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# A Hypertext Document Builder for the IBM-compatible PC and an Engineering Application

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Connie Starr Fensky
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# Abstract

The use of artificial intelligence technologies, such as expert systems and hypertext, could provide the automated facility necessary to build intelligent engineering assistants for use by the engineering experts themselves. These assistants would not only act as comprehensive aids to all engineers, but also as training tools. This research resulted in the construction of a Hypertext Document Builder (HDB) for the IBM-compatible PC platform, which alleviates the need for knowledge engineer's in the workplace while allowing engineer's access to a customized intelligent system. The HDB was built using knowledge gained through extensive research in studying and building hypertext documents for use in aerospace engineering. The HDB was applied in building an engineer's assistant for estimating boundary layer transition trip sizing and placement in transonic wind tunnel testing, to demonstrate its merit as an engineering tool.

# Table of Contents


| Section | Page |
|---|---|
| Introduction | 1 |
| 1.0 Background | 3 |
| 1.1 Hypertext | 3 |
| 1.2 Standard Format | 4 |
| 2.0 The Hypertext Document Builder | 7 |
| 2.1 Construction of the HDB | 8 |
| 2.2 Usage of the HDB | 9 |
| 2.2.1 Create a New HD | 9 |
| 2.2.2 Add To an Existing HD | 12 |
| 2.2.3 Edit an Existing HD | 12 |
| 2.3 The Resulting Hypertext Document | 13 |
| 2.3.1 Structure of the Resulting Hypertext Document | 13 |
| 2.3.2 Customization of the Resulting Hypertext Document | 14 |
| 2.4 Difference from the IHM Methodology | 14 |
| 2.5 "Missing Links" | 15 |
| 3.0 An Engineering Assistant for Boundary Layer Transition Trip Formation | 16 |
| 3.1 Hypertext Assistant Structure | 17 |
| 3.2 Included Documents | 18 |
| 3.3 The Sizing Method | 18 |
| 3.4 Application of the Sizing Method | 21 |
| 4.0 The Next Step | 24 |
| References | 25 |

Appendices ..... 28

Appendix A. Figures ..... 29

Appendix B. Grit Sizing Assistant Source Code ..... 35

Appendix C. HDB User's Manual ..... 40

Vita ..... 52

# List of Figures


Figure Page

1. A Sample Button Script ..... 30
2. HDB Main Menu Page ..... 30
3. HDB Text Appearance Page ..... 31
4. HDB HD Builder Page ..... 31
5. A Sample Title Page from a Hypertext Document ..... 32
6. A Sample Table of Contents Page ..... 32
7. A Sample Body Text Page ..... 33
8. Structure of the Engineering Assistant for Grit Sizing ..... 33
9. Boundary Layer Velocity Profiles ..... 34
10. Boundary Layer Temperature Profiles ..... 34

# Nomenclature

a coefficients of the cubic spline fit of the velocity profile

b coefficients of the cubic spline fit of the temperature profile

C constant of proportionality in the linear viscosity/temperature relation:

$$\frac{\mu}{\mu_o} = C\frac{T}{T_o}$$

k roughness particle size or height

M Mach number

R Rankine temperature measurement

$Re_k$ Reynolds number based on roughness height and local flow conditions inside the boundary layer:

$$\frac{u_k k}{\nu_k}$$

$Re_x$ Reynolds number based on distance along the x-direction to the particle:

$$\frac{Ux}{\nu}$$

T local absolute temperature, in Rankine

$T_O$ absolute temperature outside the boundary layer, in Rankine

$T_W$ wall equilibrium temperature, in Rankine:

$$T\left[1.0+0.845\left(\frac{\gamma-1}{2}M^2\right)\right]$$

T* nondimensional temperature referenced to local absolute temperature:

$$\frac{T_k}{T}$$

u local velocity parallel to the body in the boundary layer

$u_k$ local velocity at the top of the roughness particle in the boundary layer

u* nondimensional velocity referenced to the free stream velocity:

$$\frac{u_k}{U}$$

$U$ free stream velocity

$x$ direction parallel to the body in the boundary layer

$y$ direction normal to the body in the boundary layer

$\gamma$ ratio of specific heats at constant pressure to constant volume

$\eta$ nondimensional distance along the y-direction in the boundary layer:

$$\frac{y}{2x}\sqrt{\mathrm{Re}_x}$$

$\eta_k$ nondimensional height of a roughness particle:

$$\frac{k}{2x}\sqrt{\mathrm{Re}_x}$$

$\mu$ coefficient of absolute viscosity

$\mu_k$ coefficient of absolute viscosity at the top of the roughness particle in the boundary layer

$\mu_o$ coefficient of absolute viscosity outside the boundary layer

$\nu$ coefficient of kinematic viscosity

$\nu_k$ coefficient of kinematic viscosity at the top of the roughness particle in the boundary layer

$\rho$ local density, mass per unit volume

$\rho_k$ local density at the top of the roughness particle in the boundary layer

Subscripts:

$k$ condition at the top of the roughness particle

$o$ condition outside the boundary layer

$w$ condition at the body surface (at y=0)

Superscripts:

$*$ nondimensional quantity

# Introduction

Spiraling costs and declining budgets in the aerospace engineering community require that the aerospace engineer simultaneously be more productive, reduce resources consumed, and lower costs. This development entails the handling and management of more data by fewer skilled personnel. A cost effective approach to solving this problem is through the use of computer-based engineering "assistants", which manage data bases, guide the engineer toward relevant pieces of data needed for a specific task, and perform the numerical computations required to utilize the data.

An integrated environment wherein all of this is possible can be achieved through artificial intelligence technologies, the basic elements of which include:

- Expert Systems as "intelligent" assistants,
- Neural Networks as data and process monitors,
- Hypertext/Hypermedia to tie it all together in an easy to use package.

These elements lead to the concept of an Intelligent Hypertext Manual (IHM) [Ref. 1], which ties together artificial intelligence technologies, as applied to aerospace engineering, into a comprehensive aid to engineers. The IHM can be hosted on a personal computer or workstation, allowing it to sit right on the engineer's desk. The only drawback to the widespread use of this concept is the need for knowledge engineers; someone skilled in knowledge representation and acquisition must build each IHM.

This research, done to fulfill thesis requirements for a Master of Science degree, has resulted in the construction of a Hypertext Document Builder (HDB) for the IBM platform. The HDB alleviates the need for knowledge engineers in the workplace while allowing engineers access to a customized intelligent system. The HDB was built using the knowledge gained through extensive research studying and building

hypertext documents for use in engineering, and lets engineers/experts build their own systems without worrying about the building blocks of a successful IHM. The HDB was then used to build an engineer's assistant for estimating boundary layer transition trip sizing and placement in transonic wind tunnel testing.

# 1.0 Background

## 1.1 Hypertext

Hypertext is a format for storing electronic textual and graphical information allowing the user to access the information in a fast and convenient manner. Hypertext allows the reader to browse through linked, cross-referenced, annotated, and layered texts quickly in a nonsequential manner [Refs. 2-3]. The developer of the hypertext document builds "links" into the system which, when activated, bring the user directly to the desired place in a document, or series of documents. It can take the place of a bookshelf of engineering references, and supplants the need to flip through pages. If implemented on a windowing or multitasking operating system, the documents can even have links built-in which take the user to a computer program, such as a word processor, or run a FORTRAN code.

The concept of hypertext is not new. In the mid 1940's, the secretary of state foresaw machines accessing large amounts of data in an "intuitive" or "human" manner [Ref. 4]. The technology development necessary for effective hypertext implementation has only come about in the last decade. Development and wide use of software such as Windows and operating systems such as UNIX and that of the Macintosh, have allowed computer firms to market the technology under such headings as "Authoring Software" and "Graphical User-Interface", as well as Hypertext. All of these allow the developer to present to the user "instant action objects" which automatically carry out a specific function or task at the click of a mouse or other button.

Hypertext can be useful to the aerospace community in many ways. The amount of information available and actually necessary for an aerospace engineer to do his job is growing faster than the information can be read. Computer access is much faster and more accurate than searching periodicals in the library; hypertext can allow the user to access necessary information more efficiently. Also, the availability of this information is not as great as the need. Articles and papers are stored in diverse media (i.e., microfiche,

archives, etc.), and may not be on-site. The availability of a floppy disk is much greater. Once the printed word is scanned into the computer, the information moves between computers much faster than it does on paper. Note that when a co-worker borrows a book, it may not come back when it is needed. When a co-worker borrows electronic information, he is usually only copying it.

In addition, training opportunities for intelligent hypertext manuals seems huge. New engineers need more information at their fingertips to do their job than those with experience. For training purposes, hypertext manuals would increase the amount of time these new engineers spend in learning and referencing material, and lessen the time spent finding the material. The hypertext manuals could also serve to preserve knowledge when experienced engineers retire or change jobs.

## 1.2 Standard Format

In implementing the concept of a hypertext document builder, some basic intelligence needed to be intrinsic in the structure of both the HDB and the resulting hypertext document (HD). The most obvious place to start to study various ways to lay out the product HD was to look at existing printed reference material. Books usually have a preamble, body, figures, and an index and/or nomenclature section. New chapters in a book usually start on a new page. Papers usually have an introduction, body, figures, and sometimes a nomenclature section.

Studying these formats can lead to a natural format for hypertext documents--close enough to the formats the user is accustomed to, but with inherent time-saving techniques. The standard format chosen for the product of the HDB designed in this research is:

- Preamble with a Title Page, Table of Contents, and List of Figures (if needed),
- Body of text, and
- Figures (if any).

Each section, or chapter, of the document occupies one page. The Table of Contents and List of Figures are automatically linked to the respective sections and figures. Figures each occupy their own page, as well. Details of the HDB and HD format are discussed in section 2 of this thesis.

Research in the area of intelligent hypertext manuals has been done, and IHMs have been built with similar formats. That research did not address the use of the technology by engineers, only their use of the end product. The research for this thesis was based on the need for engineers to be able to build their own IHMs without requiring outside help from knowledge engineers. The following is a brief list of work done on the IHM concept at the author's worksite, from which valuable ideas for the standard format incorporated in this research were gathered.

The concept of the Intelligent Hypertext manual was originated in a paper by Dr. C.F. Lo of the University of Tennessee Space Institute (UTSI) and Dr. F. Steinle of NASA/Ames Research Center (NASA/ARC). An outline of an approach to the problems of "improving data quality and increasing personnel efficiency and management effectiveness" was presented in the paper, along with a sample expert system. [Ref. 1]

The thesis of Mr. Andes W. Hoyt, a student of Dr. Lo at UTSI, was specifically the formulation of a standard methodology for building the intelligent manuals, the Intelligent Hypertext Manual Methodologies (IHMM), and the development of an IHM using the methodology. [Ref. 5]

NASA/Marshall Space Flight Center sponsored a project to produce a Hazardous Gas Detection System Intelligent Hypertext Manual (HGDS/ IHM). This manual would serve to assist space shuttle operations personnel in using and maintaining a database of historic hazardous gas data. [Ref. 6]

NASA/ARC sponsored a project to produce a Project Engineer's Intelligent Assistant (PEIA) for their Unitary Facility. This package combined hypertext with rule-based expert systems to aid the engineer in finding information and computing wind tunnel parameters in seven areas. [Ref. 7]

NASA/ARC also sponsored a project to produce a Knowledge-Based System Developer (KBSD). This prototype software package can acquire heuristic knowledge from project engineers, and help them build a completely integrated knowledge-based system including expert systems, hypertext documents and menu-driven user-interfaces. This project was undertaken solely for the Macintosh computer, and was the germ for this work on the IBM-compatible computer based HDB [Ref. 8].

