US Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave S.W.
Washington, D.C. 20591

FEB 17 1992

Dear Colleague:

Enclosed is a copy of report **FAA/RD-90/25 entitled "Rotorwash Computer Model - User's Guide".** This model is based on measured data and it provides a means for heliport and airport designers to make decisions on some of the more complex rotorwash-related design issues.

The majority of helicopters are light in weight and it is rare for them to cause a rotorwash-related accident or incident. However, with heavy rotorcraft, rotorwash-related mishaps are more of a concern. The current FAA Heliport Design Advisory Circular addresses this issue to a limited degree. By and large, however, the assurance of safety is the responsibility of the pilot.

Anticipating the introduction of large tiltrotor and the expanded use of larger helicopters, it is appropriate to consider whether protection against rotorwash mishaps should continue to depend so heavily on pilot judgment. Would it not be better to provide an additional safety margin by addressing this issue via facility design and operational procedures guidelines? This is the avenue that the FAA has been pursuing.

The FAA approach to this task is four-fold:

a. to measure the rotorwash of helicopter and tiltrotor aircraft.

b. to develop and validate a rotorwash computer model based on the available rotorwash data.

c. to analyze rotorwash induced mishaps to see if we can determine the thresholds at which rotorwash becomes a potential hazard.

d. to apply the model to an analysis of a variety of operational scenarios using these thresholds and to determine ways of alleviating rotorwash-related accidents and incidents.

This report is the fifth in a set of documents on the issue of rotorwash. The subject is technically complex and additional research and development is required. We want to work with industry in developing cost-effective solutions.

Thus, we welcome any suggestions that you may wish to make in this regard. Please reference this report and send your suggestions to:

Vertical Flight Program Office, ARD-30
Federal Aviation Administration
800 Independence Ave., SW
Washington, DC 20591

James I. McDaniel
Manager, Vertical Flight Program Office

Enclosures:

List of related rotorwash documents
FAA/RD-90/25

RELATED FAA R&D REPORTS ON ROTORWASH

FAA/CT-TN87/54, Analysis of Heliport Environmental Data: Indianapolis Heliport, Wall Street Heliport

- Vol. 1 Summary (NTIS: ADA 206 708)
- Vol. 2, Wall Street Heliport Data Plots (NTIS: ADA 212 312)
- Vol. 3 Indianapolis Downtown Heliport Data Plots (Not available from NTIS)

FAA/CT-TN89/43 Analysis of Heliport Environmental Data: Intracoastal City, LA. (NTIS: AD-A228547)

FAA/RD-90/16, Evaluation of Rotorwash Characteristics for Tiltrotor and Tiltwing Aircraft in Hovering Flight (NTIS: AD-A231236)

FAA/RD-90/17, Analysis of Rotorwash Effects in Helicopter Mishaps (NTIS: AD-A243536)

DOT/FAA/RD-90/25

Research and Development Service
Washington, D.C. 20591

Rotorwash Computer Model - User's Guide

Samuel W. Ferguson

EMA
800 Muirfield Drive
Mansfield, Texas 76063

Dr. J. David Kocurek

Computational Methodology Associates
2900 Steve Drive
Hurst, TX 76054

November 1991

Final Report

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

U.S. Department of Transportation

Federal Aviation Administration

NOTICE

Technical Report Documentation Page

1. Report No. DOT/FAA/RD-90/25	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Rotorwash Computer Model - User's Guide		5. Report Date November 1991 6. Performing Organization Code
7. Author (s) Samuel W. Ferguson, EMA; Dr. J. David Kocurek, CMA		8. Performing Organization Report No. EMA TR-87-5-1
9. Performing Organization Name and Address Computational Methodology Associates 2900 Steve Drive Hurst, TX 76054		10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTRS57-87-P-81048
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration 800 Independence Avenue, S.W. Washington, D.C. 20591		13. Type Report and Period Covered Final Report December 1989 - June 1990 14. Sponsoring Agency Code ARD-30

15. Supplementary Notes

1. Work performed under subcontract by EMA, Mansfield, TX.
2. Work performed for the Federal Aviation Administration Vertical Flight Program Office, ARD-30.

16. Abstract

The user's guide for the Rotorwash (ROTWASH) Analysis program is documented in this report. This computer program is used to analyze the rotorwash flow field characteristics and their effect on the environment for rotorcraft in hovering and low speed flight in close proximity to the ground. The documentation provides step-by-step descriptions on the use of each analysis option and a listing of the IBM PC/PC-compatible based FORTRAN-77 software. A brief introductory section to the report describes the history of the ROTWASH analysis software. References for the mathematical models used in the analysis modules are included in the report.

A companion report entitled "Evaluation of Rotorwash Characteristics for Tiltrotor and Tiltwing Aircraft in Hovering Flight," DOT/FAA/RD-90/16, evaluates rotorwash characteristics of 11 different types of tiltrotor and tiltwing aircraft for comparison purposes. Flight test data, as correlated with analysis tools, are presented for the XV-15 tiltrotor and CL-84 tiltwing.

A second companion report, entitled "Analysis of Rotorwash Mishaps," DOT/FAA/RD-90/17, uses the ROTWASH program to analyze rotorwash induced mishaps in an effort to determine threshold levels at which rotorwash presents a potential hazard.

17. Key Words Helicopter, Rotorcraft, Rotor Downwash, Tiltrotor, Tiltwing, VSTOL	18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif (of this report)	20. Security Classif (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	153	

Form DOT F 1700.7 (8-72) Reproduction of this document is authorized

SUMMARY

The user's guide for the Rotorwash (ROTWASH) Analysis program is documented in this report. This documentation provides step-by-step descriptions on the use of each analysis option and a listing of the IBM PC/PC-compatible based FORTRAN 77 software. A brief introductory section to the user's guide describes the history of the ROTWASH analysis software. References for the mathematical modeling utilized in the various analysis modules are also included in the report.

FOREWORD

The work reported herein was performed for the Federal Aviation Administration Vertical Flight Program Office under TSC purchase order No. DTRS57-87-P-81048 between December 1989 and June 1990. The work was performed by Mr. Samuel W. Ferguson at EMA.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

LIST OF ACRONYMS

AGL	Above ground level
DAIP	Distance along the interaction plane, feet
DFAC	Distance from aircraft center, feet
DFRC	Distance from the rotor center, feet
DOT	Department of Transportation
DOS	Disk Operating System
FAA	Federal Aviation Administration
GW	Gross weight, pounds
HAGL	Rotor or sensor height above ground level, feet
HROTOR	Rotor height above ground level, feet
Hz	Hertz, cycles per second
NASA	National Aeronautics and Space Administration
PSF	Pounds per square foot
ROTHAZ	Rotorwash and Hazard Analysis Program
ROTWASH	Rotorwash Analysis Program
WAGL	Wheel height above ground level, feet

1.0 INTRODUCTION

Rotorwash flowfield characteristics of helicopter, tiltrotor, and tiltwing aircraft are quite complex in close proximity to the ground. All theoretically rigorous analyses of these characteristics require quite complex computer-based mathematical models and large high-speed computers for solution. Unfortunately, in most situations, these types of resources are either unavailable, unaffordable, or can not effectively be used when information is required in a short frame of time. Therefore, in response to the need for a simple yet effective analysis tool, the U.S. Department of Transportation (DOT) sponsored the development of the Rotorwash Hazard (ROTHAZ) Analysis methodology and its associated FORTRAN 77 software. This research effort was completed in 1986 and is documented in reference 1. In 1989, the Federal Aviation Administration identified the need for analysis of the rotorwash characteristics of eleven tiltrotor and tiltwing aircraft configurations. The results of this study are documented in DOT/FAA/RD-90/16, "Evaluation of Rotorwash Characteristics for Tiltrotor and Tiltwing Aircraft in Hovering Flight" (reference 2). As a result of this research effort, the ROTHAZ analysis methodology has been improved and is now referred to as the Rotorwash (ROTWASH) analysis methodology.

Technical features of the mathematical models used in the ROTWASH analysis continue to be based on the ROTHAZ research effort with minor improvements. One of these improvements allows for the calculation of oblique impingement of rotorwash with the ground plane. Details on the mathematical modeling approach used for this effect are contained in Appendix A. Each of the analysis options included in the earlier FORTRAN 77 software is still contained in the new software. However, extensive changes have been developed for improvement of the IBM PC/PC-compatible-based software user interface. This software interface has been completely restructured using a much more flexible and timesaving menu structure. New options have also been developed for the output of analysis results in several different formats. These options include printout of data to the screen, printer, and disk. Data files printed out to disk can also be formatted for acceptance by PC-based graphics programs for the first time.

The purpose of this report is to document each feature of the ROTWASH analysis software in a written user's guide, and this documentation is provided beginning in Section 2.0. However, it must be stated that this program and its documentation are not targeted for the novice user. Since rotorwash flowfields are quite complex and new data are in the process of being acquired, the ROTWASH analysis methodology must be considered an evolving engineering tool at the present time. Therefore, it is important that the user be familiar with this field of research to effectively interpret and use ROTWASH program output. All input data requirements, technical analysis options, and data output options are described in detail in the user's guide and example printouts are provided for user reference. Commentary is also provided that identifies known strengths and weaknesses of the various program technical modules. Sources of flight test data for correlation with output from the technical modules are referenced for researchers interested in modifying the mathematical models. Data describing most modern types of rotorcraft in the ROTWASH input data format are summarized in Appendix B. Appendix C provides a listing of the ROTWASH program as compiled and linked for use on IBM PC/PC-compatible computers using MICROSOFT FORTRAN, Version 5.0.

2.0 ROTWASH PROGRAM USER'S GUIDE

The style of the ROTWASH user's guide presented in this section is primarily narrative. This format is designed to guide the reader through a step-by-step explanation on the use of each program software option. Example output from each option is presented exactly as it would be viewed by the user on a video terminal for reference purposes. Examples of user keyboard input are presented in **<BOLD>** text as an aid to the reader.

2.1. GETTING STARTED

The ROTWASH program is executed by typing the program name at the DOS system prompt:

<ROTWASH>

To avoid possible system errors, the user should execute the program from the directory containing the program (or set the appropriate DOS system PATH command). The user should also be aware that menu and data printouts to the screen will not work correctly unless the **device=C:\DOS\ANSI.SYS** *command is contained in the CONFIG.SYS file.*

The ROTWASH program responds with the screen output as presented in figure 1. This output is the ROTWASH program header page.

```
                ROTWASH PROGRAM

       ROTORCRAFT DOWNWASH HAZARD ANALYSIS

     EMA/COMPUTATIONAL METHODOLOGY ASSOCIATES
     *** PROGRAM VERSION 2.0,  APRIL 1991 ***



                PRESS <RETURN>
```

FIGURE 1 ROTWASH PROGRAM HEADER OUTPUT

After typing the carriage return **<RETURN>** or **<ENTER>** key, the user is asked to specify the path for ROTWASH program input and output (I/O). The only option for input at the present time is the terminal keyboard. This is specified by typing **<CON>** for console or keyboard (lowercase inputs such as **<con>** are also permitted). Program output may be sent to one of three different locations. These output locations are:

OUTPUT OPTION	TYPING COMMAND
Screen	**<CON>**
Printer	**<PRN>**
Disk Plotting File	**<PLT>**

An example of the video screen output for this program menu is presented in figure 2 where the **<CON>** option has been chosen for both input and output.

```
I/O CAN BE DIRECTED TO FILES OR DEVICES

     VALID DEVICES ARE AS FOLLOWS:

        <CON>  ==>  CONSOLE
        <PRN>  ==>  PRINTER
        <PLT>  ==>  GRAPHICS FILE


  ENTER INPUT FILE/DEV NAME  ==> CON
  ENTER OUTPUT FILE/DEV NAME ==> CON
```

FIGURE 2 ROTWASH PROGRAM INPUT/OUTPUT CONTROL MENU

2.2 INPUT DATA REQUIREMENTS

Rotorcraft characteristics and atmospheric conditions that are common to all program options are input to the program using the master input data menu. Four basic configurations of rotor or propeller driven aircraft can be represented using this menu. These configurations include single and tandem rotor helicopters, tiltrotors, and twin-propeller tiltwings. This menu is presented to the user as

ROTWASH USER INPUT DATA MENU

CODE	PARAMETER	VALUE	UNITS
A	NUMBER OF ROTORS (1 OR 2)	2	-ND-
B	HUB TO HUB ROTOR SEPARATION	32.2	FT
C	ROTOR RADIUS	12.5	FT
D	GROSS WEIGHT	13000.0	LB
E	FUSELAGE DOWNLOAD FACTOR	13.0	PCT
F	ROTOR HEIGHT ABOVE GROUND	37.0	FT
G	SHAFT TILT ANGLE (<20 DEG)	.0	DEG
H	AIR DENSITY RATIO	1.0000	ND
I	AMBIENT WIND (-10 TO 10 KT)	.0	KT

ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> D

GROSS WEIGHT = 13000.0

ENTER NEW VALUE OR <RETURN> TO LEAVE AS IS ==> 13500.0

FIGURE 3 MASTER INPUT DATA MENU

shown in figure 3 after the I/O menu is completed. The default values provided in the menu define the Bell XV-15 tiltrotor. Design data describing most other modern types of rotorcraft are provided in Appendix B.

