saves you from having to repeatedly enter commands. When you tell GHS to run your Run File, it simply processes the commands from the file sequentially, line-by-line. Your Run File – in combination with the Geometry File – will produce a Report File. The report could be something simple like the results of an inclining experiment; or it could be an entire Trim and Stability book.

You could say that the purpose of this training course is to teach you how to write Run Files. Almost everything, including model building, can be done through Run Files.

The GHS Command Language

There are certain special commands that can be used to make your Run File into more than a simple sequential list. For example, there is the “IF” command, which enables you to execute some commands and not others under certain conditions. These special commands are powerful, and they allow you to do many things that you might not expect would be possible in this type of program. In fact, GHS can be used as a general-purpose programming platform. There is even a special version called GHSOS (for GHS Operating System) that includes the command language without the ship-stability functions.

The Complete GHS: Optional Modules

During the training course you will have access to the complete set of GHS modules. But since some of these modules are optional, it is possible that you will not find all of them in your own particular GHS configuration. All GHS systems include the essential model-building tools: Section Editor (SE), Model Converter (MC) and Part Maker (PM), and the essential set of calculations with their reports, including both intact and damage stability. The optional modules are,

- Condition Graphics (CG) – displays vessel and tank loads graphically on screen and in reports (highly recommended!).
- Load Editor (LE) – interactive load management essentials.
- Load Editor with Windows (LEw) – enhanced Graphic User Interface for LE.
- Longitudinal Strength (LS) - computes shear, bending, deflection and torque curves.
- Floodable Lengths (FL) – produces floodable length curves.
- Tank Soundings (TS) – computes and prints special tank sounding tables for onboard use.
- Advanced Features (AF) – probabilistic damage, oil outflow, hopper stability, bonjean tables and also GMT as a function of tank loading for submersible vessels.

- Crane (CR) – vessel mounted crane calculations including Crane Operator Output Tables. Enhanced by LEw and CG modules.
- Grain Shift (GS) – volumetric heeling moments of bulk cargo in general holds.
- Multi-Body (MB) – interactions between two or more floating bodies.
- Hull Maker (HM) – barge shaped GF file generation based on input parameters such as principal dimensions, sheer, rake, deadrise, bilge radius, etc.

Being an optional module does not necessarily mean that additional software files are involved, though in some cases it does. In all cases, access to these modules is through the GHS main program.

Installation and Setup

The organization of shortcuts, data files, and folders on your computer and/or network is a matter of personal preference and company policy, so it will not be addressed here. However, in any installation, all GHS program files must reside in a single directory (folder). For the purpose of this training, it is recommended you make a new folder in which to install your training version of GHS, keeping it separate from your permanent GHS program folder.

GHS uses various devices for copy protection. The most common is a USB dongle. When doing a new installation, do not insert the dongle until prompted to do so.

Among the files that come with GHS you will find one named `INSTALL.TXT`. It contains complete step-by-step instructions for all types of installations. On a stand-alone computer a new GHS installation, or an update, goes like this:

1. Insert the GHS installation CD (or other medium) into your computer.
2. If "Welcome to GHS" does not appear, run `INSTALL.EXE` from the CD.
3. Click through the installation procedure, following any special instructions that might appear.
4. If your computer is installing a USB dongle for the first time, insert the dongle into a USB port and confirm any security dialogs that might appear; if New Hardware Wizard starts up, select the automatic option. (If you inserted the dongle before installing GHS, see Troubleshooting in `INSTALL.TXT`.)

Starting Up the Program

GHS can be started using a Windows “shortcut”. A shortcut created on the desktop will default to a working folder where the GHS main program file, `GHS.EXE`, is located. However this should never be used as the working folder. Therefore, be sure to change the “Start in” folder of the “shortcut” to a working folder where you want to keep your data files for a particular project. <u>The working folder must never be the GHS program folder, nor should it be a sub-folder within the windows program files directory.</u>

It is important that you understand the significance of having a separate working folder for each project. Not only does it help to keep your files organized, it also avoids having to specify paths with your file names. The project menu can help with this.

The GHS Main Screen

The various elements found on the GHS main screen are shown below.

Window bar – program name and Project name if defined (otherwise Geometry File name).

Menu bar – pull-down menus

Title bar – GHS Version, Title as defined in Geometry File, Project name.

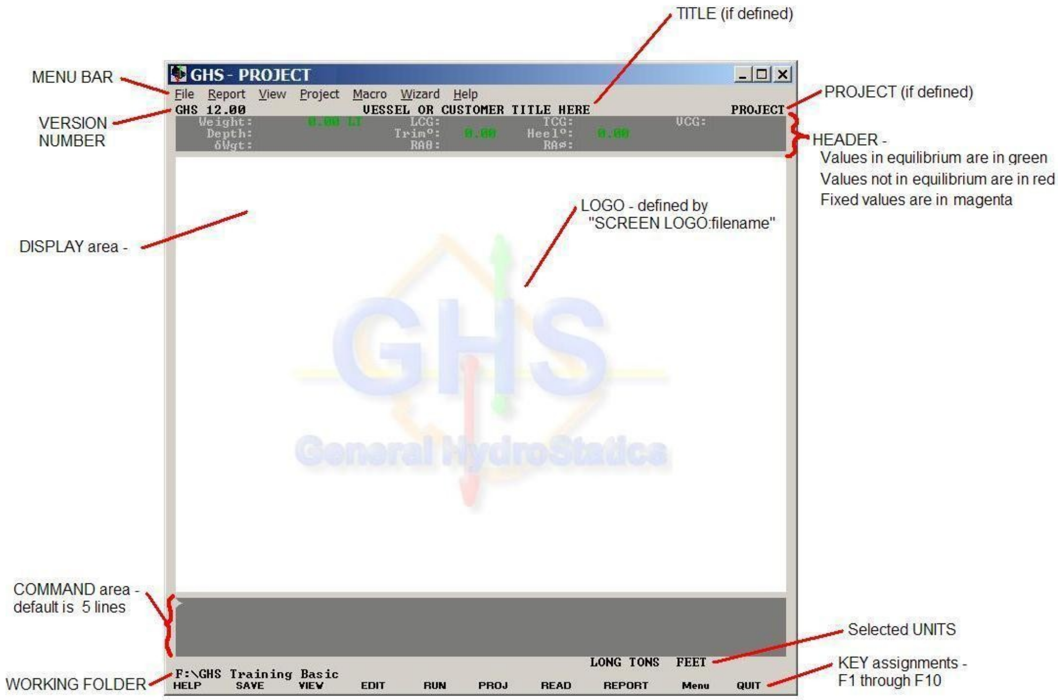
Header with data box showing (this data box can be turned off using the View menu).

Logo – screen background shows the GHS logo (can be changed via the View menu).

Display/Command Area – configurable via the View menu.

Status bar – shows the working folder, report file, units setting.

Function Keys (footer buttons) – Configurable via the KEY command.



Pull-Down Menus

At the top of the GHS screen are several pull-down menus. Almost all of the activities that you access through these menus are also available through commands. In fact, when you make a selection from a menu, the equivalent command appears in the command area – the menu mechanism actually generates and runs the command. That means you can place any of those commands in your Run Files to produce the same action that you would get through the menu.

If there is a dialog box active, such as the “GHS Executive” (discussed below), you will have to close it before you can access the pull-down menus.

The menu that you will find most useful is Help, which provides quick access to nearly all of the GHS User's Manual. It is organized by command name, making it easy to look up the description and parameters of a given command. There is also a global search, allowing you to search the entire manual for any word. Help opens a separate window that stays open until you deliberately close it even after closing the GHS session. Right click anywhere in a Help window to bring up the index.

Printer Setup

GHS will use your Windows default printer unless you direct it to use another one. You will notice there is a separate Report menu where all of the report functions, including printing, are grouped together (rather than being in the File menu as you might expect).

If you want to change the printer that GHS will be using, use Setup Printer at the bottom of the Report menu.

Text Editor Setup

In the File menu there is a Setup Paths selection, and under it the Editor Program selection allows you to specify any text editor for editing your Run Files. Notepad is the default editor, and it is quite adequate. We recommend that you do not use a full-featured editor, since GHS only recognizes basic ASCII text.

The User Library Folder

As you become more familiar with the power of the GHS command language, you may want to have some of your Run Files easily available to you regardless of which working folder you are using. Such files would be general-purpose Run Files that you would reference in other Run Files. In this case they would be called Library Files and would use the file-name extension `.LF`; however, the command structure and everything else about the file is the same as any other Run File. A User Library folder can be established in which GHS will automatically look for your Library Files when needed.

Under the File menu, Setup Paths, you will find the User Library function which allows you to establish the location of your User Library folder.

The Executive Dialog Box

Normally (exceptions discussed below) there will appear at program start-up a GHS Executive dialog box positioned at the bottom of the GHS main screen. (This is also known as the Executive Wizard.) This is a handy helper for managing files, and it has a built-in Help system that can be used by anyone who is new to the program (or has forgotten what was learned in training). Any time the menus are active, the Executive can be quickly brought up since it is the first item in the Wizard menu. It can also be brought up via the command, `RUN EXECUTIVE.WIZ`.

The automatic appearing of the Executive at program start-up can be turned off and on by the Executive itself. Press the Executive's Help button and at the top of the Executive Help screen are buttons for turning the automatic appearing on and off.

Automatic Start-up Run Files

There are two special Run File names that GHS looks for and runs at program start-up: GHS.LF and GHS.SAV. GHS looks in the working folder, the user library folder and the GHS program directory for these Run Files. If both GHS.SAV and GHS.LF exist, GHS.SAV runs before GHS.LF. Note that if either of these special start-up files exist, the Executive dialog will not appear unless the `RUN EXECUTIVE.WIZ` command appears in the start-up file.

`GHS.LF` – This auto-run file could be used to customize the user interface as well as set printer options. It could also set any of the screen options from the View menu. Of course, this file does not have to exist at all; for most users, the defaults are fine and `GHS.LF` is not needed.

`GHS.SAV` – GHS.SAV is the default filename for the SAVE command. SAVE writes an “environment” file that can be used to restore the state of the program. While it would be quite reasonable to have a GHS.SAV file in a working directory, inadvertantly storing a GHS.SAV file in the User Library or the program directory can lead to confusing behavior and should be avoided.

Direct Command Entry

Exit the Executive Wizard dialog if it is present, and you will see somewhere on the screen a blinking cursor. This is the command prompt for typing a command directly. For example, you could type, QUIT to close GHS.

In most cases the command name can be abbreviated. The minimum abbreviation is indicated in the User's Manual by underlining. A quicker way to find out the minimum abbreviation is in the Help menu where it is capitalized.

The Structure of Commands

Commands follow certain formatting rules. All commands start with the command name, which, as mentioned earlier, usually can be abbreviated.

After the command name there are usually parameters that help to define what you want to happen when the command is executed by the program. Separators can be spaces or commas. In many cases you can also separate the command name from the first parameter with an equals (”=”) sign, and sometimes that looks better.

Each command has its own syntax, which is shown in detail in the User's Manual. But there are certain syntax conventions that are followed throughout the program. More will be presented on this later. For now it is sufficient to understand that there will always be:

- A command name (possibly abbreviated);
- Zero, one or more parameters following the command name.

  Regarding the parameters:

  - The order of the parameters is often significant.
  - Certain parameters must be enclosed in parentheses, if they appear at all;
  - Some parameters must be enclosed in quotation marks;
  - Some parameters must begin with a slash ("/").

The case used in commands and parameters does not matter; it can be either upper or lower case or a mixture of upper and lower.

Changing the Working Folder

The path to the current working folder is shown on the left side of the status bar at the bottom of the GHS window. To switch to a different working folder, use the File menu and its first selection, Change directory.

Setting the Project Name

The command "PROJECT *name"* defines a short (8 characters maximum) *name* that appears at the top right corner of the GHS screen, and in a similar location on every page of the reports. It also forms default file names. Once the project name is defined you can enter the direct command, "EDIT", or simply "ED", and the text editor will come up ready to create or edit the Run File named accordingly. For example,

```
PROJ DAY1
ED
```

Now you are ready to edit the file `DAY1.RF` in the current working folder.

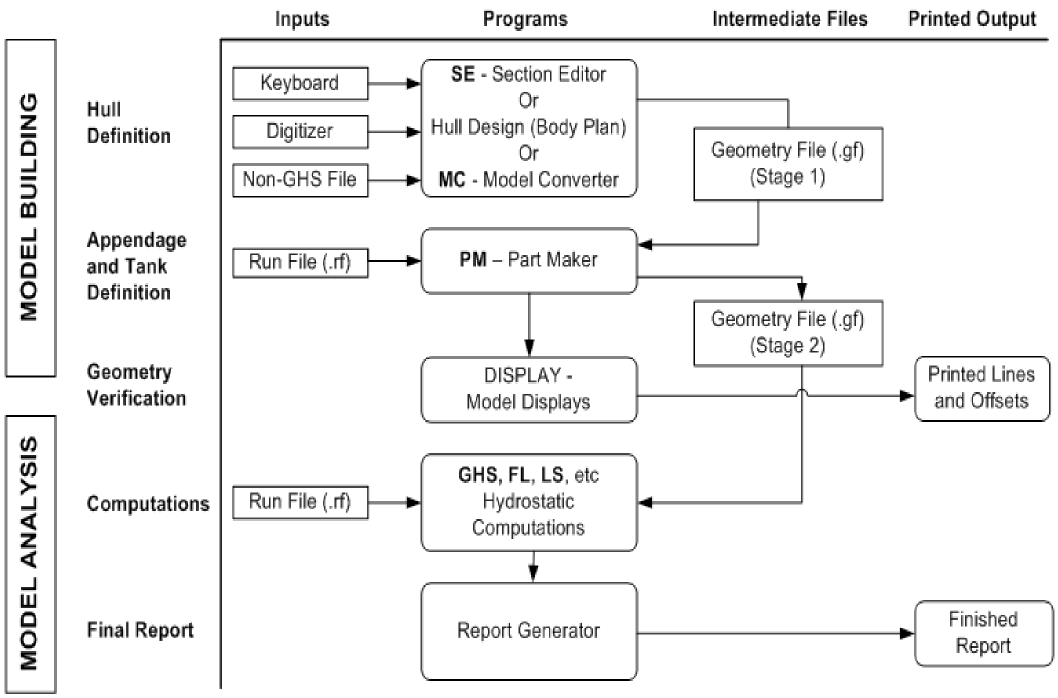
The Project Folder System

If you pull down the Project menu you will see that there is a complete facility for managing project folders and sub folders. If you do not already have an established structure for your projects, you might want to consider using this system. It is optional, and is explained in the manual under the PROJECT command. For lack of time it will not be covered in this course.

The Phases of a Project

The chart below depicts the steps involved in producing a report, how the various divisions in the software relate to these steps, and which files are involved. It is worth studying this chart. It will help you keep your bearings as you navigate through the process from starting to build geometry to producing the final report.

Note the two main phases: 1) Model Building; and 2) Analysis using the model. Model Building here refers to the process of creating the Geometry File. In one sense, as noted earlier, this is not the complete model, since light-ship weight, and other non-liquid weights are also essential to the overall model. But we do not include them in the Model-Building phase since they are provided in the Run File during the Analysis phase.



Geometry Organization: Understanding the Model

Whether creating a GHS geometry file by importing an existing file or building one from scratch, an understanding of the model hierarchy is required. The essentials of the GHS geometry data structure are shown below in outline form (it is fully described in an appendix of the GHS manual). Note that there are three levels in the hierarchy.

At the highest level are the Parts. Each Part has an unique name and belongs to one of three classes:

- Displacer Parts, providing the upward or buoyant forces;
- Tank Parts, providing downward forces;
- Sail parts contributing only to wind heeling moments and not to buoyancy or weight.

Additional attributes of Parts are as shown below in the outline.

At the next level are the Components. Components belong to Parts. In other words, each Part is the collection of its Components. Since each Component belongs to only one Part, Component names need be unique only within the Part. Therefore, when you refer to a particular Component, it is helpful to mention the Part to which it belongs. A complete Component reference is written as, *Part\Component*. Notice the back slash between the Part name and the Component name.

<u>Part</u>
- name (optional description)
- class
- substance
- Reference Point
- Sounding-tube Definition (optional for tanks only)
  - <u>Component</u>
    - name
    - side
    - effectiveness or permeability factor (adding vs. deducting)
    - shape factor (optional for sail or displacer parts only)
    - translation Vector
    - margins (optional)
      - <u>Shape</u>
        - name
        - shell thickness (optional)
          - Section
            - longitudinal coordinate and number of points
              - Point
                - transverse coordinate
                - vertical coordinate
                - longitudinal line code (optional)

At the lowest level in the hierarchy are the Shapes. This is where the bulk of the data resides. The Shape is a 3-D solid model represented by sections, where each section (or “station”) is a closed 2-D curve represented by a series of points. The lines between points are straight; therefore curves need to be represented using enough points to make the errors in the linear approximations negligible. Likewise the “area curves” derived from the sections are considered to be linear between the sections; so the sections need to be spaced closely enough that the errors due to the linear approximations are negligible here as well. You can experiment with point and section spacings, observing the slight differences in results. In most cases 25 – 35 sections gives acceptable accuracy. Typically there is little if anything gained by using more than about 40 sections. GHS enforces a maximum station spacing of 1/20 of the overall length.

Interpreting Shapes

Note what the Component does: It gives a particular interpretation to the points that comprise the Shape. It also sets their final location on the vessel. By this we mean, the final curve you get from the points in a section will depend on the Side and Vector attributes of the Component.

If the Side is Starboard, the points remain unchanged. The last point connects to the first, making a closed curve. If the Side is Port, the points are seen in their mirror image, i.e. the transverse coordinates are negated, and the order is reversed. If the Side is

Centerline, the points are taken first to last, then again from last to first with the transverse coordinates negated. Thus, the same Shape can serve both port and starboard Components, and only half of a Centerline Component needs to be given.

The Purpose of the Hierarchy

If you want to experience the full power of model building in GHS and avoid a lot of trouble and confusion, then take the time to understand the Part-Component-Shape hierarchy. There are good reasons for this structure.

When you finally produce a report, showing vessel loading conditions, the report will list the Parts only. This is a great feature because it allows you to build up a complex hull or tank/compartment using many Components, yet the report will show only the summation of all Components belonging to the Part. So the purpose in having Components within Parts is to make the construction of the model easier without having unnecessary detail in the final report.

Then why have an additional level for Shapes? Because you can use a Shape in more than one place! How is that possible if two objects are not to be occupying the same space? What makes it possible is the translation Vector at the Component level. Each Component “points to”, or we might say “makes use of”, one and only one Shape. But a Shape can be used by any number of Components since a Component can “vector” the Shape to a position that is suitable to its own purposes. The most common use of this is where symmetrical port and starboard Tank Parts have Components that share the same Shape. In this case the translation Vector is not even needed since the Component can also use the Shape as its mirror image simply by designating its Side as Port or Starboard, as noted above.

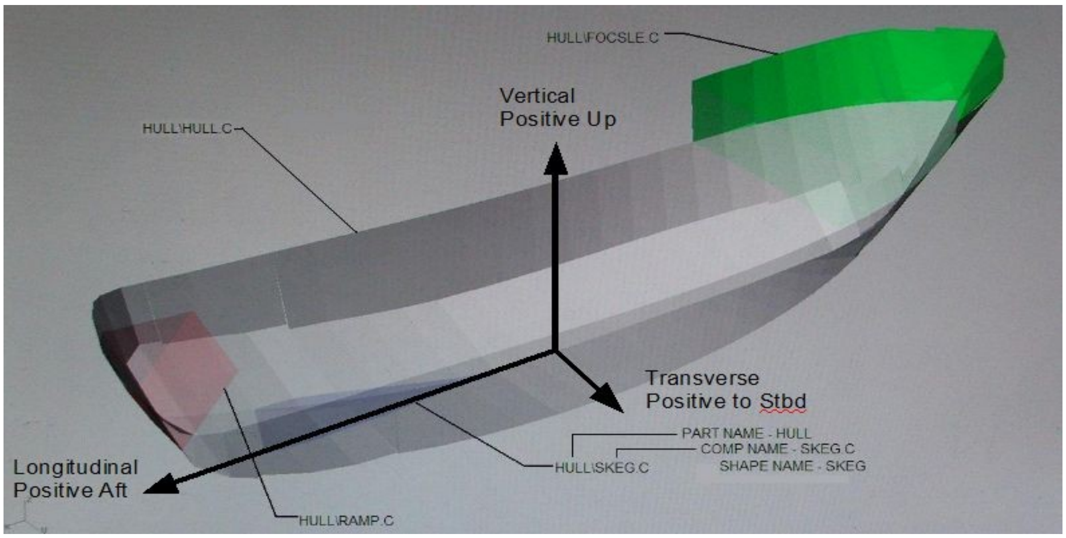
It is worth reading the User's Manual section entitled Understanding the Model in the GHS System Overview. There you will find a diagram that shows the Components of two tanks sharing the same Shape.