# 2.0 The Hypertext Document Builder

The hypertext document builder was constructed during this research with the aid of a Windows-based authoring software package, Asymetrix ToolBook, which offers a scripting language which can be used to build hypertext documents. The scripting language is a high level language, like FORTRAN or C resembling natural language, but very specifically used for generating the graphical instant action objects which are the basis of hypertext. Each object created has a "script" which is executed whenever that object is clicked. The script may send messages to other objects to execute their scripts, send messages which are received by scripts called "handlers", or run applications outside ToolBook. In this manner, the scripts and handlers perform all graphical manipulation on the screen, and control the software's operation. A sample script for a button in the HDB is shown in Figure 1[1]. All scripting written for use in the HDB is the author's.

The hypertext document builder automates some basic tasks in building any hypertext document. It asks the user for the Title of the document and names the computer file with that title. It prompts for custom font, size, style & type justification for each of the title, section headers and body text. It asks for the individual section and figure titles as well as the body text and figures attached to each of these titles. It automatically puts links from the Table of Contents to each section and from the List of Figures to each figure, if any. The HDB also allows the user to make custom links with "hotwords". Specific details of the construction and usage of the HDB, as well as the resulting hypertext document, are included as the following sections.

The User Interface Builder builds a main menu with which to hold many related documents together in the same framework. The user tells the system where to link each entry in the menu.

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[1] All figures contained within this thesis appear in Appendix A.

## 2.1 Construction of the HDB

The HDB was constructed on an IBM-compatible PC-386, equipped with Microsoft DOS 6.0, MS Windows 3.1, MS Word 2.0a, and Asymetrix Multimedia ToolBook 1.53. The main authoring software was ToolBook. ToolBook runs under the Windows operating environment, and so can directly call any other program, which also runs under Windows, to run in a foreground or background window alongside the ToolBook program. This is the means by which the HDB is able to run the word processing program to select the input text, and stay running itself. When the user exits Word, he is back in the HDB just where he left off. ToolBook can also, by the same principle, run multiple instances of itself. This capability can be seen to be utilized in the custom linking process, and is essential to the HD building process, although it is transparent to the user in this case. The multitasking abilities of Windows was imperative when designing an integrated graphical-user-interface such as the HDB.

The original HDB was implemented in the Macintosh System 7.0 Operating System, which has a multitasking, windowing environment similar to Microsoft Windows. Macintosh systems only occupy a small percentage of the scientific personal computer market, so the IBM-compatible route is decidedly more beneficial to the aerospace community.

ToolBook, by Asymetrix, was chosen to be the HDB's authoring software due to the author's familiarity with the software. It offers the capability of "scripting" any object on the screen. In other words, any object which can be seen by the user can be made into an instant-action object requiring the user to merely click on it for some sequence of events to be performed immediately. The objects offered by ToolBook include buttons, fields, recordfields, graphics objects and paint objects. Recordfields differ from fields in that they may appear with the same properties on more than one page, each page's potentially having different text. ToolBook's pages each have a background and a foreground. A background may be shared

by many pages, and it is there that a recordfield is contained. The HDB uses the recordfield in the HD to ensure that each section's text appears the same and is in the same position on each page.

## 2.2 Usage of the HDB

This section presents only a basic guide for usage of the Hypertext Document Builder. If the user is familiar with Windows applications it will probably provide enough direction; however, for step-by-step instructions on using the HDB, see the user's manual in Appendix C. All button labels are in boldface type for clarity.

Each screen of the HDB has a standard menu-bar. This consists of four buttons across the top of the screen: **BackTrack** and **Main Menu** to the far left, and **Help** and **Exit** to the far right. These buttons have standard functions. In particular, clicking on **BackTrack** brings the user to the last screen he was viewing in ToolBook, clicking on **Main Menu** brings the user to the HDB Main Menu screen, and **Exit** brings the user out of the HDB and ToolBook, leaving him in Windows.

The first screen, or page, the user sees upon starting the HDB program is the HDB Main Menu. It has the menu-bar described above, without the **Main Menu** button which would be immediately to the right of the **BackTrack** button. It is titled "Welcome to the HDB" and has a series of buttons in the center of the screen, namely, **Create, Add** and **Edit**. A picture of the HDB Main Menu is shown in Figure 2. The functions of each of the buttons are described in the following sections.

### 2.2.1 Create a New HD

Clicking on the Create button will bring up a dialogue box which asks the user to enter a name for the hypertext document. When a name is entered, the user is brought to a screen titled "Text Appearance". Along the left-hand side of this screen are three buttons in a column, labeled **Document Title, Section**

**Title** and **Body Text**, respectively. The user must press each of these buttons to set the appearance of the text which will be used in each of the three categories. Upon pressing a button, the default text font, style, size and justification names will appear in the appropriately labeled fields. An example of the text with the default characteristics will be displayed in the large field above the name fields. A dialogue box will also appear asking the user if he wishes to override the defaults. If so, clicking on the **Yes** button in the dialogue box will bring up the Character and Paragraph dialogue boxes with which the user can change the font, style, and point size of the text characters and the alignment of the paragraphs. The example text will change to reflect the user's decisions. When all text appears as the user wishes, he should click on the button **Continue** at the bottom of the screen. The Text Appearance screen is shown in Figure 3.

Clicking on the **Continue** button brings the user to the main working screen of the HDB--the HD Builder Screen. The HD Builder Screen is dominated by a large scrolling field in the center, with a row of buttons across the top and bottom and a small scrolling field directly below the large one. The large field holds the text of the document while the user is building the hypertext version. The smaller field is an auxiliary working field intended to be used for typing and editing supplementary text. For example, if a section's title does not appear exactly as desired in the main field, the user can type, copy or paste text into the auxiliary field to reflect the proper title. Figure 4 shows the HD Builder Screen.

In addition to the standard menu-bar buttons, added buttons along the top of the screen are: **Input Text** and **Open MS Word**. The buttons along the bottom of the screen are, from left to right, **HD Title, Section Title, Body Text, Figure, Add To HD, Create HD**, and **Edit HD**. The **HD Title** button vanished after the document title was declared. When clicked, each of the first four of these buttons cause a small box to appear in the lower right corner of the screen. The box instructs the user to select the text he wishes to fill the specified capacity (document title, section title, body text, or figure caption) and then click on the small included button **OK**. For every button but **Figure**, the text is adopted immediately. It should be noted that when selecting a section title, the words should be preceded by the section number

because the HDB selects the first word of the selected section title text, delimited by a space, to be the button label on the Table of Contents page of the HD.

The figure caption selected, on the other hand, should only be text. Because the figures are all at the end of the HD, it may be clearer to number them consecutively. The user is given a dialogue box in which to type the desired figure number after selecting the caption and pressing the **OK** button. The default figure number is the next consecutive integer. After typing in the correct figure number and clicking **OK** in the dialogue box, or selecting the default figure number by merely clicking **OK** in the dialogue box, another box appears which asks the user from where the figure should be imported: a file or the clipboard. If the figure resides in a standard graphics file (.bmp, .tif, etc.), the user should click the button **From a File**. The standard Windows open dialogue box will appear from which the user can select the name of the proper file. If the figure is not in a standard graphics file, or is not alone in the file, the user must import it from the clipboard and should click on the button so labeled. A fourth pop-up box will appear in the center of the screen instructing the user to place the figure into the clipboard at that time, and then click on the box. The easiest way to accomplish this task is to iconize the HDB, open the file in which the image can be found in Windows, select and copy the image, re-instantiate the HDB, and click on the box. The image will automatically be pasted in the proper place for addition to the HD.

Once the user has entered all text and figures desired, he should click on the **Create HD** button. When finished, the HDB will return the user to the HD Builder Screen. The user may then add more text and figures in the same manner and pressing the **Add To HD** button, or go directly to the HD to build custom links by pressing the **Edit HD** button. Alternatively, the user may return to the HDB Main Menu to work with another document, or exit the HDB.

### 2.2.2 Add To an Existing HD

Clicking on the **Add** button on the HDB Main Menu will bring up a dialogue box which asks the user to enter the name of the hypertext document. When a name is entered, the user is brought directly to the HD Builder Screen. From here, he can select section titles, body text, and figures to be added to any existing hypertext document built with the HDB. When all new material has been selected, the user should press the **Add To HD** button to build it into the existing document. After the new material is added into the HD, the HDB will bring the user back to the HD Builder Screen from which he can either add more material to the document, edit the document, return to the HDB Main Menu to work with another document, or exit the HDB.

### 2.2.3 Edit an Existing HD

Clicking on the **Edit** button on the HDB Main Menu will bring up a Windows-style Edit dialogue box which asks the user to select the name of the hypertext document to be edited. When a name is selected, the user is brought directly to the HD to browse or add custom links. The Title, Table of Contents, and List of Figures pages each have a **Return to HDB** button which will take the user back to the HDB at any time. The title page of each HD has a **Continue** button which brings the user to the Table of Contents of the document. A sample title page is shown in Figure 5, and a sample Table of Contents page in Figure 6. Each section in the document is here listed. Clicking on the button numbered with the desired section number will bring the user to the page which holds that section. Each page except the title page has **Previous** and **Next** buttons, which bring the user one page to the left or right, respectively, in the HD. The Table of Contents and List of Figures pages have these buttons at the bottom of the page, whereas all body text and figure pages have them at top center. These buttons, along with the **Table of Contents** and BackTrack buttons on the top left of the body text and figure pages, are the main navigation buttons in the HDs built with the HDB. The List of Figures page(s) are placed after the Table of Contents page(s), and can be reached by repeatedly pressing the **Next** button from the first Table of Contents page. All figures included in the document are listed here. Clicking on the button numbered with the desired figure

number will bring the user to the page which holds that figure. Body text pages appear after the List of Figures, and all figure pages appear after them. A sample body text page is shown in Figure 7. Custom links may be created on any body text page; this process will be discussed in the next section. The user may also wish to re-size and/or reposition the bitmap images on the figure pages, but this may only be done if the authoring version of ToolBook is available on his computer.

## 2.3 The Resulting Hypertext Document

### 2.3.1 Structure of the Resulting Hypertext Document

The hypertext document built by the HDB is set up so that each subsection is contained on a single page. Mr. Hoyt's IHM methodology [Ref. 5] maintains that each subsection should be contained in its own file, its own "book" in ToolBook terminology, but keeping a logical book or document in a single file generally increases the speed with which the user can navigate the HD. Thus the structure chosen is more desirable. In all other respects, Mr. Hoyt's methodology was used as a basis for the HD structure.

A logical book may also be split into more than one file if it is very long, in the interests of navigational speed. Once a book is built with more than a certain number of pages, an increased delay in switching between pages is noted. This increased delay may also be felt if some of the pages are graphics-intensive; the page then takes more memory to store and more time to draw on the screen. Graphics objects may be converted into paint-objects after importing to somewhat alleviate this condition, but paint objects may not be imported from a file, or re-sized.

Each document's Table of Contents acts as a menu for document navigation. The documents also have **Previous** and **Next** buttons which simulate the action of turning one page in a printed book. The user may thus browse through the book in a sequential manner, or use the custom links (built as described in the next section of this thesis), to move to a related section of the same or a different document. Since

each document built with the HDB has the same format, the user will find navigation very simple and intuitive.

### 2.3.2 Customization of the Resulting Hypertext Document

After creating an HD, the user may create custom links from any word or group of words in the document to any page in that or other HDs. The buttons along the bottom of the body text pages, **Link To...**, **Activate Links** and **Add Links**, are for creating custom links (see Figure 7). When the user wishes to make a custom link, he should select the word or group of words which will become the "hotword" for that link and click on the **Link To...** button. A small window will appear on the screen with three buttons in it: **Link To This Book, Link To This Page,** and **Cancel**. If the link is intended to go to another page in the same HD, then the user should navigate to that page and click on the **Link To This Page** button. If the link is intended to go to another HD, the user should use the ToolBook **Open...** command from the pull-down **File** menu on the larger window to open the other HD, then either click on **Link To This Book** or navigate to the proper page in that HD and click **Link To This Page**. If the user chooses to cancel, the small window will disappear and no link will have been made. After the linking procedure is complete, the hotword will appear boxed and bold. After creating custom links, the user must press the **Activate Links** button before they can be used. Then, when clicked, the hotword will bring the user directly to the linked page, or the first page of the linked book if **Link To This Book** was chosen. If at any time the user wishes to create more links after the links have been activated, he must click on the **Add Links** button before adding them, then on the **Activate Links** button to use the links after they have been made.