The first input data variable listed on the menu is the number of rotors (or propellers). This value will always be 2 except for single main rotor helicopters (the tail rotor is not considered a lifting rotor by the ROTWASH analysis). The next four menu variables define the design details of the rotorcraft configuration. These variables are the hub-to-hub separation distance for twin-rotor configurations (in feet), rotor radius (feet), rotorcraft gross weight (pounds), and the rotor on wing download factor (percent). The download factor represents the percent increase in hover rotor thrust required to overcome the rotor-induced vertical drag force on the airframe (where thrust is initially assumed to equal gross weight). For most helicopters, this value is less than 5 percent. Download on tiltrotors can generally be expected to vary from 8 to 13 percent because of the large wing area under the rotor.

The next two input data variables define the position of the rotor with respect to the ground plane. The rotor height (feet) is defined as the distance from the ground surface to the plane of the rotor. The mast angle (degrees) is defined as the tilt of the rotor plane with respect to the ground plane (this improvement to the ROTWASH methodology is described in detail in Appendix A). The mast angle is defined as 0 degrees when the plane of the rotor is parallel to the ground plane and a positive angle is a forward tilt of the mast (which is presently limited in the program to 20 degrees). Since most rotorcraft hover with the plane of the rotor parallel to the ground, it is recommended that caution be exercised when non-zero values are used for mast angle. Non-zero uses of the variable might involve hover investigations for tiltwing aircraft with the wing tilted forward (where a pitch fan provides the trim pitching moment). Also, limited rotorwash investigations for takeoff and landing maneuvers might be attempted if approximate rotor thrust levels are known for various segments of the maneuvers.

The last two input data variables on the menu define the atmospheric conditions. The air density ratio is defined as the ratio of the desired air density to the sea level standard air density (0.0023769 slugs/feet^3). Ambient wind speed (knots) is specified by the user up to a limit of 10 knots. Values greater than this limit are believed to invalidate several empirically determined mathematical modeling assumptions (limits are discussed in reference 1).

The mechanics of using the menu are quite simple. The user types in the code value for the variable to be changed and then types **<RETURN>**. The next prompt asks for the new parameter value. After this value and another **<RETURN>** are typed, the menu is rewritten to the screen with the new value. This simple process is continued until the user specifies each variable to its desired value. At this point, the **<RETURN>** key is typed by itself. This menu can also be reached from most of the other menus in the program whenever the user decides that the basic configuration needs to be modified. This is accomplished by typing **<N>** for NEW CASE when the option is offered.

2.3 ANALYSIS PROBLEM DEFINITION

After the master input data menu is completed, the user specifies the desired type of analysis option. Figure 4 presents the program logic/comment menu and the associated list of default values. This menu has two groupings of parameters which need to be specified.

The first parameter on the menu specifies the choice of either the velocity calculation analysis option or the hazard analysis option. The velocity analysis option is the default option on the menu. This option is otherwise chosen by typing the code **<A>**, then **<RETURN>**, then **<V>**, and finally **<RETURN>**. The same process is used to specify the hazard analysis option except that **<H>** is substituted for **<V>** as the parameter value. The second menu parameter provides an interactive toggle switch for the option which writes out data files to disk for graphics programs (This parameter is also offered as an option on the initial ROTWASH menu by

```
                ROTWASH PROGRAM LOGIC/COMMENT MENU

CODE              PARAMETER                         VALUE

  A       ANALYSIS TYPE,    <V> OR <H>               V
  B       GRAPHICS FILE,    <Y> OR <N>               N


       USER INPUT COMMENTS (FOR "PRN" AND "PLT" OUTPUT)

         <---                50 SPACES                     --->
  C      BELL XV-15 CHARACTERISTICS ARE USED AS INPUT DATA
  D      GROSS WEIGHT MIGHT BE ONE OF THE COMMENT STRINGS

ENTER CODE FOR DATA INPUT OR <RETURN> TO CONTINUE ==>
```

FIGURE 4 ROTWASH PROGRAM LOGIC/COMMENT MENU

typing **<PLT>**). There is no limit to the number of times this switch can be toggled. As long as the parameter has a **<Y>** or "yes" value, the user must specify output filenames before data files are written to disk. The user is not allowed to write over files previously written to disk by specification of the same filename twice.

The last two lines in the menu are used to specify user comments in all data files that are written to disk. These comments are also written out as header information on screen output sent directly to the printer. Both of the comment lines can be changed at any time during program execution. The only restriction is that the character strings on both lines be less than or equal to 50 characters. The arrowhead symbols above the comment lines in the menu define a 50-space line width.

If the velocity analysis option is specified, the user is then required to choose one of the four analysis options presented in figure 5. Velocity analysis options reached through this menu are the:

1. simple wall jet (for both single and twin-rotor configurations),

2. interaction plane (twin-rotor only),

3. ground vortex (single rotor only), and

4. disk edge vortex (single rotor only).

SELECT TYPE OF FLOW TO BE ESTIMATED

WALL JET PROFILE	TYPE <W>
INTERACTION PLANE PROFILE	TYPE <I>
GROUND VORTEX	TYPE <G>
DISK VORTEX	TYPE <D>
TO EXIT PROGRAM	TYPE <X>

ENTER DATA ENTRY CODE ==> W

FIGURE 5 VELOCITY ANALYSIS OPTION MENU

Each of these four options is described with flowfield characteristics sketches in subsequent sections. For technical details and discussion on practical limitations of these options, the user is referred to Sections III and IV of reference 1. The choice of one of these menu options is made by typing the appropriate code and **<RETURN>**. If one of the five allowable characters is not chosen, the menu will reappear and the user will be forced to choose an acceptable option.

If the hazard analysis option is specified, the user is presented with the figure 6 menu. This menu allows the user to choose either:

1. human overturning force/moment analysis, or
2. particulate cloud analysis.

Both of these analyses can be applied to either single or twin rotor configurations. The mechanics of this menu operate exactly like those of the velocity analysis option menu.

2.4 THE WALL JET OPTION

Rotorwash velocity profiles are calculated for single main rotor helicopter configurations using the wall jet option. Velocity profiles along the 90 and 270 degree azimuths for twin rotor configurations are also calculated using this option (90 degrees is out the right wing on a tiltrotor and along the centerline of the fuselage for tandem rotor helicopters). Figure 7 provides a three-dimensional view of the rotorwash flowfields associated with

SELECT TYPE OF HAZARD

OVERTURNING FORCE/MOMENT	TYPE <M>
PARTICULATE CLOUDS	TYPE <C>
TO EXIT PROGRAM	TYPE <X>

ENTER HAZARD CODE ==>

FIGURE 6 HAZARD ANALYSIS OPTION MENU

both rotor configurations. Figure 8 provides a cross sectional view of the non-dimensionalized ROTWASH wall jet velocity profile model. The program menu associated with the use of this option is presented in figure 9.

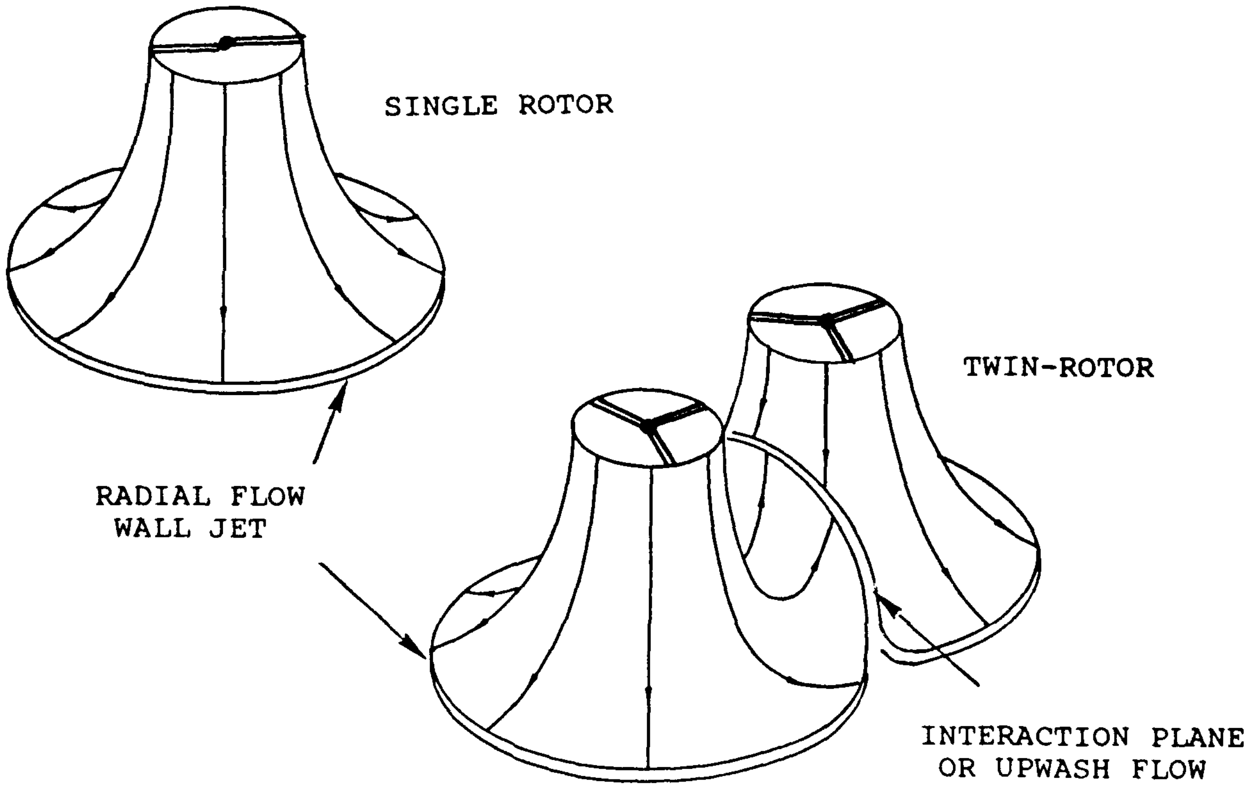


FIGURE 7 ROTORWASH FLOWFIELD CHARACTERISTICS OF SINGLE AND TWIN ROTOR CONFIGURATIONS OPERATING IN CLOSE PROXIMITY TO THE GROUND

