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USER'S MANUAL FOR MacGrid

by

G.W. McMahon — B. L. Fanning

FANTECH CONSULTING SERVICE
67 Spikenard Street
Dartmouth, Nova Scotia, Canada
B2W 3B6

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Scientific Authority

Christopher J. Purcell

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Ce document est un manuel d'utilisation du prototype de programme d'ordinateur MacGRID, qui sert à générer des modèles à éléments finis pour le code d'analyse MAVART. Comme son nom l'indique, MacGRID est conçu pour tourner sur micro-ordinateur Macintosh d'Apple et peut utiliser tous les menus qui se retrouvent normalement dans une application Macintosh, en plus des menus spéciaux nécessaires pour générer un modèle à éléments finis. L'application comporte deux fenêtres, la première montrant le modèle sous forme graphique et permettant la création et la manipulation du modèle à l'aide d'une interface à souris. La seconde fenêtre est une zone de texte servant à afficher et à modifier le fichier de données du modèle selon les techniques normales d'édition Macintosh.

USER'S MANUAL FOR MacGRID

Phase Ia

1. INTRODUCTION

GRID [1], a program for generating a finite element mesh for MAVART, was originally written for a DEC-20 computer and used a digitizing table for defining coordinate, connectivity and other data needed for the input data file. The Macintosh computer is an ideal platform to generate such a mesh, using only the devices that are normally available on any Macintosh. FanTech Consulting Service, under research contract No. W7707-4-3046/01-HAL (Phase Ia), has developed a working version of GRID for the Macintosh. MacGRID, the Macintosh version of GRID, is the subject of this Manual.

MacGRID follows the Macintosh Human Interface Guidelines as much as possible, so, with the interface presented to the user, mesh generation is a simple, almost intuitive procedure. In this early version of MacGRID, there are a number of limitations that will be eliminated in future versions. These are discussed in Section 7.

This Manual first describes briefly the present input data format required by MAVART. Then the Windows, Dialogs, Palettes, and Menus that comprise the Macintosh user interface are described, along with instructions on how they are used to generate a new model or modify an existing model. Finally, some limitations of the present program and plans for future modification are discussed.

2. MAVART INPUT DATA FORMAT

The MAVART input data file generated by MacGRID is an ASCII text file. It uses the same format that has been used historically. It consists of (1) a title line, (2) a problem identification line, (3) node lines, one for each node in the FE mesh, (4) material lines, (5) element lines, one for each element in the FE mesh, and (6) numerical data lines that prescribe some parameters of the analysis such as frequencies. Associated with a node line, there may be an extra line (3b) that prescribes non-zero fixities on the nodal degrees-of-freedom. Also, associated with the element line, there may be a 'POLANG' line (5b) that specifies certain element attributes, such as the symmetry angle of the material matrix. For details of the input data format, the reader is referred to the User's Manual for Program MAVART [2].

MacGRID is primarily concerned with (3), (4), and (5); however, dummy lines (1) and (2) are generated for a new model and these may be edited in the text window. New material lines consist of the (negative) material number only, although full material matrices are retained for a model that is input from an existing data file. Fixity lines (3b) can only be inserted by editing the text window for a ~~completed~~ model. Provision is made for inserting (5b), a POLANG value. Lines (6) can also be added by editing the text window. Lines (3b), (5b), and (6) are retained for a model that is input from an existing data file.

3. WINDOWS

Two windows are provided in MacGRID, a graphics window **MacGRID Plot** and a text window **MacGRID Text**, selectable via the **Windows** Menu, as described in Section 6. Most of the mesh generation for a model will take place in the graphics window, using Palettes to assign the required action. The Palettes are described in Section 5. Nodes, materials, and elements in the model are reflected in the text window, which displays the current MAVART data file as it is being generated.

An existing MAVART input data file can be read, using **Open** in the **File** Menu; the model is displayed in the graphics window and the data file is displayed in the text window. The title of the text window changes to that of the input data file. This model can then be changed by user action in the graphics window and these changes are again reflected in the text window. The input data file might represent a partially generated model that has been saved earlier, and the model generation is now being continued.