## 2.4 Difference from the IHM Methodology

Although the research of Mr. Hoyt formed a basis for further work done in the area of intelligent hypertext manuals, the HDB herein discussed has some pertinent differences. Each section is a page, rather than each section being a file. This is quicker for the software and computer chosen for implementation, and

allows the user to make the accustomed "turning of a single page". There is also a lack of intelligence in the form of expert systems contained within the HDB. All of the intelligence attributed to the HDB is in the form of the structure and content of the result. This feature was based on a calculated decision that the effort required to develop an extra expert system would add no more credibility to the engineering aspects of this research project. As discussed in the next section, this feature should be added to the HDB in the future.

## 2.5 "Missing Links"

The HDB as discussed in this thesis is not intended to be a marketable product, as is. Some more work, and possibly more research, should be done before it will fill all the claims of the IHM concept. More intelligence should be added, such as an expert system instead of the context-sensitive Help facility, and a way to inform the user of necessary places to install the links. The index and nomenclature segments of the document should be added, with automatic links back to the body text where the indicated term is presented. The graphical user-interface may also bear improvement as further research in this area is done; colors on the screen and placement of the navigation and function buttons might be improved. The Table of Contents may be changed to resemble an outline, therefore giving the end-user a glimpse of the document's hierarchical structure. As it stands, the HDB is sufficient to verify the potential of the concept, as is evident by the Engineer's Assistant for Boundary Layer Transition Tripping, discussed in the next section, Section 3, of this thesis. This is a product of the HDB, and is a valid engineering tool for wind tunnel engineers.

# 3.0 An Engineering Assistant for Boundary Layer Transition Trip Formation

There are two major categories of forced boundary layer transition methods used in wind tunnel testing. The first is solid trips, which involve particle addition to the surface of the model. The second is so-called "active" boundary layer control. The latter requires special considerations in making the model, such as the inclusion of a mass flow system , or special considerations in choosing a wind tunnel, such as facilities equipped with wall porosity or pressure wave generation. During this author's experience as a wind tunnel test engineer, contractors coming in to use the tunnel were using pre-existing models, and were looking for inexpensive tunnel operation fees. This precludes active boundary layer control and so this method was not addressed in this thesis.

In addition, some of the solid trip methods also require a specially fabricated model, for example one which has been blasted with grit, or mechanically or chemically machined. For a quick turn-around tunnel, these methods are also precluded. The more precise methods of solid tripping require exact placement of the tripping particles (spheres, cylinders, etc.), or creation of tripping matrices or bands. These both lengthen start-up time for the test, during which the contractor pays the tunnel fee but gains no data.

The method which tended to be used the most in transonic testing, and which the contractors seemed to expect, was usually a distributed roughness technique. The Braslow and Knox method [Ref. 9] of sizing was primarily employed with carborundum grit being used as the particles. This method is widely used in transonic wind tunnel testing [Refs. 10, 11]. Although the grit can be dissipated during the testing and may have to be reapplied, in the interests of expediency no more advanced method was sought. Also, repeatability of test data was surprisingly good [Ref. 12]. In this light, a hypertext assistant for wind tunnel engineers has been designed which will not only place the supporting information they need to

choose an appropriate tripping method at their fingertips, but will also do the trip sizing for them, as long as model geometry and certain tunnel parameters are known. This could be a great aid to speed up start-up time for wind tunnel testing, as well as to train new engineers.

The Braslow and Knox method [Ref. 9] for the sizing of distributed roughness boundary layer trips is included in the automated engineering assistant developed in this thesis. A computer program was written to calculate the roughness size required to trip the boundary layer given certain tunnel and model parameters. The program is coupled with a graphical user-interface which allows the user to change the parameters easily and quickly. Supporting information in the form of hypertext documents is also included for the user's reference and can be reached and browsed with a few clicks of the mouse.

Although a literature search was conducted, it seems little new research has been done on transonic solid tripping methods or correlations since the middle 1960's. The most recent study found did state in its conclusions that grit may trip the boundary layer more realistically than discrete particles, especially at high lift [Ref. 13]. The main document in the hypertext assistant is a summary of the material on distributed roughness boundary-layer transition tripping found in the literature search, such as Braslow, Hicks, and Harris' summary [Ref. 14], and all of the included documents can be reached both from a main menu, and from their point of reference in this summary document.

## 3.1 Hypertext Assistant Structure

The hypertext assistant was built using the Hypertext Document Builder discussed in the previous sections. Therefore, each document contained within it has the basic structure which was build into the HDB: A preamble including a title page, table of contents, and list of figures, a body of text, and a set of figures. The system is held together by a main menu which is the first page encountered when entering. This menu allows the user direct access to the title page of each included document, as well as the entry

screen of the user interface for each sizing method. The system can as such be represented in a tree structure, with the main menu at the top level, the preambles of each of the documents and the entry pages of the methods at a second level, and the individual sections of each at the bottom level. Figure 8 shows this structure. Since the hypertext documents are built with each section occupying its own page, the bottom level includes every page of body text, and the data input and output pages of the sizing methods.

## 3.2 Included Documents

As stated previously, the main document of the hypertext assistant is a compilation of material on distributed roughness boundary-layer transition tripping. Many papers are referenced in this summary, but only those which have direct bearing on the computational part of this thesis have been included as hypertext supporting documents. Specifically, the original papers by Braslow and Knox [Ref. 9], and Potter and Whitfield [Ref. 15], a paper by Braslow, et al, on the general use of grit-type trips [Ref. 14], a more general paper by Braslow and Horton on surface roughness effects on transition [Ref 16], and the second paper by Potter and Whitfield on the supersonic extension to their method [Ref. 17] have been included as supporting documentation.

## 3.3 The Sizing Method

The Braslow and Knox method is for sizing grit particles to be used as an artificial boundary layer transition trip in subsonic/supersonic wind tunnel testing. The method is formulated under the idea that the height of the roughness particle required to cause transition can be correlated with a Reynolds number based on the local flow at the top of the grit particle, as long as the particle is submerged inside the boundary layer. The method assumes negligible pressure gradients both in the streamwise direction and normal to the body. Other simplifying assumptions are zero heat transfer rate and a linear viscosity-

temperature dependence. The method is applicable up to Mach 4, gives negligible grit drag additions, and is developed as follows:

A Reynolds number based on the local flow at the top of a grit particle, the roughness Reynolds number, can be defined as:

$$\mathbf{Re}_k = \frac{u_k k}{\nu_k} \qquad \text{(Eqn. 1)}$$

A Reynolds number based on the streamwise position of the grit particle, the streamwise Reynolds number, can be defined as:

$$\mathbf{Re}_x = \frac{Ux}{\nu} \qquad \text{(Eqn. 2)}$$

A non-dimensional roughness height is:

$$\eta_k = \frac{k}{2x}\sqrt{\mathbf{Re}_x} \qquad \text{(Eqn. 3)}$$

The roughness Reynolds number can be multiplied and divided by the streamwise Reynolds number, giving:

$$\mathbf{Re}_k = \left(\frac{u_k k}{\nu_k}\right)\mathbf{Re}_x\left(\frac{\nu}{Ux}\right) = \frac{k}{x}\mathbf{Re}_x\left(\frac{u_k}{U}\right)\left(\frac{\nu}{\nu_k}\right) \qquad \text{(Eqn. 4)}$$

Then, the linear viscosity-temperature relationship can be substituted as:

$$\frac{\nu_k}{\nu} = \frac{\mu_k \rho}{\mu \rho_k} = C\frac{T_k}{T}\frac{\rho}{\rho_k} \qquad \text{(Eqn. 5)}$$

where C is the constant of proportionality:

$$C = \sqrt{\frac{T_w}{T}}\left(\frac{T + 216°R}{T_w + 216°R}\right) \qquad \text{(Eqn. 6)}$$

and $T_w$ is the laminar recovery temperature, given by:

$$T_w = T\left[1.0 + 0.845\left(\frac{\gamma - 1}{2}M^2\right)\right] \qquad \text{(Eqn. 7)}$$

Then, dividing through by the square root of the streamwise Reynolds number results in:

$$\frac{\mathrm{Re}_k}{\sqrt{\mathrm{Re}_x}} = \frac{2}{C}\eta_k \frac{u_k}{U}\left(\frac{T}{T_k}\right)^2 \qquad \text{(Eqn. 8)}$$

The method may be applied by following certain steps. Given test Mach number (M), tunnel unit Reynolds number, and roughness location (x), the user may determine the roughness height by:

- Determining the $u_k/U$ and $T_k/T$ from the curves given,
- Calculating the $\eta_k$ from equation 8, and
- Calculating grit size, k, from equation 3.

The recommended roughness Reynolds number, $\mathrm{Re}_k$, which will guarantee transition, is 600. Experimental results show that this value falls in a plateau [Ref. 12] and that significant grit drag is avoided.

The exact transition location is not given quantitatively by the method, it is only guaranteed to be shortly downstream of the grit particles. Also, after determining the roughness height, the user must make sure

that it is less than the boundary layer height, or the assumptions in the method no longer apply, and transition without significant grit drag is not guaranteed.

## 3.4 Application of the Sizing Method

The Braslow and Knox method for sizing grit particles was implemented through a program written in C by the author. The Braslow and Knox paper gives curves of the velocity and temperature profiles, calculated via the approach given in Reference 18. Numerical integration programs being readily available, it was decided not to spend time recalculating these numbers -- instead, the curves from Braslow and Knox's paper have been fit with a 3rd degree polynomial cubic spline in the form:

$$\frac{u_k}{U} = u^* = a_o + a_1\eta + a_2\eta^2 + a_3\eta^3$$

and

$$\frac{T_k}{T} = T^* = b_o + b_1\eta + b_2\eta^2 + b_3\eta^3$$

A cubic spline fits a function to a set of discrete data points which goes through all of the points, is continuous, and smooth. Since the calculations necessary to develop the Braslow and Knox method cannot be carried out in closed form, numerical integration is necessary and all data are in the form of discrete points.

The functional form of the fit is used in the C language calculation routine for the grit size and placement. In particular, two- and three-dimensional boundary layer velocity and temperature profiles were spline fit for Mach numbers 0, .5, 1.0, and 1.5, the transonic range for which this assistant is designed. The velocity profiles are shown in Figure 9, and the temperature profiles in Figure 10. The coefficients of the actual curve fits are shown in Table 1.