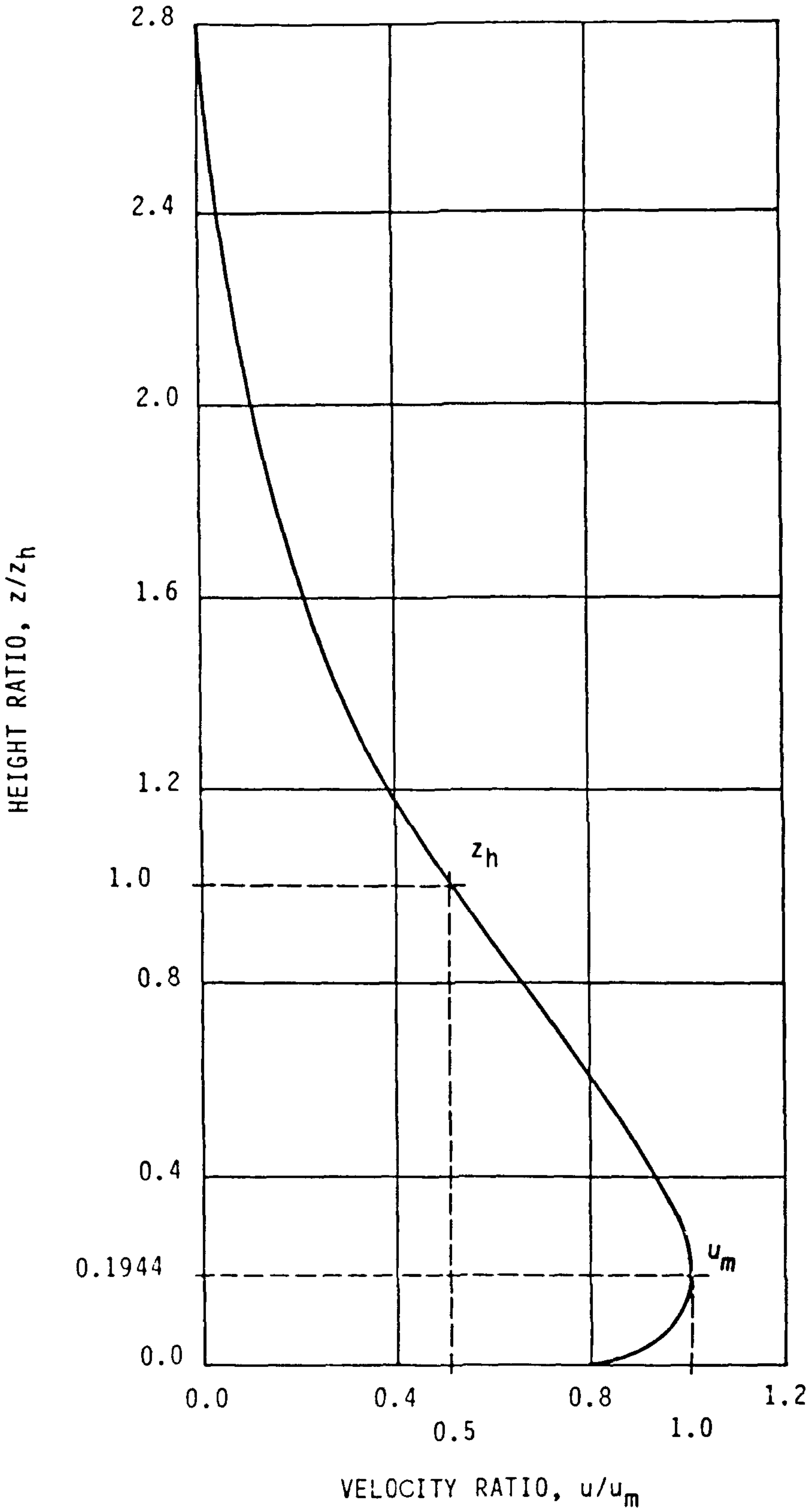


FIGURE 8 VERTICAL SECTION OF THE NONDIMENSIONAL WALL JET VELOCITY PROFILE

VELOCITY PROFILE STATUS MENU

CODE	PARAMETER	VALUE	UNITS
A	PROFILE STATION POSITION	50.00	FT
B	VERTICAL INCREMENT	1.00	FT
C	MAXIMUM PROFILE HEIGHT	10.00	FT
D	DATA OUTPUT FILENAME	DFRC.PTS	

ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> A

PROFILE STATION POSITION = 50.0000

ENTER NEW VALUE OR <RETURN> TO LEAVE AS IS ==> 60.0

FIGURE 9 VELOCITY PROFILE STATUS MENU

The velocity profile status menu provides the user the option to specify three parameters before calculations are conducted. The horizontal distance on the ground from the <u>center</u> of the rotor where the velocity profile should be calculated is the first parameter specified on the menu. Figure 10 is provided to graphically illustrate this geometry using the Bell XV-15, which is the more complex example (flight test data results associated with this figure are documented in reference 3). To specify the profile station position for the wall jet with the XV-15 (270 degree radial), the user would measure the distance from the aircraft centerline (DFAC) and subtract 16.1 feet (the distance from the centerline to the center of the rotor). The remaining parameters to be specified are the vertical calculation increment and the maximum height above ground level (AGL) to which the profile should be calculated. The default values for these three parameters are 50 feet, 1 foot, and 10 feet respectively. Each of these parameters is input by typing the appropriate code, **<RETURN>**, the new input data value, and **<RETURN>** to end the sequence. The last parameter on the menu is the filename for data that is written to disk if the graphics file toggle switch is set to **<Y>**.

The wall jet velocity profile, as calculated by the program using default inputs, is presented in figure 11 when the **<RETURN>** key is typed by itself. Output from the analysis describes the shape of both the mean and peak velocity profiles; an example being presented in figure 12 as correlated with Bell XV-15 flight test data (this particular example correlates to an HROTOR height of 37.5 feet and a DFAC value of 66.1 feet on figure 10).

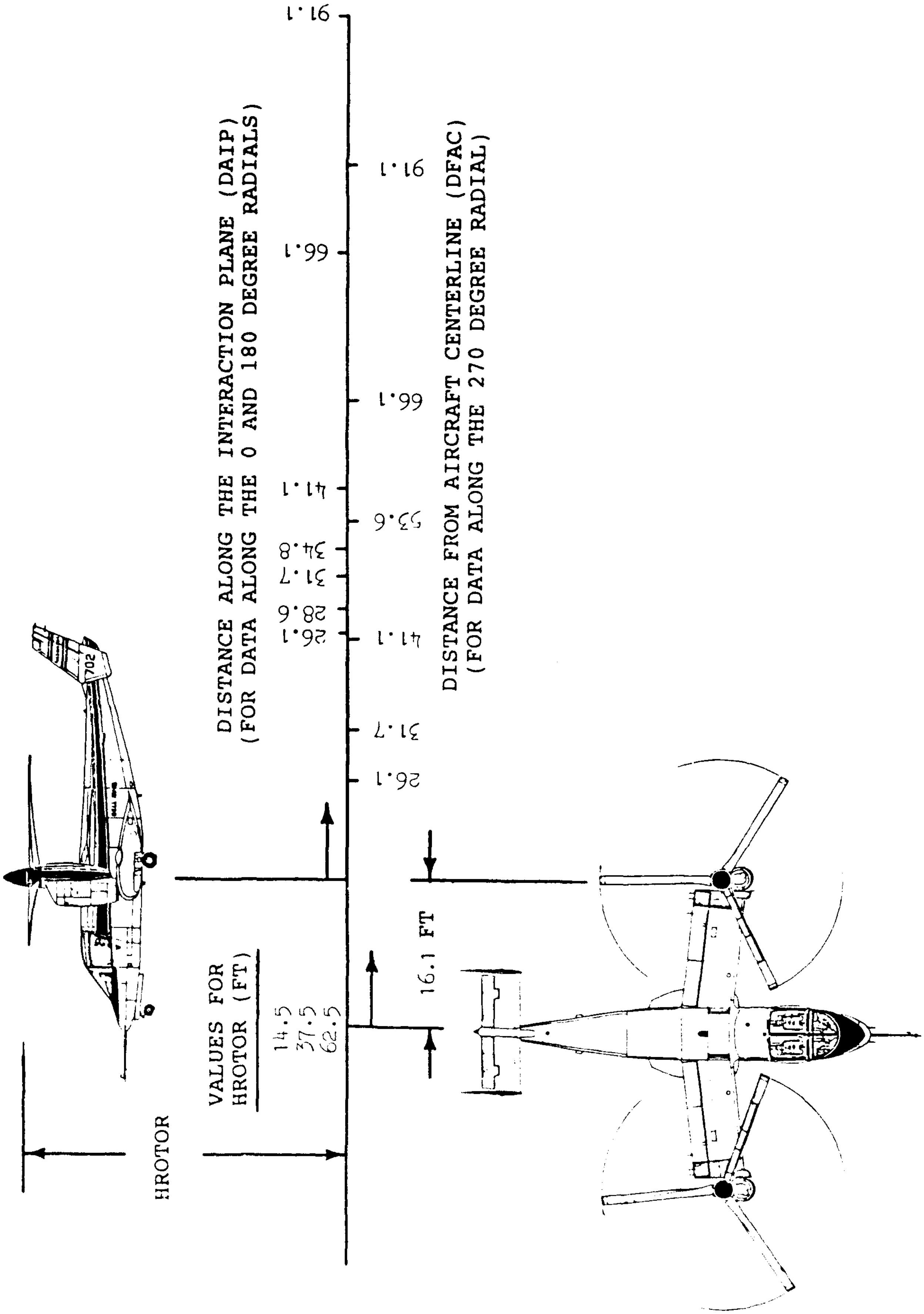


FIGURE 10 XV-15 FLIGHT TEST DATA MEASUREMENT LOCATIONS

SINGLE ROTOR VELOCITY PROFILE AT RADIUS = 50.0 FT

PROFILE BOUNDARY HEIGHT = 10.35 FT
HALF-VEL.HEIGHT = 3.70 FT
MAX-VEL HEIGHT = .72 FT

HEIGHT (FT)	MEAN VELOCITY (FPS)	MEAN VELOCITY (KN)	PEAK VELOCITY (FPS)	PEAK VELOCITY (KN)	MEAN Q (PSF)	PEAK Q (PSF)
.00	.000	.000	.000	.000	.000	.000
1.00	41.424	24.555	77.788	46.110	2.039	7.191
2.00	33.642	19.942	70.006	41.497	1.345	5.824
3.00	26.396	15.647	62.760	37.202	.828	4.681
4.00	19.903	11.798	56.267	33.353	.471	3.763
5.00	14.252	8.448	50.615	30.003	.241	3.045
6.00	9.495	5.629	45.859	27.184	.107	2.499
7.00	5.672	3.362	42.036	24.918	.038	2.100
8.00	2.811	1.666	39.175	23.222	.009	1.824
9.00	.936	.555	37.299	22.110	.001	1.653
10.00	.064	.038	36.428	21.593	.000	1.577

TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE, E<X>IT ==>

FIGURE 11 WALL JET VELOCITY PROFILE OUTPUT FORMAT

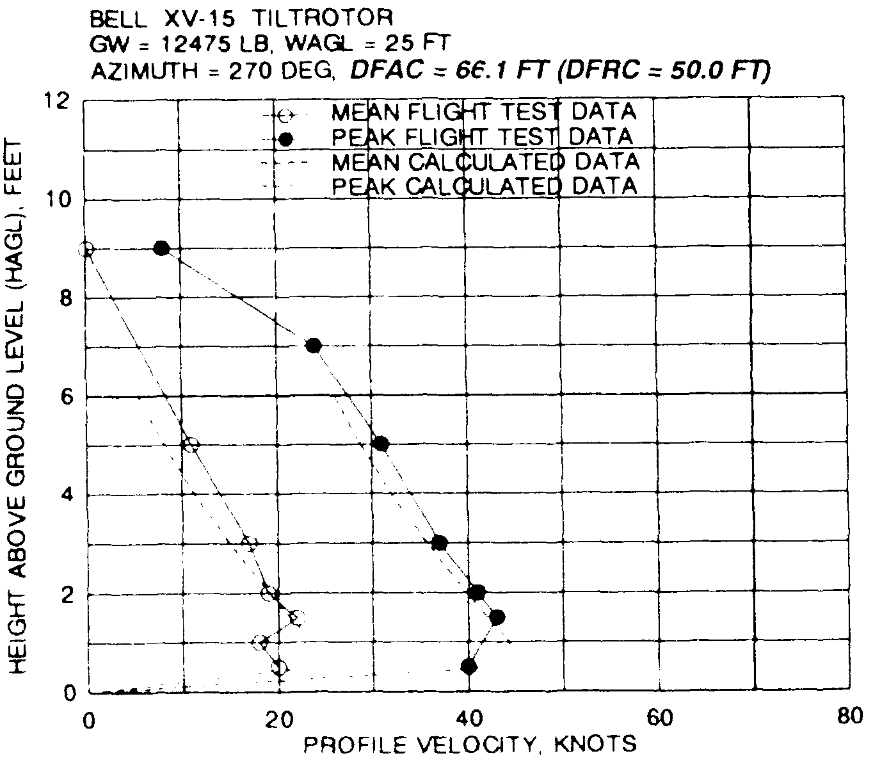


FIGURE 12 XV-15 VELOCITY PROFILE CORRELATION

The output format provides velocity profile data in units of either feet per second, knots, or pounds per square foot (also referred to as dynamic pressure).