The Vessel Coordinate System

The ship model uses a 3-D Cartesian coordinate system, but rather than refer to the axes as X, Y and Z, we call them L, T and V (Longitudinal, Transverse and Vertical), and they always appear in that order. The sense of these axes is positive aft, positive to starboard, and positive upward. We can also denote the longitudinal by means of a letter suffix. For example, “-10.0” would be 10.0 units of length forward of the origin; but it could also be denoted as “10.0f”. Likewise, “10.0” could be written as “10.0a”. Similarly, in the transverse direction , “p” and “s” suffixes can be used. Especially in reports, the f/a and p/s suffixes are used so that the reader does not need to remember the GHS sign convention.

The origin of the coordinate system (i.e. the point 0,0,0) is usually located near the keel, in the plane of transverse symmetry and at one of the perpendiculars. In other words, it is usually located the same as on the original lines plan or hull model. The base plane, by definition, runs through the origin, as does the center plane. But this is only terminology, and you are free to locate the origin anywhere you choose. Remember that ultimately the model may be used in an on-board GLM, where the shipboard personnel will expect that locations refer to an origin they are familiar with.

The origin appears as a blue crosshair in Section Editor, Display and the vessel graphic when it is displayed in the background of the GHS main screen.

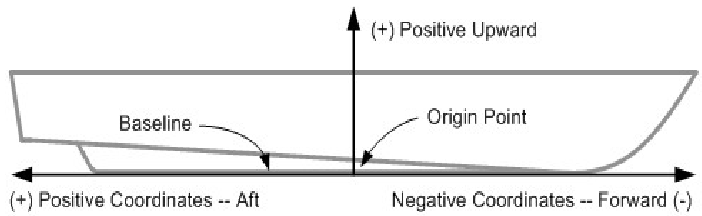


Waterplane Coordinates

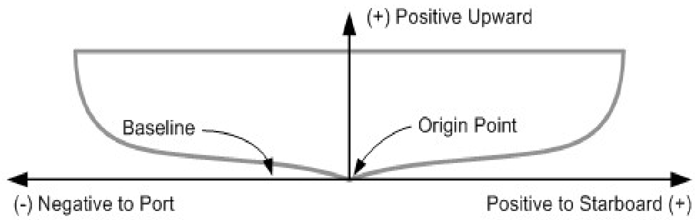
The following illustration emphasizes that the vessel coordinate system is attached to the ship. Centers of gravity and centers of buoyancy are always with respect to the ship coordinate system. However the direction of buoyant and weight forces is perpendicular to the waterplane, which is, only parallel to the baseplane when the ship is upright.

At equilibrium, the CB (center of buoyancy) and the CG (center of gravity) are on a line perpendicular to the waterplane. If heel or trim are present, this line will not be vertical in the vessel coordinate system. Therefore you can expect to see a difference in the longitudinal and transverse coordinates of the CB and the CG even at equilibrium. This is illustrated in the bottom diagram.

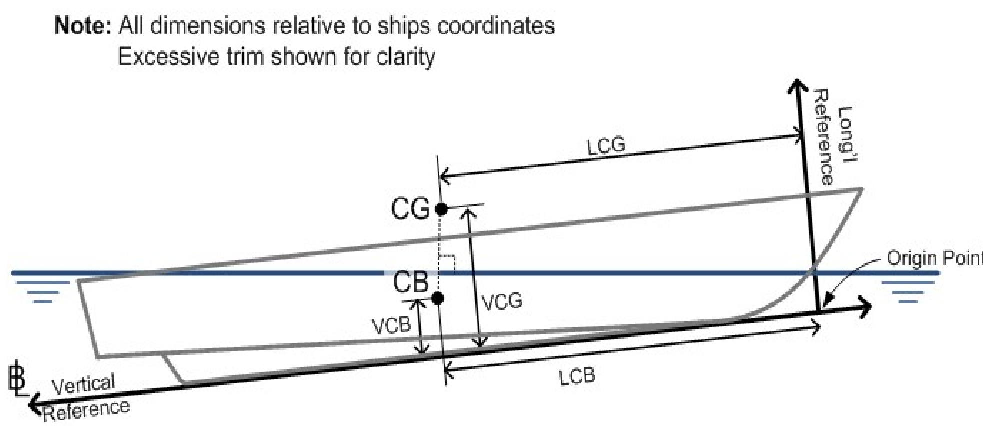
Coordinate System Diagrams



The Longitudinal and Vertical Axes
Profile View



The Transverse and Vertical Axes
Body View (Looking Forward)



Model Building: Creating the Geometry

The tools essential to the process of creating and modifying geometry are:

<u>Part Maker (ENTER PM command)</u>

Part Maker is typically used for building tanks, appendages, and superstructure into Geometry Files that have an existing hull Part. It can be used to create hulls, but if the hull is of ship-shape form, Model Converter or Section Editor would be a better choice. Other hulls that consist primarily of cylinders and rectangular shapes can be created quite efficiently using Part Maker alone.

Components of Parts (typically tanks and superstructure) are created by specifying simple boundaries and then trimmed to the required shapes by fitting to existing Components. For example, if given the end bulkheads, the inboard bulkhead, the top, and the bottom boundaries, a wing tank can be easily fitted to the hull.

We will get into the details of actually using of Part Maker later.

Model Converter (MC command or IMPORT and EXPORT commands)

Model Converter is used to import and, in some cases, to export the following files, which are listed here under the file name extensions that Model Converter recognizes.

GF - GHS geometry file.

DXF - Drawing eXchange File, commonly available from CAD programs.

IDF - IMSA (International Marine Software Associates) data file for exchange of geometry definitions between marine software products.

SHC - Ship Hull Characteristics Program data file. Contains a hull description. If bulkhead offsets are included, a Part Maker Run file can be written to create the compartments thus described. Conversion from GF to SHP is not available.

OFE - Offset Editor file format used by some hull design software.

SHP,HUL,CMP,CMA - Herbert Engineering Corp. file format. Hull geometry and tank geometry information may be found in separate files. Model Converter will read certain of these files and write the result to a GF file. Conversion from GF to HEC is not available.

EAG – A simple hull definition file originating from the PIAS software.

Model Converter FIXUP Mode (FIXUP command)

In this mode, Model Converter provides a rich set of operations that you can perform on your Geometry Files. For example, you can have it change, add or delete sections, define deck edge, specify margin or specify shell thickness. When directed to do so, it can also delete all tanks, delete all parts except tanks and reorder the sequence of tanks.

Some of these operations are also available in Section Editor and Part Maker. Model Converter is especially useful as a command in a Run File, which leads to a greater degree of automation in your work.

We will learn more about Model Converter later.

Section Editor (SE command)

Section Editor can be used to edit Components and Shapes. You can add, delete or move sections and points. Filling between sections by interpolation is also possible. Deck edge definitions (used for deck-immersion criteria and margin line assignments) can be added and edited. SE can also be used to create hull Parts from a table of offsets or by digitizing body plans using digitizing tablets.

For viewing the geometry without an editing capability, it can be used in DISPLAY mode (DISPLAY command).

Starting Section Editor

If a Geometry File is in main memory, the same file is automatically read by SE when started. If no geometry file was in memory, you can use the Read command while in SE. In order to become familiar with Section Editor, do the following:

1) With the command prompt is showing in the GHS main program, first make sure there is no Geometry File currently in memory (use the CLEAR command if necessary);

2) Type, `READ FV.GF`, which will read the fishing vessel model that comes with GHS;

3) Give the command `SE` to bring up Section Editor.

Now you should be looking at the Section Editor's main screen showing profile and plan views of this simple fishing vessel model. Here are some things to explore: Use the Tab, Shift-Tab, and Enter to display different views of the geometry. Tab will cycle through the profile/plan – isonometric – body views. The Enter key toggles between the profile/plan mode and the iso/body mode. Shift-Tab will toggle between the profile and plan views or the iso and body views. To go from Part to Part, press the Page Up and Page Down keys. It cycles back to the first part after the last part. To go from Component to Component within the same Part, use the Up-arrow and Down-arrow keys.

Note that on the left side of the screen there is a vertical array of Function Key reminders. Pressing F1 (on the keyboard, not the screen) will bring up the complete Section Editor usage information. Go to the end of it and you will find a handy alphabetical list of the SE commands. These commands are also summarized on pages 22 & 23.

Commands in SE all begin with different letters of the alphabet. When you type the first letter of a command, the rest of the command word appears automatically. This action is unique to Section Editor and its derivative, DISPLAY.

A Section Editor Exercise

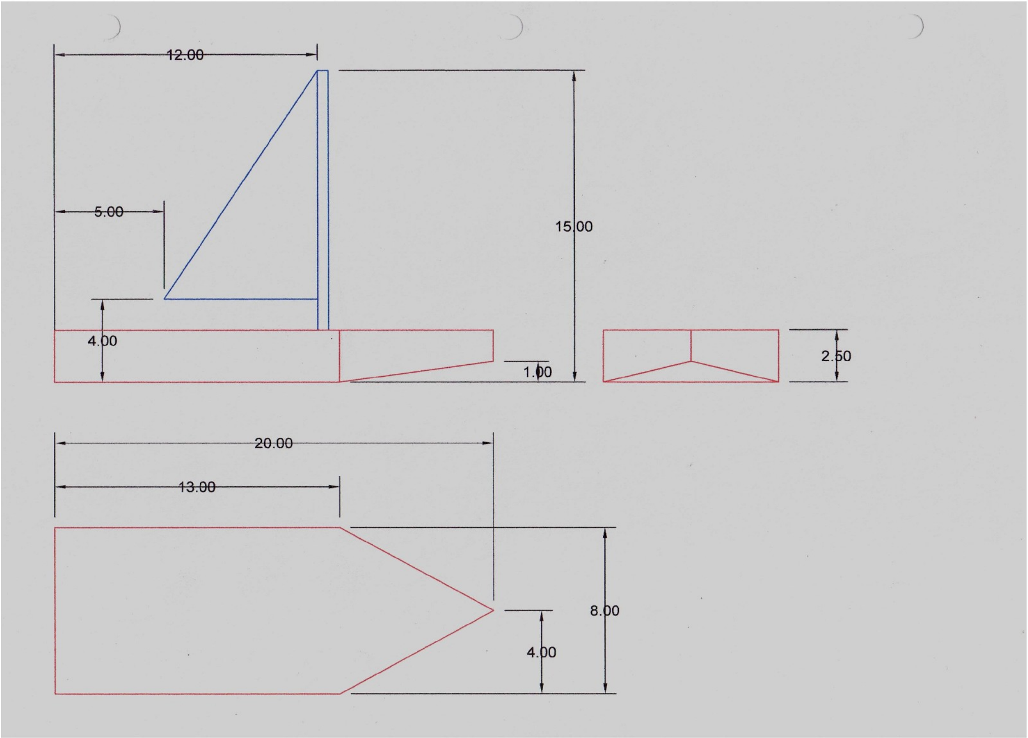
As an exercise, try to create the geometry model shown below using Section Editor. The finished Geometry File will have two Parts: a Hull-class Part and a Sail-class Part (in this case the Sail Part is actually a sail).

If you are now in Section Editor and there is some geometry showing, give the command **`R`**`ead` **`clear`** to get ready to create the new model.

When there is no geometry in Section Editor, it goes directly to the body-view screen so that you can begin entering points immediately. You can declare the name of the Part and Component now or you can do it later. Let's do it now. We will be naming the hull Part “HULL” and its single Component will be “HULL.C” (the “.C” meaning it will be a Centerline component so that we will only need to create the starboard half to get the complete symmetrical hull).

Enter **`N`**`ame` **`hull\hull.c`** to provide this information. Actually “HULL\HULL.C” is the default, and you only needed to press `N` then the Enter key. Notice these names appearing at the top of the screen. You will also notice that the Shape has been named automatically as HULL

Select your own origin point.



About Names of Parts, Components and Shapes

Part and Component names look about the same. Both are limited to 14 characters and must have no embedded spaces. Component names carry a Side designation by means of the suffix (".S", ".P" or .C"). Tank Part names generally carry a side designation in the same way, but other Part names do not (Hull-class and Sail-class parts do not have this side suffix). Although the side suffix is available on Tank Part names, it is the Components that actually determine how each Shape is interpreted, and whether it goes on the port or starboard side, as explained previously.

Shape names are limited to eight characters and obviously do not need side designations since that information is provided at the Component level. Most of the time you will not be concerned with Shape names since the system will assign them automatically. When you refer to a particular Shape, you can always do it through a Component, since all Shapes are referenced by at least one Component.

About Units in Section Editor

Section Editor allows you to work in any convenient units and even to switch between units. The Units command will change the displayed units. Use the arrow keys to scroll through the options. You can also enter units different from the displayed units by including the appropriate forms of the numbers. To see what those forms are, simply try different display units and note how the coordinates are shown.

Entering Offsets with Section Editor

Now we're ready to enter points for the first section – or shall we call it a station? The terms are interchangeable in this context. A prompt to enter the longitudinal location of the first station appears automatically. This is the **S**tation@ command, which you can give any time you want to add a new station. Decide where you want the origin to be, then enter the station's location relative to the origin. Stations can be entered in any order. To delete a station, hit Ctr-F4. You can always go back and edit a station if necessary.

After you give the section location, start entering its points. The Insert command will automatically appear, waiting for you to enter the transverse and vertical coordinates of the first point. A comma or a space can be used as a delimiter between these two numbers. Let the first point be at the centerline, on the bottom of the hull. So the first number will be zero, followed by the height above baseline. Assuming you are making a station in the full-beam portion of the vessel, the offsets would be,

Point 1: `0.0, 0.0`
Point 2: `4.0, 0.0`
Point 3: `4.0, 2.5`
Point 4: `0.0, 2.5`

Points always proceed in the counterclockwise direction. Normally you start at the keel and go around and up to the deck edge. Since we are dealing with a centerline Component, you can stop at the deck edge (omitting point 4). The other side is implied.

What about the top of the section from the deck edge to the centerline? It, too, is implied. Since all sections are closed curves by definition, there is no such thing as an "open" top.

For this simple hull, you need only three points per station. At the stem you can use small transverse offsets slightly greater than zero for the second and third points.

If a point is entered incorrectly, move to that point using the F5 and F6 keys to bring the cursor to the point. Then press F2 to switch from Insert mode to Replace mode, then retype or edit the numbers to the correct values. Alternatively, pressing K puts it in Key Editing Mode where the arrow keys can be used to move the point to the correct location. Pressing K again or F2 will return to insert mode.

Another way to insert and edit points is by means of the right mouse button. It will insert after the current point or replace the current point with coordinates derived from the present mouse pointer. The left mouse button can be used to select points.

Since the Insert mode will always have your new point inserted after the current point, how do we insert a point before the first point? Go to the first point, then while in Insert mode press F5 and it will say "pre insert", which means the point you now enter will be inserted before the first point (now becoming the first point.)

To delete the current point, hit F4.

Saving Your Work: Writing the Geometry File

Writing your work to a Geometry File is done using the Write command. For example, `Write EX1.GF` will write your current model to a Geometry File named EX1.GF. You can also scroll through the ".GF" files in the working directory using the arrow keys. If an existing file is selected, it is overwritten *without* warning. It is easy and prudent to save your work often using the Write command.

The Arc Command

Shall we add a bilge radius? The Arc command makes it easy. On any station, go to the point at the intersection of the bottom and side, then give the command Arc radius 1.0 and the original point becomes an arc.

How Many Stations?

There is no need to enter more than three stations in this simple exercise: one at each end and one at the knuckle will be sufficient.

GHS requires station spacing no greater than 1/20 of the overall model length. Section Editor will write a geometry file even if the station spacing is too large, in which case, a "Station spacing too great" error will appear when trying to read the file into GHS main memory. If this happens, you can immediately give the main-program's FILL command and it will send the Geometry File through Model Converter FIXUP to fill-in the missing stations.

But we can easily generate the missing stations with the Fill command in SE before we leave. Note that this filling operation, whether done by SE or MC, uses nonlinear interpolation. It will detect obvious abrupt changes in the original and use linear interpolation in such cases. However, it is not a bad idea to put closely-spaced stations at any discontinuity before Filling. Try the FILL command with the original three stations, then Undo (Ctrl+U) and add a station near the knuckle (12.9?) and try the FILL again.

Making the Sail

To complete the model in this exercise, Enter the Name command again and instead of accepting the default prompt HULL\, enter

```
Name sail:rig\sail.c
```

The "SAIL:" prefix tells SE that it is to be a Sail-class Part. It will come back asking "Want to create part RIG?". This is to guard against accidentally starting a new Part when you only wanted to switch to an existing Part. In this case we do want to start a new Part, so the answer is "Yes".

The rest is similar to what we did to make the hull. Give it some slight transverse offset, not simply zero. For example,

Point 1: `0.0,  4.0`

Point 2: `0.01, 4.0`
Point 3: `0.01, 15.0`
Point 4: `0.00, 15.0`

For the last aft-most point out at the clew, still use four points and make the last two points slightly higher than the second rather than having two points at the same location.

Two stations are sufficient (but you will still have to Fill).

If you want to make the mast as an additional Component, create the second Component, again with the Name command:

Name **rig\mast.c**

Tab to the Body view if you are not there already and go ahead with the first station on the mast. Note that the SAIL.C component is still showing since it is within the same Part. If you want to have only one Component showing, press Ctr-P. Two stations will suffice for the mast, and no filling is necessary since the spacing is already close enough.

Supposing you accidentally made the mast Component such that it overlaps the sail Component, and you want to move the sail aft a bit. You may remember the mention of Component Vectors previously, and you will have noticed that the Section Editor screen shows the Vector of the current Component. You can change this vector through the Edit command. First, make sure you are looking at the Component whose vector you want to change, using the Up/Down arrow keys if necessary. In this case, while highlighting the RIG\SAIL.C, enter the command,

Edit **vector 0.5, 0, 0**

This will shift the sail 0.5 units aft of where it was originally.

Other SE Commands

To quit Section Editor and go back to the main program, use the Quit command (or press the Escape key) which will bring up a prompt to confirm quitting.

Other interesting SE commands include:

- `Ctrl+U:` Undo
- `Ctrl+R:` Redo
- **D**elete Component; the Part is also deleted if it has only one Component.
- **E**dit changes Component parameters Effectiveness, Margin, and Vector.
- **L**ocation relocates a station, optionally moving neighboring stations to Lengthen or Shorten the shape.
- **T**itle adds a title to be saved with the geometry file.
- **X**late toggles translate mode. In this mode, moving a point moves the entire station.

A list of Viewing and Editing commands for Section Editor are provided below for Reference. The Viewing commands also work in Display.

Section Editor / Display — Viewing Commands

Change view:

TAB	cycles through view: plan/profile → isometric → body → plan/profile
SHIFT+TAB	toggles view: profile ↔ plan OR body ↔ isometric
ENTER	toggle views: plan/profile ↔ isometric OR plan/profile ↔ body
ALT + ←↑→↓	rotates model in isometric view

Viewing Options:

CTRL+B	toggle background color black ↔ white
CTRL+K	toggle deck edge (and centerline) display on & off
CTRL+L	toggle single station ↔ all stations (in single station mode, F7 & F8 display adjacent stations)
CTRL+O	toggle component/shape information on ↔ off
CTRL+P	part toggle: entire part ↔ single component

Zoom:

CTRL+F9	centers cursor on selected point
F9	restore normal view, entire part fills screen
F10	zoom in
Z – ZOOM	zoom by a sets the zoom factor; default is 1.0 which doesn't change the scale, but does center the cursor on selected point

Change selected part:

PAGE DOWN	selects next part
PAGE UP	selects previous part
SPACE	cycles through parts, only in plan/profile view

Change selected component:

↓ (down arrow)	selects next component in present part
↑ (up arrow)	selects previous component in present part

Change selected station:

F7	more to next station (aft) in shape
F8	move to previous station (forward) in shape
CTRL+F7	move to last station is shape
CTRL+F8	move to first station in shape

Change selected point:

F5	move to prior point on station
F6	move to next point on station
CTRL+F5	move to first point on station
CTRL+F6	move to last point on station

See following page for SE/Editing Commands

Section Editor Only

Editing Commands

Note: Section Editor uses only the first letter of a command. Once the first letter is typed, the command becomes active. Additional letters typed are perceived by the program as input to the command.

See HELP SE-REF for more details about Section Editor commands and functions.

Input Mode Keys

F2	edit mode toggle: insert ↔ replace (move)
CTRL+F2	toggle key edit mode ↔ insert/replace mode (see K command below)

Commands for editing geometry:

A – Arc	converts present point to an arc of specified radius
F3	duplicate present point
F4	delete present point
CTRL+F4	delete present station
D – Delete	delete component; if only one component, deletes the part also
E – Edit	edit the component vector, effectiveness factor, or margin
F – Fill	interpolate stations on the present shape to fill gaps larger than given interval
K – Keyedit	toggle keyedit mode enabling arrow keys to nudge selected point - ARROW keys (← ↑ → ↓) nudge point by 0.010 - CTRL + ARROW moves larger increments (0.100)
L – Location	move present station; can be used lengthen or shorten vessel
N – Name	select, create new, or rename a part/component
S – Station	new station, copy present station, or interpolate new station
X – Xlate	toggles translate mode, moving a single point moves entire station

CTRL+SHIFT+D	toggle deck edge marking for the current point
CTRL+D	construct deck edge for the current component
CTRL+Z	deconstruct deck edge for the current component

CTRL+U	Undo
CTRL+R	Redo

Other commands:

F1	help window
Q – Quit	to exit section editor, will prompt to save changes.
R – Read	read a geometry file, if already read in GHS, will be read automatically.
T – Title	to add a title to the geometry file
U – Units	to set units for input and display
W – Write	saves the current geometry to a file

Model Converter: Importing and Exporting Geometry

Model Converter is used when you import or export geometry data. The IMPORT and EXPORT commands are most useful for these operations, and when you use these commands you are actually using Model Converter indirectly.