Table 1. 3rd Degree Cubic Spline Velocity and Temperature Profile Equations

(a) Coefficients of 2-Dimensional Velocity Profile Equations

| *Mach* | $a_o$ | $a_1$ | $a_2$ | $a_3$ |
|---|---|---|---|---|
| 0.0 | –0.01511 | 0.84057 | –0.20168 | 0.01148 |
| 0.5 | –0.01022 | 0.79804 | –0.17646 | 0.00766 |
| 1.0 | –0.01349 | 0.68661 | –0.99566 | –0.00553 |
| 1.5 | –0.01139 | 0.53450 | –0.00781 | –0.19332 |

(b) Coefficients of 3-Dimensional Velocity Profile Equations

| *Mach* | $a_0$ | $a_1$ | $a_2$ | $a_3$ |
|---|---|---|---|---|
| 0.0 | –0.00302 | 1.46623 | –0.67789 | 0.09992 |
| 0.5 | –0.00339 | 1.45134 | –0.66625 | 0.09772 |
| 1.0 | –0.02525 | 1.36026 | –0.57977 | 0.07983 |
| 1.5 | –0.03036 | 1.23310 | –0.47590 | 0.05958 |

(c) Coefficients of 2-Dimensional Temperature Profile Equations

| *Mach* | $b_0$ | $b_1$ | $b_2$ | $b_3$ |
|---|---|---|---|---|
| 0.0 | –0.00302 | 1.46623 | –0.67789 | 0.09992 |
| 0.5 | –0.00339 | 1.45134 | –0.66625 | 0.09772 |
| 1.0 | –0.02525 | 1.36026 | –0.57977 | 0.07983 |
| 1.5 | –0.03036 | 1.23310 | –0.47590 | 0.05958 |

(d) Coefficients of 3-Dimensional Temperature Profile Equations

| *Mach* | $b_0$ | $b_1$ | $b_2$ | $b_3$ |
|---|---|---|---|---|
| 0.0 | –0.00302 | 1.46623 | –0.67789 | 0.09992 |
| 0.5 | –0.00339 | 1.45134 | –0.66625 | 0.09772 |
| 1.0 | –0.02525 | 1.36026 | –0.57977 | 0.07983 |
| 1.5 | –0.03036 | 1.23310 | –0.47590 | 0.05958 |

The functions are linearly interpolated within the calculation program for solutions for Mach numbers not explicitly given. The program asks for Mach number, tunnel temperature, tunnel unit Reynolds number, critical Reynolds number, chord length of the body in question, and percentage chord for application of the transition strip. Default values of 5% chord and 600 for critical Reynolds number (as discussed in Section 3.3.1) are given as a guideline. The program automatically calculates a grit size, from equations (8) and (3) in section 3.3.1, then calculates whether that grit size will be submerged in the boundary layer at the trip position. This latter calculation is done by checking that the velocity ratio equation yields $u/U<1$ for that nondimensional grit size. The grit size and position results of the program are presented, along with buttons which take the user to text guiding application of the grit or to a table of nominal carborundum grit sizes. The user interface and source code of the program is presented in Appendix B.

# 4.0 The Next Step

Follow-on research and development suggested to improve the HDB and it's product hypertext documents includes:

- Building an expert system to act as a guide to the user which would either give instructions in using the HDB, advice in which information to peruse, or direct access to the data needed.
- Developing and implementing a method for insuring that the user of the HDB installs the necessary links in his product HDs.
- Changing the graphical user-interface of the HDB to be more effective and easy to use.
- Restructuring the Table of Contents so that the user of the HD can glean the structure of the document at a glance.
- Automating the building of the index and nomenclature sections of the HD.

Another area where the HDB may be improved is in user control of the resulting document. Inherent in the present hypertext format is the ability of the user to navigate anywhere in the system at the click of a mouse. Especially if the purpose of the HD is training, a capability needs to be added which lets the user know where he is in the system, so he cannot possibly get lost in the information. This can be done by adding a map, which shows the user graphically the system layout, and his position within it. This feature could be automated so that while the HD is being built, a map is also constructed.

As far as the assistant developed using the HDB in this research, discussed in Section 3, further improvement may be made by extending it's use to hypersonic wind tunnel testing. There has been far more research done recently in this area because it is applicable to space travel. Of course, the assistant could be extended to include other areas of wind tunnel testing, as well, but these questions are primarily driven by the user's area of expertise. The existing assistant has shown that the idea is feasible and useful to the aerospace community.

# LIST OF REFERENCES

# LIST OF REFERENCES


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# Appendices

# Appendix A

# Figures

```
to handle buttonUp
      system HDName, parmName, HDFigs
      ask "What do you wish to name your hypertext\
       document (HD)?"
      if it is not null
            put it into HDName
            send clearVars
            put 1 into i
            do
                  put character i of HDName after parmName
                  put character i of HDName after HDFigs
                  put i+1 into i
            until (character i of HDName is ".") OR (i=7)
            put "P.txt" after parmName
            put "F.tbk" after HDFigs
            send next
      end if
end buttonUp
```