If the specified increment in vertical height is small or the maximum calculated height is large, the quantity of data to be output to the screen may exceed the ten line limit for one screen frame. When this situation occurs, the typing of **<C>** at the prompt (at the bottom of the screen) results in the next 10 lines of data being written to the screen. If the code value **<P>** is typed, the program returns to the wall jet analysis menu. The typing of code **<N>** results in the program returning to the master input data menu. If the code **<X>** is typed, the program returns to the DOS system prompt.

Flight test data, as correlated with output from the wall jet option, are presented in references 1 and 2 for the Bell XV-15, Sikorsky CH-53E, and Canadair CL-84. Original sources for these data are references 3 through 5. As based on the correlation conducted for references 1 and 2, it is generally recommended that the wall jet option be used for calculation of velocity profiles at distances greater than 1.5 times the rotor radius from the center of the rotor. At distances less than this value, the mathematical model is not detailed enough to accurately predict rotorwash flowfield characteristics. This limitation is not serious because distances closer to the rotor tip than 1.5 times the rotor radius have little practical reason for being analyzed for rotorwash effects on the environment. Collision avoidance with respect to objects in close proximity to the rotorcraft is the critical issue at this close a distance.

2.4 THE TWIN-ROTOR INTERACTION PLANE OPTION

The twin-rotor interaction plane option calculates the velocity profile contained in the plane which is oriented perpendicular to the ground and to the line segment which connects the center of both rotor hubs (refer to figure 7). After choosing the interaction plane option on the velocity analysis option menu, the user must specify the same parameters on the velocity profile status menu that are required with the wall jet option. The only difference between the parameters is the reference position for specification of the horizontal location of the velocity profile with respect to the rotor (the first menu option). For the interaction plane analysis, this distance is referenced as zero at the intersection of the interaction plane and the line connecting the rotors and not directly to the center of one of the two rotors (i.e. the input value for distance along the interaction plane (DAIP) for a tiltrotor is along a line that is an extension of the fuselage centerline as seen in figure 10). No velocity profile differences are assumed to exist by the mathematical model for points equidistant along the interaction plane but on opposite sides of the line connecting the rotors. For a tiltrotor, this means that the calculated velocity profiles both directly in front of and directly aft of the aircraft are the same when equidistant along the interaction plane.

Example output from the interaction plane option is presented in figure 13. This data format closely resembles that of the wall jet option except that both horizontal and vertical velocity profile components are calculated. The horizontal velocity component is identified by the "H" in the column following the height column and the vertical component by the "V". The mechanics for viewing data on the screen (if more data exist than will fit on one screen frame) and for transferring to other me[illegible]s are exactly as are described for the wall jet option.

TWIN ROTOR INTERACTION PLANE VELOCITY PROFILE AT STATION = 50.0 FT

HEIGHT (FT)		MEAN VELOCITY (FPS)	MEAN VELOCITY (KN)	PEAK VELOCITY (FPS)	PEAK VELOCITY (KN)	MEAN Q (PSF)	PEAK Q (PSF)
.00	H	.000	.000	.000	.000	.000	.000
	V	.000	.000	.000	.000	.000	.000
1.00	H	59.870	35.489	106.42[illegible]	63.086	4.260	13.461
	V	20.476	12.137	36.398	21.575	.498	1.574
2.00	H	59.072	35.016	105.007	62.245	4.147	13.104
	V	21.384	12.676	38.012	22.533	.543	1.717
3.00	H	58.251	34.529	103.546	61.379	4.033	12.742
	V	22.252	13.190	39.555	23.447	.588	1.859
4.00	H	57.409	34.030	102.049	60.492	3.917	12.377
	V	23.078	13.680	41.024	24.318	.633	2.000

TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE, E<X>IT ==>

FIGURE 13 INTERACTION PLANE VELOCITY PROFILE OUTPUT FORMAT

Output from the interaction plane option, as correlated with XV-15 flight test data, is presented in figure 14 as an example. These data are excerpted from reference 2. Other original flight test data for both the Bell XV-15 and Canadair CL-84 (tiltwing) are documented in references 3 and 5.

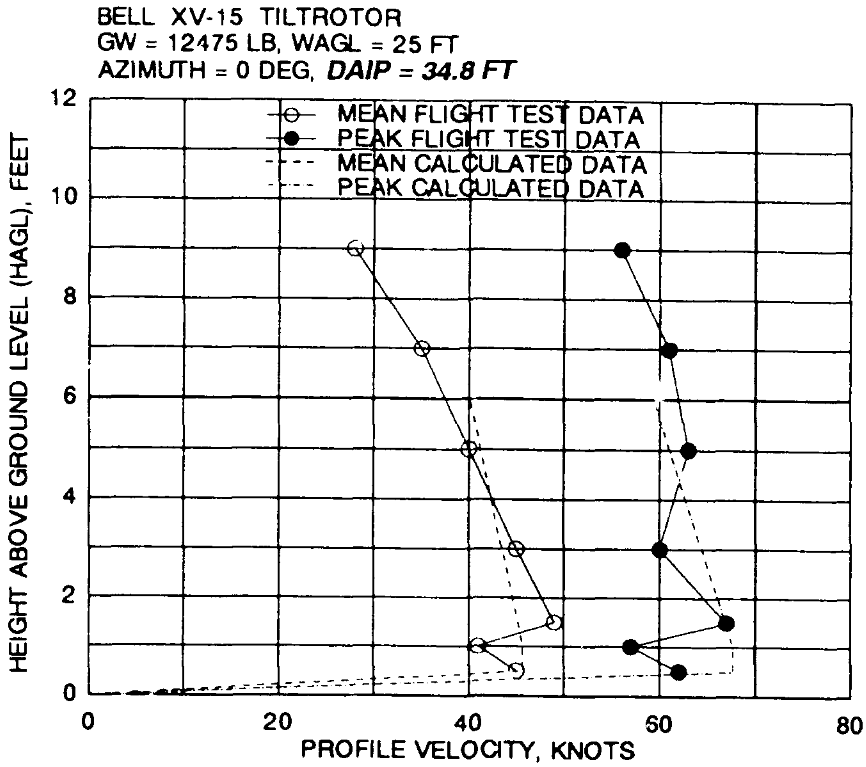


FIGURE 14 XV-15 INTERACTION PLANE VELOCITY PROFILE CORRELATION

Several practical recommendations need to be noted for users of the interaction plane option. When analyzing tiltrotor and tiltwing configurations, the user must be careful to avoid choosing analysis locations that are coincident with components of the nose or tail structure on the aircraft. Also, locations in close proximity to the nose or tail of a real aircraft should not be expected to have rotorwash flowfield characteristics identical to calculated velocity profiles. At these locations unmodeled airframe aerodynamic interferences significantly influence the rotorwash flowfield structure. Flight test data obtained from the XV-15 and CL-84 indicate that measured mean and peak velocity profiles at points equidistant along the interaction plane (both in front of and aft of an actual aircraft) often do not yield identical results as might be expected. Therefore, output from this analysis option should be calibrated with flight test data whenever possible in an attempt to determine whether positions forward or aft of the aircraft may be more critical for analysis.

2.5 GROUND VORTEX ANALYSIS OPTION

A ground vortex structure is formed when ambient wind and/or rotorcraft translational velocity overcome the rotor-induced wall jet flowfield. A diagram of the ground vortex is presented in figure 15. Due to the elementary nature of

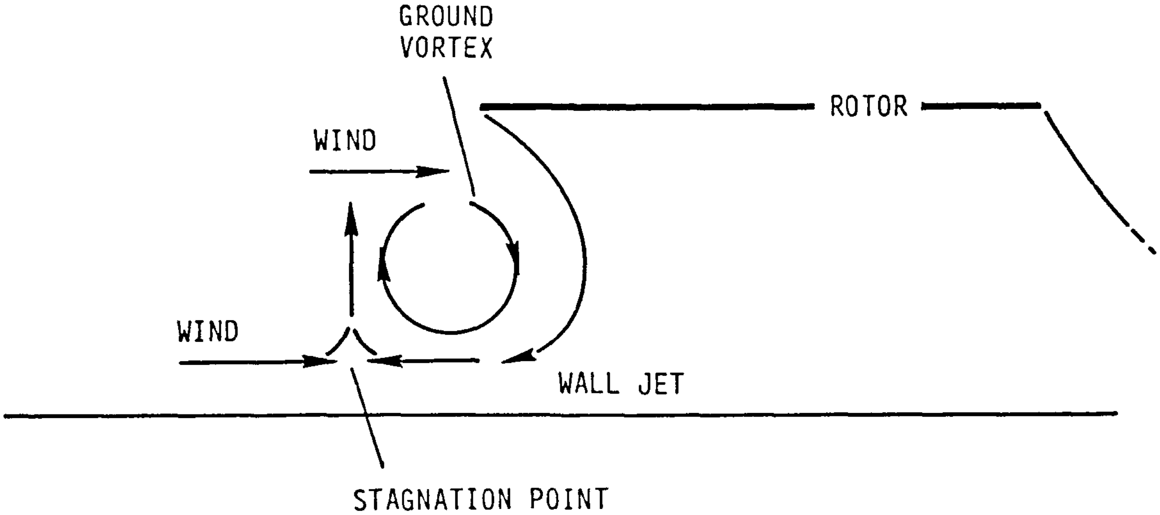


FIGURE 15 DIAGRAM OF THE GROUND VORTEX STRUCTURE

the mathematical model formulation used in the ROTWASH program, the ground vortex option should be used with caution. As discussed in reference 1, almost no test data exist to validate the mathematical model. Also, the single main rotor helicopter is the only configuration that can be analyzed with the model as presently formulated. Since all examples presented up to this point in the user's guide have been for the XV-15, it is necessary to define input data for a single main rotor helicopter before the ground vortex option is explained in detail. The Sikorsky CH-53E configuration has been chosen for this task. The main input data menu for this configuration, as typed into the program, is presented in figure 16.

The ground vortex analysis option is specified by selection of the character **<G>** on the velocity analysis option menu as shown in figure 5. The user is then required to complete the ground/disk vortex input data menu which is presented in figure 17. Two of the parameters specified on this menu are rotorcraft configuration parameters. These parameters are the rotor tip speed (ft/sec) and the number of rotor blades. The next parameter to be specified is the rotorcraft translational velocity with respect to the surrounding air mass (i.e., an input of 15 knots can be either 15 knots ground speed on a no-wind day or 0 knots

ROTWASH USER INPUT DATA MENU

CODE	PARAMETER	VALUE	UNITS
A	NUMBER OF ROTORS (1 OR 2)	1	-ND-
B	HUB TO HUB ROTOR SEPARATION	.0	FT
C	ROTOR RADIUS	39.5	FT
D	GROSS WEIGHT	56000.0	LB
E	FUSELAGE DOWNLOAD FACTOR	5.0	PCT
F	ROTOR HEIGHT ABOVE GROUND	30.0	FT
G	SHAFT TILT ANGLE (<20 DEG)	.0	DEG
H	AIR DENSITY RATIO	1.0000	ND
I	AMBIENT WIND (-10 TO 10 KT)	.0	KT

ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==>

FIGURE 16 CH-53E INPUT DATA FOR THE GROUND VORTEX EXAMPLE

GROUND/DISK VORTEX INPUT DATA MENU
(FOR SINGLE MAIN ROTOR HELICOPTERS ONLY)

CODE	PARAMETER	VALUE	UNITS
A	ROTOR TIP SPEED	600.00	FPS
B	NUMBER OF ROTOR BLADES	7.00	-ND-
C	TRANSLATIONAL SPEED	16.00	FPS
D	XT POSITION	-80.00	FT
E	YT POSITION	.00	FT
F	ZT CALCULATION INCREMENT	2.00	FT
G	MAXIMUM CALCULATION HEIGHT	10.00	FT

ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==>

FIGURE 17 GROUND/DISK VORTEX INPUT DATA MENU ground speed on a day with a 15 knot headwind). Each of these values is input with the keyboard using the same techniques that have been previously discusssed.