The windows are full-screen in size, and are presently available only for the 13-inch colour monitor. The text window has a Close Box and a vertical Scroll Bar, while the graphics window has neither; however, both windows may be closed using **Close** in the **File** Menu. At start-up, both windows are opened and are devoid of data. The user may then begin model generation, or may read an existing data file and make modifications, or continue an interrupted model generation. After a new model is started, **Open** is disabled, so the user cannot inadvertently open an existing file. Also, after closing both windows, the only options available to the user are **New** or **Quit** in the **File** Menu. Selecting **New** opens both windows and initializes MacGRID the same as on start-up. The user must close both windows and select **New** before attempting to start generation of a new model.

The graphics window cannot be saved as a document; it can however, be printed, using **Print** in the **File** menu). The text window can be saved or printed. On closing the text window or quitting MacGRID, the user is prompted as to whether a Save is desired.

The text window is fully editable, with all items in the **Edit** menu operational except **Undo**. However, changes in the text are not reflected in the model displayed in the graphics window, so that any editing of nodal or element data should be done only on a completed model. Alternatively, an edited data file for an unfinished model can be saved then re-opened by MacGRID, after closing both windows or quitting and restarting MacGRID. The edited changes will now be displayed in the graphics window and the model generation can continue.

4. DIALOGS & ALERTS

Several Dialogs and Alerts are invoked by user action in MacGRID, either when using certain Palette items, when selecting certain Menu items, or when clicking on a node or element. Dialogs request user input of data and are self-explanatory when displayed. In response to a Dialog, the user may click the 'Cancel' button, or the 'OK' button after ensuring that the requested data is correct.

Alerts signal an inappropriate action, a warning, or instruction to the user and will specify such in a message. Generally, no action is available to the user except clicking the 'OK' button. The user should then comply with any instruction or take other appropriate action.

The Dialogs and Alerts in MacGRID will be described in the following Sections in conjunction with the Menu or Palette action where they are invoked.

5. PALETTES

Six Palettes are included in the graphics window, three dealing with node action and three with element action. The node Palettes are **Node Type**, **Node Action**, and **Coordinates**. The element Palettes are **Element Type**, **Element Action**, and **POLANG**. For a new model, the first task is node generation, as no elements can be generated without nodes. Each of the Palettes is described below:

a) **Node Type** Palette

This Palette allows the selection of the desired type of node to be generated. The six node types used in MAVART models are solid '**S**', piezoelectric '**A**', fluid '**F**', electric '**E**', elastic shell '**H**', and rigid '**R**'. The default type is '**S**'. A selected setting remains in effect until another is selected or until an element Palette item is chosen, when it reverts to the default.

b) **Node Action** Palette

The names displayed on the Palette buttons are self-explanatory, 'No Action', 'Create Node', 'Delete Node', 'Move Node', 'Change Type', and 'Fixity...'. The initial setting of this Palette is 'No Action'. The user should first select the type of node required, using the **Node Type** Palette, if the default, '**S**' is not the desired type.

- '**Create Node**' allows the creation of a node wherever the mouse button is clicked in the graphics region. This action may be modified by a selection in the **Coordinates** Palette, as described below. When 'Create Node' is selected to create the first node of a new model, the **Axis Scales...** Dialog is invoked, asking for user input of the minimum and maximum Z and R axis values. Initial values are 0.0 and 1.0 metre for each axis. This Dialog is also invoked by the **Scales** Menu, as described in Section 6. New nodes are always placed at the end of the node list in the data file, and if there are unused node numbers in the list, these are assigned first before higher node numbers are assigned.
- '**Delete Node**' causes any node that is selected by mouse clicking to be deleted. The arrow cursor must be within 5 pixels of an existing node if the node is to be selected; if not, an Alert is displayed informing the user that there is no node where the mouse was clicked. If the user attempts to delete a node that is used by an element, an Alert is displayed indicating that the delete action is rejected.
- '**Move Node**' allows the user to move a node by mouse action. Moving is accomplished by first clicking on the node you wish to move (within 5 pixels), then clicking on the point to which you want it moved; do not drag the node to the new position.
- '**Change Type**' and 'Fixity...' are not yet implemented.

c) **Coordinates** Palette

This Palette provides several different ways to set the coordinates of a node. Again, the labels displayed on the Palette buttons are self-explanatory, 'Choose Z', 'Choose R', 'Choose Z&R', 'Same Z&R', 'Same Z', 'Same R', 'Same Z as', 'Same R as', and 'As Clicked'.