Figure 1. A Sample Button Script

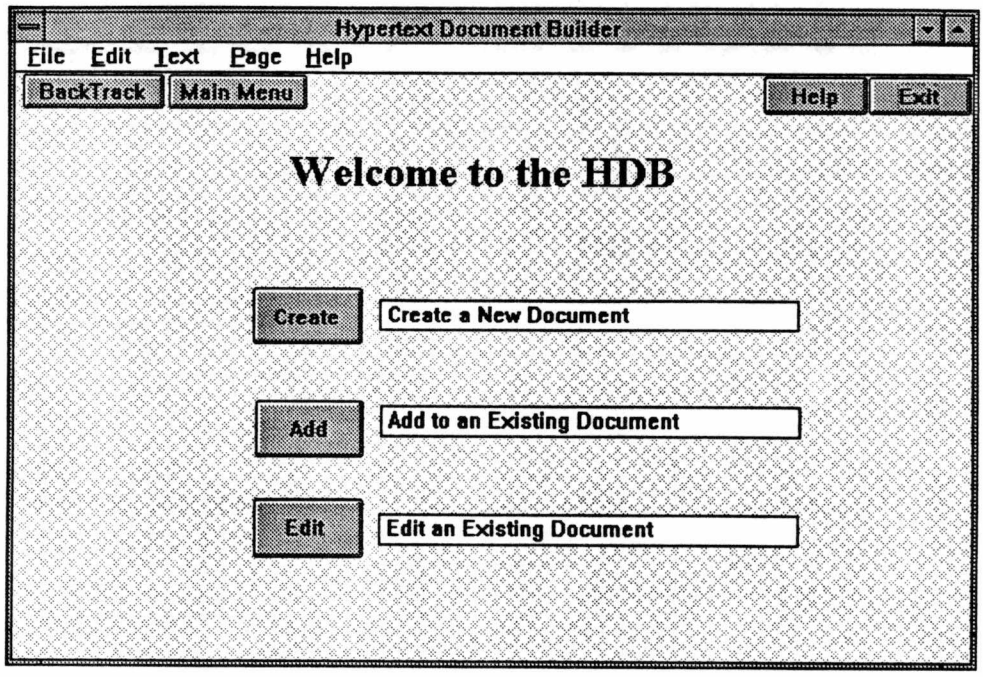


Figure 2. HDB Main Menu Page

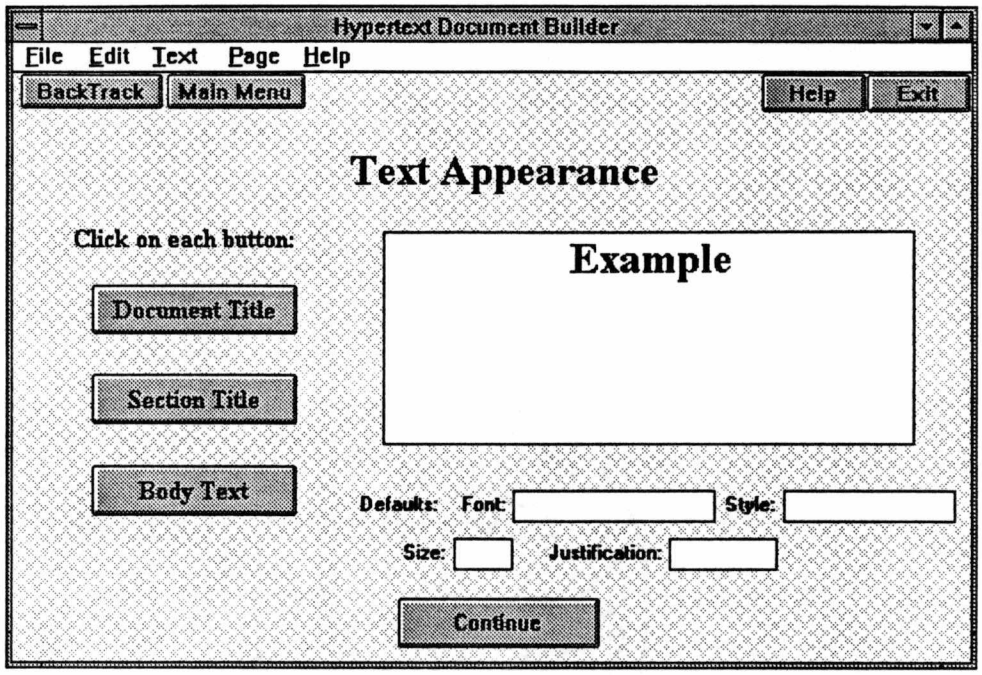


Figure 3. HDB Text Appearance Page

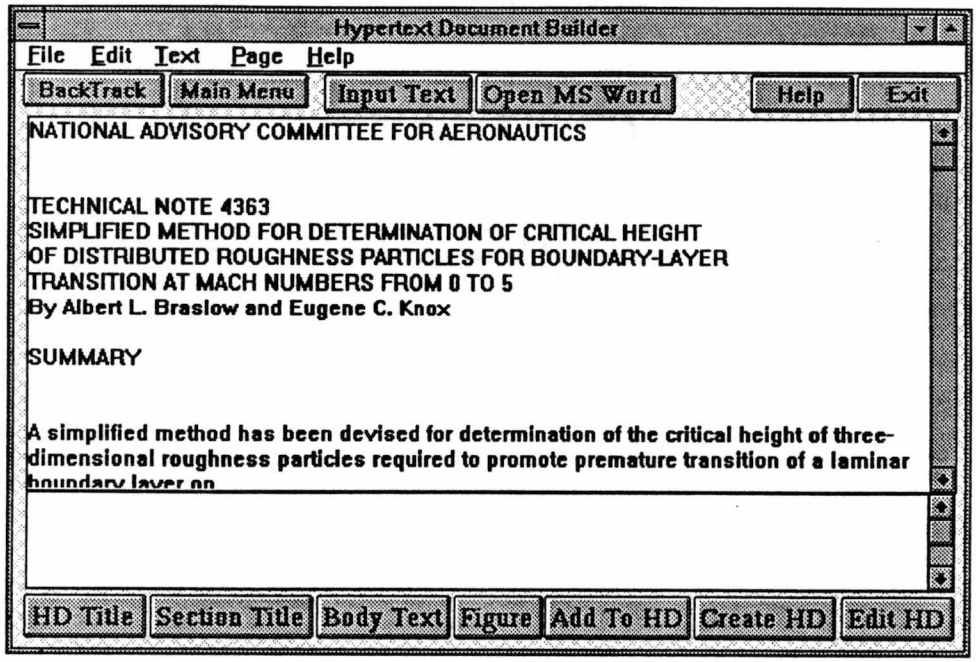


Figure 4. HDB HD Builder Page

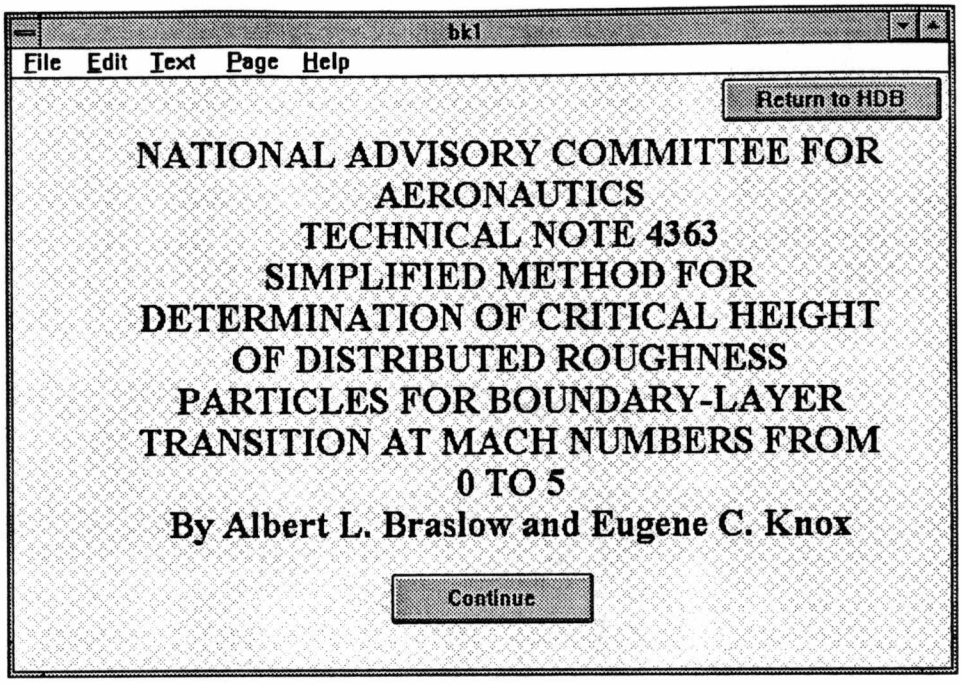


Figure 5. A Sample Title Page from a Hypertext Document

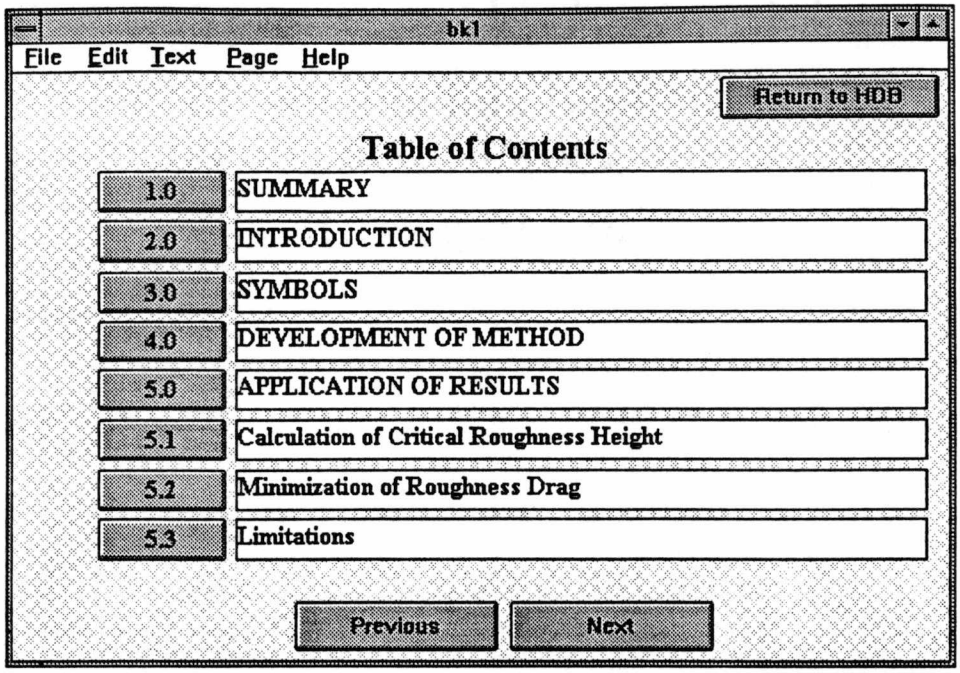


Figure 6. A Sample Table of Contents Page

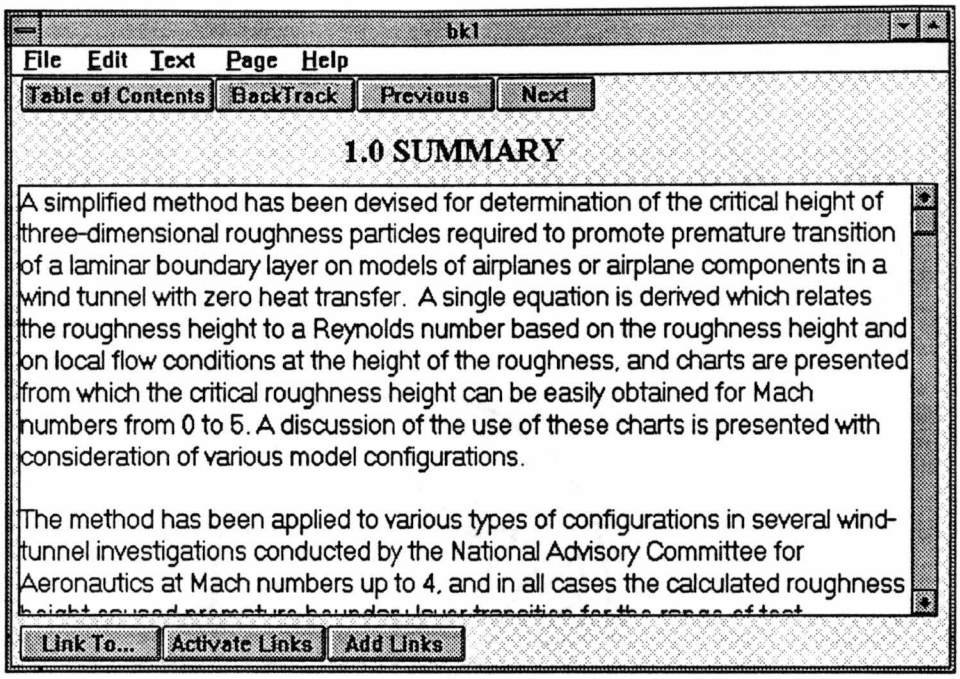


Figure 7. A Sample Body Text Page

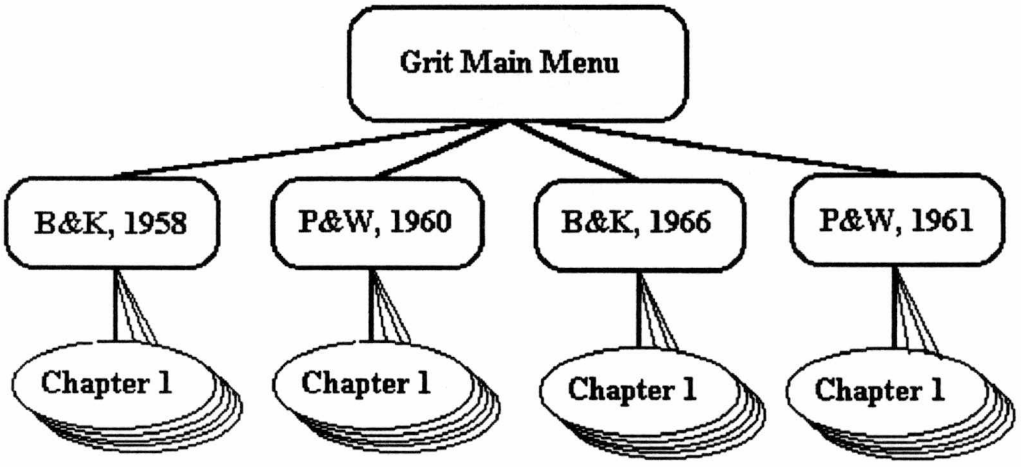


Figure 8. Structure of the Engineering Assistant for Grit Sizing

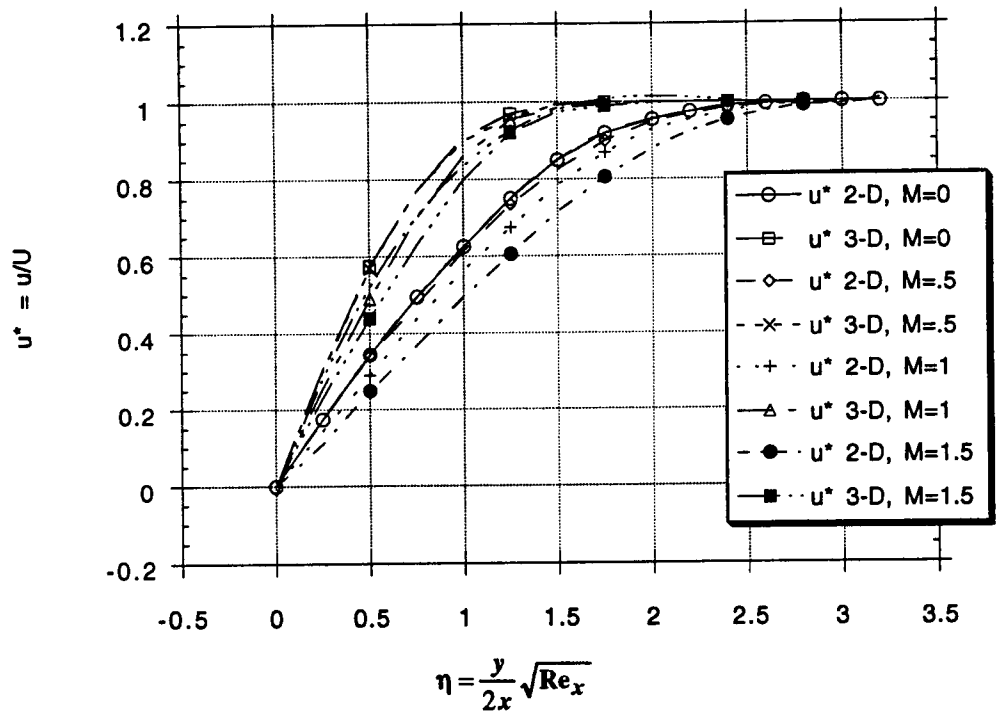


Figure 9. Boundary Layer Velocity Profiles

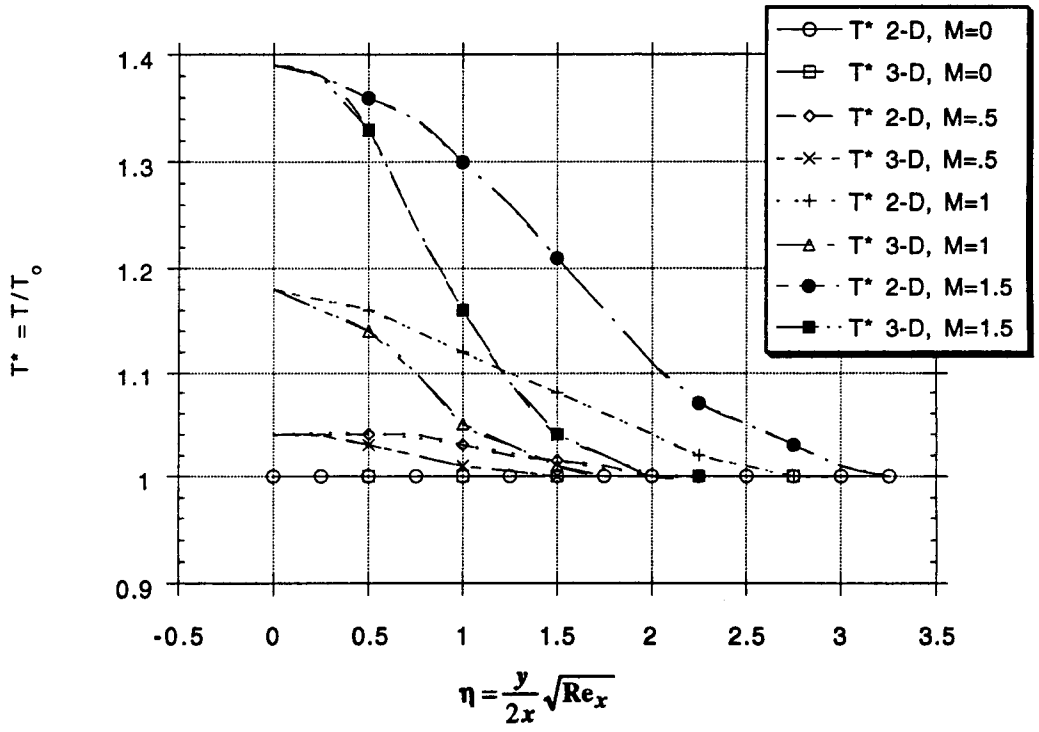


Figure 10. Boundary Layer Temperature Profiles

# Appendix B

# Grit Sizing Assistant
# Source Code

/* grit.c program for sizing distributed roughness particles (grit) */

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>

FILE *stream, *stream2;

void main()
{
        double MachNo, ReCrit, ReUnit, chord, xk, Temp;   /* input variables */
        int dimFlag;                                      /* another input variable */
        double gritSize, ustar;                           /* output variables */
        double ustar1, ustar2, tempstar, tempstar1, tempstar2, diff;
        double ReHalf, Rek, eta=0.0, etak, C, Tw;         /* extra needed vars */
        char *inName = "c:/hdb/gritin.dat", *outName = "c:/hdb/gritout.dat";  /* filenames */