The next four menu parameters define the position in three-dimensional space (feet) where the velocity profile will be calculated (see figure 18). The positive directions for the coordinate system are aft and right from the center of the rotor. Therefore, in order to calculate a slice of the ground vortex directly in front of the rotor, a negative X-value (longitudinal position) is input along with a zero Y-value (lateral position). The Z-axis increment (feet) and maximum calculation height (feet) parameters define the number of points that are calculated between the ground level and the maximum height of interest.

After each input data parameter has been specified the user types the **<RETURN>** key to initiate the analysis. The response of the program is to list three calculated parameters which are followed by a prompt. An example of this response is provided in figure 19. The calculated values are the nondimensionalized rotor height above ground and two advance ratio parameters. The program prompt following the screen output requires the user to input the ground vortex strength ratio which is obtained from the graph in figure 20 using the three calculated parameters. Background on the use of this figure is discussed in Section III of reference 1. The limits presented on the graph in figure 20 define the advance ratio range wherein the ground vortex would be expected to occur. At advance ratios much less than 0.035, the ground vortex does not have favorable conditions for formation. At advance ratios slightly greater than 0.055, the ground vortex is dispersed by the rotor because the translational velocity relative to the air mass is too high for the vortex to maintain position. After the user has entered the ground vortex strength ratio, the program calculates the ground vortex circulation and the position of the ground vortex core with respect to the axis system presented in figure 18. This output is also presented in figure 19 below the prompt for the ground vortex strength ratio.

Engineering data from the ground vortex analysis option is obtained by typing the **<RETURN>** key after the vortex position parameters are displayed. An example of the output format is presented in figure 21. Calculated field velocities at the various points along the profile Z-axis are presented in both a vectorial XYZ component format and as a total resolved magnitude in both units of feet per second and knots. These same data are also provided to the user as dynamic pressures in units of pounds per square feet.

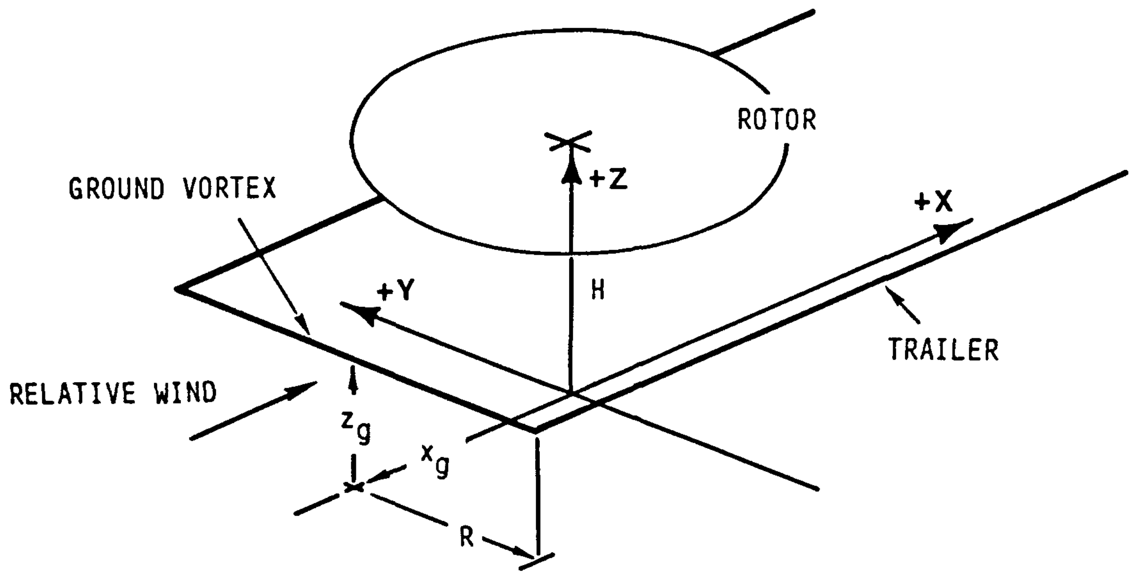


FIGURE 18 HORSE SHOE VORTEX GEOMETRY FOR THE GROUND VORTEX ANALYSIS OPTION

```
ROTOR HEIGHT ABOVE GROUND H/D          .3797
ADVANCE RATIO MU-STAR                  .5373
ADVANCE RATIO MU                       .0450


ENTER GROUND VORTEX STRENGTH RATIO
       (SEE FIGURE 18)                ==> 4.0


      GROUND VORTEX CORE POSITION

X-LOCATION (XXGV)          =    -69.51   FT
Y-LOCATION (ZZGV)          =      5.93   FT

GROUND VORTEX CIRCULATION =    1192.92   FT**2/SEC


      PRESS <RETURN> TO CONTINUE
```

FIGURE 19 GROUND VORTEX ANALYSIS INTERMEDIATE OUTPUT

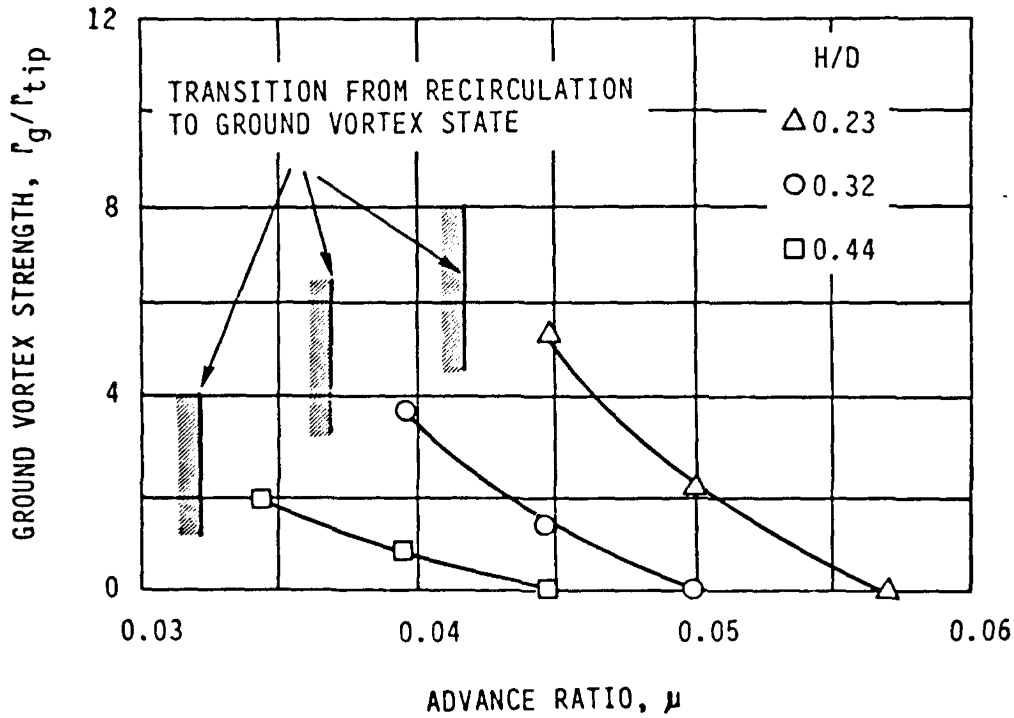


FIGURE 20 GROUND VORTEX CIRCULATION STRENGTH AS A FUNCTION OF ADVANCE RATIO

HEIGHT (FT)		MEAN VELOCITY (FPS)	(KN)	MEAN Q (PSF)
.00	X	-14.839	-8.796	.262
	Y	.000	.000	.000
	Z	.000	.000	.000
	T	14.839	8.796	.262
2.00	X	-13.988	-8.291	.233
	Y	.000	.000	.000
	Z	4.257	2.523	.022
	T	14.621	8.667	.254
4.00	X	-11.601	-6.877	.160
	Y	.000	.000	.000
	Z	7.768	4.605	.072
	T	13.961	8.276	.232

TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE, E<X>IT ==>

FIGURE 21 GROUND VORTEX VELOCITY FIELD OUTPUT DATA

2.6 DISK EDGE VORTEX ANALYSIS OPTION

The disk edge vortex analysis option was developed to provide a capability to estimate the strength of trailing vortices behind helicopters in forward flight as described by figure 22. Like the ground vortex option, this option is limited to use with the single main rotor helicopter configuration. Approximations of vortex core size are not calculated by the mathematical model and must be estimated using flight test data. Limited data are presented in section IV of reference 1. However, the FAA has recently conducted flight tests to measure additional data. Therefore, the interested researcher should be alert for future FAA publications documenting these efforts. All examples presented in the user's guide for this analysis option utilize the same CH-53E input data array that was described previously.

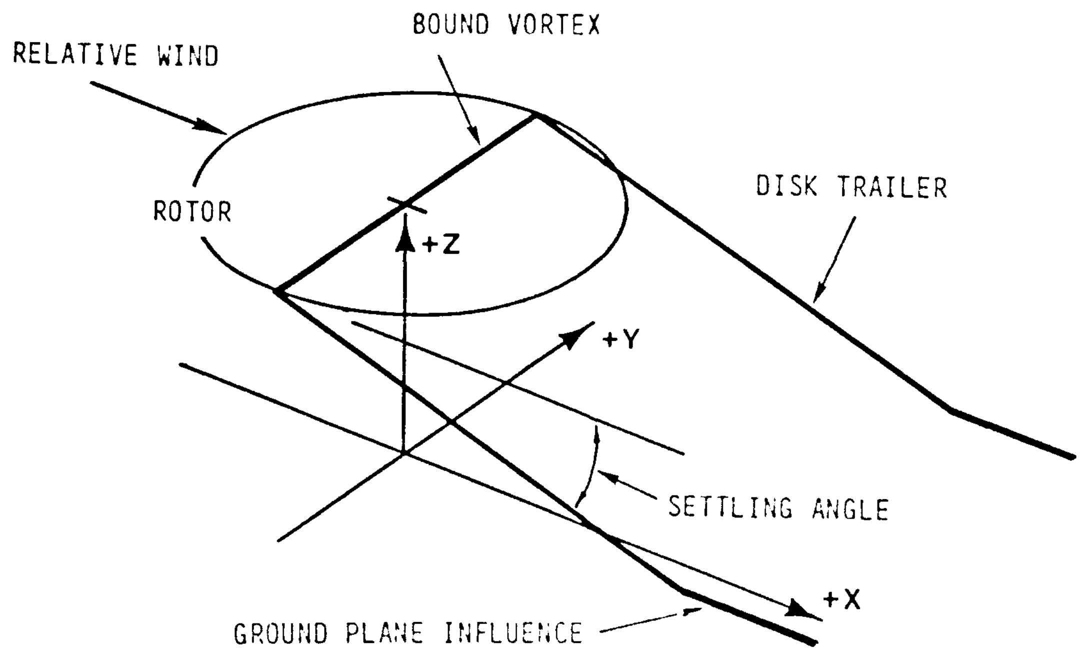


FIGURE 22 DISK EDGE VORTEX GEOMETRY DEFINITION

Execution of the disk edge vortex option is initiated by choosing **<D>** on the velocity analysis option menu shown in figure 5. The ground/disk vortex input data menu, as shown in figure 17, must then be completed as was discussed in the previous section. All sign conventions used in the specification of locations for the calculation of field velocities are the same as for the ground vortex option. After the input data menu is completed, the analysis option is executed by typing the **<RETURN>** key.