The DXF drawing file is one source of geometry data that the IMPORT command recognizes. For example, if you have a CAD drawing and can export the hull sections as a DXF, you can then import the data from the DXF into a GHS Geometry File.

It is recommended that the data in the DXF be in the form of a 3D drawing. Model Converter will also handle 2D drawings, but it becomes more complicated since section locations have to be communicated explicitly. Model Converter offers you several ways to do this, such as using layer numbers or names to represent the longitudinal location of the section on that layer.

Since the DXF file fundamentally represents a drawing, there is no guarantee that a coherent model can be extracted from it. For example, there is nothing to prevent the DXF from having lines that are coincident. Model Converter must piece together line segments, polylines and arcs from the DXF in order to make a 3D solid model suitable for the GHS Geometry File. The DXF file format does not require that these drawing elements be in any particular order, even if it is a 3D drawing.

A Model Converter Exercise

For this exercise we will generate suitable DXF files the easy way: simply by using the EXPORT command. We will export two components from the FV.GF model as two separate DXFs, then import them back into a singe Geometry File. If you have a CAD program on your computer you can look at the DXFs that we will be generating.

This is a good time to use a Run File. We will place the EXPORT and IMPORT commands in a Run File named `MKHULL.RF`. At the GHS main program prompt, enter the command “PROJECT MKHULL”. Then enter the command “EDIT”. This should bring up the Run File editor ready to create or edit MKHULL.RF. The first thing to put on this file is that PROJECT command again. This will save some time if you come back to this file later, since it will define the project name itself when your run it.

Next we will use the READ command to read FV.GF into main program memory. Then type in the EXPORT command as shown below.

```
PROJECT MKHULL
READ FV.GF
EXPORT (HULL\HULL.C)   HULL.DXF   /3D:XYZ
```

You can now close the editor, saving the file first, and when you get back to the GHS main program command prompt, enter the command “RUN”. Since the project name is MKHULL, it will run MKHULL.RF. Unless you include the /NOWAIT parameter, there will be an informational MC window that you will need to close before it will continue.

The result of this run is the file HULL.DXF, and you will find it in the working folder. If you are familiar with the DXF format, you might like to have a look at it. Since DXF files are text files, you can view it as text using the VIEW command: “VIEW HULL.DXF”. Much more useful would be to look at the DXF through a drawing program that reads or imports DXFs. If you have one on your computer you might want to take a look at this drawing that Model Converter has created.

As you may have guessed, the parameter “/3D:XYZ” has something to do with the way the drawing is laid out. It tells Model Converter to make a 3D drawing and to make the drawing's X,Y and Z axes correspond to the L, T and V axis of the GHS model.

Now let's complete the exercise by doing the following.

First, add a second EXPORT command to your Run File, this one exporting the Component HULL\FOCSLE.C to the file FOCSLE.DXF.

Next put the command “CLEAR”. This will clear the geometry from main program memory so that we can be sure that what we see next will actually be what was imported.

Follow this with an IMPORT command to take the drawing data from HULL.DXF and place it on the Geometry File FV1.GF. Now the command needs to be more explicit. The EXPORT command needed only to state the name of the file to receive the output, implying that the currently-read Geometry File would be the source. Now we must specify both the input, or source, and the output file. The command would be,

```
IMPORT   HULL.DXF (HULL\HULL.C) FV1.GF   /3D:XYZ  /NOFILL
```

Here are some things to observe: 1) The reason we need to specify the Part and Component names is that the DXF does not carry this information; 2) the /3D parameter must match that in the EXPORT command exactly (i.e. it must accurately indicate the form in which the drawing portrays the 3D model); and 3) the /NOFILL parameter tells Model Converter to not bother with filling-in extra stations since we know that it already had enough.

Finally, add the second IMPORT command.

Of course, if the drawing had contained other elements, they could be similarly imported as additional Components of the hull, as Sail-class Parts and even as tank Parts (but in most cases Part Maker is the best way to put tanks into the model).

After importing the geometry, you will want to mark the deck edge for each hull component as appropriate. Section Editor and Part Maker can do that, but we will show how you can use Model Converter through the FIXUP command to accomplish this as well. The command to mark the deck edge on HULL.C would be,

```
FIXUP FV1.GF (HULL\HULL.C) /DECKEDGE /NOFILL
```

Your completed Run File could look something like the following, but without the SHELL command, which is shown here to demonstrate what you could do if you had Rhino or some other CAD program on your computer and wanted to automate the step of examining a DXF before importing it.

```
PROJ MKHULL
```

```
READ FV.GF
EXPORT (HULL\HULL.C) HULL.DXF /3D:XYZ /NOWAIT
SHELL OPEN HULL.DXF /SPAWN
EXPORT (HULL\FOCSLE.C) FOCSLE.DXF /3D:XYZ /NOWAIT
CLEAR
IMPORT HULL.DXF (HULL\HULL.C) FV1.GF /3D:XYZ /NOFILL
IMPORT FOCSLE.DXF (HULL\FOCSLE.C) FV1.GF /3D:XYZ /NOFILL
FIXUP FV1.GF (HULL\HULL.C) /DECKEDGE /NOFILL
FIXUP FV1.GF (HULL\FOCSLE.C) /DECKEDGE /NOFILL
DISPLAY
```

Deck Edge Considerations

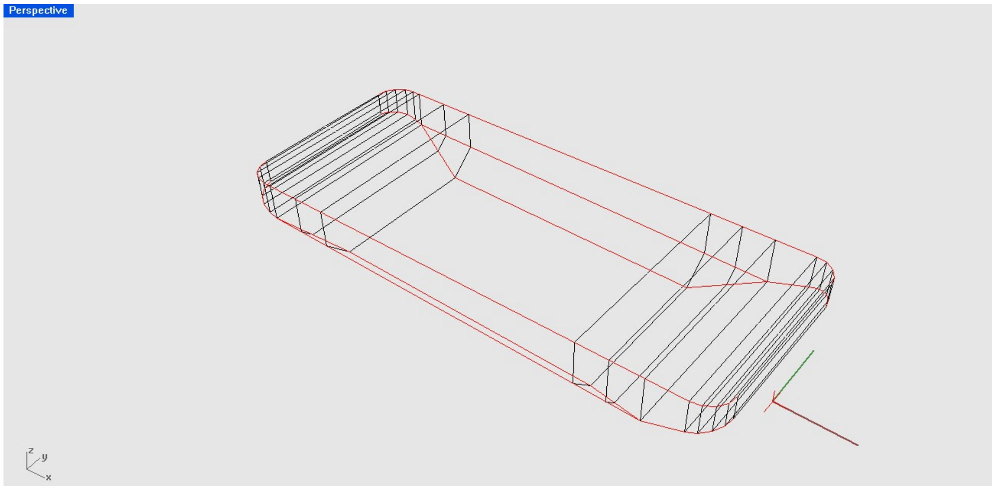
If you bring up DISPLAY or SE, and you have marked the deck edge on both HULL.C and FOCSLE.C, you will notice brown lines in the iso view, showing where Model Converter put the deck edge. Now here is a problem: Does this represent reality? In this case the answer would be “no”, since the FOCSLE.C Component is a watertight structure that covers the main deck forward. We would like to remove the deck-edge marks from HULL.C where it is covered by FOCSLE.C. It is not difficult to do this using Section Editor. If you move the point marker to the point at the deck edge, you will see “DK” following the point's coordinates. Simply deleting the “DK” removes the deck edge mark on that station. You could do this for all of the stations on HULL.C that are in way of FOCSLE.C. But you can also do it with the FIXUP command. By adding a range of locations to the /DECKEDGE parameter we can specify the length over which the deck edge is to be marked:

```
FIXUP FV1.GF (HULL\HULL.C) /DECKEDGE:-23.2, 41  /NOFILL
```

Another Model Converter Exercise

Convert BARGE.DXF into a GF file. We will use the resulting Geometry File later for the Part Maker Exercise. In this case BARGE.DXF happens to be a 3D drawing with axis assignments such that we need the parameter /3D:XYZ. Here are the commands to put on your Run File MKBARGE.RF:

```
PROJECT MKBARGE
IMPORT BARGE.DXF  BARGE.GF /NEWGF /3D:XYZ
DISPLAY
```



The second part of this exercise is to add parameters to the IMPORT command line to orient station 0 at the head log with the hull positioned aft (to the left as viewed in profile/plan). The /SCALE parameter on the IMPORT command will be useful for this. You can use a negative scale factor to reverse the longitudinal coordinates.

Getting Into Part Maker

To enter the Part Maker environment, the command is "ENTER PM", which you can issue either from the GHS command prompt or from a Run File, but not from the Executive dialog.

The basic layout of any session begins with ENTER PM and ends with QUIT PM. All of the commands between these two will be processed by Part Maker. You can include your Part Maker command sequence in any Run File.

The Part Maker command that creates geometry is the CREATE command. This is a multi-line command; i.e. it always takes more than one line of text. The first line starts with CREATE and the last line is a single forward slash.

The lines between the CREATE and the terminating slash look like additional commands, but since they are within the multi-line command we call them Statements. They are essentially parameters that define what is to be created. Here is an example of a simple Part Maker run to create a double bottom tank on the starboard side with its top at 2.5 ABL and extending from the centerline to the shell:

```
ENTER PM
READ OLDSHIP.GF
CREATE TANK1.S
  ENDS 12.34f,  4.56a
  TOP 2.5
  FIT HULL\HULL.C
/
WRITE NEWSHIP.GF
QUIT PM
```

It is assumed that the hull geometry, at least, was already present in the GHS main memory, causing the file that it came from to be read into PM by the ENTER process.

This example generates not only the new Part, TANK1.S, it also generates the first Component within the new Part. Since we did not specify the Component name, it becomes the same as the Part name. The Component's Side, of course, is starboard. It also creates the Shape to carry the actual offsets, most of which were derived from the hull in order to give it the proper shape where it is bounded by HULL.C.

It is was not necessary to declare the Class in this example because class TANK is the default.

There is a Part Maker tutorial at, www.ghsport.com/support/tutor/pmtut and you may also find it included in your GHS Help system: From the Help menu select “Web Help” then “GHSport on disk” then select “Customer Support” then “Tutorials” and finally “Part Maker Tutorial”.

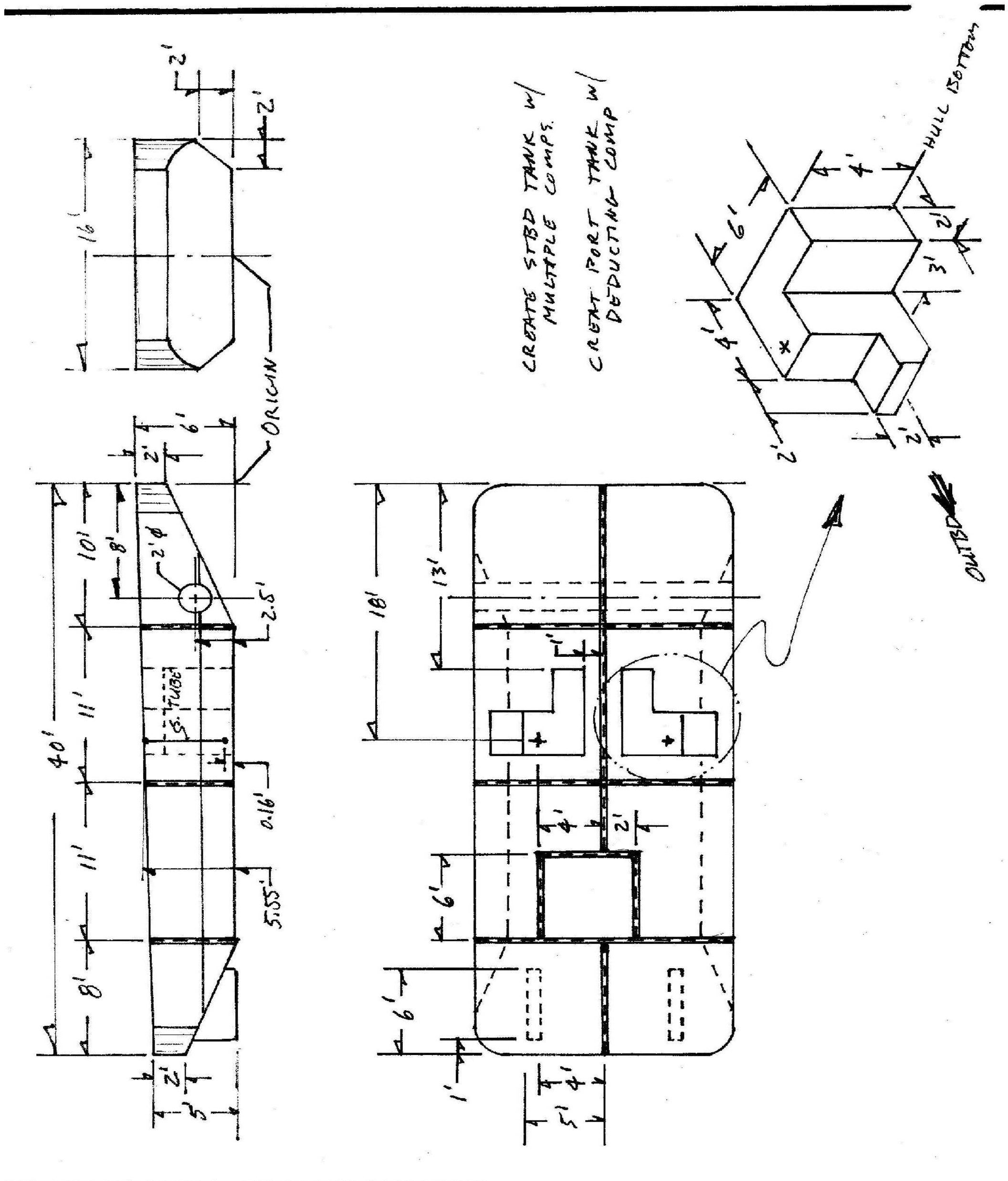
Under the Help menu you will find PM, which is the summary reference document for Part Maker. At the end of that document is an alphabetical list of the Part Maker commands and statements. The Help entry PM-TM explains in detail about making tanks, and PM-AM similarly covers appendage making with Part Maker.

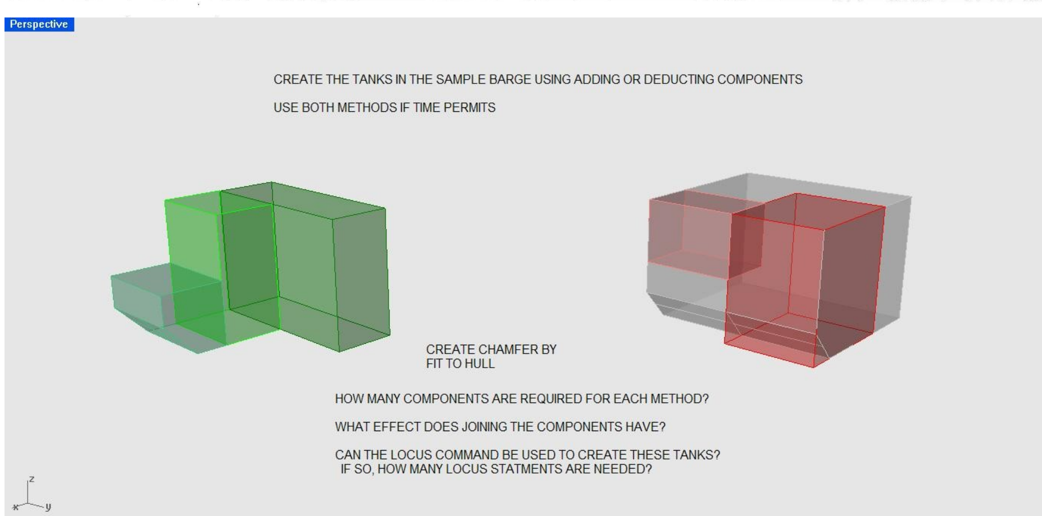
A Part Maker Exercise

Using the barge hull created in the second Model Converter Exercise above, add the hull Components THRUSTER and SKEGS and also the compartments and independent tanks shown in the drawing below. Here is a start for the Run File.

```
PROJECT MKTANK
READ BARGE.GF
ENTER PM
ECHO ON
UNITS F
TITLE 40X16X6 BARGE
COMM HULL CREATED BY MODEL CONVERTER FROM BARGE.DXF
COMM TANKS ADDED PER TANK DWG

CREATE HULL\TUNNEL.P
 DEDUCT
 CYL 8, 0, 2.5   8, 8, 2.5,  2.0
 FIT HULL
/
CREATE HULL\SKEG.C
 ENDS 34, 39
 TOP 4
 BOT 0
 IN 4
 OUT 5
 FIT HULL
/
`CREATE REMAINING TANKS PER SKETCH
UNITS M
WRITE BARGE.GF1
DISPLAY
QUIT PM
```


CREATE STBD TANK W/
MULTIPLE COMPS.
CREAT PORT TANK W/
DEDUCTING COMP
HULL BOTTOM
ORIGIN
S. TUBE
OUTBD


Perspective
CREATE THE TANKS IN THE SAMPLE BARGE USING ADDING OR DEDUCTING COMPONENTS
USE BOTH METHODS IF TIME PERMITS
CREATE CHAMFER BY
FIT TO HULL
HOW MANY COMPONENTS ARE REQUIRED FOR EACH METHOD?
WHAT EFFECT DOES JOINING THE COMPONENTS HAVE?
CAN THE LOCUS COMMAND BE USED TO CREATE THESE TANKS?
IF SO, HOW MANY LOCUS STATMENTS ARE NEEDED?

Generating Reports

In order to generate a report, you need to open a report file to receive information. The “REPORT filename” command is used for this. From the time GHS receives the REPORT command to open a file until the time it gets a “REPORT OFF” command to close the report file, you will be capturing a record of anything displayable that issues from your commands. At any time while a report is open, the command “PRINT PREVIEW” or "REPORT /PREVIEW" will bring up a window allowing you to see the report as it would look if it were printed.

The preferred and default file name extension for report files is “.PF”. Through the Report menu you can View (text only) and Preview (text and graphics) report files.

The Basic Run File Structure for Reports

So far we have made Run Files that are oriented toward creating geometry. From this point on, we will be using the geometry that was created previously, and our Run Files will be structured accordingly.

Here is the basic pattern for any Run File that reads existing geometry and performs calculations based on it:

```
PROJECT name
READ filename.GF
REPORT repname.PF
  ...
REPORT /PREVIEW
REPORT OFF
```

The purpose of the "REPORT /PREVIEW" command, as noted earlier, is to allow you to see the report without printing it. You can always print it later through the Report menu.

Annotating Run Files

It is helpful to have notes in your Run Files – information that will be ignored by GHS when it processes the commands from the file. The left apostrophe (above the Tab key on most keyboards) is ignored, as well as anything after it on the same line.

Printing Out the Geometry

To get a hard copy of the geometry, use the “DISPLAY PRINT” command:

```
READ FV.GF
REPORT FVDISPLAY.PF  `Opens the report file
DISPLAY PRINT /NOOFF
REPORT /PREVIEW
REPORT OFF  `Closes the report file
```

The `/NOOFF` parameter causes it to omit listings of the offsets. There are many other parameters available as well, which you can read about in the User's manual or through Help DISPLAY.

For example,

```
DISPLAY PRINT /PREVIEW
```

gives you the on-screen preview of the geometry hard-copy report even when there is no report file open.

Caution: If you simply give the command,

```
DISPLAY PRINT
```

without a report file being open and without the /PREVIEW, the report will be sent to the printer immediately, which can consume a great amount of paper.

This printout can serve as documentation of a particular Geometry File.

Annotating Reports

You can place text and graphics in your report by means of the NOTE command. This command has a special abbreviation: the back slash ("\"). For example,

```
\Case 3 - Arrival
```

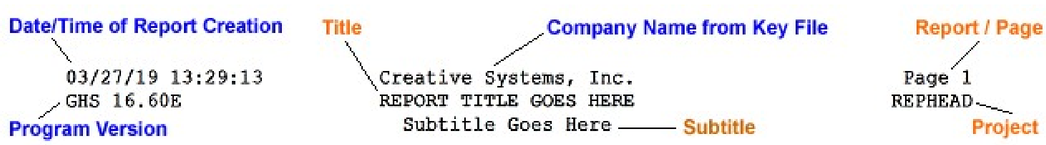
This places the text "Case 3 - Arrival" on the current line of the report file starting at the left margin. To have it centered horizontally in the line, put another back slash at the end:

```
\Case 3 - Arrival\
```

An advantage of using the back slash rather than NOTE is that it preserves the case (NOTE capitalizes everything).

There are many other features of the NOTE command, including its ability to place a graphic image in the report. Look in HELP NOTE for all the details.

The report header contains some information such as the Title and Subtitle that provide useful information. The image below indicates the various parts of the report header. Labels in red are GHS commands that can modify the header object. Labels in blue generally can't be customized except for the company name. To update the company name, please contact Creative Systems, Inc.