        /* Open input file for read (will fail if file does not exist) */
        if( (stream  = fopen( inName, "r" )) != NULL )    /* succeeded */
        {
                while( !feof( stream ) )
                                                          /* Attempt to read in 10 bytes: */
                        fscanf(stream,"%lf%lf%lf%lf%lf%lf%d",&MachNo,&ReCrit,&ReUnit,\
                        &Temp,&chord,&xk,&dimFlag);
                fclose( stream );
        }
        else
        {
                ustar = 99.0;                             /* this is error code for read error */
                exit(1);
        }
        Tw = Temp*(1.0+0.845*.2*MachNo*MachNo);
        C = sqrt(Tw/Temp)*(Temp+216)/(Tw+216);
        xk = xk*chord/100;                                /* absolute units from percent chord */
        ReHalf = sqrt(ReUnit*xk);
        etak =  1.0;                                      /* initial guesstimate, eta=.5 */
        while ( (diff = fabs(etak - eta)) > .01)
        {
                eta = (etak-eta)/2.0 + eta;               /* halve the difference--ensure convergence */
                if (dimFlag)                              /* dimension flag set to 0 for 2-D, these are 3-D */
                {
                        if (MachNo == 0.0)
                        {
                                ustar = -0.0030162390759 + 1.4662313738*eta - \
                                0.6778932818*eta*eta + 0.099917578252*eta*eta*eta;
                                tempstar = 1.0;
                        }
                        if (MachNo == 0.5)
                        {
                                ustar = -0.0033875986349 + 1.4513424344*eta - \
                                0.66625431041*eta*eta + 0.09771742806*eta*eta*eta;
                                tempstar = 1.0408181602 - 0.0039999257951*eta - \
```

```
        0.044813954985*eta*eta + 0.019393978697*eta*eta*eta;
}
if (MachNo == 1.0)
{
        ustar = -0.025249285704 + 1.3602642179*eta - \
        0.57976695808*eta*eta + 0.079829974953*eta*eta*eta;
        tempstar = 1.1811110576 - 0.050471235147*eta - \
        0.11838399383*eta*eta + 0.049562338627*eta*eta*eta;
}
if (MachNo == 1.5)
{
        ustar = -0.030359091616 + 1.2331000382*eta - \
        0.47590356222*eta*eta + 0.059584150697*eta*eta*eta;
        tempstar = 1.4017482374 - 0.082835932619*eta - \
        0.2314220553*eta*eta + 0.08491068694*eta*eta*eta;
}
if ((MachNo > 0.0) && (MachNo < 0.5))
{
        ustar1 = -0.0030162390759 + 1.4662313738*eta - \
        0.6778932818*eta*eta + 0.099917578252*eta*eta*eta;
        ustar2 = -0.0033875986349 + 1.4513424344*eta - \
        0.66625431041*eta*eta + 0.09771742806*eta*eta*eta;
        ustar = MachNo/0.5*(ustar2 - ustar1) + ustar1;
        tempstar1 = 1.0;
        tempstar2 = 1.0408181602 - 0.0039999257951*eta - \
        0.044813954985*eta*eta + 0.019393978697*eta*eta*eta;
        tempstar = MachNo/0.5*(tempstar2 - tempstar1) + tempstar1;
}
if ((MachNo > 0.5) && (MachNo < 1.0))
{
        ustar1 = -0.0033875986349 + 1.4513424344*eta - \
        0.66625431041*eta*eta + 0.09771742806*eta*eta*eta;
        ustar2 = -0.025249285704 + 1.3602642179*eta - \
        0.57976695808*eta*eta + 0.079829974953*eta*eta*eta;
        ustar = (MachNo-0.5)/0.5*(ustar2 - ustar1) + ustar1;
        tempstar1 = 1.0408181602 - 0.0039999257951*eta - \
        0.044813954985*eta*eta + 0.019393978697*eta*eta*eta;
        tempstar2 = 1.1811110576 - 0.050471235147*eta - \
        0.11838399383*eta*eta + 0.049562338627*eta*eta*eta;
        tempstar = (MachNo-0.5)/0.5*(tempstar2 - tempstar1) + tempstar1;
}
if ((MachNo > 1.0) && (MachNo < 1.5))
{
        ustar1 = -0.025249285704 + 1.3602642179*eta - \
        0.57976695808*eta*eta + 0.079829974953*eta*eta*eta;
        ustar2 = -0.030359091616 + 1.2331000382*eta - \
        0.47590356222*eta*eta + 0.059584150697*eta*eta*eta;
        ustar = (MachNo-1.0)/0.5*(ustar2 - ustar1) + ustar1;
        tempstar1 = 1.1811110576 - 0.050471235147*eta - \
        0.11838399383*eta*eta + 0.049562338627*eta*eta*eta;
        tempstar2 = 1.4017482374 - 0.082835932619*eta - \
        0.2314220553*eta*eta + 0.08491068694*eta*eta*eta;
```

```
                tempstar = (MachNo-1.0)/0.5*(tempstar2 - tempstar1) + tempstar1;
        }
}
else                                    /*  these are two-dimensional fits */
{
        if (MachNo == 0.0)
        {
                ustar = -0.0030162390759 + 1.4662313738*eta - \
                0.6778932818*eta*eta + 0.099917578252*eta*eta*eta;
                tempstar = 1.0;
        }
        if (MachNo == 0.5)
        {
                ustar = -0.010222135918 + 0.79803891191*eta - \
                0.17645701447*eta*eta + 0.0076613626851*eta*eta*eta;
                tempstar = 1.0390069558 + 0.021293685986*eta - \
                0.04037292187*eta*eta + 0.010256400475*eta*eta*eta;
        }
        if (MachNo == 1.0)
        {
                ustar = -0.013485754159 + 0.68661116824*eta - \
                0.099565668439*eta*eta + 0.0055281596596*eta*eta*eta;
                tempstar = 1.1796702638 - 0.023536314656*eta - \
                0.045794308841*eta*eta + 0.011188831641*eta*eta*eta;
        }
        if (MachNo == 1.5)
        {
                ustar = -0.011389453271 + 0.53450540395*eta - \
                0.0078072829457*eta*eta + 0.019332277037*eta*eta*eta;
                tempstar = 1.3889285612 + 0.0040409924694*eta - \
                0.1210589633*eta*eta + 0.025734269438*eta*eta*eta;
        }
        if ((MachNo > 0.0) && (MachNo < 0.5))
        {
                ustar1 = -0.0030162390759 + 1.4662313738*eta - \
                0.6778932818*eta*eta + 0.099917578252*eta*eta*eta;
                ustar2 = -0.010222135918 + 0.79803891191*eta - \
                0.17645701447*eta*eta + 0.0076613626851*eta*eta*eta;
                ustar = MachNo/0.5*(ustar2 - ustar1) + ustar1;
                tempstar1 = 1.0;
                tempstar2 = 1.0390069558 + 0.021293685986*eta - \
                0.04037292187*eta*eta + 0.010256400475*eta*eta*eta;
                tempstar = MachNo/0.5*(tempstar2 - tempstar1) + tempstar1;
        }
        if ((MachNo > 0.5) && (MachNo < 1.0))
        {
                ustar1 = -0.010222135918 + 0.79803891191*eta - \
                0.17645701447*eta*eta + 0.0076613626851*eta*eta*eta;
                ustar2 = -0.013485754159 + 0.68661116824*eta - \
                0.099565668439*eta*eta + 0.0055281596596*eta*eta*eta;
                ustar = (MachNo-0.5)/0.5*(ustar2 - ustar1) + ustar1;
                tempstar1 = 1.0390069558 + 0.021293685986*eta - \
```