DISK VORTEX VELOCITY PROFILE DATA

```
X-LOCATION (XT)      =      150.00  FT
Y-LOCATION (YT)      =         .00  FT

VORTEX CIRCULATION =     3712.40  FT**2/SEC
SETTLING ANGLE       =        9.29  DEG
```

PRESS <RETURN> TO CONTINUE

FIGURE 23 DISK EDGE VORTEX OPTION INTERMEDIATE OUTPUT

The initial program response, figure 23, is to write to the screen the calculated values for the vortex circulation and the settling angle of the trailing vortex components as defined in figure 22. When executing this option, it is important that the user confirm that the calculated settling angle is less than approximately 45 degrees. At settling angles larger than this value, the airspeed of the helicopter is probably too slow to sustain the formation of the trailing edge vortex system which is predicted using this mathematical model, and results should be considered suspect. User specified velocity field calculations are presented after the **<RETURN>** key is typed in the same format as was discussed with the ground vortex option. An example output for the CH-53E is presented in figure 24.

Other features of the mathematical model which should be noted include:

1. The calculated trailing vortex strength does not decay as a function of increasing distance from the helicopter or with increasing time. This weakness will affect correlation with flight test data and could result in greater-than-predicted values for field velocities.

2. The decay of the trailing vortex structure after impingement with the ground is not modeled. Any prediction of field velocities significantly behind the initial impingement point should not be considered valid. The location of the impingement point with respect to the ground and

HEIGHT		MEAN VELOCITY		MEAN Q
(FT)		(FPS)	(KN)	(PSF)
.00	X	-.996	-.590	.001
	Y	.000	.000	.000
	Z	.000	.000	.000
	T	.996	.590	.001
50.00	X	-1.113	-.660	.001
	Y	.000	.000	.000
	Z	-1.933	-1.146	.004
	T	2.230	1.322	.006
100.00	X	-1.651	-.979	.003
	Y	.000	.000	.000
	Z	-6.133	-3.636	.045
	T	6.352	3.765	.048

TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE, E<X>IT ==>

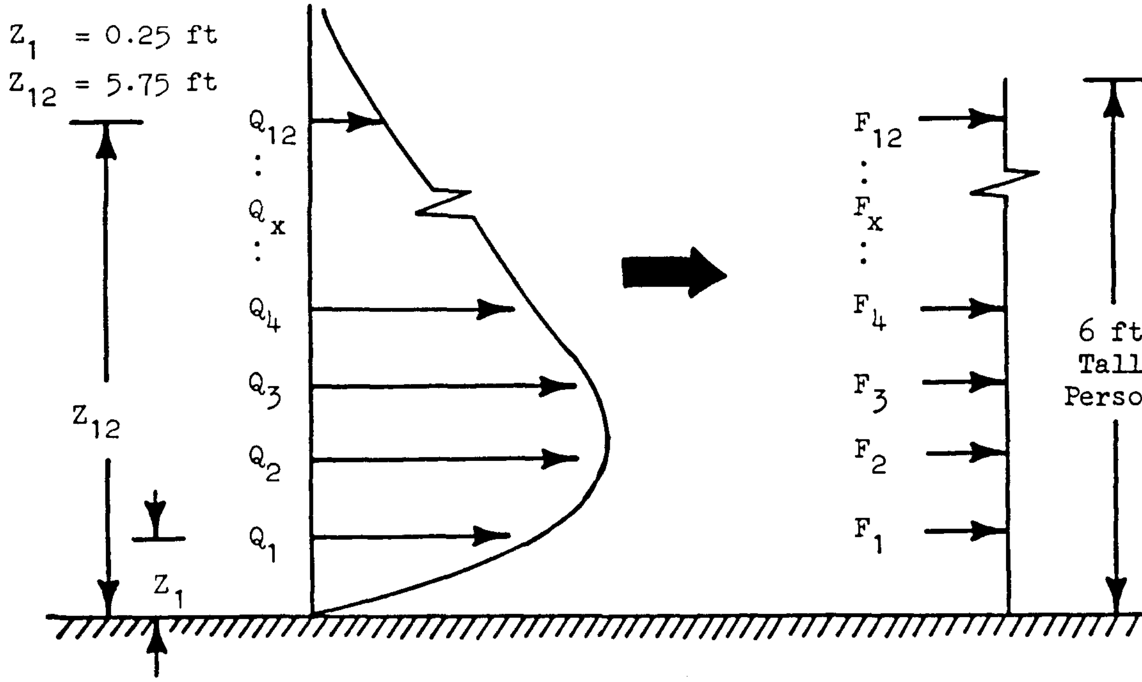
FIGURE 24 VELOCITY FIELD OUTPUT DATA FROM THE DISK EDGE VORTEX OPTION

the location of points specified for velocity field calculations must be checked by hand calculation to ensure that geometry constraints are not violated This is accomplished by using the rotor height and the settling angle to calculate the horizontal distance behind the helicopter where the impingement occurs.

2.7 PERSONNEL OVERTURNING FORCE AND MOMENT ANALYSIS

The personnel overturning force and moment analysis model is formulated for use with both the single main rotor and twin-rotor configurations. The initial task of the model is to calculate the velocity profile for a specified location. The calculated velocity profile is then integrated over the projected area of a human body to obtain estimates of the applied aerodynamic force and moment. This analysis technique is summarized by figure 25.

Use of the overturning force and moment option is initiated by choosing **<H>** on the program logic/comment menu. This is followed by the choice of **<M>** on the hazard analysis



STEPS:

(1) Calculate the dynamic pressure at twelve vertical stations.

(2) Use the dynamic pressure to calculate twelve force values (multiply each Q_x value by the projected body surface area at that Z_x value, in this case 0.5 ft by 1.1 ft).

(3) Sum the twelve individual F_x values in order to obtain the total force (F_{peak}).

(4) Multiply each F_x value by its corresponding Z_x value, and sum the incremental overturning moments to obtain the total peak moment (M_{peak}).

FIGURE 25 OVERTURNING FORCE AND MOMENT CALCULATION PROCEDURES option menu as shown in figure 6. The user then specifies the parameters listed on the overturning force and moment data menu as presented in figure 26. The first parameter on this menu specifies the use of either the wall jet or the interaction plane analysis for creation of velocity profile data. The second option specifies the use of either the "large" (six feet in height) or "small" (four feet in height) human body mathematical model. The third parameter provides the user the capability to specify a graphics output filename (assuming this option has been toggled ON using the program logic/comment menu). If the user executes the option without changing the filename and a file already exists with the same filename, the user is notified and required to change the filename. The last three menu variables define the locations that are to be analyzed using the option. These variables, all in units of feet, are the initial station position for analysis, the increment in station position, and the final station position respectively. The mechanics for input of the desired values using this menu are as described for previous menus.

```
                  OVERTURNING FORCE/MOMENT DATA MENU

 CODE              PARAMETER                      VALUE    UNITS

  A     <W>ALL JET OR <I>NTERACTION PLANE           W
  B     <L>ARGE OR <S>MALL PERSON                   L
  C     DATA OUTPUT FILENAME                    OTDFRC.PTS

  D     INITIAL STATION POSITION                  50.00     FT
  E     HORIZONTAL INCREMENT                      10.00     FT
  F     MAXIMUM STATION POSITION                 100.00     FT

ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==>
```

FIGURE 26 OVERTURNING FORCE AND MOMENT DATA MENU

After the analysis is executed by typing the **<RETURN>** key, the calculated results are written out in the format as presented in figure 27. Three columns of data are written using this format. The first column identifies either the distance from rotor center (DFRC) for the wall jet option or the distance along the interaction plane (DAIP) for the interaction plane option. The second and third columns are

SUMMARY OF OVERTURNING FORCES AND MOMENTS

RADIUS (FT)	TOTF (LB)	TOTM (FT-LB)
50.00	35.185	86.233
60.00	32.114	83.975
70.00	26.383	71.428
80.00	21.770	60.359
90.00	18.094	51.075
100.00	15.168	43.438

TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE, E<X>IT ==>

FIGURE 27 SIMPLIFIED OUTPUT FORMAT FOR THE OVERTURNING FORCE AND MOMENT ANALYSIS

the associated total force and total moment values as calculated for the projected area of a human body. Example data for the XV-15 using this option are presented in figure 28 for reference. At the bottom of the screen, the user is required to return to the previous menu by typing **<P>**, the master input data menu by typing **<N>**, or to exit the program by typing **<X>**. By typing **<C>**, the user can view the next video screen of data if more than one screen of data are generated. Otherwise, the **<C>** option works identically to the **<P>** option.

If the user needs to examine the detailed calculations used to create the summary output, he specifies the desired analysis location as the initial station position. This input is followed by specification of the increment value as 0.0 (as shown in figure 29). The resulting "large" person output using this option is presented on two screen frames as shown in figure 30. The first output frame presents a summary of the velocity profile calculations as a function of height above ground at the specified station position. The second output frame presents the associated calcultions for dynamic pressure, overturning force, and overturning moment. The last two columns in the second table are values of total force and moment as summed for the incremental increase in height.

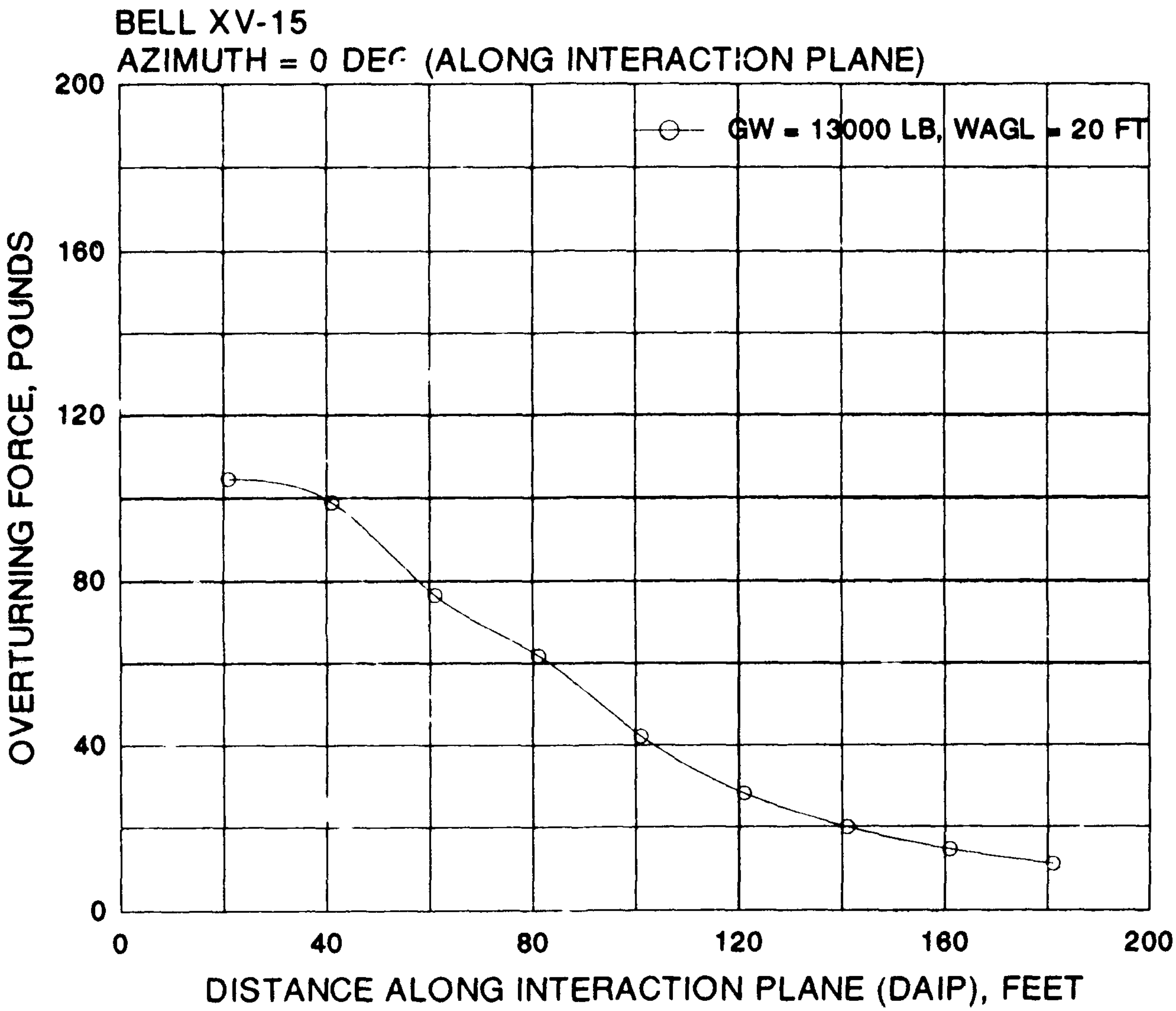


FIGURE 28 BELL XV-15 OVERTURNING FORCE AS A FUNCTION OF DISTANCE ALONG THE INTERACTION PLANE (0 DEGREE AZIMUTH)

```
                OVERTURNING FORCE/MOMENT DATA MENU

CODE            PARAMETER                          VALUE    UNITS

 A    <W>ALL JET OR <I>NTERACTION PLANE              W
 B    <L>ARGE OR <S>MALL PERSON                      L
 C    DATA OUTPUT FILENAME                       OTDFRC.PTS

 D    INITIAL STATION POSITION                     50.00     FT
 E    HORIZONTAL INCREMENT                           .00     FT
 F    MAXIMUM STATION POSITION                    110.00     FT

ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==>
```