- '**As Clicked**' is the default action, causing a node to be created at the location where the mouse button is clicked.
- '**Choose Z**' (or '**Choose R**') invokes a Dialog requesting that the user type in a value for the appropriate coordinate. The other coordinate is set by the position where the mouse button is clicked.
- '**Choose Z&R**' is not implemented at present.
- '**Same Z&R**' invokes an Alert asking the user to click on the node with the required coordinates. This action procedure remains in effect until some other palette item is chosen.
- '**Same Z**' (or '**Same R**') causes a node to be created with the same Z (or R) coordinate as the previously created node, the other coordinate being set by the position where the mouse button is clicked. This allows a series of nodes to be created along a horizontal (or vertical) line.

- 'Same Z as' (or 'Same R as') waits for the user to click the mouse button at some location in the window, then invokes an Alert asking that the desired reference node be identified by clicking on it. The location of the original mouse click sets the other coordinate.

d) **Element Type** Palette

This Palette allows the user to select any of the 16 types of element used by MAVART. Types **1** to **4** are triangular elements, Types **12** to **15** are quadrilateral elements, and Types **5** to **10**, and **16** are line elements. Type **11** is a one-noded RING element. The default type is **1**, a SOLID triangle. Element Types **9** and **11** are not yet supported by MacGRID.

e) **Element Action** Palette

This Palette selects user action relating to elements. The default is 'No Action'.

- 'Create' allows the user to create an element by mouse action. New elements are placed at the end of the element list in the data file, and if there are unused element numbers in the list, these are assigned first before higher element numbers are assigned.. The desired element type is first selected using the **Element Type** Palette, if the default, '**1**' is not the desired type. Appropriate corner or end nodes must exist before an element can be created. The user clicks on the two end nodes for a line element, the three corner nodes for a triangular element, and the four corner nodes for a quadrilateral element. The other required nodes of the element are then automatically created if they do not already exist. To create a FTOS element, solid and fluid end nodes must exist with the same coordinates. If a node is selected that is of the wrong type for the current element, an Alert is displayed informing the user of the error. '**S**', '**H**', or '**A**' nodes are accepted for a SOLID, SOLIDQ, or FTOS element. If there is no node within 5 pixels of the mouse click, a "No node" Alert is displayed. This Alert is also displayed when creating a FTOS element, if two nodes of the proper types do not exist at the end positions. If a node is selected that is not a corner or end node of an element, and not an unattached node, an Alert is displayed informing the user of the inappropriate selection.
- 'Delete' allows the user to delete an element by clicking on it. For a line element, the click must be within 5 pixels of the centre node; for an areal element, the click must be at least 5 pixels inside the element boundary. Otherwise, an Alert is displayed informing the user that no element exists where the mouse was clicked. When an element is being deleted, all nodes of that element that are not used by another element are also deleted.
- 'Material' allows selection of a material number for the element being created. A Dialog is invoked asking the user to type in a material number. The default value is 1; zero must not be used and the maximum value accepted by MAVART is 30. If the first element on a new model is being created, the Material Dialog is displayed automatically. For each material selection, only a single material line, with the negative of the material number, is placed in the data file. This instructs MAVART to look for the material properties on a separate materials file, which is generated by program MATER. New materials are placed at the end of the materials list.

f) **POLANG** Palette

This Palette allows selection of a POLANG value for the element being created. The default value is zero. The commonly used values, π , $\pi/2$, and $3\pi/2$ can be selected on the Palette. Other values are specified by selecting '?...!', which invokes a Dialog asking the user to type in the desired value. The latter item (?...) is not yet implemented.

6. MENUS

The MacGRID menu bar includes the standard Macintosh menus, **Apple**, **File**, and **Edit**, which contain the usual items and will not be described here. In addition, there are four special menus, **Nodes**, **Elements**, **Scales**, and **Windows**. Each of these is described below:

a) **Nodes Menu**

The **Nodes** menu deals with display and creation of nodes and contains three items. The first item, **Reorder** has not yet been implemented. The second item causes the display or non-display of node numbers on the plot, toggling between **Show Numbers** and **Hide Numbers**. The third item **NodesOnRadius...** invokes a dialog asking for user input of (1) the Z and R coordinates of the centre of the arc on which new nodes are to be created, (2) the radius of the arc, and (3) the number of nodes to be created. At present, the Z and R coordinate input is not implemented and the values are fixed at zero, i.e., the centre of the arc is the origin and the arc angle is 90° between the positive Z and R axes. If **NodesOnRadius...** is used to create the first nodes of a new model, the **Axis Scales...** Dialog is invoked, asking for user input of the minimum and maximum Z and R axis values.