The subtitle is especially useful for identifying the condition or stability criterion for the report reader.

The MESSAGE Command

This command has many uses. The most basic one is to place a message on the screen. For example,

```
ME Hello GHS
```

Try this and you will find “HELLO GHS” on the screen. Note that everything became capitalized. To prevent the capitalization, start your message with a quotation mark (no need to put one at the end):

```
ME "Hello GHS
```

System Variables

Certain information internal to the program is accessible to you without having to take it from reports. The means of accessing this information is the System Variable. For example, there is a System Variable named PROJECT. You get whatever information is currently held under the name of a System Variable by enclosing the name in braces, sometimes called "curly brackets". For example,

```
PROJ RIVERQ
ME "The project name is {PROJECT}
```

Compared to report output, this is a more intimate way of communicating with the program. It may not be obvious now, but eventually you will find it quite useful.

Two Kinds of Calculations

There are two kinds of calculations: Those that do not require a particular condition or load, and those that are based on one particular condition.

The calculations that are independent of any particular load condition typically result in a table and graph of some vessel characteristic as a function of displacement or load. This includes curves of form, hydrostatic properties, cross curves of stability, maximum VCG curves and tank characteristics curves. In a slightly different category, but of the same kind, are those that are entirely independent of any waterplane: Component skin area and tonnage.

Those calculations that are based on a specific condition include the status report of particular hydrostatic properties, righting-arm curves, maximum VCG in a particular condition, longitudinal strength curves and floodable length curves.

Parts and Components in the Calculations

As mentioned earlier, one reason for the hierarchy of Parts and Components is to simplify the presentation in reports. Similarly, nearly all of the commands in the GHS main program deal with whole Parts. For the most part, the user need not be aware of the Components within the Parts.

The exception to this is the COMPONENT command. This is the only command that produces reports based on individual Components. There are three uses for this. One is to get component properties: coefficients of form, curves of form, wetted surface and skin surface area. The second use is setting those component parameters that are adjustable: permeability/effectiveness and shape factor. The third use is delving into the Component level to investigate how individual Components contribute to the properties of Parts. This can be carried even further, down to the section level, examining section properties and sectional-area curves.

Reference Points of Parts

One of the attributes of a Part is its Reference Point. Each Part has a Reference Point attached to it, which can be set and reset at any time. This point is used for various purposes. Usually it marks some special point on the Part. However, the initial default setting of Reference Points on all Parts is (0,0,0); i.e. the same as the origin of the coordinate system. Any Reference Point can be set to any location by means of a statement in Part Maker at the time the Part is created, and that setting is kept in the Geometry File. Reference points can also be changed at any time in the main program by means of the REFPT command. For example, to change the reference point of a Part named HULL, the command would be,

```
REFPT (HULL)  = l, t, v
```

Remember the discussion about system variables? (These are certain values internal to the program that are accessible to the user.) One of them is the height, relative to a waterplane, of the Reference Point of the given Part. This is accessed through the HEIGHT system variable. For example,

```
PART = HULL
MESSAGE  "Height of HULL Ref Point is {HEIGHT}
```

Notice that we had to establish HULL as the Current Part by means of the PART command so that the program would know which Part we were interested in.

The Current Parts List

In many occasions you will need to address a certain Part or a certain collection of Parts. One way to do this is to make use of the Current Parts list. As we saw in the previous section, the PARTS command does this.

Note that the Current Parts list shows up at the bottom of the screen – at least it shows as much of it as will fit in the space available. (The list itself is not truncated; only the display of it may be incomplete.)

Some commands act on certain Parts. Generally there are two ways to tell the program which parts you want it to act upon. One is simply to provide the name or names of the Parts right in the command that will be acting on them. This is always the first parameter of the command and in most cases is enclosed in parentheses. If a Current Parts list exists, the parenthetical list can be omitted, and the Current Parts list will be used instead. (If neither exists, the command will issue an error message.) An exception to this rule is the COMPONENT command, where it goes ahead with all Parts in the model; but the COMPONENT command is exceptional in several ways, as we shall see.

To set a Current Parts list of tanks the command is, TANKS = *list* (the trailing asterisk can be used on the tank names in *list)*. To set the list to all tanks the command would be,

```
TANKS = *
```

To turn off the Current parts list; i.e. to make it empty, the command is,

```
TANKS OFF
```

Similarly the PARTS command can be used. One difference is that TANKS will only accept the names of tank Parts. Another difference is that PARTS is smart when you give it the name HULL and there is no Part by that name. Instead of issuing an error, it defers instead to the first hull-class Part in the model. This is useful when you want to know the height above water of a certain part, as was demonstrated in the previous section.

Heel Angles and Trim Angles

The Heel angle is best visualized looking at a body plan, keeping the body plan upright and rotating the waterplane. Where the waterplane cuts a section in the body plan, you have a line; and the angle that line makes with the base line is the Heel angle. The sense is positive or “starboard” if the Heel angle is at a positive rotation from the baseline in the counterclockwise direction. Heel angles can range between 180 degrees to port and 180 degrees to starboard. The HEEL command sets the Heel angle. For example, HEEL=10 sets the Heel at 10 degrees to starboard.

The Trim angle is best visualized on the same body plan. The lines cutting the sections are parallel to one another and the more trim you have, the greater the distance between them. From any two sections you can calculate the Trim angle by taking the arc tangent of the distance between the water lines divided by the distance between those two sections. The sense is positive for “aft trim” when the water line on the section further aft is above the other. Trim angles can range between 90 degrees forward to 90 degrees aft. The TRIM command sets the trim angle. For example, “TRIM=2.0” sets two degrees aft trim without affecting the Heel angle.

Origin Depth vs. Draft

The waterplane is specified and reported primarily by means of three parameters: Trim angle, Heel angle and origin depth. The origin depth is the distance between the waterplane and the coordinate system's origin (0,0,0) . This distance is taken perpendicular to the waterplane, and it is positive when the origin is under water, negative if the origin is above the waterplane.

Draft is not the same as the origin depth for three reasons: 1) Draft is always measured perpendicular to the base plane of the ship's coordinate system, while origin depth is measured on a line that is perpendicular to the waterplane; 2) Draft requires additional qualification, viz. the location along the length of the vessel at which the draft is taken (draft at the FP, draft at the AP, LCF draft, etc); and 3) Draft can reference some line other than the base line (keel draft, for example).

A certain form of the DRAFT command is used to change the draft reference line. For example,

```
DRAFT "Keel" = -0.04 @ 50f,  -1.04 @ 50a
```

defines a sloping "draft line" that is below the base line. After this command has been issued, all drafts in the reports will be referenced to this "Keel" draft line, and all draft inputs will assume this line as well. To revert to baseline drafts, the command is simply,

```
DRAFT BASELINE
```

When the ship is upright or nearly so, draft is often used because it relates to markings on the hull of the actual ship. As the inclination becomes greater, draft becomes less useful. At 90 degrees heel, draft is undefined. GHS will allow draft to be used only at inclination angles less than 45 degrees. Origin depth is always usable regardless of the inclination.

We will defer the discussion about how to set drafts until we get to setting up specific load conditions.

FP, AP and LBP

GHS does not derive the locations of the perpendiculars automatically from the geometry. If you want it to acknowledge these locations, you must declare them explicitly be means of the LBP command. In the simplest form of the LBP command, you can simply specify the length between perpendiculars. This is useful for enabling the representation of trim as a distance instead of an angle. Or you can give the FP and AP locations using the command in the form,

LBP = L_{fp}, L_{ap}

where the L values are longitudinal locations in the ship's coordinate system.

Trim Angle vs. Trim Distance

Although trim is fundamentally an angle, it is often more convenient to represent it as the difference between forward and aft drafts. However, this is not a precise definition unless the ship is at zero heel. Exactly how does GHS represent trim as a distance? It simply takes the tangent of the Trim angle and multiplies it by the LBP.

After the LBP has been defined, the reports will show trim as distance and also mention the LBP length so that there is no question about the length. If FP and AP have both been defined, some of the reports will show drafts at both points rather than trim. In that case, the trim distance will not be exactly the same as the difference in those drafts unless the heel angle is zero. This follows from the definition of Trim given above: Trim is based on the heeled waterplane while draft is to the ship's baseline.

What about trim input? When trim is involved in any command, GHS expects it to be an angle unless a slash appears along with the given number. For example, if you say “TRIM=1.5a” it takes this to mean 1.5 degrees of trim aft. But if you say “TRIM=1.5a/150.” it assumes this to be a ratio of distances, and computes the trim angle as its arctangent, or 0.573 degrees. If you have defined the LBP, and want to base your trim input on that, you can use the slash with nothing following it; for example, “TRIM=1.5a/”.

Curves of Form

Curves of form are form coefficients plotted against a range of drafts or waterplane levels. Since the coefficients of form are intended to compare form characteristics of hulls, or possibly other fair-body objects, they are available only for individual Components. Hence, in a Hull Part that includes appendages as separate Components, it would be a main fair-body Component (usually HULL.C, but not necessarily so) that would be a good candidate for curves of form.

The command to get curves of form is,

```
COMPONENT HULL\HULL.C  /FORM  /DEPTH: d1, d2, … dn
```

where the *d* values are Reference Point depths of the Part's Reference Point, not the coordinate system's origin (though, of course, a Reference Point can be at the origin). Why use Reference Point depths rather than origin depths or drafts? Drafts are not used since they are not always well defined (as discussed above). Origin depths are not used because curves of form are not limited to hull Parts. Even tank Components can have their curves of form, in which case it is the “waterplane” within the tank, not the vessel's draft that is relevant.

Curves of form are available at any trim and heel angle.

The first parameter in the COMPONENT command is actually optional. The default is to repeat the calculations for each Component of each Part in the entire model. However, if one or more Current Parts have been defined by means of the PARTS or TANKS command, these reports are limited to them.

Curves of Hydrostatic Properties

Here we deal with the properties of the entire vessel at a series of waterplane levels. All Parts that are subject to the waterplane are included, even flooded tanks, and any Wave that may have been specified is taken into account. Tank TYPES and the WAVE command will be discussed in more detail later.

There are two sorts of hydrostatic properties. One is “pure” hydrostatic properties that have nothing to do with the center of gravity. These are available through the HS command, where origin depth is the independent variable. For example,

```
HS 2 2.1 ... 8 `Hydrostatics from 2 to 8 feet, 0.1 increments.
```

The other sort of hydrostatic properties recognizes the effect of the CG and therefore is able to include moments to trim. The command for this is GHS and the independent parameter is displacement weight or draft. In the GHS command, draft is assumed to be at the LCF, by default, but any other draft location can be specified. For example,

```
GHS DRAFT @ 0 = 2 2.1 ... 8
```

while,

```
GHS 2 2.1 ... 8
```

will assume the drafts are to be at the LCF. If there is no trim it makes no difference where the drafts are taken. If there is trim, the location of the LCF generally depends on the draft, which means that the program must do some extra work to set the LCF draft to a given value (but it does so very quickly).

An Exercise in Curves of Hydrostatic Properties

Write a Run File to compute curves of hydrostatic properties including graphs using the FV.GF model.

```
CLEAR
READ FV.GF
REPORT HSTATICS.PF
...
REPORT /PREVIEW
```

More About Station Spacing

In order to get nice, smooth curves of hydrostatic properties, you may have to add more stations to your hull geometry model near the ends, especially when there is little or no deadrise in the station curves – such as you would have in the rakes of a barge. The reason for this has to do with the waterplane properties that depend on the plane that is obtained by cutting through the stations. At the ends of this plane there can be a severe lack of definition, particularly when its ends fall between stations. If the station bottoms are V-shaped, the waterplane endings will be fine, and this problem is usually insignificant. But where the stations are broad on their bottoms, the waterplane endings will also be wide and blunt, and their exact shapes will be difficult to get by cutting through the existing stations. GHS makes an attempt to extrapolate properties for such poorly-defined waterplane endings, but the results are not as accurate as they would be from closer station spacings.

If you get your curves of hydrostatic properties at closely-spaced drafts, this effect will be more apparent, and it may take a large number of additional stations at the ends of the hull to yield smooth curves. The displacement-related curves are not affected by this to any significant degree. It is only the waterplane-related curves such as KM, Weight to Immerse and Moment to Trim that are subject to this problem.

These extra stations that might be added in order to smooth the curves of hydrostatic properties will have no significant effect on the displacement or the stability calculations. With the possible exception of GM, stability information does not depend on waterplane calculations. When free surface moments are used (GHS does not normally use FSM in its treatment of free surface, as will be explained later) the tank "waterplanes" are also significant. Generally, if the hull is producing smooth curves of waterplane properties, the tank FSMs will also be sufficiently accurate if the tanks have been FIT to the hull during their creation in Part Maker.

Either Model Converter or Section Editor can be used to conveniently insert additional stations into a hull model by interpolation. In most cases the interpolation yields acceptable results. But you should always inspect the new stations in Section Editor and make any necessary corrections. Since extra stations require extra calculation time, it is not productive to have more stations than necessary. Closely-spaced stations in the mid body contribute little to accuracy but may add significantly to the run time.

Choosing your Drafts

Another irregularity in the plots of the curves of hydrostatic properties occurs when there is an abrupt change in the waterplane at some draft. Since the curves are plotted using non-linear interpolation, this can result in "overshooting" at the draft where an abrupt change occurs. It may be necessary to select closely-spaced drafts on both sides of the transition in order to force the curves to change their direction abruptly.

Cross Curves of Stability

In case you need cross curves, they are available (there should be little need for them in the modern world). The command is CC and, like the GHS command, the independent parameter is either displacement or draft. For example,

```
CC  2.0  2.5 ... 8.0  /MARK:DECK
```

computes the righting arms for the range of drafts specified and includes a line at deck immersion. Another example:

```
CC DISPL:50 100 ... 300 /MARK:FLOOD
```

computes the righting arms for the given range of displacements, including a line at downflooding.

Cross curves can be run with fixed or variable trim and with the assumed VCG at any value. If you want to fix the trim, the command is FIX TRIM; and to restore free trim the command is VARY TRIM.

Macros

A macro is simply one or more commands that have been stored under a certain name so they can be conveniently executed by giving that name. It is easy to define a new macro. For example,

```
MACRO ST
 STATUS WEIGHT, DISPLACEMENT, FREEBD
/
```

Now we can execute that rather lengthy STATUS command simply by saying, “EXECUTE ST”, or even more simply by

```
.ST
```

where the dot is the short way of saying “EXECUTE “.

Note that the MACRO command is a multi-line command, where all of the lines between the word MACRO and the final slash are stored under the name that appears on the first line. No processing of these lines takes place until the macro is executed.

You might be tempted to ask whether this doesn't violate the rule about sequential processing that we learned early in the course. The answer is, “no”; commands are always processed in the order in which they are presented to the command processor. The Macro command is processed, like any other command, when it comes up in the sequence. It does its thing, which is simply to store its body in the program's memory.

The Macro command doesn't care what is in those lines. Later, when the command to execute the macro is encountered, the lines from the body of the macro are retrieved from memory and fed to the processor one by one in sequence. If you remember that everything is done sequentially, you will have no trouble getting into macros with parameters, macros executing other macros, macros defining macros and macro loops; and you will begin to utilize the full power of macros to organize and shorten your Run Files, and, most importantly, to automate your work.

An important feature that is provided with macros is the ability to modify the commands within the macro at the time the macro is executed. There are several ways of doing this -- using variables and macro redefinitions -- but the primary method is through macro parameters. Here is an example.

```
MACRO T
 TRIM=%1/
 GHS 3.0, 3.5, ..., 9.0
/
.T 1f
.T 0
.T 1a
```

The “%1” is called a “dummy parameter”, since it simply reserves the place where the real parameter will be substituted when the macro is executed. In this example the macro “T” is executed three times. In the first execution the TRIM command becomes “TRIM=1f/”. In other words, it sets the trim to 1.0/LBP forward.

Up to nine different dummy parameters can be used; i.e. %1, %2, etc.

Nested Run Files

Another way to encapsulate a series of commands to be used later is to have them reside on a separate Run File. At some point in your master Run File you would use the RUN command to run the separate file. The command processor then begins taking commands from that file until it comes to its end or encounters the END command. Then it may or may not revert to the next command in your master Run File, depending on the form of the Run command.

For example, if you have, within your Run File, the commands,

```
RUN MORE.RF
MESSAGE "Back from More and continuing.
```

it will process the commands from MORE.RF but will not return to process the Message command. The way to make it return and keep going is to include the parameter /CALL with the RUN command. For example,

```
RUN MORE.RF /CALL
MESSAGE "Back from More and continuing.
```

will return and continue, processing the Message command.

If you develop a general-purpose Run File, the place to put it would be in your User Library folder so that it becomes easily accessible from any working folder.

A word of caution: Nested Run files are not easy to manage and can become confusing. They should be used only when there is a good reason.

The WRITE Command

There are several forms of the WRITE command. We encountered one of them when we were dealing with geometry: Both Section Editor and Part Maker have WRITE commands that write Geometry Files. In the context of the main program, the WRITE command writes various forms of Run Files. These are files that you can use later by issuing the RUN command. For example,

```
WRITE (SAVE) ABC.DAT
```

will write a file named ABC.DAT that contains all the commands necessary to restore the state of the program to its current state. In other words, it has the READ command to bring in the geometry, commands like HEEL and TRIM to restore the waterplane, etc. The file name extension .DAT was used in this case to distinguish it from ordinary Run Files. This is merely a convention and not a requirement. (It could have been named “ABC.RF”.)

Then when you want to restore everything to the way it was at the point when you did the WRITE command, simply issue the command,

```
RUN ABC.DAT
```

There are other, more specialized, files that the WRITE command will generate, as we shall see later.

Stability Criteria: Introduction to the Limit Command

GHS provides for stability criteria through the LIMIT command. Various properties of the righting-arm curve are addressed; viz: area, area ratios, minimum angles, etc. The Limit command does not reference any particular stability criterion; rather, you write Limit commands using parameters that, in your judgment, represent the requirements of a given criterion. Several of these limits can be in effect simultaneously, thereby addressing each aspect of the criterion. However it is usually not possible to represent more than one stability criterion simultaneously with the same set of Limit commands. For example, you would treat ordinary energy stability separately from weather stability.

You will want to become very familiar with the Limit command in all or most of its forms. The User's Manual is the best source for this information, which is also available through the Help LIMIT. At the end of the Limit documentation you will find some examples.

Limit commands will be covered in more detail when we get to righting arm curves and specific conditions. For our immediate purposes, here are two sets of Limit commands representing two different stability criteria:

```
UNITS LT
```

```
LIMIT(1) AREA FROM 0 TO 30 > 10.3
LIMIT(2) AREA FROM 0 TO 40 OR FLD > 16.9
LIMIT(3) AREA FROM 30 TO 40 OR FLD > 5.6

LIMIT(1) GM UPRIGHT > 0.49
LIMIT(2) RA AT 30 OR MAX > 0.66
LIMIT(3) ANGLE AT MAX > 25
```

Critical Points

GHS gives you the ability to mark any point on the vessel, inside or out, with points that are of interest with respect to their distance from the waterplane. The most common use for these points is marking places on the vessel where some significant downflooding would occur if the point were to become submerged even briefly. Therefore when you define a critical point, it is assumed to be a downflooding point (we call it a Flood or FLD point) -- unless you specify otherwise.

The CRTPT command defines critical points. Each Critical Point has a number, which is enclosed in parentheses. For example,

```
CRTPT(1) "Engine room vent" 22.85f, 5.50, 16.5
```

This defines Critical Point #1. If there was already a Critical Point definition in the #1 slot, it is replaced with this new one. In addition to the number, you must supply a brief description in quotation marks.

A related form of the Critical Point is used to mark weathertight points: places where downflooding would be significant if the point were permanently submerged. These we call TIGHT points. For example,

```
CRTPT(3) "Main hatch side” 8.0f, 5.3, 14.5 /TIGHT
```

In some of the LIMIT commands above, you will notice the FLD keyword appears. This means that the program is to check for any critical points that become submerged, and to give no credit for stability beyond that heel angle. In other words, the criterion expects there to be sufficient energy in the righting moment curve prior to the immersing of any downflooding point. If there happens to be a TIGHT point that is submerged as the vessel sits at equilibrium, the stability is considered to be failing in that case also.

Curves of Maximum VCG

The MAXVCG command produces these curves, and the independent parameter is draft or displacement weight, just like we saw in the GHS and CC commands. In addition, the MAXVCG command will take a list of trims or LCG values so that you can get a family of curves, where each curve represents the highest VCG that meets the current Limits at each given initial trim or LCG.

There must have been one or more Limit commands issued to establish a stability criterion before the MAXVCG command is issued. The process which GHS uses to find maximum VCG values involves generating righting-arm curves and evaluating their characteristics according to the Limits in effect. The VCG is experimentally elevated until it reaches the point where one of the Limits is exceeded.

The report that is generated shows the result of evaluating each of the Limits at the maximum VCG. These are shown as margins relative to the Limit value. If everything goes well, at least one of the margins will be zero and the others positive. The Limit with the zero margin is the one that limited the VCG at that displacement.