FIGURE 29 MENU SPECIFICATION OF DETAILED FORCE/MOMENT OUTPUT

In this example, the force and moment values of 35.2 pounds and 86.2 foot-pounds respectively at 5.75 feet are the total force and moment values as would normally be printed out in the summary output (figure 27). These values are checked by totaling the individual height related values in the overturning force and moment columns (second and third columns). An example output for the second screen of the "small" person option is presented in figure 31 for reference.

Both qualitative and quantitative overturning force and moment data are presented in reference 1 as correlated with ROTWASH program output for the Bell XV-15, Sikorsky CH-53E, and the Sikorsky S-61. These calculated data all assume a coefficient of drag for a human body of 1.1 (which according to Hoerner, reference 6, can vary from 1.0 to approximately 1.3).

2.8 PARTICULATE CLOUD ANALYSIS OPTION

The methodology used in the calculation of particulate cloud size is presented in Section V of reference 1 along with a very limited amount of flight test data. This option is applicable to both single main rotor and twin-rotor configurations. The particulate cloud geometry utilized in the analysis option is presented in figure 32.

SINGLE ROTOR VELOCITY PROFILE AT RADIUS = 50.0 FT

HEIGHT (FT)	MEAN VELOCITY (FPS)	MEAN VELOCITY (KN)	PEAK VELOCITY (FPS)	PEAK VELOCITY (KN)	MEAN Q (PSF)	PEAK Q (PSF)
.25	37.456	22.203	73.819	43.758	1.667	6.476
.75	43.341	25.691	79.704	47.246	2.232	7.550
1.25	39.457	23.389	75.820	44.944	1.850	6.832
1.75	35.553	21.075	71.917	42.630	1.502	6.147
2.25	31.768	18.831	68.132	40.386	1.199	5.517
2.75	28.142	16.682	64.506	38.237	.941	4.945
3.25	24.698	14.640	61.062	36.195	.725	4.431
3.75	21.450	12.715	57.814	34.270	.547	3.972
4.25	18.409	10.912	54.773	32.467	.403	3.565
4.75	15.582	9.237	51.946	30.792	.289	3.207
5.25	12.977	7.692	49.341	29.248	.200	2.893
5.75	10.598	6.282	46.962	27.837	.133	2.621

TYPE <RETURN> TO CONTINUE

SINGLE ROTOR FORCE PROFILE AT RADIUS = 50.0 FT

HEIGHT (FT)	PEAK Q (PSF)	FOVER (LB)	OVERM (FT-LB)	TOT F (LB)	TOT M (FT-LB)
.25	6.476	3.918	.980	3.918	.980
.75	7.550	4.568	3.426	8.486	4.405
1.25	6.832	4.133	5.167	12.619	9.572
1.75	6.147	3.719	6.508	16.338	16.080
2.25	5.517	3.338	7.510	19.676	23.589
2.75	4.945	2.992	8.227	22.667	31.817
3.25	4.431	2.681	8.713	25.348	40.530
3.75	3.972	2.403	9.012	27.752	49.542
4.25	3.565	2.157	9.167	29.909	58.709
4.75	3.207	1.940	9.216	31.849	67.925
5.25	2.893	1.750	9.190	33.599	77.115
5.75	2.621	1.586	9.118	35.185	86.233

TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE, E<X>IT ==>

FIGURE 30 DETAILED OUTPUT FORMAT FOR THE "LARGE" PERSON ANALYSIS OPTION

SINGLE ROTOR FORCE PROFILE AT RADIUS = 50.0 FT

HEIGHT (FT)	PEAK Q (PSF)	FOVER (LB)	OVERM (FT-LB)	TOT F (LB)	TOT M (FT-LB)
.25	6.476	2.493	.623	2.493	.623
.75	7.550	2.907	2.180	5.400	2.803
1.25	6.832	2.630	3.288	8.030	6.091
1.75	6.147	2.366	4.141	10.397	10.233
2.25	5.517	2.124	4.779	12.521	15.011
2.75	4.945	1.904	5.236	14.425	20.247
3.25	4.431	1.706	5.545	16.131	25.792
3.75	3.972	1.529	5.735	17.660	31.527

TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE, E<X>IT ==>

FIGURE 31 DETAILED OUTPUT FORMAT FOR THE SECOND SCREEN FRAME OF THE "SMALL" PERSON ANALYSIS OPTION

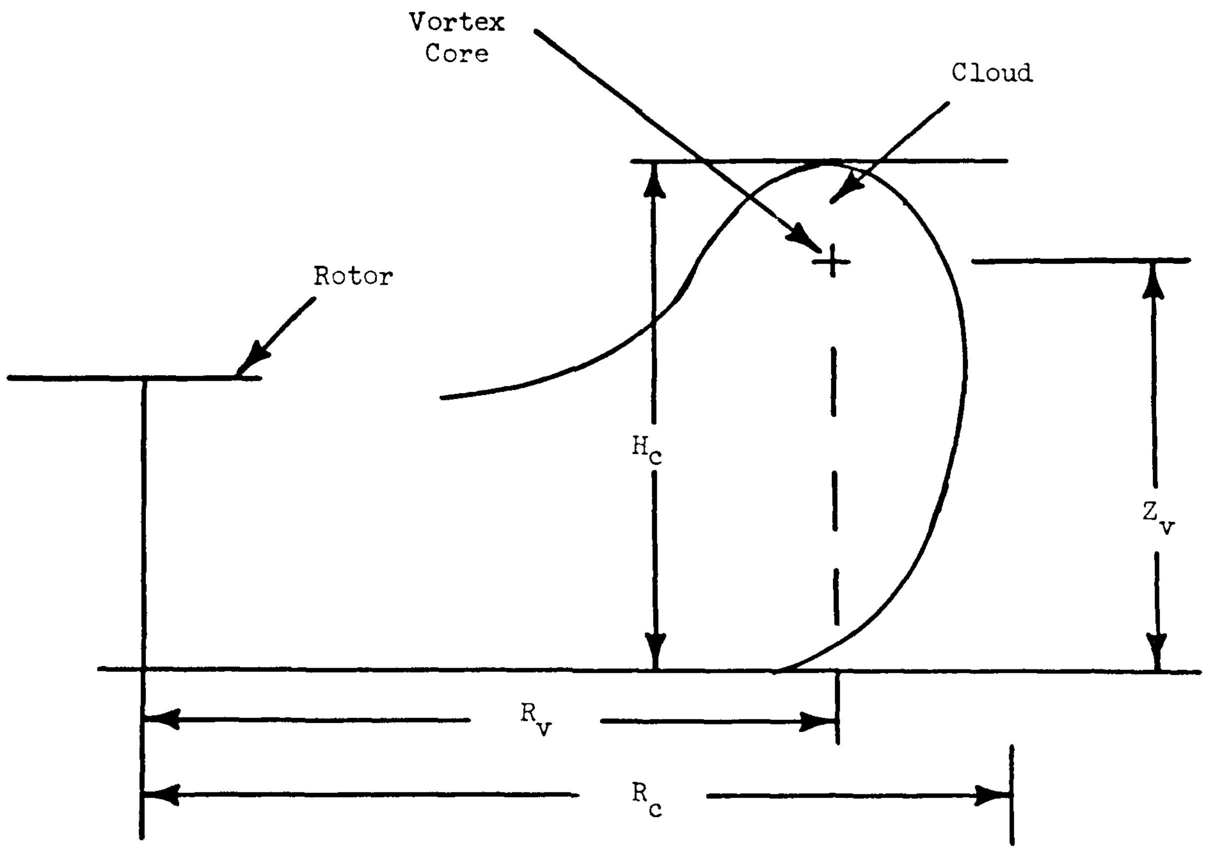


FIGURE 32 PARTICULATE CLOUD ANALYSIS GEOMETRY DEFINITION

The particulate cloud option is initiated with the typing of <C> on the hazard analysis option menu as shown in figure 6. The screen that is subsequently written presents the user with a prompt for input of the terrain erosion factor. The value for this factor is chosen from the graph in figure 33.

The output format for the particulate cloud option is designed for both single main rotor and twin-rotor aircraft as shown in figure 34. In this example, using the XV-15, the particulate cloud boundaries located at the 90 and 270 degree azimuths (out the span of the wing) are specified by the single rotor or "SR" row of output values. The interaction plane or "IP" row defines the cloud boundaries which exist straight out in front of and directly aft of the aircraft along the aircraft centerline. If a single main rotor configuration is being evaluated, the "IP" row in the printout will contain all zeros.