```
                        0.04037292187*eta*eta + 0.010256400475*eta*eta*eta;
                        tempstar2 = 1.1796702638 - 0.023536314656*eta - \
                        0.045794308841*eta*eta + 0.011188831641*eta*eta*eta;
                        tempstar = (MachNo-0.5)/0.5*(tempstar2 - tempstar1) + tempstar1;
                }
                if ((MachNo > 1.0) && (MachNo < 1.5))
                {
                        ustar1 = -0.013485754159 + 0.68661116824*eta - \
                        0.099565668439*eta*eta + 0.0055281596596*eta*eta*eta;
                        ustar2 = -0.011389453271 + 0.53450540395*eta - \
                        0.0078072829457*eta*eta + 0.019332277037*eta*eta*eta;
                        ustar = (MachNo-1.0)/0.5*(ustar2 - ustar1) + ustar1;
                        tempstar1 = 1.1796702638 - 0.023536314656*eta - \
                        0.045794308841*eta*eta + 0.011188831641*eta*eta*eta;
                        tempstar2 = 1.3889285612 + 0.0040409924694*eta - \
                        0.1210589633*eta*eta + 0.025734269438*eta*eta*eta;
                        tempstar = (MachNo-1.0)/0.5*(tempstar2 - tempstar1) + tempstar1;
                }
        }       /*  end dimension if */
        etak = ReCrit/ReHalf/ustar/2.0*tempstar*tempstar*C;
}       /* end while */
gritSize = etak*2*xk/ReHalf;                    /* latest version of ustar is returned */
                /* Open output file for write (will fail if file does not exist) */
if( (stream2  = fopen( outName, "w" )) != NULL )  /* succeeded */
{
        fprintf(stream2," %lf, %lf",gritSize,ustar);
        fclose( stream2);
}
}
```

# Appendix C

# HDB User's Manual

# 1. Package Contents and Installation

## Package Contents

Your demonstration disk should contain:

| | | |
|---|---|---|
| HDB | (folder) | |
| | hdb.tbk | (ToolBook document) |
| | hdb1.tbk | (ToolBook document) |
| | text.txt | (sample text file) |

## System Requirements

The HDB runs on any IBM-compatible PC with the following:

- o 2 MB of RAM (or more)
- o Windows v. 3.1 (or later)
- o A 12" (or larger) monitor
- o A word processor (such as Microsoft Word) is recommended
- o A paint program (such as PaintBrush) is recommended

## Installation

Installation is easiest from the File Manager in Windows. Simple drag the entire contents of the floppy disk to the hard disk. The operation of some of the buttons within the HDB depends on the placement of files within specific directories. If Microsoft Word is already installed, make sure the autoexec.bat contains its path name so that Windows can find it from within any directory. If you do not have Microsoft Word, that's OK, but some features may not work, as we will discuss later.

# 2. Quick Start

The following is a step-by-step procedure to follow when starting to use the HDB:

1. Double click on the hdb1.tbk file in the File Manager. This will bring you to the HDB Main Menu screen as shown in Figure 2.1.

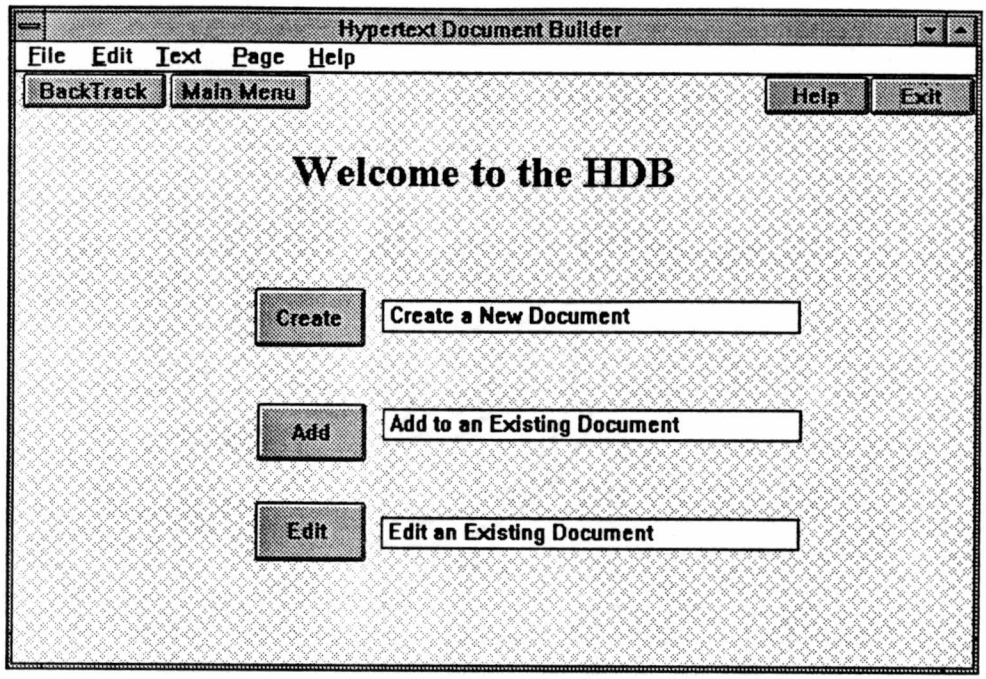


Figure 2.1 HDB Main Menu Screen

2. You are now in the HDB and may choose one of the specific options listed in the main menu, namely **Create, Add** and **Edit**.
3. Navigate and operate within the HDB by:
   a. Using the pull-down menus in the ToolBook menubar at the top of the screen. These menus behave like typical Windows application menus.
   b. Using the push-button menubar. This menubar is HDB specific. When clicked on with the mouse, each button will immediately execute the indicated action.
   c. Clicking on any boxed item (hotword) in the white part of the screen will cause the program to execute a link, e.g., display another screen.
   d. Any italicized item will temporarily display a pop-up note when clicked on with the mouse. The note will remain for as long as the left mouse button is held down.

# 3. Using the Hypertext Document Builder

Each screen of the HDB has a standard menu-bar. This consists of four buttons across the top of the screen: **BackTrack** and **Main Menu** to the far left, and **Help** and **Exit** to the far right. These buttons have standard functions. In particular, clicking on **BackTrack** brings the user to the last screen he was viewing in ToolBook, clicking on **Main Menu** brings the user to the HDB Main Menu screen, and **Exit** brings the user out of the HDB and ToolBook, leaving him in Windows.

The first screen, or page, the user sees upon starting the HDB program is the HDB Main Menu. It is titled "Welcome to the HDB" and has a series of buttons in the center of the screen, namely, **Create**, **Add** and **Edit**. A picture of the HDB Main Menu was shown in Figure 2.1. The functions of each of the buttons are described in the following sections.

## 3.1 Create a New HD

Clicking on the **Create** button, labeled "Create a New Document" on the HDB Main Menu Screen, will let the user start to build a new hypertext document. A dialogue box which asks the user to enter a name for the hypertext document will appear. The user may type in the name he wishes the new document to have and click on **OK**, or press **Cancel**. The name, concatenated with ".tbk", will also become the name of the file in which the new hypertext document will be stored when created.

### 3.1.1 Set the Text's Appearance

When a name is entered, the user is brought to a screen titled "Text Appearance" as shown in Figure 3.1. Along the left-hand side of this screen are three buttons in a column, labeled **Document Title**, **Section Title** and **Body Text**, respectively. The user must press each of these buttons to set the appearance of the text which will be used in each of the three categories. Upon pressing a button, the default text font, style, size and justification names will appear in the appropriately labeled fields. An example of the text with the default characteristics will be displayed in the large field above the name fields. A dialogue box will also appear asking the user if he wishes to override the defaults. If the user wishes to keep the default settings for each of the three text categories, he may simply click on the **No** button for each and then on **Continue** at the bottom of the screen after seeing all three. If not, he must change the default settings using the following procedure. The example text will change to reflect the user's decisions. When all text appears as the user wishes, he should click on the button **Continue** at the bottom of the screen.

How to change default settings:

1. Click on the **Yes** button in the dialogue box to bring up the Character dialogue box.
2. Select a preference for text font by clicking on the arrow to the right of the Font list box and selecting the desired font from the list by clicking on its name.
3. Select a preference for text style by clicking on the radio button(s) which is labeled with the desired style: **Bold**, **Italic**, or **Underline**. The strikeout style is not directly supported by the HDB.
4. Select a preference for text size by clicking on the arrow to the right of the Point Size list box and selecting the desired size from the list by clicking on its name.
5. Click on the "OK" button when satisfied with all the character settings. The example text will change to reflect the user's decisions. The Paragraph dialogue box will appear.

6. Select a preference for text alignment by clicking on the radio button(s) which is labeled with the desired alignment: **Left, Right, Center** or **Justify**. The other paragraph settings are not directly supported by the HDB.
7. Click on the "OK" button when satisfied with the alignment setting. The example text will change to reflect the user's decisions.
8. Repeat steps 1-7 for each of the three text categories.
9. Click on the **Continue** button when finished.

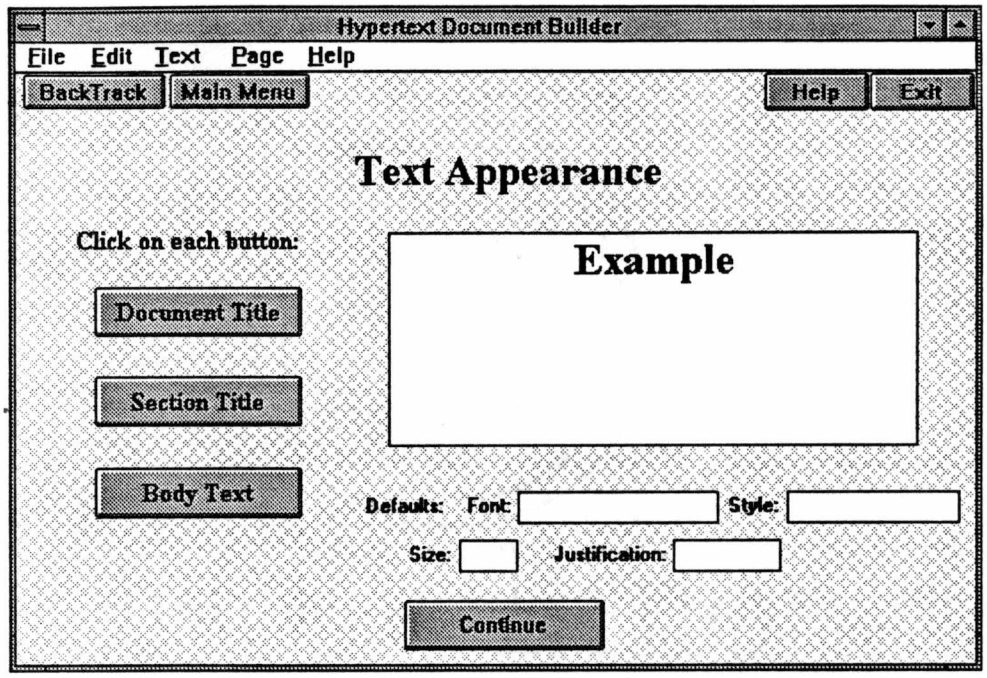


Figure 3.1 Text Appearance Screen for HDB

## 3.1.2 Build the Hypertext Document

Clicking on the **Continue** button on the text appearance screen brings the user to the main working screen of the HDB--the HD Builder Screen. The HD Builder Screen is dominated by a large scrolling field in the center, with a row of buttons across the top and bottom and a small scrolling field directly below the large one. The large field holds the text of the document while the user is building the hypertext version. The smaller field is an auxiliary working field intended to be used for typing and editing supplementary text. For example, if a section's title does not appear exactly as desired in the main field, the user can type, copy or paste text into the auxiliary field to reflect the proper title. The HD Builder Screen is shown in Figure 3.2.

In addition to the standard menu-bar buttons, added buttons along the top of the screen are **Input Text** and **Open MS Word**. The buttons along the bottom of the screen are, from left to right, **HD Title, Section Title, Body Text, Figure, Add To HD, Create HD,** and **Edit HD**. When clicked, each of the first four of these bottom-row buttons cause a small box to appear in the lower right corner of the screen. The box instructs the user to select the text he wishes to fill the specified capacity (document title, section

title, body text, or figure caption) and then click on the small included **OK** button . For every button but **Figure**, the text is adopted immediately.

Once the user has entered all text and figures desired, he should click on the **Create HD** button. When finished, the HDB will return the user to the HD Builder Screen. The user may then add more text and figures in the same manner and pressing the **Add To HD** button, or go directly to the HD to build custom links by pressing the **Edit HD** button. Alternatively, the user may return to the HDB Main Menu to work with another document, or exit the HDB.

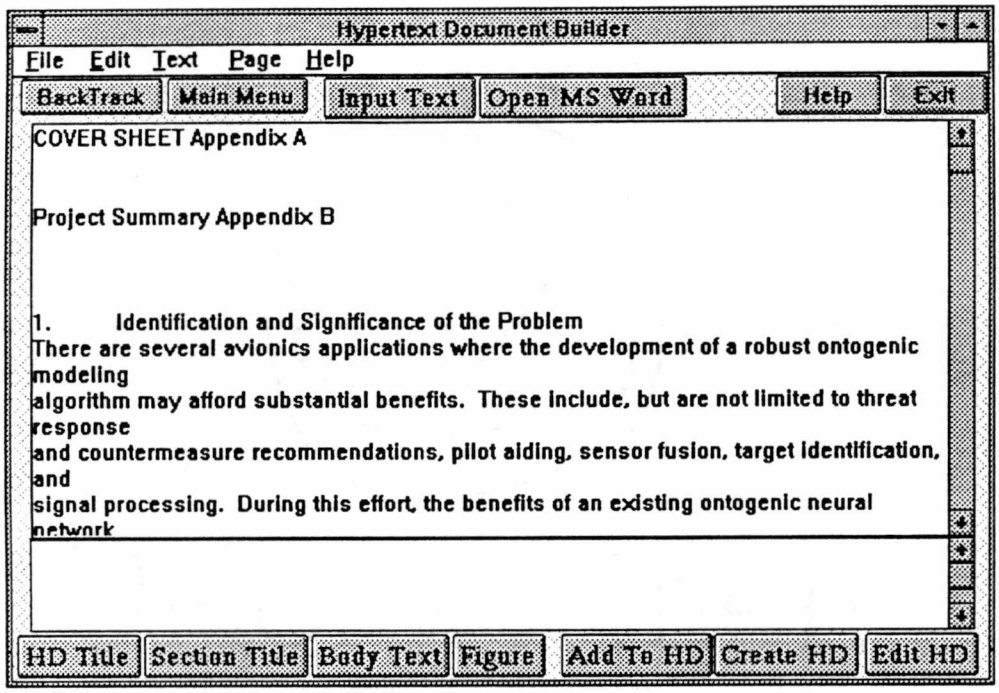


Figure 3.2 HD Builder Screen

To build a new hypertext document, follow the steps below (each step is described in detail in one of following sections):

1. Input text
2. Make a document title
3. Make a section title or titles
4. Make body-text for the section(s) made in step 3
5. Repeat steps 3 & 4 until you make all the sections for the new hypertext document for the time being
6. (optional) Make figures
7. Click on the button **Create new HD** to construct the hypertext document

#### 3.1.2.1 Input text

The text file which is to be converted into a hypertext document should be input using one of the buttons **Input Text** or **Open MS Word**.

If using the **Input Text** button:

An open dialogue box will appear. Select the text file which you want to input into the HDB, then click on **OK**. A sample text file, called "text.txt", is included with the HDB for practice.

If using the **Open MS Word** button:

An open dialogue box will appear. Select the text file which you want to input into the HDB, then click on **OK**. Microsoft Word will be launched and the text file will be opened within. After MS Word is loaded, follow these steps:

1. Select and copy the desired text
2. Choose **Exit** from the **File** pull-down menu.
3. Click at the top of the large text field on the HD Builder Screen.
4. Paste the text (using the **Paste** command from the **Edit** pull-down menu, or Shift+Ins)

**Note:**

In both cases, only text will be input into the field. The figures can be input using the **Figure** button later. If you do not have Microsoft Word, you may not use the "Open MS Word" button!!

#### 3.1.2.2 Make a document title

Follow the steps below to make the document-title for the hypertext document:

1. Click on the button **HD Title**. A small box will appear in the lower right corner of the screen. The box instructs the user to select the text he wishes to become the document title.
2. Highlight text to use as the document title from the large text field.

   **OR**

2. Type the document title in the typing-field located at the lower part of the screen, then highlight the typed text.
3. Click on the small **OK** button in the pop-up field.

The **HD Title** button vanishes after the document title has been chosen.