If the program finds that no matter how low it makes the VCG, one or more of the Limits are still negative, it will not show a maximum VCG result in that case. (The most common cause of this is early downflooding, since the angle of downflooding normally does not increase much when the VCG is lowered.) How low does it attempt to bring the VCG? No lower that the initial VCG setting. This is called the Floor VCG. You can use the VCG command to set the floor before you issue the MAXVCG command. For example, VCG=5.0. If you take the trouble to specify a floor value that is not so low as to be unreasonable, it will speed the MAXVCG process.

There are cases where it is impossible to satisfy all of the Limits while having one limit be zero. This is caused by discontinuities in the Limit values as a function of VCG. For example, there are cases where it is impossible to find a VCG that gives a certain value to the area up to the maximum RA, because the RA curve is flat on the top or has two equal peaks and one gives an area value greater than required and the other gives a lesser value.

The MAXVCG command assumes that the vessel has port/starboard symmetry with respect to its center of gravity. If any tank loads or other weight declarations exist from prior commands, they will be ignored. The parameters of the command specify what displacements are to be used; therefore light ship and existing loads are irrelevant.

All that is needed in order to generate maximum VCG curves with damage is to have used the TYPE command to set one or more tanks to the FLOODED type. Of course a stability criterion appropriate to damage stability should have been established with the Limit commands.

Vessels that carry a significant portion of their cargo as liquids are not suitable subjects for maximum VCG curves with damage, because the theory behind maximum VCG breaks down when a given initial condition is changed by the damage differently for different loads. If damaged tanks are initially loaded, the runoff will change the displacement and TCG of the vessel. For this reason, it is becoming more common for everyday onboard stability calculations to go back to first principles rather than using maximum VCG curves. They are evaluating each loading condition by running the RA curves, even including checking a large number of damage cases. GHS is doing this in some of its onboard installations and does it fast enough even with very complex vessel models. Since this is now possible, there is little reason to continue to use maximum VCG curves. Like cross curves, curves of max VCG are being made obsolete by fast computers.

Other parameters called for by the stability criterion will also need to have been specified. These might include heeling moments and Roll specification when dealing with weather criteria. These will be covered later.

A MAXVCG Exercise

Calculate Maximum VCG Curves using FV.GF for displacements from 50 to 250 long tons by 50 LT increments and for a range of LCG values from 5.0f to 1.0a. Use the first set of Limit commands shown above. Your Run File would look something like the following.

```
PROJ MAXVCG1
READ FV.GF
REPORT
CRTPT(2) "Focsle door" 23f, 8.0, 14.0
UNITS LT
LIMIT(1) AREA FROM 0 TO 30 > 10.3
LIMIT(2) AREA FROM 0 TO 40 OR FLD > 16.9
LIMIT(3) AREA FROM 30 TO 40 OR FLD > 5.6
MAXVCG DISPL: 50  100 ... 250 /LCG: 5.0f  4.0f ... 1.0a
REPORT /PREVIEW
REPORT OFF
```

The “Focsle door” critical point was added as another flood point in order to demonstrate the effect of earlier flooding. This will become significant when we do composite max VCG curves in the next exercise.

Composite Maximum VCG Curves

Often you will need to produce a set of max VCG curves that reflects the results of more than one stability criterion. In other words, you want the maximum VCG at any point to be the lowest of the maximum VCGs found under two or more criteria or for several damage cases. The way this is accomplished is to repeat both the set of Limits and the MAXVCG command for each criterion. If you are finding the composite max VCG curve for a series of damage scenarios, you would not need to change the Limits, but you would be changing the flooding zone.

There is one more thing: The second MAXVCG command and all those that follow it, if there are more than two, must include the /COMPOSITE parameter. In all other respects the MAXVCG commands must be identical. Sounds like a good place to use a macro!

Oh yes; there is another thing: When doing composites at more than one initial trim, use the /LCG option rather than giving trims directly. The reason for this requirement is that the internal organization of the maximum VCG data uses LCG and displacement. Trim depends on the VCG itself, while LCG does not.

A Exercise in Composite Max VCG

For the same range as above, create composite Maximum VCG curves based on the two criteria shown above. The plan of this Run File would be,

```
Project
Read
Define critical point #2
Report
Criterion #1
Maxvcg
Criterion #2
Maxvcg /COMPOSITE
WRITE (MAXVCG) MAXVCG.DAT
Preview
Report off
```

This is only a plan for the Run File, not actual commands – except the WRITE command, which can appear exactly as it is written. What it does is write a special Run File that contains all of the maximum VCG information that was being held within the program at that point. This will save you from having to rerun the original MAXVCG calculations when you want to make use of these particular max VCG curves.

When you get this exercise up and running you will notice that it appears that the second MAXVCG report is independent of the first one. Each one is reporting the results of the particular criterion it is dealing with. However, there remains in the program's memory a record of the composite maximum VCG data. This is the data that the WRITE command put out.

MAXVCG LOOKUP

After the MAXVCG command completes, the information that appeared in the tabular report is held in the main program's memory, as we have said. One way to utilize this information is to use the MAXVCG command in LOOKUP mode. In this mode it does not actually compute or generate any new max VCG information. It merely goes to the information stored in its memory.

If the MAXVCG command issued in LOOKUP mode has all the same parameters as the one that originally generated the information, its job is easy, since it will be simply retrieving information at the same points. But if different drafts or displacements appear in the LOOKUP mode, it will be doing interpolations within the stored data.

A MAXVCG LOOKUP Exercise

Perhaps you really wanted your composite maximum VCG curves to be at constant trim, not constant LCG. This can be done in LOOKUP mode -- since the MAXVCG /LOOKUP command parameters do not have to match those used originally.

For this exercise, write a new Run File that picks up your MAXVCG.DAT file and produces a separate report of the composite curves where each curve is at a certain trim value. Of course if the parameters you supply with this MAXVCG command cause it to look outside of the data previously computed, it will return nothing and the curve will be incomplete.

Your Run File should look something like this:

```
PROJ MAXGCG3
READ FV.GF
REPORT
RUN MAXVCG.DAT /CALL
UNITS MT
MAXVCG DISPL: 50  100 ... 250 /TRIM: 0.5f  0  .5  1 /LOOKUP
REPORT /PREVIEW
REPORT OFF
```

Specific Conditions: Setting Up a Waterplane

Earlier we discussed the HEEL and TRIM commands, which provide for the waterplane's attitude or inclination. The third waterplane parameter is the origin depth, which was also introduced at that time. You can set the origin depth directly using the DEPTH command; for example, DEPTH=5.0 changes the origin depth without affecting the trim and heel angles. If you define a waterplane in this manner, be sure that your TRIM command comes before the DEPTH command.

Here's why. When you change the trim by any significant amount, the position (but not the trim or heel) of the waterplane becomes undefined. GHS deliberately makes the origin depth undefined as a result of changing the trim. Changing the trim alone would rotate the waterplane, keeping the origin depth constant (which is what happens when you change the heel angle). If the origin happened to be located near midship, this might be an acceptable result, since the draft at one end would increase while the draft at the other end would decrease. But if the origin were near one end of the vessel, the draft at the other end would show nearly all the change.

Of course there are other ways that the program might have been designed, but causing the origin depth to go undefined avoids unnecessary complexity. In many cases you will want to keep the displacement constant, which is easily done with the SOLVE command as will be explained shortly.

If the vessel is upright or nearly so, you can use the DRAFT command. For example, DRAFT = 5.0 sets the origin depth such that the draft at the LCF is 5.0. DRAFT @0 = 5.0 sets the origin depth such that the draft at the origin is 5.0. Another useful form of the DRAFT command sets origin depth and trim simultaneously. For example,

```
DRAFT = 5.0 @ FP, 5.5 @ AP
```

sets both origin depth and trim such that the drafts at the FP and AP are as given. Of course this requires that the LBP command has defined the FP and AP locations. Literal locations can be used also. If a DRAFT command similar to the example above is given with more than two locations, it can define a nonlinear waterplane, which we can use to represent hog or sag. In that case GHS fits a parabola through the given drafts and reports the results, showing any deviations from the parabola.

The draft at any location is always considered to be the average of port and starboard draft. In other words, it is the draft that you would find in the centerplane if you had a draft sensor at that point. Since the draft measurement is taken with respect to the current heel angle, if the vessel is inclined, be sure to set heel before draft.

Draft Surveys

Deadweight surveys, inclining surveys and salvage surveys all depend on being able to model a waterplane that accurately represents the survey condition. Heel angle is straightforward. If the heel is not great, the multi-point drafts could be used to establish both the trim and the origin depth. Of course, freeboards would have to be converted to drafts before they could be used.

If the heel angle is large, such as in a salvage situation, it might be more convenient to set the trim as an angle and set the origin depth indirectly through the HEIGHT command. The HEIGHT command references a particular critical point. You would set up a critical point at some convenient point, then take a plumb-line measurement to the water surface from there. This would be the “height” of that point above the waterplane. The command to reference critical point 21 where the height is 5.43 would be,

```
HEIGHT (21) = 5.43
```

Tank Loads

In order to make use of your tank geometry, tanks can be loaded up to specified levels. The LOAD command is used for this. For example,

```
LOAD (tankname) = 0.98
```

sets the surface in the tank such that the volume is at 98% of the tank's capacity. There are many other ways to specify tank loads: via soundings and ullages, for example.

The surface attitude in a loaded tank automatically follows the heel and trim angles of the external waterplane, so that the center of gravity is recalculated each time the inclination changes. This is how GHS represents free surface. It is something like a “moment of transference” method. We call it simply CG shifts in tanks, and it gives similar results.

As in the TYPE command presented earlier, *tankname* in the LOAD command can be a list of tanks, and the asterisk “wildcard” can appear at the end of any of those names.

Coefficients of Form, Wetted Surface and Sectional Area Curves

These calculations all apply to single Components and therefore come under the COMPONENT command. They differ from the COMPONENT commands covered earlier in that they are based on current waterplanes. If the Component belongs to a Hull- or Sail-class part, or a tank in flooded mode, its waterplane is the external waterplane of the vessel. If the Component belongs to an intact tank, its waterplane is the surface of the liquid in the tank.

```
COMP /FORM
```

produces coefficients of form for Parts in the Current Part list, or if the Current Part list is empty, it does it for all Components of all Parts including tanks.

```
COMP HULL\HULL.C /FORM
```

produces the coefficients of form for the HULL\HULL.C component.

```
COMP HULL\HULL.C /SECTIONS
```

produces station section properties.

```
COMP HULL\HULL.C /WETTED
```

is like /FORM with wetted surface area included.

Free Surface and Free Surface Moments

A misconception we encounter frequently is that free surface is described by its free surface moment (FSM). This is only partially true. Free surface is the surfaces of liquids in tanks, which causes the centers of gravity in such tanks to shift depending on the heel and trim of the ship. FSM indicates how much the center of gravity will shift with a small change of heel or trim at a particular heel and trim. FSM is like GM: it gives you the initial slope but does not tell you anything about what happens at greater angles.

GHS always takes free surface into account (unless you deliberately shut it off by explicitly freezing tank contents, in which case you no longer have free surface). Normally it does so by constantly recalculating the locations of the CGs in the tanks whenever the ship's heel or trim changes. As mentioned before, this is sometimes called the “moments of transference” method. We call it simply CG shifts, and that is why we consider tank weights to be variable and non-liquid weights to be “Fixed”.

The phrase "free surface correction" often appears in stability regulations. Even when actual CG shifts are allowed, it is described as a "correction based on the actual moment of transfer". This language implies that there is something deficient that needs to be corrected. It views the calculation of a righting arm as a process that must include a "correction" in order to produce a realistic result. But this is not true. GHS has always, starting with version 1.00, produced realistic righting arms without applying any corrections. The term "moment of transfer" implies an alternative to "free surface moment". Technically GHS does not use "moment of transfer", though the results are the same – if the moment of transfer is done rigorously and in all directions, not simply transversely.

A different subject is GM. The calculation of GM from the waterplanes does not involve any CG shifts, and it is incorrect to talk about “moment of transference” in that context. More about GM later.

If that were the end of this subject, FSM would not seem too difficult to apply. But there is more, and it is like opening the proverbial “can of worms”. Things get messy when you try to force artificial methods on reality. But that's what the regulations do in many cases.

The first issue is how the FSM is derived. There are many options as listed below, consult the relevant regulations:

1) true FSM at the equilibrium angle;

2) true FSM from zero heel and equilibrium trim;

3) true FSM from zero heel and zero trim;

4) true FSM for tanks that are not nearly full, and zero for those that are;

5) some reduced FSM value when the load is below a certain near-empty level and true FSM above that;

6) maximum FSM at some heel and trim for some or all tanks;

7) maximum FSM regardless of the current load, or zero for empty or pressed tanks;

8) true FSM subject to a floor value;

9) true FSMs subject to a floor values for each type of substance in certain tanks;

10) any of the above subject to an overall floor FSM?

GHS allows you to use any of these methods. The FSMMT and FSMFLOOR commands apply. The FSMMT command allows you to assign three FSM methods to each tank. Each method is active for a range of loads defined by two preset boundaries. This allows, if necessary, a method for nearly-empty, nearly-full and any load in between. The FSMFLOOR command provides for assigning the floor values to certain tanks as well as an overall floor value.

There is some reason behind all of these options, though only one of them has to do with being more realistic. The others are about: a) conforming to old methods that date back to the days of slow or expensive computing methods; or b) trying to build in an extra safety margin that recognizes the development of additional free surface relative to the current condition. Ironically there are cases (deep tanks) where the CG shift method gives a more pessimistic stability result than some of the FSM methods.

One of the FSM "methods" that you can assign to any tank is MAX. The command,

```
FSMMT (FO*) = MAX
```

finds the loads in the named tanks where the FSM is maximum, and assigns those FSMs to the tanks as "fixed" values. It does this at the current heel and trim angles. An important side effect is that it leaves the tanks loaded where it found the maximum FSMs. Therefore, it is best to do the FSM assignments before setting the load condition.

When the Contents of a tank is changed from one substance to another and where the densities are different, the FSM also changes in proportion even if it is a "fixed" assigned value.

About GM

The traditional way to calculate GM is from the waterplane moment of inertia, which, together with displaced volume yields BM and applying that to the CB we get the metacenter location and hence can arrive an GM. All this depends on the vessel being at equilibrium; otherwise we have to assume a CG location that would put it in equilibrium.

When slack liquid loads are present in tanks, the metacenter is affected, which affects the GM. However the traditional approach to this is to leave the metacenter alone and "correct" the VCG using the FSM. Obviously this is technically incorrect since the CG does not change as a result of the free surface: You could freeze the tanks and have the same CG, yet the GM would increase.

Therefore, GHS always puts the free surface effect in the BM, where it belongs, rather than leaving it out of the BM and making a VCG "correction". Either way yields the same GM, but the BM from GHS will not agree with the BM from a method that "corrects" the VCG.

GM can also be calculated from the RA curve, since GM equals the slope of the RA curve. GHS gives you this option, and it has the advantage of being less sensitive to waterplane discontinuities. This GM option appears as optional parameters on the GHS, SOLVE and RA commands.

Hydrostatic Properties for the Current Condition

Several commands produce reports of hydrostatic properties in the current condition. It need not be a realistic "solved" condition. The only requirement is that the waterplane be defined. Here are the commands and a brief description of what you can expect to get from them.

HS – This is the "pure hydrostatics" report that is entirely independent of the CG.

GHS – This is similar to the HS report, but it takes the CG into consideration and shows GML and GMT. If the CG is not on the BM line it assumes a CG position that puts it on the BM line without changing the VCG. The optional /GMRA parameter causes it to get the GM from the righting-arm curve, but only when it is in equilibrium.

STATUS – This command has many options and is frequently used. The recommended form is STATUS GHS, which presents all the information that you would get from using both STATUS and GHS, but in a more compact form since nothing is duplicated. The rightmost column in the standard STATUS report shows Reference Point heights, which you may not need, and in that case you can eliminate it by including the /NOREF parameter. Alternatively you can get FSM in that column by including the /FSM parameter.

There are 19 different categories of information that you can get from the STATUS command. If you want a certain mixture of them, it is usually better to specify them all in one STATUS command since the report will be more compact than if you give separate STATUS commands. When multiple status reports are specified, the order in which they are reported is fixed regardless of the order of the parameters.

LOAD (*tanklist*) STATUS TANKS – This produces a report that is similar to the presentation in the Tanks screen of the Load Editor. It omits centers of gravity, but includes Part descriptions, which are absent form STATUS reports. With petroleum loads you can get gross and net volumes depending on temperature.

LOAD STATUS FIXED – This report is similar to the presentation in the Weights screen of the Load Editor.

DISPLAY (tanklist) STATUS – This is the Condition Graphics report, which is a graphical representation of the current status and is very effective when used immediately after the STATUS command. In most cases you will want all tanks that have any loads in them, or that are flooded, to be shown, and so the command would be,

```
DISPLAY (*) STATUS
```

By default you get plan and profile views. There are many other options that you can read about in Help CG.

Deadweight

There are two ways to get a deadweight report through the STATUS command.

The STATUS DW report includes a Deadweight Status line showing the difference between total displacement and total light ship. It always includes the displacement at the current waterplane.

The STATUS /DEADWEIGHT report shows Deadweight Loaded, which is simply the sum of added weight items and tank loads above light ship. You can get this report without the displacement information:

```
STATUS WEIGHT /DEADWEIGHT
```

More on the Structure of Commands

As we get into writing more extensive Run Files, it will be helpful to revisit the topic of command structure and to carry it farther. Let's look at two examples:

```
ADD "Crew and effects”,  12.34,  45.0f, 0.0, 15.5
LOAD (FO*) STATUS /ULLAGE /VOLUME:BB
```

The primary parameters appear immediately after the command name, and sometimes their order is important. If the first parameter is optional, it is enclosed in parentheses to make sure that the program has no trouble determining whether or not it is present.

After the primary parameters there may be “slash” parameters that are almost always optional and have no particular order requirement.

A parameter might have one or more sub-parameters. In the example above, BB is a sub-parameter.

As you can see in the above examples, parameters are often numbers. Sometimes they are strings of characters enclosed in quotation marks. And sometimes they are keywords.

When a command line ends in either a comma or a semicolon, it is considered to be incomplete and the next line is appended to it. For example,

```
ADD "Deck cargo”,  0.23 @ 20f,
                   0.67 @ 10f,
                   0.67 @ 8f,
                   0.0, 17.5
```

This is considered to be all one command. You can do the opposite also: More than one command can go on one line when you separate the commands with the “vertical bar” character “|”. For an example, see the next section.

Light Ship Weight

If you know the light ship weight and its center of gravity, use the WEIGHT command to enter this information:

```
DELETE ALL WEIGHTS
WEIGHT = weight, lcg, tcg, vcg
```

The reason for the DELETE ALL WEIGHTS is to make sure you do not have any added fixed weights in effect. Normally you would give the WEIGHT command before any ADD commands (see the next section), so the DELETE command here would not be necessary. You see, the WEIGHT command actually sets the total Fixed Weight including all ADDed weights that might be present. It does that by setting the Light Ship weight to the difference.

Another way to get a light ship weight is to derive it from a given waterplane: Set up the waterplane, then solve for the required light ship at that waterplane. Here is an example/exercise:

```
HEEL=0 | TRIM=1a | DRAFT=5.5
VCG=6.5
SOLVE WEIGHT, LCG, TCG
STATUS
```

After setting up the waterplane we specified the VCG, then solved for the displacement weight, LCG and TCG to make the weights equal the buoyancy and the centers be in alignment perpendicular to the waterplane. It does that by changing the Light Ship weight, preserving all other weights that may be present.

If you try this with a nonzero trim as in the example above, you will find that the LCG does not exactly equal the LCB. Why is that?

Adding Other Fixed Weights

The ADD command is used to add either point loads or distributed fixed weights. An example is in the section above on the structure of commands. You can change an ADDed weight by repeating the command with the same description. Also the weight of an ADDed weight item can be adjusted relative to the declared /MAX value with the LOAD command. These weight items can be deleted with the DELETE WEIGHT command.

Finding Equilibrium

Suppose you have your light ship and then you change the load configuration. Now you want to see how the draft, trim and heel have responded and to get some hydrostatic properties. Simply issue the SOLVE command without parameters, then use any of the commands discussed above under Hydrostatic Properties.

Load Editor and LEw

The LOAD command addresses the loading of tanks (or produces a report of tank loads as we saw with the LOAD STATUS command). Instead of LOAD (tanklist) = value, you can say LOAD (tanklist) EDIT, in which case you bring up a spreadsheet-like interactive tool called the Load Editor or LE.

There are two versions of the Load Editor: LE and LEw. LEw is the more advanced version and gives you “loads” of options. If LEw is installed on your computer, that is what you get with the LOAD EDIT command. If not, you get the “bare bones” version that is still fully capable of editing loads, both in tanks and your added weights.

Inclining

Setting up for an inclining calculation is much like the setup we did for the light ship solving earlier. Of course in that case we somehow knew the VCG. In the inclining calculation we're trying to find the VCG as well as light ship weight and the other components of its CG. However, setting up the waterplane, setting any tank loads and other loads (such as inclining weights that are aboard and not to be included in light ship) is all the same. No doubt the DRAFT command will be more elaborate – more like what we saw earlier when the DRAFT command was first introduced: listing several drafts taken at different locations, and expecting it to result in some deflection.