b) **Elements Menu**

The **Elements** menu contains three items dealing with creation, modification, and display of elements. The first item, **AbortCreate** allows the user to abort the creation of a new element for any reason, such as clicking on the wrong node or selecting the wrong material. An Alert is displayed, instructing the user to start over again choosing the nodes. Of course, this menu item must be chosen before clicking the final node; otherwise the bad element must be deleted. The second item **Show/Hide Numbers** is the same as in the **Nodes** Menu, except that element numbers are displayed or not displayed. The third item **Straighten** moves all nodes so that the mid-nodes on the sides of each element are centred between the corner or end nodes; centre nodes on quadrilateral elements are placed at the element centroid. Fluid-to-fluid mid-nodes are not affected.

c) **Scales Menu**

The **Scales** menu contains three items that allow the user complete flexibility in setting the axis scales of the graphic display. The first item, **Select Region** activates a mouse dragging routine to allow the user to drag a dotted rectangle over the region of the plot that is to be expanded to fill the window. The second item, **Axis Scales...** invokes a dialog that asks for user input of the minimum and maximum Z and R axis values, allowing the user to choose any desired scale. The third item, **Full Scale** reverts to the original values of axis scales after a new region has been chosen by **Select Region**. If **Axis Scales...** has been used to select the region, **Full Scale** has no effect.

d) **Windows Menu**

The **Windows** menu contains only two items, allowing selection of either of the two windows, **MacGRID Plot** or **MacGRID Text**. The currently selected menu item is marked by a check mark (✓). The **Nodes**, **Elements**, and **Scales** menus are disabled when the text window is selected.

7. LIMITATIONS OF VERSION 0.5

1. End nodes must now be clicked to create a FTOS element. In future versions, FTOS elements will be generated automatically when contiguous FLUID and solid elements are created.
2. If the user mistakenly chooses the wrong nodes in creating an areal element, an element with no area can be created. It is then impossible to delete the bad element by mouse clicking. The user must then remove the element by editing the text window, saving, and closing both windows. The saved file can then be read in by MacGRID and model generation can continue. In future, an item will be added to the **Elements** Menu, invoking a Dialog that allows the user to type in the bad element number for deletion.

3. The largest file that can be displayed in the Text Window at present is 32767 characters. This is only about 30% that of a full-size MAVART model and will be extended in future versions.
4. When an element is deleted, all nodes in that element are also deleted, unless they are used by another element. In future versions, the user will have the options of retaining or deleting the nodes. At present, before deleting an element, the user should create a new node or nodes at the location(s) where they are needed, using the 'Same Z&R' Palette item.
5. The NodesOnRadius Dialog is now limited to 90° arcs centred at the origin. A more versatile Dialog will be set up in future versions.
6. Element types 9 (SLIDER) and 11 (RING), which are not yet supported, will be supported in future versions.
7. Although MAVART no longer uses column 35 (JFIX), MacGRID requires this number for reading existing files. This can be changed for future versions, as some existing data files will not be read properly.
8. Some dialogs that are presented to the user do not behave properly when the Cancel button is clicked. If new data was input before the cancel action, the old data may not have been restored. The code causing this has been identified; by the time this manual is published, the problem may be eliminated.

8. REFERENCES

- [1] **Bruce A. Armstrong**, GRID, *A Fortran Program for Using a Digitizing Table to Enter a Finite Grid for MAVART*. DREA Technical Memorandum 84/Y, November 1984.
- [2] **E. Skiba and G. McMahon**, *User's Manual for Program MAVART*, DREA Technical Memorandum 91/201, January 1991.

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This document is a user's manual for the prototype computer program MacGRID, whose purpose is to generate finite element models for the analysis code MAVART. MacGRID, as its name suggests, is designed to run on an Apple Macintosh computer, and all of the standard menus found in a Macintosh application are supported, in addition to the special menus required to generate a finite element model. The application has two windows, one shows the model in graphical form, where the model can be created and manipulated with a mouse driven interface. The other is a text window, which allows the model data file to be viewed and edited using standard Macintosh editing techniques.

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