#### 3.1.2.3 Make a section title

Follow the steps below to make a section title for the hypertext document:

1. Click on the button **Section Title**. A small box will appear in the lower right corner of the screen. The box instructs the user to select the text he wishes to become the section title.
2. Highlight text to use as the section title from the large text field.

   **OR**

2. Type the section title in the typing-field located at the lower part of the screen, then highlight the typed text.
3. Click on the small **OK** button in the pop-up field.

It should be noted that when selecting a section title, the words should be preceded by the section number because the HDB selects the first word of the selected section title text, delimited by a space, to be the button label on the Table of Contents page of the HD.

3.1.2.4 Make body-text for the sections

Follow the steps below to make body-text for a section of the hypertext document:

1. Click on the button **Body Text**. A small box will appear in the lower right corner of the screen. The box instructs the user to select the text he wishes to become the body of the section.
2. Highlight text to use as the section body from the large text field.

   **OR**

2. Type the section body text in the typing-field located at the lower part of the screen, then highlight the typed text.
3. Click on the small **OK** button in the pop-up field.

3.1.2.5 Make Figures

The figures can be either imported from a bitmap image file or from the clipboard. Follow the steps below to make figures:

1. Click on the button **Figure.** A small box will appear in the lower right corner of the screen. The box instructs the user to select the text he wishes to become the figure caption.
2. Highlight text for the figure caption from the large text field.

   **OR**

2. Type the figure caption in the typing-field located at the lower part of the screen, then highlight the typed text.
3. Click on the small **OK** button in the pop-up field. A dialogue box will appear asking for the figure number. The default figure number is the next consecutive integer (1 if this is the first figure).
3. Choose the default figure number or type in the correct one. Click on **OK**. A dialogue box will appear asking the user from where the figure should be imported: a file or the clipboard.
4. <u>If the figure resides in a standard graphics file (.bmp, .tif, etc.)</u>:

   (1). Click on the button **From a File.** A dialogue box will appear asking for the complete pathname of the proper file.
   (2). Type the complete pathname of the graphics file.
   (3). Click on **OK**.

   <u>If importing the image from clipboard:</u>

   If the figure is not in a standard graphics file, or is not alone in the file, the user must import it from the clipboard.

   (1). Click on the button **From the Clipboard**. A fourth pop-up box will appear in the center of the screen instructing the user to place the figure into the clipboard at that time, and then click on the box.
   (2). Iconize the HDB by clicking on the down arrow in the upper right corner of the HDB window.

(3). Open the file in which the image can be found in Windows.
(4). Select and copy the image.
(5). Re-instantiate the HDB by double clicking on its icon.
(6). Click on the pop-up box. The image will automatically be pasted in the proper place for addition to the HD.

You can also cancel making this figure by clicking on **Cancel** at any time.

**Important Notes**
The figure caption selected should only be text. Because the figures are all at the end of the HD, it may be clearer to number them consecutively; thus the option.

A figure should be imported from a .tif file. If it is imported from a .bmp file, it will likely cover some or all of the page on which it is pasted, since it cannot be re-sized. If the file is a .tif graphics file, then the figure is automatically resized and repositioned to the middle of the page by the HDB. In addition, unless the authoring version of ToolBook is installed on the host computer, the user cannot manually reposition or resize any figures.

#### 3.1.2.6 Adding to the hypertext document

Clicking on the button **Add To HD** will add more sections and figures to the hypertext document. This button will be described in detail in the section entitled Adding to an Existing Hypertext Document, Section 3.2.

#### 3.1.2.7 Construct the hypertext document

Clicking on the button **Create HD** will start to construct the hypertext document. The title and sections installed so far are automatically built by putting the highlighted text into its corresponding place and assigning it the selected appearance according to its type. The Title Page, Table of Contents, and List of Figures are automatically created. Hyper-links between standard parts of a document, such as between the Table of Contents buttons and each section of the document, or the List of Figures buttons and each figure, are also automatically installed during this process.

After constructing all the sections built so far, the HDB will return to the HD Builder Screen. The user may then:

- Add more material to the document,
- Edit the document,
- Return to the HDB Main Menu to work with another document, or
- Exit the HDB.

#### 3.1.2.8 Editing a hypertext document

Clicking on the button **Edit HD** will allow the user to edit the new hypertext document just created or changed. Within the document, you can make custom Hyper-links, add notes, and change the appearance of each page of the document. For details on these options, please see Section 3.3, Editing an Existing Document.

## 3.2 Add To an Existing HD

The button **Add**, labeled Add to an Existing Document on the HDB Main Menu Screen, lets the user append new sections and figures to an existing hypertext document built with the HDB. Follow the steps below:

1. Clicking on the **Add** button on the HDB Main Menu will bring up a dialogue box which asks the user to enter the name of the hypertext document.
2. Type in a valid ToolBook document name and press the **OK** button. The user will be brought directly to the HD Builder Screen.
3. The user may now:
   - Select section titles and bodies to be added to the document following the procedure described in Section 3.1.2.3 and 3.1.2.4.
   - Select figures to be added to the document following the procedure described in Section 3.1.2.5.
4. When all new material has been selected and installed, the user should press the **Add To HD** button to build it into the existing document. After the new material is added into the HD, the HDB will bring the user back to the HD Builder Screen.
5. The user may now:
   - Add more material to the document,
   - Edit the document,
   - Return to the HDB Main Menu to work with another document, or
   - Exit the HDB.

**NOTE:** To add more material to the document after having just been returned to the HD Builder Screen, just start at step 3 above.

## 3.3 Edit an Existing Hypertext Document

The **Edit** button , labeled "Edit an Existing Document" on the HDB Main Menu Screen, allows the user to customize an existing hypertext document by making custom Hyper-links. Clicking on it will bring up a Windows-style dialogue box, titled Edit, which asks the user to select the name of the hypertext document to be edited. When a name is selected, the user is brought directly to the HD to browse or add custom links. A typical hypertext document as created by the HDB is shown in Figure 3.3. The Title, Table of Contents, and List of Figures pages each have a **Return to HDB** button which will take the user back to the HDB at any time. The title page of each HD has a **Continue** button which brings the user to the Table of Contents of the document. Each section in the document is here listed. Clicking on the button numbered with the desired section number will bring the user to the page which holds that section. Each page but the title page has **Previous** and **Next** buttons, which bring the user one page to the left or right, respectively, in the HD. The Table of Contents and List of Figures pages have these buttons at the bottom of the page, whereas all body text and figure pages have them at top center. These buttons, along with the **Table of Contents** and **BackTrack** buttons on the top left of the body text and figure pages, are the main navigation buttons in the HDs built with the HDB. The List of Figures page(s) is placed after the Table of Contents page(s), and can be reached by repeatedly pressing the **Next** button from the first Table of Contents page. All figures included in the document are listed here. Clicking on the button numbered with the desired figure number will bring the user to the page which holds that figure. Body text pages appear after the List of Figures, and all figure pages appear after them. Custom links may be created on any body text page; this process will be discussed in the next section. The user may also wish to resize and/or reposition the bitmap images on the figure pages, but this may only be done if the authoring version of ToolBook is available on his computer.

## 3.4 Create Custom Links

While editing an HD, the user may create custom hyper-links from any word or group of words in the document to any page in that or other HDs. The buttons along the bottom of the body text pages, **Link To..., Activate Links** and **Add Links**, are for creating custom links. When the user wishes to make a custom link, he should follow the steps below:

1. Click on the button **Add Links** to make sure the existing Hyper-links are **not** activated.

2. Select the word or group of words which will become the "hotword" for that link.

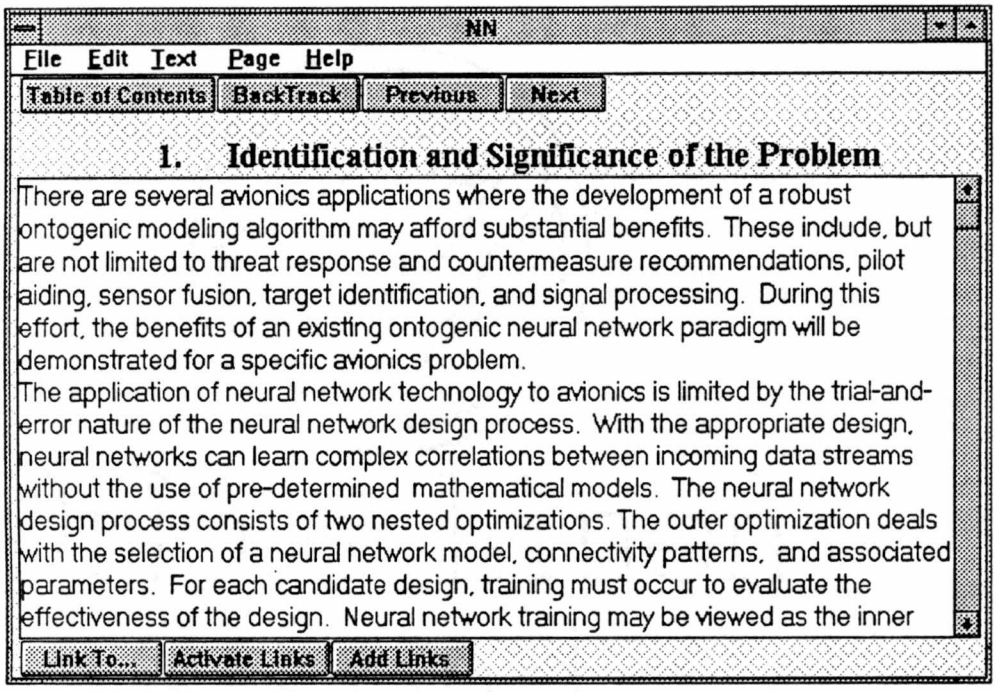


Figure 3.3. A typical hypertext document

3. Click on the **Link To...** button. A small window will appear on the screen with three buttons in it: **Link To This Book, Link To This Page,** and **Cancel. Do not click on any of the buttons in the box at this point unless you want to cancel!**

4. If the link is intended to go to another page in the same HD, then the user should navigate to that page and click on the **Link To This Page** button.

   **OR**

4. If the link is intended to go to another HD, the user should use the ToolBook **Open...** command from the pull-down **File** menu on the larger window to open the other HD, then either click on **Link To This Book** or navigate to the proper page in that HD and click **Link To This Page**.

   **OR**

4. If the user chooses to cancel, the small window will disappear and no link will have been made.

5. Repeat steps 2-4 to create all the custom hyper-links.
6. After creating custom links, the user must press the **Activate Links** button before they can be used. Then, when clicked the hotword will bring the user directly to the linked page, or the first page of the linked book if **Link To This Book** was chosen.
7. If at any time the user wishes to create more links after the links have been activated, he must click on the **Add Links** button before adding them, then on the **Activate Links** button to use the links after they have been made.

**NOTE:** After the linking procedure is complete, the hotword will appear boxed and bold.

# Vita

Connie Starr Fensky was born in Bridgeport, Connecticut, on November 9, 1962. She attended grades K-12 in the Newtown, Connecticut, school system, and graduated from Newtown High School in June, 1980. She attended Virginia Tech in Blacksburg, Virginia, and was involved in the cooperative education program. Her co-op experience was gained at David Taylor Research Center in Bethesda, Maryland. Upon graduation with a Bachelor of Science degree cum laude from Virginia Tech in June, 1985, she entered employment as an Aerospace Engineer at David Taylor Research Center. After several years of acting as project engineer in charge of wind tunnel testing at David Taylor, she returned to college at the University of Tennessee Space Institute, in Tullahoma, Tennessee. She received her Master of Science degree in Aerospace Engineering in December, 1993.