Having done all that, the final step is to use the GMTMMT command, which takes as a parameter the GM moment. This is the slope of the righting moment curve that you derive during the inclining experiment.

The easy way to do the inclining calculations is to use the Incline wizard. You will find it in the Light Ship category within the Wizard menu.

About Wizards

Several “wizards” are provided with GHS. They are software extensions that make use of GHS to perform specific tasks. If you have used or attempted to use wizards in other software environments, you will find that GHS wizards are a little different. Rather than leading you through a linear sequence of steps, the GHS wizards present an interface that helps you establish the parameters of your problem, then goes ahead and generates the solution, complete with a report in many cases. Also, GHS wizards usually save your inputs so that you never have to redo things that you are not changing. Some of the more elaborate wizards write Run Files and launch separate sessions of GHS.

All wizards are designed to be self-explanatory. All necessary documentation is built in, or at least that is the intention. There are no manuals or separate documents for wizards.

If you open a wizard file in a text viewer, you will see that it is actually a Run File. Some wizards use coded files that are not viewable because the programming in them is complex and we do not want to have to support versions that users have modified. However, you are free to write your own wizards for your own use or even to share with others. All that is needed is some experience using macros, variables and templates (see the TEMPLATE command).

Some of the wizards that are distributed with GHS are updated frequently, and they may require the latest versions of GHS. At www.ghsport.com/support/downloads.htm you will find links to the latest wizards for downloading them.

Most wizards involve more than one Run File. There may be one or more library Run Files as well as the ".WIZxx" file. In any case, when you get the file package, copy all files into your GHS program folder.

User Variables and the SET Command

User variables are similar to system variables. But rather than providing information from inside the GHS program, they hold information that you put there by means of the SET command. This doesn't sound useful until you see what the SET command can do. With it you can perform arithmetic calculations. There are trig functions and many other handy functions that you can use to prepare parameters for other commands.

More on Limits and Stability Criteria

GHS does not provide preset stability criterion options. However, using the LIMIT command, you can define a stability criterion to be considered when performing an analysis. The proper set of Limit commands will address known regulations. But there are possible variations and interpretations of the regulations that are left up to the user's discretion.

Basically, the Limits are about the righting-arm curve, the heeling arm curve and the residual righting arm curve, which is the difference between the first two curves. They apply to various aspects of these curves, establishing metrics that relate to stability and safety. There are several types of Limits, and each type is designed to examine a certain quantity such as area or range of heel angles. In most cases it is intervals between significant heel angles that are of interest. The GHS keywords for some of the significant angles are:

EQU – angle of stable equilibrium;
RA0 – angle of the "second intercept" or unstable equilibrium;
FLD – angle of downflooding;
MAX – angle at maximum righting arm;
ROLL – angle after rolling to windward;
PRE – angle before rolling to windward;
DI – angle of deck immersion.

For the complete list, see Help Limit.

The types of Limits are,

- Angle limits – these apply directly to significant angle ranges or values.
- Area and Area Ratio – these require some minimum area or ratio of areas.
- Arm, Arm Ratio and Arm Rise limits – these look at righting arm levels at certain angles.
- Gm limits – these require minimum GM values.

The RAH Command

This command produces the righting-arm curve in a particular load condition. It is essential to almost all stability work. If you accept the defaults and simply issue the RA command with no parameters, you will get a reasonable result. But if you have established a stability criterion with Limit commands, you will need to include the /LIM parameter:

```
RA /LIM
```

There are two ways to specify the range of angles that the RA command will use. One way is to list the angles on the command itself:

```
RA 0, 5, ..., 60
```

A better way is to manipulate the ANGLES list. This list is held in the program's memory, and is what the RA process uses when you do not give angles with the command. Initially this list is 0, 5, ..., 60. Changing it involves the ANGLES command. For example,

```
ANGLES = 0, 2, ..., 10, 15, ..., 90
```

establishes the angles at 2-degree increments up to 10 degrees, then 5-degree increments to 90 degrees.

If you want the heel angles to progress to port instead of to the starboard side, use negative angles. If you want the direction to go in whichever direction the vessel is heeling initially, the commands would be,

```
SOLVE
ANGLES *
```

This looks at the present heel angle and reverses the direction of the existing angles list if necessary in order to make it go in that same direction.

It is important to know that RA normally starts the curve at the present heel angle. In other words, the angles, whether given directly with the command or through the ANGLES list, are relative to the heel angle at the time the RA command is issued. This is useful if you want to start the curve at equilibrium:

```
SOLVE | ANGLES *
RA
```

But if you want to start at zero heel, use a HEEL command before RA:

```
SOLVE | ANGLES *
HEEL=0
RA
```

Normally the RA process performs CG shifts in slack tanks, which is the most realistic way to represent the free surface effect. If you need to have it apply Free Surface Moments instead, there are some FSM options:

• /FSM causes it to use the formal FSM (i.e. whatever FSM methods have been assigned to the tanks);

• /TRUEFSM forces it to calculate true FSM for each tank regardless of the method assignments;

• /EXTRAFSM allows the shifting of tank contents and in addition elevates the center of gravity such that the initial GM is the same as would result from using the formal FSM.

When FSM is being applied, the report header preceding the RA table shows the FSM application – showing exactly how the CG was changed. In the CG-shift mode, this is not necessary, and only the Fixed-weight CG is shown in the header since the total CG is variable.

If GM is involved in the Limits, the waterplane-derived GM will be used unless a GM parameter appears. There are several possibilities here for which Help RA is the best reference.

Several options are available for the graphs. The default option is to get the full set of graphs, plotting righting arms or moments, area or energy, and flood point heights. Normally the graphs include score lines at significant angles. These can be turned off with `/GRAPH:CLEAN`, which is appropriate if the Limits are not of the sort that address those angles.

With Limits in effect, there is a choice as to how the Limit evaluations are to be shown. Normally the margins are shown, as they are in the MAXVCG report. The /LIM:ATTAINED parameter will cause the attained values to be shown. When the special-case area limit that requires two sequential limits is present (see Help LIMITS) the /LIM:ATTAINED:COMBINE parameter will result in the best presentation.

There are many additional features of the RA command, all of which are well-documented in Help RAH.

Heeling Moments

GHS provides for heeling moments with the HMMT command. You can give a fixed value or function, or have the heeling moment be derived from wind pressure, turning or tank CG shifts.

A heeling moment report is available from the HMMT REPORT command. It includes all of the sources that go to make up the current heeling moment.

Wind Heeling

In order to get heeling moments from wind pressure, the WIND command must precede the HMMT command. Wind pressure can be given as a constant, as a profile depending on height above the water, or as a speed in knots referenced to 10 meters above the water with a standard profile implied.

In order to produce an adequate heeling moment from wind pressure, the geometric model must include all elements of the superstructure and rig that are significant contributors to the wind heeling moment.

Two methods of extracting effective lateral plane areas for wind heeling are available: 1) the traditional lateral plane projection where the area is the summation of the lateral projection of all above-water components of all hull- and sail-class Parts; 2) the Band method where areas are accumulated in horizontal bands starting at the waterplane and going up to the highest element of the model.

The lateral plane method ignores lateral overlaps of Components. Therefore it tends to yield unrealistically large lateral areas if the calculation is done at other than zero heel. However a wind heeling moment based on the lateral plane at zero heel is an accepted method and is prescribed in some regulations.

The Band method is able to recognize overlaps in the lateral projections and produce heeling moments that are more realistic at any heel angle. However it requires more calculation time and so may slow the righting-arm calculations compared to the lateral plane method.

The command "HMMT WIND" causes the heeling moment to be based on the specified wind pressure and lateral area. By default you get the lateral plane method. The optional parameter for the Band method is "/BAND:*w*" where w, if present, specifies the "width" of the bands (which of course are more like heights). The smaller the *w* value the slower the calculations will be, and if too small it will run very slowly with no significant improvement in accuracy.

A table and plot of wind pressure or speed as a function of height above the waterplane is available from the WIND REPORT command.

Severe Wind and Rolling Calculations

When wind and waves are on the beam, the ship will need to have enough righting energy available to absorb the kinetic energy during a rebound from a severe roll upwind of its steady-wind induced heel. GHS provides a mechanism for conveniently arriving at the windward heel angle so that these energies can be compared in the righting arm curve.

With a heeling moment in effect, the equilibrium heel angle can be found simply by issuing the SOLVE command (without parameters). Now if the magnitude of the initial roll is known, the upwind heel angle can be set simply by giving the command,

```
HEEL = *-r, where r is the roll angle.
```

A more convenient way of specifying the roll angle is provided by the ROLL command. For example,

```
ROLL = 20
```

```
HEEL *-ROLL
```

does essentially the same thing, except that it conveniently moves the heel angle in the direction opposite to the initial heel angle. Further, if the value of the Roll is not fixed, but is to be calculated from the present condition according to the IMO rolling formula, then the ROLL command can be given once in the form,

```
ROLL IMO
```

and the actual roll value will be recalculated at the time it is used.

A typical sequence of commands to check the energy available to resist an IMO roll would be:

```
ROLL IMO
UNITS MT
WIND (PRESSURE) 0.0514    `in current units (wt/length^2)
HMMT WIND /CONST
SOLVE
HEEL *-ROLL
RA /AREA
```

If an increase in the heeling moment (due to a gust of wind) occurs at the rolled angle, it can be modeled by using a /GUST parameter on the HMMT command. The issuance of the `HEEL=*-ROLL` command then automatically causes the heeling moment to be multiplied by the gust factor from then on -- until another HMMT command is issued. For example,

```
...
HMMT WIND /CONST /GUST: 1.5
SOLVE
HEEL *-ROLL  `<- The gust factor takes effect after this.
RA /AREA
```

When using the MAXVCG process, the roll angle and gust factor are automatically applied in the proper sequence. Thus,

```
ROLL IMO
WIND (PRESSURE) p
HMMT WIND /CONST /GUST: 1.5
SOLVE MAXVCG
```

is all that is necessary.

Further, the MAXVCG command automatically recalculates the wind moments at each new draft when they are based on the lateral plane. Hence,

```
ROLL IMO
HMMT WIND /CONST /GUST: 1.5
MAXVCG ...
```

produces maximum VCG curves for a stability criterion involving the ROLL angle.

If the ROLL angle keyword appears in a Limit, it actually refers to the heel angle arrived at by *-ROLL. For example,

```
LIMIT RESIDUAL RATIO FROM ROLL TO ABS 50 OR RA0 > 1
LIMIT RESIDUAL RATIO FROM ROLL TO  FLD   OR RA0 > 1
```

expresses the area comparison portion of the IMO criterion for severe wind and rolling.

If the PRE angle keyword appears in a Limit, it refers to the heel angle which was current immediately prior to *-ROLL. For example,

```
LIMIT ANGLE FROM PRE TO ABS 16 OR 80%DI0 > 0
```

expresses the limitation on the “angle of heel under the action of steady wind” from the IMO criterion for severe wind and rolling. In this case a SOLVE must preceed the windward roll in order to ensure that PRE refers to equilibrium with the non-gust heeling moment.

When you want to run the righting-arm curve either to port or starboard, depending on the vessel's initial (non-wind) list, things get a little more complicated. The MAXVCG process handles this automatically; but when you are doing an individual righting-arm curve you have to make sure that certain commands are in the correct order. The procedure is as follows.

1. With the heeling moment off, solve for the equilibrium heel angle.
2. Set the ANGLES direction accordingly.
3. Set the heeling moment.
4. Set the HMMT direction according to the heel angle.
5. Solve for the equilibrium heel (with steady wind).
6. Apply the roll.
7. Do the RA /LIM command.

Here is an example.

```
HMMT OFF
SOLVE
ANGLES *
HMMT WIND/CONST/GUST:1.5 /TRIMALLOW
HMMT *
SOLVE
HEEL=*-ROLL
RA /LIM
```

More about FSM

The only way to prevent GHS from recalculating the centers of gravity in tanks is to Freeze the tanks' contents: `TYPE(*) FROZEN`. However, you can have it temporarily suspend the CG shifting during righting-arm curve calculations by including the /FSM parameter with the RA command. That causes it to temporarily freeze the tanks and to compensate by elevating the overall center of gravity according to a free surface moment.

After we have decided what the total FSM number is in a given load condition, the next thing is to decide when to freeze the tanks: 1) at zero heel and trim; 2) at zero heel and equilibrium trim; 3) at equilibrium with the CG elevated; 4) at normal equilibrium; 5) at equilibrium before or after wind heeling? Communicating your choice here is intended to be a natural result of your preparation before the RA command.

Finally, we have to decide in which direction to move the CG. If it is elevated at some angle other than equilibrium it will change the angle of equilibrium. Should it be elevated at the same heel and trim at which the tanks are frozen? This can make a substantial difference in the stability results. Generally if you do your equilibrium solving using the form,

```
SOLVE /FSM:UPRIGHT
```

things will work out in a reasonable way with the CG elevation being done at zero heel.

If you want to use FSM rather then CG shifts in a Severe Wind and Rolling calculation, it gets a little more complicated than what was shown in the previous section. There are some choices to make about when and how to apply the FSM. Here is the recommended sequence:

```
ROLL IMO /FSM
HMMT OFF
SOLVE /FSM:UPRIGHT
ANGLES *
HMMT WIND ...
HMMT *
SOLVE /FSM:UPRIGHT
HEEL *-ROLL
RA /LIM /FSM
```

An Intact Stability Exercise

Find out whether FV.GF complies with these intact criteria (described more fully on the following pages):

- 46 CFR 170.173, Paragraph B (Vessels of Unusual Proportion and Form)
- 46 CFR 170.170 (GM Weather Criterion)
- IMO Severe Wind and Roll

Assume the following:

Light Ship:

```
156.0 Long Tons at 0.56f, 0, 10.56
```

Downflooding points:

```
(1) "ER VENTS"           22.8f, 7.0s, 15.0 /SYM
(2) "PORT CABIN DOOR"    10.0f, 9.0p, 14.0 /TIGHT
(3) "STBD CABIN DOOR"     5.0a, 9.0s, 14.0 /TIGHT
```

Load sequence: (changes only)

Fixed loads:		Tank loads:	
Departure:			
Crew&effects	2.0, 25f, 0, 25.0	WT1*	0.95
Stores	12.0, 14f, 0, 15.0	WT2*	0.95
Net on deck	5.0, 20a, 0, 13.0	WT3*	0.95
		FODAY*	0.95
		LUBE.S	0.95
		HYDR.P	0.95
		FW*	0.98
		HOLD*	0.0
Arrival at fishing grounds:			
Stores	8.0, 14f, 0, 15.0	WT1*	0.05
		LUBE.S	0.66
		HYDR.P	0.66
		FW*	0.66
Departing fishing grounds – good catch:			
Stores	4.0, 14f, 0, 15.0	WT2*	0.05
		LUBE.S	0.33
		HYDR.P	0.33
		FW*	0.33
		HOLD*	1.0
Depart fishing grounds – no catch:		holds empty	
Arrival – good catch:			
Stores	0.2, 14f, 0, 15.0	WT3*	0.05
		LUBE.S	0.10
		HYDR.P	0.10
		FW*	0.10
		HOLD*	1.0
Arrival – no catch:		holds empty	

Intact Stability Exercise specification, continued:

• The CFR 170.173 criterion requires several Limit commands. See the highlighted portion of the regulation text. Reference HELP LIMIT for the Limit commands. This criterion is easily addressed with a simple RA /LIM starting from upright heel.

• The CFR 170.170 weather criterion appears to have been formulated as a simplification of a criterion that limits the angle of wind heeling by requiring a minimum GM. There is a discussion of this in the GHS User Bulletin WEATHER.HTM, which is on ghsport.com. A way to address the criterion is presented there, but it does not meet the "letter of the law". Therefore it is recommended that the C170170 macro library be used. Here are the steps (after setting up the load condition):

```
RUN C170170.LIB /CALL
SET P=0.005
.170_170
```

For all three criteria,

• Calculations to be performed using CG shifts.

• Report to include subtitles, Status with GM & Critical Point heights and righting arm data with evaluation of each stability criterion with graphs.

• Use P=0.005 for the purpose of 170.170.

• Do not include Reference Point data in output.

• Questions:

1. Do the results indicate the vessel meets all three criteria?
2. Do you suspect any error with input information?

§ 170.173 Criterion for vessels of unusual proportion and form.

(a) If required by the Coast Guard Marine Safety Center or the ABS, each mechanically powered vessel less than 328 feet (100 meters) LLL, other than a tugboat or towboat, must be shown by design calculations to comply with—

(1) Paragraph (b) or (c) of this section if the maximum righting arm occurs at
an angle of heel less than or equal to 30 degrees; or

(2) Paragraph (b) of this section if the maximum righting arm occurs at an angle of heel greater than 30 degrees.

(b) Each vessel must have—

(1) An initial metacentric height (GM) of at least 0.49 feet (0.15 meters);

(2) A righting arm (GZ) of at least 0.66 feet (0.20 meters) at an angle of heel equal to or greater than 30 degrees;

(3) A maximum righting arm that occurs at an angle of heel not less than 25 degrees;

(4) An area under each righting arm curve of at least 10.3 foot-degrees (3.15 meter-degrees) up to an angle of heel of 30 degrees;

(5) An area under each righting arm curve of at least 16.9 foot-degrees (5.15 meter-degrees) up to an angle of heel of 40 degrees or the downflooding angle, whichever is less; and

(6) An area under each righting arm curve between the angles of 30 degrees and 40 degrees, or between 30 degrees and the downflooding angle if this angle is less than 40 degrees, of not less than 5.6 foot-degrees (1.72 meter-degrees).

(c) Each vessel must have—

(1) An initial metacentric height (GM) of at least 0.49 feet (0.15 meters);

(2) A maximum righting arm that occurs at an angle of heel not less than 15 degrees;An area under each righting arm curve of at least 16.9 foot-degrees (5.15 meter-degrees) up to an angle of heel of 40 degrees or the downflooding angle, whichever is less;

(4) An area under each righting arm curve between the angles of 30 degrees and 40 degrees, or between 30 degrees and the downflooding angle if this angle is less than 40 degrees, of not less than 5.6 foot-degrees (1.72 meter-degrees); and

(5) An area under each righting arm curve up to the angle of maximum righting arm of not less than the area determined by the following equation:

A=10.3+0.187 (30 - Y) foot-degrees

A=3.15+0.057 (30 - Y) meter-degrees

where—

A=area in foot-degrees (meter-degrees).

Y=angle of maximum righting arm, degrees.

46 CFR 170.170 Weather Criterion

§ 170.170 Calculations required.
(a) Each vessel must be shown be design calculations to have a metacentric height (GM) that is equal to or greater than the following in each condition of loading and operation:

GM > PAH / (W tan(T))

Where –
P=0.005+$(L/14{,}200)^2$ tons/ft^2 or 0.055+$(L/1309)^2$ metric tons/m^2. . . for ocean service, Great Lakes winter service, or service on exposed waters.
P=0.0033+$(L/14{,}200)^2$ tons/ft^2 or 0.036+$(L/1309)^2$ metric tons/m^2. . . for Great Lakes summer service, or service on partially protected waters.
P=0.0025+$(L/14{,}200)^2$ tons/ft^2 or 0.028+$(L/1309)^2$ metric tons/m^2. . . for service on protected waters.
L=LBP in feet (meters).
A=projected lateral area in square feet (square meters) of the portion of the vessel and deck cargo above the waterline.
H=the vertical distance in feet (meters) from the center of A to the center of the underwater lateral area or approximately to the one-half draft point.
W=displacement in long (metric) tons.
T=either:

(1) the lesser of either 14 degrees heel or the angle of heel in degrees at which one half the freeboard to the deck edge in immersed; or
(2) for a sailing vessel, T = the lesser of either 14 degrees or the angle of heel in degrees to the deck edge.

The deck edge is to be taken as the intersection of the sideshell and the uppermost continuous deck below which the sideshell is weathertight.

(b) If approved by the Coast Guard Marine Safety Center or the ABS, a larger value of T may be used for a vessel with a discontinuous weather deck or abnormal sheer.

(c) When doing the calculations required by paragraph (a) of this section for sailing vessel or auxiliary sailing vessel, the vessel must be assumed –

(1) To be under bare poles; or
(2) If the vessel has no auxiliary propulsion, to have storm sales set and trimmed flat.

(d) The criterion specified in this section is generally limited in application to flush deck, mechanically powered vessels of ordinary proportions and form that carry cargo below the main deck. On other types of vessels, the Coast Guard Marine Safety Center or the ABS requires calculations in addition to those in paragraph (a) of this section. On a mechanically powered vessel under 328 feet (100 meters) in length, other than a tugboat or a towboat, the requirements of §170.173 are applied.

Severe wind and rolling criterion (weather criterion)

3.2.1 Assumptions

The ability of a ship to withstand the combined effects of beam wind and rolling is to be demonstrated for each standard condition of loading, with reference to Fig 1 as follows:

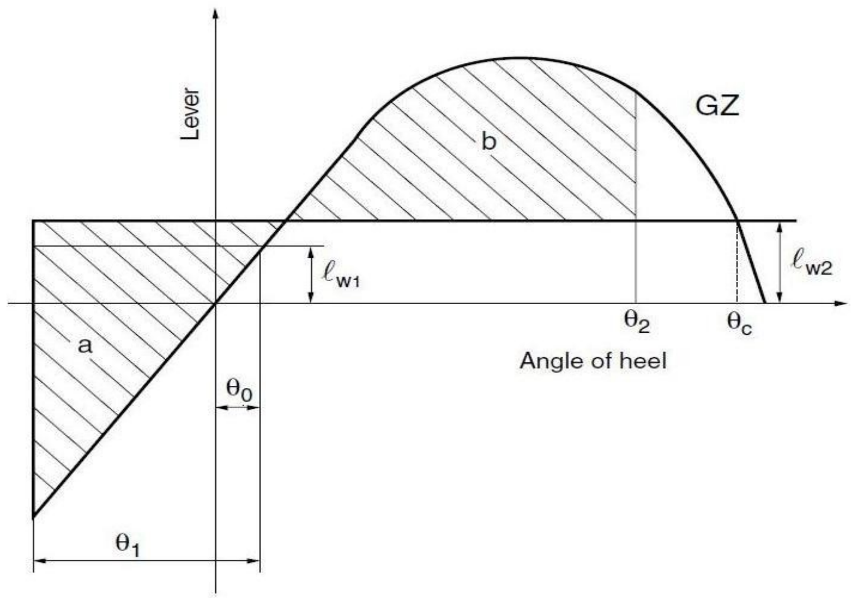
• the ship is subjected to a steady wind pressure acting perpendicular to the ship's centerline which results in a steady wind heeling lever (w1);

• from the resultant angle of equilibrium (θ0), the ship is assumed to roll owing to wave action to an angle of roll (θ1) to windward;

• the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever (w2);

• free surface effects, as described in [4], are to be accounted for in the standard conditions of loading as set out in Ch 3, App 2, [1.2].

Figure 1 : Severe wind and rolling



3.2.2 Criteria

Under the assumptions of [3.2.1], the following criteria are to be complied with:

• the area "b" is to be equal to or greater than area "a", where:

a : Area above the GZ curve and below w2, between θR and the intersection of w2 with the GZ curve

b : Area above the heeling lever w2 and below the GZ curve, between the intersection of w2 with the GZ curve and θ2.

• the angle of heel under action of steady wind (θ0) is to be limited to 16° or 80% of the angle of deck edge immersion, whichever is less.

3.2.3 Heeling levers

The wind heeling levers w1 and w2, in m, referred to in [3.2.2], are constant values at all angles of inclination and are to be calculated as follows:

$$\ell_{W1} = \frac{PAZ}{1000 g \Delta}$$

and

$$\ell_{W2} = 1,5 \ell_{W1}$$

where:
P : 504 N/m2 for unrestricted navigation notation. The value of P used for ships with restricted navigation notation may be reduced subject to the approval of the Society;
A : Projected lateral area in m2, of the portion of the ship and deck cargo above the waterline;
Z : Vertical distance in m, from the center of A to the center of the underwater lateral area or approximately to a point at one half the draught;
Δ : Displacement in t;
g = 9,81 m/s2.

3.2.4 Angles of heel
For the purpose of calculating the criteria of [3.2.2], the angles in Fig 1 are defined as follows:
$\theta 0$: Angle of heel, in degrees, under action of steady wind
$\theta 1$: Angle of roll, in degrees, to windward due to wave action, calculated as follows:

$$\theta_1 = 109 k X_1 X_2 \sqrt{rs}$$

$\theta 2$: Angle of downflooding (θf) in degrees, or 50° or θc , whichever is less
θf: Angle of heel in degrees, at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open;
θc : Angle in degrees, of second intercept between wind heeling lever w2 and GZ curves
$\theta R = \theta 0 - \theta 1$
X1 : Coefficient defined in Tab 1
X2 : Coefficient defined in Tab 2
k : Coefficient equal to:
k = 1,0 for a round-bilged ship having no bilge or bar keels
k = 0,7 for a ship having sharp bilge
For a ship having no bilge keels, a bar keel or both, k is defined in Tab 3.

r = 0.73 +/- 0.6 (OG)/T1

OG : Distance in m, between the center of gravity and the waterline (positive if center of gravity is above the waterline, negative if it is below)
T1 : Mean moulded draught in m, of the ship

s : Factor defined in Tab 4.
Note 1: The angle of roll $\theta 1$ for ships with anti-rolling devices is to be determined without taking into account the operations of these devices.
Note 2: The angle of roll $\theta 1$ may be obtained, in lieu of the above formula, from model tests or full scale measurements.
The rolling period TR, in s, is calculated as follows:
where:
The symbols in the tables and formula for the rolling period
are defined as follows:
LW : Length in m, of the ship at the waterline
T1 : Mean moulded draught in m, of the ship
AK : Total overall area in m2 of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas, or area of the lateral projection of any hull appendages generating added mass during ship roll
GM : Metacentric height in m, corrected for free surface effect.

4 Effects of free surfaces of liquids in tanks
4.1 General

4.1.1 For all loading conditions, the initial metacentric height and the righting lever curve are to be corrected for
the effect of free surfaces of liquids in tanks.

4.2 Consideration of free surface effects
4.2.1 Free surface effects are to be considered whenever the filling level in a tank is less than 98% of full condition. Free surface effects need not be considered where a tank is nominally full, i.e. filling level is 98% or above. Free surface effects for small tanks may be ignored under the condition in [4.9.1].
4.2.2 For ships having cargo tanks with a breadth greater than 60% of the ship's maximum beam, the free surface
effects when the tanks are filled at 98% or above may not be neglected.

4.3 Categories of tanks
4.3.1 Tanks which are taken into consideration when determining the free surface correction may be one of two categories:
• Tanks with fixed filling level (e.g. liquid cargo, water ballast). The free surface correction is to be defined for the
actual filling level to be used in each tank.
• Tanks with variable filling level (e.g. consumable liquids such as fuel oil, diesel oil, and fresh water, and also liquid
cargo and water ballast during liquid transfer operations). Except as permitted in [4.5.1] and [4.6.1], the free
surface correction is to be the maximum value attainable among the filling limits envisaged for each tank, consistent
with any operating instructions.

4.4 Consumable liquids
4.4.1 In calculating the free surfaces effect in tanks containing consumable liquids, it is to be assumed that for each
type of liquid at least one transverse pair or a single centerline tank has a free surface and the tank or combination
of tanks taken into account are to be those where the effect of free surface is the greatest.
4.5 Water ballast tanks
4.5.1 Where water ballast tanks, including anti-rolling tanks and anti-heeling tanks, are to be filled or discharged during the course of a voyage, the free surfaces effect is to be calculated to take account of the most onerous transitory stage relating to such operations.
4.6 Liquid transfer operations
4.6.1 For ships engaged in liquid transfer operations, the free surface corrections at any stage of the liquid transfer
operations may be determined in accordance with the filling level in each tank at the stage of the transfer operation.

4.7 GM0 and GZ curve corrections
4.7.1 The corrections to the initial metacentric height and to the righting lever curve are to be addressed separately as indicated in [4.7.2] and [4.7.3].

4.7.2 In determining the correction to the initial metacentric height, the transverse moments of inertia of the tanks are to be calculated at 0 degrees angle of heel according to the categories indicated in [4.3.1].

4.7.3 The righting lever curve may be corrected by any of the following methods:
• Correction based on the actual moment of fluid transfer for each angle of heel calculated; corrections may be
calculated according to the categories indicated in [4.3.1]

• Correction based on the moment of inertia, calculated at 0 degrees angle of heel, modified at each angle of
heel calculated; corrections may be calculated according to the categories indicated in [4.3.1]
• Correction based on the summation of Mfs values for all tanks taken into consideration, as specified in [4.8.1].

4.7.4 Whichever method is selected for correcting the righting lever curve, only that method is to be presented in the ship's trim and stability booklet. However, where an alternative method is described for use in manually calculated loading conditions, an explanation of the differences which may be found in the results, as well as an example correction for each alternative, are to be included.

4.10 Remainder of liquid
4.10.1 The usual remainder of liquids in the empty tanks need not be taken into account in calculating the corrections,
providing the total of such residual liquids does not constitute a significant free surface effect.

Longitudinal Strength

Prerequisite to any Longitudinal Strength calculation is establishing a longitudinal weight distribution for light ship and any other fixed weights aboard that extend over a significant length. Weights from tank loads are distributed automatically. Both the WEIGHT and the ADD commands will take multiple weight density curves in lieu of point weights.

Getting a light-ship distributed weight curve to exactly match the known total light ship weight and LCG is made easier by a feature where GHS scales its magnitudes and shifts its locations to match the known values. For example,

```
WEIGHT  6.0 @ 97.57f,
       14.0 @ 85.05f,
       19.6 @ 85.04f,
       22.8 @  5.03f,
       20.0 @  5.03f,
       21.2 @  2.90a;
        5.5 @ 12.0f,
        3.3 @  0.0
WEIGHT 2981.257, 48.419f, 0.000, 6.503
```

The first WEIGHT command establishes the light ship weight distribution, giving weights in tons/meter at several locations. Note that there are actually two curves; the second being separated from the first by a semicolon. The program automatically combines the two curves.

Each curve is a series of weight density numbers @ their corresponding locations. Note that the curve goes from point-to-point. It is not a series of weight blocks. It is a series of weight density points. If you need to input an existing weight curve that is in the form of blocks, you will have to use two points for each block where the density values are the block weights divided by the block lengths.

The locations in the example above are shown going from forward to aft. It is not necessary that the points be given in that order, since the program sorts them into order of ascending locations (fwd to aft). Discontinuities are best represented by two weight densities at nearly the same location. If two points on the same curve are at the same location, it is important that the one belonging to the forward segment come before the one belonging to the aft segment. A good practice is to always give the point locations in ascending order.

The second WEIGHT command also sets the light ship weight and CG, but it does not discard the distribution that has already been defined; rather it scales and shifts it as necessary so that it has the required total weight and LCG. The same thing can be done with SOLVE WEIGHT. For example, if you have drafts in a known load condition, you can set up that condition, enter the light-ship weight curve, then give the command "SOLVE WEIGHT, LCG" and it will scale and shift the existing light ship distribution as necessary.

The example above is very simple with only two curves. In real life distributed weight curves are usually much more detailed, often involving several curves and many more points.

If you need to go beyond bending moments and get stress and/or deflection, you will need to provide section modulus and/or section moments of inertia as well. For this you would use the SMOD command. Single values or curves can be specified. Section moments of inertia can be given as well, either in place of section modulus (SMOD=*I*/) or in a ratio (SMOD=*I*/*c*) where section modulus is given as the moment of inertia divided by the distance from neutral axis. Section moduli for both keel and deck stress can be given. See HELP SMOD for details. If deflection is being calculated, and there is no wave present, the resulting waterplane with deflection remains after the LS calculation is complete. However any change you make in the waterplane after that will remove the deflection.

You can provide shear and bending moment limits by means of the LSLIM command. The limits themselves and also how the results compare to the limits will be shown in the reports.

If a wave profile is to be included in the LS calculation, issue the WAVE command also. Remember that a Condition Graphic at this point (after a SOLVE) will help to verify that the wave has been set up as expected.

After providing this information, simply issue the LS command to get a table of the LS results including shear, bending moment and optionally deflection. There are some options about what is to be included In the table. One of the options is to show the results only at specified frame locations. A special Frame File provides frame names and locations. See the HELP LS for more information about the options and about preparing the Frame File.

An LS Exercise

Make a Run File to produce a longitudinal strength curve using TANKER.GF and the weight curves shown above, tank loads and a wave. Include the SMOD command and get deflection. If you want to use the Load Editor to set up your tank loads, you can do it in two phases with two Run Files arranged as shown below. The first run sets up the load condition, saves it to the file LS1.DAT. The second run picks up LS1.DAT, establishes wave and generates the report.

```
PROJECT LS1
READ TANKER.GF
WEIGHT ...
SMOD 4000/
LOAD (*) EDIT
SAVE  LS1.DAT
END

PROJECT LS2
```

```
RUN LS1.DAT /CALL
REPORT
\\\LS with Waves\
WAVE 0, 100
SOLVE
DISPLAY (*) STATUS PROFILE:OUTBOARD, PROFILE
LS
REPORT /PREVIEW
REPORT OFF
END
```

Waves

GHS allows you to specify a wave profile that gets superimposed on the waterplane. This is used primarily for longitudinal strength calculations, but the wave profile will be recognized in all other calculations as long as it is there. The WAVE command is used to establish the wave. The three primary wave parameters are Phase, Length and Amplitude. By default, the Length is the same as the LBP and the Amplitude is 1/20 of the length. But the Phase must always be specified. If you think of a periodic wave being based on angles running from 0 to 360 degrees, Phase is the angle of the crest relative to the origin. Suppose the origin is at the mid section and the wave length is LBP. Then when the peak of the wave is midship the Phase is zero (WAVE=0), and when peaks are at the end perpendiculars the phase is 180 degrees (WAVE=180). If the LBP is not defined, or you want some other wave length, a second parameter must be included giving the Length to be used. Pull down the Help menu and look at the WAVE command document to see all of its available parameters.

To turn off a wave and revert to the flat waterplane, the command is WAVE OFF.

Floodable Lengths

After setting up a condition, the FL command will produce a series of floodable-length curves at various values of assumed permeabilities. A list of tentative bulkhead locations can be given on the same command line by means of the /BHD parameter. Here is an example, where the /NC parameter specifies how many adjacent compartments are to be included when the "tepees" are drawn.

```
PROJECT FL1
READ TANKER.GF
REPORT
DRAFT 5
VCG 6
SOLVE WEIGHT, LCG
FL 0.7,0.8, 0.9 /BHD:85f,70f,60f,40f,25f,10f,0 /NC:2
REPORT /PREVIEW
REPORT OFF
END
```

Report Options

The following Run File illustrates some of the options available for reports.

```
project reports
read fv.gf
draft 5 | vcg 7 | solve weight, lcg
add "crew&effects" 0.5, -25,0,25
add "stores" 1, -14,0,15
add "net on deck" 2 20 0 13
load (wt*,fo*,lu*,fw*) 0.95
print configure /nofoot
`print configure  /font:courier /foot:footfoot.txt /logo:minilogo.bmp
`report /nofoot
`report /nographs
`report /box:classic
`report /box:bw
report /box:color
report `/p:0
`report /p:45
solve
status
page
ra
report /preview /thick:4 /count
report off
```

As you know by now, REPORT *filename* opens an output file for the reports using the specified file name. If no name is given, the project name is used with the `.PF` extension. The REPORT command also has other modes and options in which it can:

- append to an existing file,
- preview an opened file,
- close the report file with or without printing it.

Parameters that you can use when opening a report allow you to control:

- whether graphs are to be included,
- page numbering,
- lines per page (useful for paper other than 11” long),
- whether to use footers.

Three levels of visual enhancements are also available:

`/BOX` – boxes are drawn around tables,

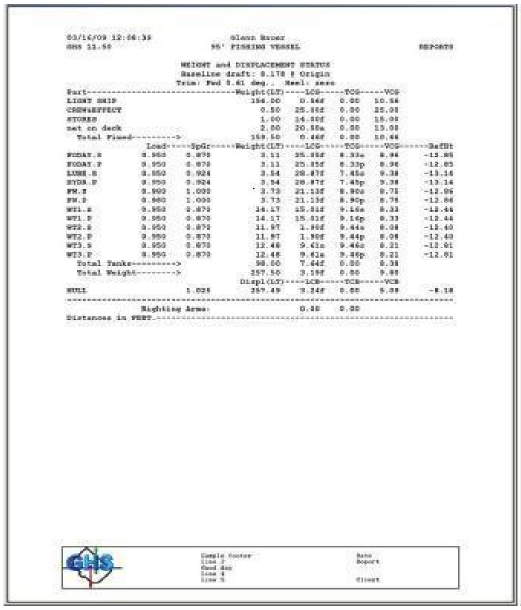
`/BOX:BW` – enhanced "fancy" boxes and fonts,

`/BOX:COLOR` – adds background colors in tables.

Some of the features you might want to include in your reports must be specified in the printer setup, which can be done either through the Report pull-down menu or through the PRINT command. You can select a font, footer, logo, thickness of graphs, shading, left margin and more.

You can email report files by means of PRINT /EMAIL. The recipient will need to have GHS or the free GHS Public Print Utility available from the Downloads link at

www.ghsport.com/support



03/16/09 12:08:35 Glenn Bauer
GHS 11.50 95' FISHING VESSEL REPORTS

WEIGHT and DISPLACEMENT STATUS
Baseline draft: 8.170 @ Origin
Trim: Fwd 0.61 deg., Heel: zero

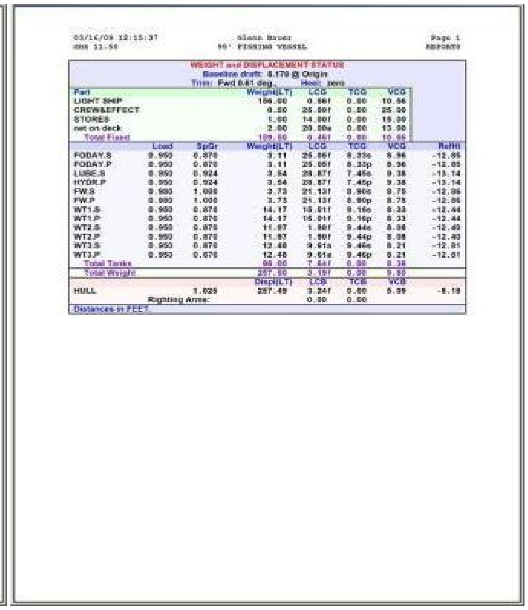
Part			Weight(LT)	LCG	TCG	VCG	
LIGHT SHIP			156.00	0.56f	0.00	10.56	
CREW&EFFECT			0.50	25.00f	0.00	25.00	
STORES			1.00	14.00f	0.00	15.00	
net on deck			2.00	20.00a	0.00	13.00	
Total Fixed			159.50	0.46f	0.00	10.66	
	Load	SpGr	Weight(LT)	LCG	TCG	VCG	RefHt
FODAY.S	0.950	0.870	3.11	25.05f	8.33s	8.96	-12.85
FODAY.P	0.950	0.870	3.11	25.05f	8.33p	8.96	-12.85
LUBE.S	0.950	0.924	3.54	28.87f	7.45s	9.38	-13.14
HYDR.P	0.950	0.924	3.54	28.87f	7.45p	9.38	-13.14
FW.S	0.980	1.000	3.73	21.13f	8.90s	8.75	-12.86
FW.P	0.980	1.000	3.73	21.13f	8.90p	8.75	-12.86
WT1.S	0.950	0.870	14.17	15.01f	9.16s	8.33	-12.44
WT1.P	0.950	0.870	14.17	15.01f	9.16p	8.33	-12.44
WT2.S	0.950	0.870	11.87	1.90f	9.44s	8.08	-12.40
WT2.P	0.950	0.870	11.87	1.90f	9.44p	8.08	-12.40
WT3.S	0.950	0.870	12.48	9.61a	9.46s	8.21	-12.81
WT3.P	0.950	0.870	12.48	9.61a	9.46p	8.21	-12.81
Total Tanks			98.00	7.64f	0.00	8.38	
Total Weight			257.50	3.19f	0.00	9.80	
			Displ(LT)	LCB	TCB	VCB	
HULL		1.025	257.49	3.24f	0.00	6.09	-8.18
	Righting Arms:			0.00	0.00		

Distances in FEET.

Sample footer
Line 2
Good day
Line 4
Line 5

Base
Report

Client



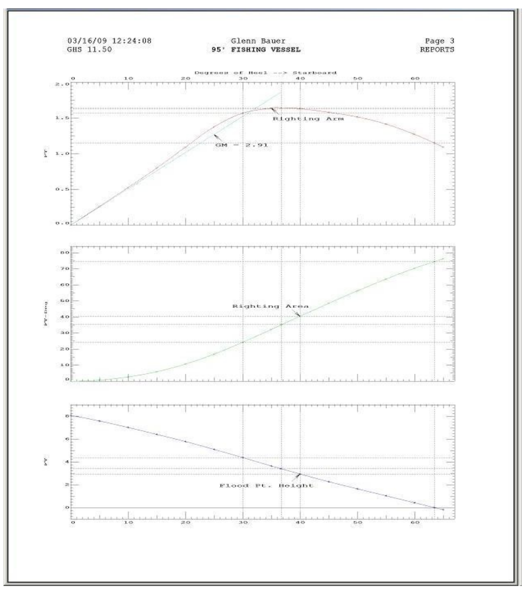
03/16/09 12:15:37 Glenn Bauer Page 1
GHS 11.50 95' FISHING VESSEL REPORTS

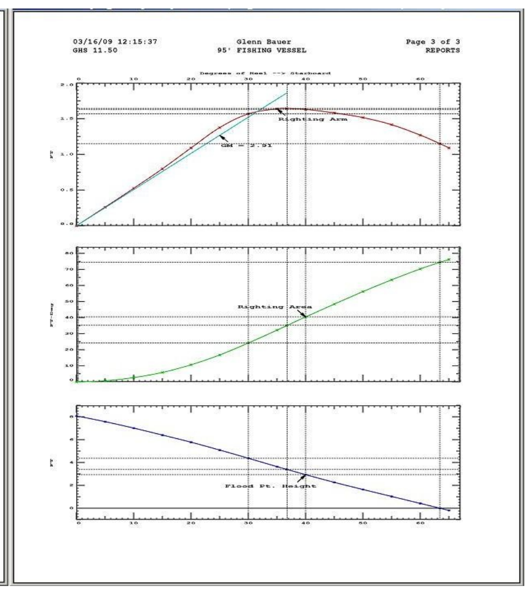
WEIGHT and DISPLACEMENT STATUS
Baseline draft: 8.170 @ Origin
Trim: Fwd 0.61 deg., Heel: zero

Part			Weight(LT)	LCG	TCG	VCG	
LIGHT SHIP			156.00	0.56f	0.00	10.56	
CREW&EFFECT			0.50	25.00f	0.00	25.00	
STORES			1.00	14.00f	0.00	15.00	
net on deck			2.00	20.00a	0.00	13.00	
Total Fixed			159.50	0.46f	0.00	10.66	
	Load	SpGr	Weight(LT)	LCG	TCG	VCG	RefHt
FODAY.S	0.950	0.870	3.11	25.05f	8.33s	8.96	-12.85
FODAY.P	0.950	0.870	3.11	25.05f	8.33p	8.96	-12.85
LUBE.S	0.950	0.924	3.54	28.87f	7.45s	9.38	-13.14
HYDR.P	0.950	0.924	3.54	28.87f	7.45p	9.38	-13.14
FW.S	0.980	1.000	3.73	21.13f	8.90s	8.75	-12.86
FW.P	0.980	1.000	3.73	21.13f	8.90p	8.75	-12.86
WT1.S	0.950	0.870	14.17	15.01f	9.16s	8.33	-12.44
WT1.P	0.950	0.870	14.17	15.01f	9.16p	8.33	-12.44
WT2.S	0.950	0.870	11.87	1.90f	9.44s	8.08	-12.40
WT2.P	0.950	0.870	11.87	1.90f	9.44p	8.08	-12.40
WT3.S	0.950	0.870	12.48	9.61a	9.46s	8.21	-12.81
WT3.P	0.950	0.870	12.48	9.61a	9.46p	8.21	-12.81
Total Tanks			98.00	7.64f	0.00	8.38	
Total Weight			257.50	3.19f	0.00	9.80	
			Displ(LT)	LCB	TCB	VCB	
HULL		1.025	257.49	3.24f	0.00	6.09	-8.18
	Righting Arms:			0.00	0.00		

Distances in FEET.

Output without page numbers and footer with logo. **With page numbers and boxed in color.**





Graphs at one pixel thickness **Graph at /THICK:4 and page count in effect.**

Special Message Commands

Certain special messages are recognized by the program and cause it to display information about your computer, operating system and program settings:

```
ME PATH `paths to certain folders used by GHS
ME EXPIRE `expiration time of limited or roaming licenses
```

Other special Message commands provide for changing certain program settings:

```
ME DATEFORMAT Year-Month-Day `sets date formatting
ME ERRBEEP ON/OFF `turns beep on errors on or off
ME REPFONT `enhances NOTE font in fancy reports
ME REPFONT OFF `turns off enhanced NOTE font
```

See Help MESSAGE for all of the special messages.

You can switch Message output that would normally go to the screen to go to a text file instead:

`ME (REPORT)` *filespec*

opens the file to receive the message output. Of course you would not use this if *filespec* is already open. The /APPEND parameter is available for adding to an existing file.

```
ME (REPORT) OFF
```

closes the file.

User-generated reports and plots are also controlled through Message commands. This is covered in one of the Advanced Training sessions.

Tank Characteristics

The TC command produces tank tables and plots suitable for design work or inclusion in a T&S book. There are several options for what is to be included in the tables. The default option gives tables like this:

TANK CHARACTERISTICS
No Trim, No Heel
Tank: HOLD1.C, Contents: SALT WATER at 1.025 Specific Gravity
FORWARD HOLD

Ref Ht	Load	Weight LONG TONS	Center of Gravity LCG	TCG	VCG	GML	GMT	FSM Ft-LT
-4.73	.100	8.57	9.57f	0.00	4.29	65.0	16.8	144.1
-5.60	.200	17.13	9.57f	0.00	4.73	32.5	8.4	144.1
-6.48	.300	25.70	9.57f	0.00	5.16	21.7	5.6	144.1
-7.35	.400	34.26	9.57f	0.00	5.60	16.2	4.2	144.1
-8.23	.500	42.83	9.57f	0.00	6.04	13.0	3.4	144.1
-9.11	.600	51.40	9.57f	0.00	6.48	10.8	2.8	144.1
-9.98	.700	59.96	9.57f	0.00	6.92	9.3	2.4	144.1
-10.86	.800	68.53	9.57f	0.00	7.35	8.1	2.1	144.1
-11.73	.900	77.09	9.57f	0.00	7.79	7.2	1.9	144.1
	1.000	85.66	9.65f	0.00	8.23			

Distances in FEET.
HOLD1.C Reference Point: Long.= 0.00 Trans.= 0.00 Vert.= 0.00

Output includes Reference Point height, load fraction, contents, weight, CG and free surface information. Other display options are possible, such as tank volumes and sounding/ullages. See Help TC for the full range of options.

Tank Characteristics Exercise

Starting with the Run File listed below, add statements to produce additional tank characteristics reports for:

DB0.S and DB1.S giving volume in gallons and no surface information;

WT1.S and WT2.S using tank soundings and no load fractions.

```
PROJECT TC1
READ FV.GF
REPORT
TC (HOLD1.C) .1 .2 ... 1 /NOREF /VOLUME:GA
TC (WT2.S) SO:0 .25 ... 12 /NOREF
REPORT /PREVIEW
REPORT OFF
```

Tank Sounding Tables

The TS command produces several formats of detailed tank soundings tables that are designed for everyday shipboard use. Included are the following.

1 - Volume vs Sounding arranged four columns per row (default);

2 - Volume vs Sounding & Ullage in Ft & Inches or M. & Decimeters;

3 - Volume, Cu.Ft/M., Center & Moments vs Sounding;

4 - Volume, Cu.Ft/M., Center, Trim Corr. & Transverse Moment vs Sounding;

5 - Cu.Ft/M., Volume & Weight vs Sounding & Ullage;

6 - Volume, Cu.Ft/M., Weight, Center & FSM vs Sounding.

A report file must be open, since these reports have no screen-only counterparts.

Example:

```
PROJECT TSOUND
READ FV.GF
REPORT
TS (WT1.S) /FORMAT:1
REPORT /PREVIEW
REPORT OFF
```

Flooding Tanks

Tanks can be intact or flooded. When flooded they become negative displacers since they are considered to be open to the sea. In other words they see the same waterplane that the hull sees, but instead of making a positive contribution to displacement they subtract from it.

The command to switch a tank from Intact type to Flooded type is the TYPE command. Initially all tanks are intact. To make a particular tank flooded, the command is,

`TYPE (`*`tankname`*`) = FLOOD`

then to restore it to the intact type,

`TYPE (`*`tankname`*`) = INTACT`

In both cases *tankname* can be a list of tanks separated by spaces or commas, and each member of the list can end with an asterisk to match all tanks whose names have a common beginning. This is especially useful when you want to make sure all tanks get restored to intact:

```
TYPE (*) = INTACT
```

Damage Stability

All of the commands and methods used for intact stability apply to damage stability as well. The only difference is that one or more tanks/compartments will have TYPE=FLOODED. This is the only tank type that is used in regular damage stability work. TYPE=DAMAGED is reserved for special simulations since it requires a specific point of damage.

A Damage Stability Exercise

For the loading used in the intact stability exercise, determine if the fishing vessel meets the following criterion:

- Angle at equilibrium less than 7 degrees
- No deck immersion (Can the margin line be immersed? `DI` vs `DI0`)
- Righting energy to the lesser of 30 degree or flood is greater than 10 ft-deg.

Check these two damage cases:

- Engine room, starboard LUBE and starboard FODAY tanks flooded.

• Starboard WT2 and DB1 tanks flooded.

Tonnage Calculations

A report that is useful for International Tonnage is available through the COMPONENT command:

```
COMPONENT /TONNAGE
```

Skin Areas

Skin Area of any component is now available (beginning with GHS version 12.28) through COMPONENT /SKIN. This calculation was previously available in the optional SA module, and is now included in the main program. Skin areas are useful for estimating hull materials, plating weight and CG, and areas for painting.

Important Wizards

Some areas of GHS application are best done with wizards because the sophistication of the Run Files required is beyond what most users would have the time or desire to develop.

There are two classes of wizards. Major wizards are complete application programs for specific purposes. Other wizards can be integrated with your Run Files. Typically they involve library files having the same name as the wizard with the `.LIB` extension, that are used by the wizard and are also usable directly in your Run File. To get information about using such a library file directly, execute the LIBINFO macro. For example,

```
RUN FLDINTER.LIB
.FI.LIBINFO
```

RIG Wizard

This is a major wizard essential for MODUs and any other vessels where least stability is not necessarily in the transverse direction or where trim becomes large when heeling transversely. The RIG wizard finds the weakest or critical axis and produces composite maximum VCG curves including intact and damage. It can import wind heeling moment files to take advantage of wind-tunnel tests, or it will derive wind heeling moments from the geometry in any direction and as a function of heel. This is a flexible and powerful wizard with years of real-world experience. It produces complete reports and is easy to use. Condition Graphics is highly recommended but not essential.

DAMSTAB2 Wizard

The new probabilistic damage regulations are so complex that this major wizard is virtually essential. It greatly simplifies the task of defining subdivisions and takes over every aspect of setting up and producing damage stability. It applies to cargo and passenger ships. It required the Advanced Features module. Condition Graphics and Load Editor are highly recommended.

GLM_MAKER

All GLM configurations are done by means of this wizard. It offers every option that has ever appeared in any GLM, and makes configuring and testing GHS Load Monitor systems easy. Condition Graphics and Load Editor with windows (LEw) are required. If longitudinal strength is involved, the LS module is also required. If a GLM utilizes Multi-Body operations the MB module is required. If it involves complex cranes, the Crane module is required.

CRANE Wizard

Complex crane modeling, including capacity tables and extensive graphics are managed with this wizard. Load Editor with windows and the Crane module are required.

FLDINTER Library and Wizard

This library provides the essential macro for intermediate stages of flooding including blending densities of cargo and sea water. Unlike the major wizards above, it is designed to be embedded in the User's Run file. No optional modules are required.

C170170 and C171050 Libraries and Wizards

These libraries address GM criteria that are not well suited to the usual criteria represented by Limit commands. They provide for the evaluation of load conditions and will also produce maximum VCG curves. They can be utilized through their wizards or by using libraries directly. No optional modules are required.

WOD – Water on Deck Wizard and Library

New regulations for assessing the effect of water on decks of RO-RO and ferry vessels are addressed in the WOD library and wizard. No optional modules are required.

Topics for Advanced Training

Tank Groups and transfers within a group
Advanced Tank Types: Damage, Spilling, Bubble, WDF, Flooded Plus, Deck
Water on deck criteria
Water on deck wizard and WOD library

LEw
Weight categories
GLM_MAKER

Axis: heeling in all directions
Rig stability
Rig wizard

Progressive flooding
Intermediate stages of flooding
FLDINTER wizard library
Probabilistic damage
DAMSTAB2 wizard

Oil outflow

Grain shift
Maximum heeling moments
MaxHMMT wizard and library

Crane operations
Crane wizard
Crane criteria

Ground reactions
Launching
Dry docking

Multi-Body
Salvage procedures

Submarine stability

Advanced command language
Templates
Making wizards
User tables
User graphs

Hopper spilling with mud lag

EXERCISE RUN FILES

Importing the Barge Hull from a DXF

```
PROJ MKBARGE
IMPORT BARGE.DXF  BARGE.GF /NEWGF /3D:XYZ /SCALE:-1,1,1
DISPLAY
```

Making the Barge Appendages and Tanks

```
PROJECT MKTANK
READ BARGE.GF
ENTER PM
ECHO ON
UNITS F
TITLE 40X16X6 BARGE
COMM HULL CREATED BY MODEL CONVERTER FROM BARGE.DXF
COMM TANKS ADDED PER TANK DWG

CREATE HULL\TUNNEL.C
 DEDUCT
 CYL(12) 8, 0, 2.5   8, 8, 2.5,  2.0
 FIT HULL
/
CREATE HULL\SKEG.C
 ENDS 34, 39
 TOP 4
 BOT 0
 IN 4
 OUT 5
 FIT HULL
/

`CREATE REMAINING TANKS PER SKETCH

CREATE TANK.S\C1.S
 ENDS 13, 16
 IN 1
 OUT 3
 TOP 4
 FIT HULL
COMP
 LOCUS @ 16 = 1,-1,  7,-1, 7,2,  5,2,  5,4, 1,4
 LOCUS @ 19 = 1,-1,  7,-1, 7,2,  5,2,  5,4, 1,4
 FIT HULL
 JOIN C1.S
/

CREATE TANK.P\C1.P
 ENDS 13, 19
 IN 1
 OUT 7
 TOP 4
 FIT HULL
DEDUCT C2.P
 ENDS 13, 16
 IN 3
 OUT 7
 TOP 4
 BOT 0
 SPACING 1
DEDUCT C3.P
 ENDS 16, 19
 IN 5
 OUT 7
 TOP 4
 BOT 2
 SPACING 1
/

CREATE VOID1.S
 ENDS 0, 10
```

```
 FIT HULL
/
CREATE VOID1.P
 OPP VOID1.S
/
CREATE VOID2.S
 ENDS 10, 21
 FIT HULL
DEDUCT
 SHAPE TANK.S\C1.S
/
CREATE VOID2.P
 ENDS 10, 21
 FIT HULL
DEDUCT
 SHAPE TANK.P\C1.P
COMP
 SHAPE TANK.P\C2.P
COMP
 SHAPE TANK.P\C3.P
/
CREATE VOID3.S
 ENDS 21, 26
 FIT HULL
COMP
 ENDS 26, 32
 INB 2
 FIT HULL
 JOIN VOID3.S
/
CREATE VOID3.P
 ENDS 21, 26
 FIT HULL
COMP
 ENDS 26, 32
 INB 4
 FIT HULL
 JOIN VOID3.P
/
CREATE VOID4.S
 ENDS 32, 40
 FIT HULL
/
CREATE VOID4.P
 OPP VOID4.S
/
CREATE WELL.P
 ENDS 26, 32
 INB -2
 OUT 4
 FIT HULL
/

UNITS M
WRITE BARGE.GF1
DISPLAY
TANKS
ECHO OFF
MESSAGE Except for VOID3, P&S volumes should match.
WAIT
QUIT PM
```

Composite Max VCG

```
PROJ MAXVCG2
READ FV.GF
REPORT

CRTPT (2) "Focsle door" 23f, 8.0, 14.0

UNITS LT
LIMIT(1) AREA FROM 0 TO 30 > 10.3
LIMIT(2) AREA FROM 0 TO 40 OR FLD > 16.9
LIMIT(3) AREA FROM 30 TO 40 OR FLD > 5.6
```

```
MACRO MV
 MAXVCG DISPL: 50  100 ... 250 /LCG: 5.0f 4.0f ... 1.0a %1
/
.MV

LIMIT(1) GM UPRIGHT > 0.49
LIMIT(2) RA AT 30 OR MAX > 0.66
LIMIT(3) ANGLE AT MAX > 25

.MV /COMPOSITE

WRITE (MAXVCG) MAXVCG.DAT

.MV /LOOKUP

REPORT /PREVIEW
REPORT OFF
END
```

Load Condition Setup Library

```
`File FVSTAB.LF
`FV Stability Load Condition Setup Library
READ FV.GF
UNITS LT
WEIGHT 156.0, 0.56f, 0, 10.56
CRTPT (1) "ER VENTS"          22.8f, 7.0s, 15.0 /SYM
CRTPT (2) "PORT CABIN DOOR"   10.0f, 9.0p, 14.0 /TIGHT
CRTPT (3) "STBD CABIN DOOR"    5.0a, 9.0s, 14.0 /TIGHT

MACRO COND1
 SUBTITLE
 \Departure\
 UNITS LT
 ADD "Crew&effects"  2.0, 25f, 0, 25.0     /NOWARN
 ADD "Stores"       12.0, 14f, 0, 15.0  /NOWARN /MAX:12.0
 ADD "Net on deck"   5.0, 20a, 0, 13.0 /NOWARN
 LOAD (*) 0 /QUIET
 LOAD (WT*,FODAY*,LUBE*,HYDR*) 0.95
 LOAD (FW*) 0.98
 LOAD (HOLD*) 0.0
/
MACRO COND2
 .COND1
 SUBTITLE
 \Arrival at fishing grounds\
 LOAD "Stores" 0.66
 LOAD (WT1*) 0.05
 LOAD (LUBE*,HYDR*,FW*) 0.66
/
MACRO COND3
 .COND2
 SUBTITLE
 \Departing fishing grounds - good catch\
 LOAD "Stores" 0.33
 LOAD (WT2*) 0.05
 LOAD (LUBE*,HYDR*,FW*) 0.33
 LOAD (HOLD*) 1.0
/
MACRO COND4
 .COND3
 SUBTITLE
 \Depart fishing grounds - no catch\
 LOAD (HOLD*) 0
/
MACRO COND5
 .COND3
 SUBTITLE
 \Arrival - good catch\
 LOAD "Stores" 0.017
 LOAD (WT3*) 0.05
 LOAD (LUBE*,HYDR*,FW*) 0.10
/
```

```
MACRO COND6
 .COND5
 SUBTITLE
 \Arrival - no catch\
 LOAD (HOLD*) 0
/
MACRO CONDS `%1 - condition number, %2 - command to execute
 .COND%1
 PAGE
 %2
/
MACRO SHOW
 SOLVE
 STATUS GHS
 DISPLAY (*) STATUS PROFILE, PLAN
/
MACRO DOCRIT
 LIMITS OFF
 HMMT OFF
 .CRIT%1
 IF "%2"<>"" THEN .ALLCONDS .CALC ELSE PAGE | .CALC
/
MACRO ALLCONDS
 .CONDS (6,1) 1, "%1"
/
MACRO BYCRIT
.ALLCONDS .SHOW
.DOCRIT ({NCRITS},1) 1, ALL
/
MACRO BYCOND
.ALLCONDS ".SHOW | .DOCRIT ({NCRITS},1) 1"
/
END
```

Intact Stability with Three Criteria

```
PROJECT INSTAB1
RUN FVSTAB.LF /CALL
REPORT /BOX:BW
\\\\\\Training Class Exercise\
\\Intact Stability\

VARIABLE NCRITS=3

MACRO CRIT1
 LIMIT TITLE 170.173
 UNITS LT
 LIMIT GM UPRIGHT > 0.49
 LIMIT RA AT ABS 30 OR MAX > 0.66
 LIMIT ABS ANGLE AT MAX > 25
 LIMIT AREA FROM ABS 0 TO ABS 30 > 10.3
 LIMIT AREA FROM ABS 0 TO ABS 40 OR FLD > 16.9
 LIMIT AREA FROM  ABS 30 TO ABS 40 OR FLD > 5.6
 MACRO CALC
  SOLVE
  ANGLES *
  HEEL 0
  RA /LIM:ATT
 //
/
RUN C170170.LIB /CALL
MACRO CRIT2
 UNITS LT
 SET P=0.005
 MACRO CALC
 .170_170
 //
/
MACRO CRIT3
 UNITS LT
 WIND (PRESSURE) 0.005
 ROLL IMO
```

```
  LIMIT TITLE IMO SWR
  LIMIT RES RATIO FROM ROLL TO ABS 50 OR RA0 > 1
  LIMIT RES RATIO FROM ROLL TO  FLD   OR RA0 > 1
  LIMIT ABS ANGLE AT PRE < 16
  LIMIT ANGLE FROM PRE TO 80%DI0 > 0
  MACRO CALC
   HMMT OFF
   SOLVE
   ANGLES *
   HMMT WIND /CONST /GUST:1.5 /TRIMALLOW
   HMMT *
   SOLVE
   HEEL *-ROLL
   RA /LIM:ATT /GRAPH:CLEAN
  //
 /
 `.BYCRIT `All conditions for each criterion
 .BYCOND `All criteria for each condition

 REPORT /PREVIEW
 REPORT OFF
 END
```

Damage Stability

```
PROJECT DASTAB1
RUN FVSTAB.LF /CALL
REPORT /BOX:BW
\\\\\\\Training Class Exercise\
\\Damage Stability\

VARIABLE NCRITS=1

MACRO CRIT1
 LIMIT TITLE DAMAGE STABILITY
 UNITS LT
 LIMIT ABS ANGLE AT EQU < 7
 LIMIT ANGLE FROM EQU TO DI > 0
 LIMIT AREA FROM EQU TO ABS 30 OR FLD > 10.0
 MACRO CALC
  SOLVE
  ANGLES *
  HEEL 0
  RA /LIM:ATT
 //
/

MACRO DODAM
 TYPE (*) INTACT /QUIET
 TYPE (%1) FLOOD
 `.BYCRIT `All conditions for each criterion
 .BYCOND `All criteria for each condition
/

.DODAM "ENGRM.C,LUBE.S,FODAY.S"
.DODAM "WT2.S,DB1.S"

REPORT /PREVIEW
REPORT OFF
END
```