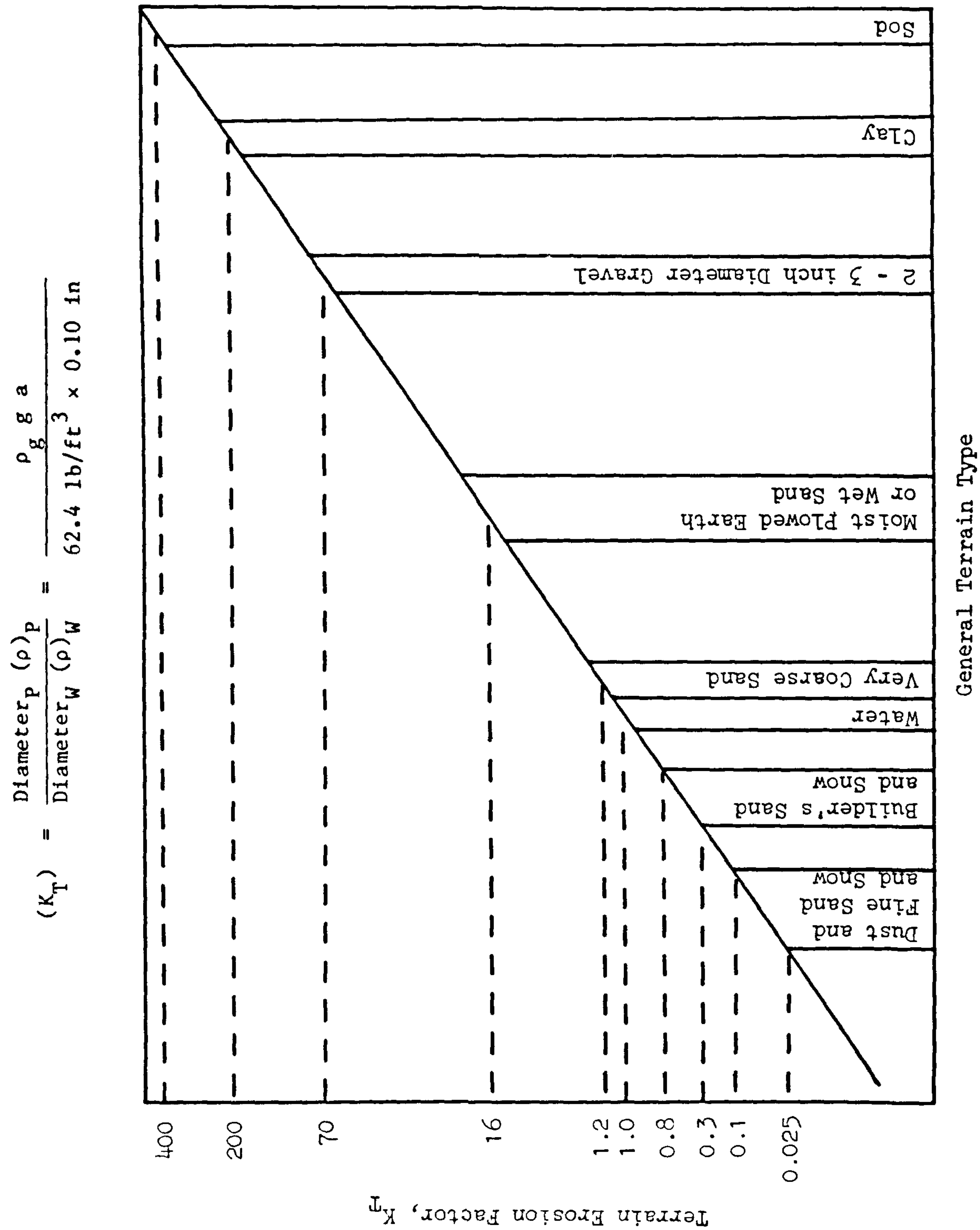


FIGURE 33 APPROXIMATE VALUES FOR THE TERRAIN EROSION FACTOR AS A FUNCTION OF TERRAIN TYPE

```
ENTER TERRAIN EROSION FACTOR (-ND-) ==> 0.4

                SUMMARY OF CLOUD BOUNDARIES

            RC AND RV ARE FROM ROTOR CENTER (FT)

            RC          RV          ZV          HC

SR         87.0        68.3        28.6        40.9
IP        122.8        96.4        40.4        57.7

QSMAX =    12.7 PSF


TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE, E<X>IT ==>
```

FIGURE 34 PARTICULATE CLOUD ANALYSIS OPTION OUTPUT

3.0 ROTWASH PROGRAM DATA OUTPUT FILE FORMATS

Four data output file formats can be specified from the ROTWASH program for use with computer graphics programs. Two of these output file formats are generated by the wall jet and interaction plane velocity profile analysis options. The other two formats are generated by the personnel overturning force and moment option. These file formats save the summary force and moment data for both the wall jet and interaction plane cases.

The first two lines in each of the four file formats are user-specified comments. These two comment lines are typed in through use of the program logic/comment menu. The rest of the data in each of the file formats is either header information or engineering data. The example files presented in this section are written for direct input to the TECPLOT Graphics Program which is written by AMTEC Engineering. This graphics program is one of several IBM PC/PC-compatible engineering graphics programs presently on the market. If the user does not have access to this program, he can easily modify the ROTWASH FORTRAN code for other types of graphics programs by modifying the appropriate write statements. Table 1 provides the user with a cross reference of the figure number for each of the four output types and the source location for the associated FORTRAN code that can be modified (see program listings in Appendix C).

TABLE 1 GRAPHICS FILE / SOURCE CODE REFERENCE MATRIX

FILE OUTPUT TYPE	FIGURE	SOURCE CODE LOCATION
Wall Jet Velocity Profile Output	35	Subroutine WJVEL
Interaction Plane Velocity Profile Output	36	Subroutine IPVEL
Overturning Force/Moment Summary (Wall Jet)	37	Subroutine HWJVEL
Overturning Force/Moment Summary (Interaction Plane)	38	Subroutine HIPVEL

BELL XV-15 CHARACTERISTICS ARE USED AS INPUT DATA
GROSS WEIGHT MIGHT BE ONE OF THE COMMENT STRINGS

```
TITLE="SINGLE ROTOR, DFRC = 50.00 FT, GW = 13500 LB, RAGL = 25 FT"
VARIABLES = X,HT
ZONE T = "MEAN PROFILE, KTS", I=11, F=POINT
    .0    .0
  24.6   1.0
  19.9   2.0
  15.6   3.0
  11.8   4.0
   8.4   5.0
   5.6   6.0
   3.4   7.0
   1.7   8.0
    .6   9.0
    .0  10.0
ZONE T = "PEAK PROFILE, KTS", I=11, F=POINT
    .0    .0
  46.1   1.0
  41.5   2.0
  37.2   3.0
  33.4   4.0
  30.0   5.0
  27.2   6.0
  24.9   7.0
  23.2   8.0
  22.1   9.0
  21.6  10.0
ZONE T = "PEAK Q, PSF", I=11, F=POINT
    .0    .0
   7.2   1.0
   5.8   2.0
   4.7   3.0
   3.8   4.0
   3.0   5.0
   2.5   6.0
   2.1   7.0
   1.8   8.0
   1.7   9.0
   1.6  10.0
```

FIGURE 35 EXAMPLE WALL JET OPTION GRAPHICS FILE FORMAT

BELL XV-15 CHARACTERISTICS ARE USED AS INPUT DATA
GROSS WEIGHT MIGHT BE ONE OF THE COMMENT STRINGS

```
TITLE="TWIN ROTOR, DAIP = 50.00 FT, GW = 13500 LB, RAGL = 25 FT"
VARIABLES = X,HT
ZONE T = "MEAN PROFILE, KTS", I=11, F=POINT
     .0     .0
   35.5    1.0
   35.0    2.0
   34.5    3.0
   34.0    4.0
   33.5    5.0
   33.0    6.0
   32.5    7.0
   31.9    8.0
   31.4    9.0
   30.9   10.0
ZONE T = "PEAK PROFILE, KTS", I=11, F=POINT
     .0     .0
   63.1    1.0
   62.2    2.0
   61.4    3.0
   60.5    4.0
   59.6    5.0
   58.7    6.0
   57.7    7.0
   56.8    8.0
   55.8    9.0
   54.9   10.0
ZONE T = "PEAK Q, PSF", I=11, F=POINT
     .0     .0
   13.5    1.0
   13.1    2.0
   12.7    3.0
   12.4    4.0
   12.0    5.0
   11.6    6.0
   11.3    7.0
   10.9    8.0
   10.5    9.0
   10.2   10.0
```

FIGURE 36 EXAMPLE INTERACTION PLANE OPTION GRAPHICS FILE FORMAT

BELL XV-15 CHARACTERISTICS ARE USED AS INPUT DATA
GROSS WEIGHT MIGHT BE ONE OF THE COMMENT STRINGS

```
TITLE="SINGLE ROTOR DFRC DATA"
VARIABLES = DFRC,TOTF,TOTM
ZONE T = "GW = 13500 LB, RAGL = 25 FT", I=7, F=POINT
  50.00    35.18    86.23
  60.00    32.11    83.97
  70.00    26.38    71.43
  80.00    21.77    60.36
  90.00    18.09    51.08
 100.00    15.17    43.44
 110.00    12.84    37.20
```

FIGURE 37 EXAMPLE PERSONNEL OVERTURNING FORCE AND MOMENT GRAPHICS FILE FORMAT CREATED WITH THE WALL JET ANALYSIS OPTION

BELL XV-15 CHARACTERISTICS ARE USED AS INPUT DATA
GROSS WEIGHT MIGHT BE ONE OF THE COMMENT STRINGS

```
TITLE="TWIN ROTOR DAIP DATA"
VARIABLES = DAIP,TOTF,TOTM
ZONE T = "GW = 13500 LB, RAGL = 25 FT", I=7, F=POINT
  50.00   90.16   268.97
  60.00   79.31   239.89
  70.00   70.66   215.84
  80.00   63.81   196.36
  90.00   55.54   172.08
 100.00   44.15   137.68
 110.00   35.78   112.18
```

FIGURE 38 EXAMPLE PERSONNEL OVERTURNING FORCE AND MOMENT GRAPHICS FILE FORMAT CREATED WITH THE INTERACTION PLANE ANALYSIS OPTION

REFERENCES

1. Ferguson, S.W., and J.D. Kocurek, "Analysis and Recommendation of Separation Requirements for Rotorcraft Operation at Airports and Heliports," Systems Technology, Inc, Report TR-1224-1, September 1986.

2. Ferguson S.W., "Evaluation of Rotorwash Characteristics for Tiltrotor and Tiltwing Aircraft in Hovering Flight," U.S. Department of Transportation, Federal Aviation Administration, DOT/FAA/RD-90/16, December 1990.

3. Harris, D.J., and R.D. Simpson, "Technical Evaluation of the Rotor Downwash Flow Field of the XV-15 Tilt Rotor Research Aircraft," Naval Air Test Center, Technical Report No. SY-14R-83, July 1983.

4. Harris, D.J., and R.D. Simpson, "CH-53E Helicopter Downwash Evaluation. Final Report," Naval Air Test Center, Technical Report No. SY-89R-78, August 1978.

5. Harris, D.J., and R.D. Simpson, "CL-84 Tilt-Wing Vertical and Short Takeoff and Landing Downwash Evaluation. Final Report," Naval Air Test Center, Technical Report No. SY-52R-76, April 1976.

6. Hoerner, S.F., <u>Fluid-Dynamic Drag</u>, Published by Author, 1958.

APPENDIX A

LETTER REPORT, OBLIQUE IMPINGEMENT OF ROTOR DOWNWASH WITH THE GROUND PLANE

EMA *Rotorcraft / Aerodynamic Analysis*

800 Muirfield Drive
Mansfield, Texas 76063
Telephone (817) 473-4820

July 20, 1990

Mr. Robert D. Smith
Federal Aviation Administration
ARD-30, Vertical Flight Program Office
800 Independence Ave., S.W.
Washington D.C. 20591

SUBJECT: Letter Report, Oblique Impingement of Rotor Downwash with the Ground Plane

REFERENCES:

(1) Ferguson, S.W., "Analysis and Recommendation of Separation Requirements for Rotorcraft Operation at Airports and Heliports", Systems Technology, Inc., STI Report TR-1224-1, September 1986.

(2) Ferguson, S.W., and Dr. J. David Kocurek, "ROTWASH Computer Model - User's Guide", EMA, EMA TR-87-5-1, July 1990.

(3) Watts, A., "V/STOL Downwash Impingement Study, Velocity Estimate", Canadair Limited, Memorandum MAA-284-001, April 1971.

BACKGROUND

A methodology which predicts the rotorwash characteristics of hovering helicopter, tiltrotor, and tiltwing aircraft was developed in 1986 in reference 1. This analysis methodology is fundamentally based upon momentum theory and the assumption (which is acceptable for most scenarios) that the hovering rotor is contained within a plane parallel to the surface of the ground. Two scenarios where this assumption does not apply are the initial segment of a departure from hover and the final segment of a deceleration to hover where zero forward velocity is obtained. During these very short intervals of time, the pilot is commanding a rotor thrust level in excess of that required to hover. This is because the tip path plane of the rotor is tilted in such a way as to either command an increase in forward airspeed (a departure from hover to forward flight) or a decrease in airspeed (a flare to a hover from forward flight). A third scenario where the assumption does not apply involves analyses of hovering tiltwing aircraft where the wing is tilted either forward or aft of the vertical. In these situations, the pitch propeller or fan is used to trim out the pitching moment generated by the tilted wing (In contrast, hovering tiltrotor aircraft always have the plane of the rotor parallel to the ground because pitching moments can not be trimmed out. If the nacelle angle is varied, the pitch attitude must also vary).

METHODOLOGY IMPROVEMENTS

Since the developed methodology was incapable of analyzing scenarios involving tilted rotor tip path planes in hover, an effort was initiated in 1989 to develop a solution for this problem. Technical aspects of this effort are documented in this letter report. Modifications to the user interface of the rotorwash analysis computer software (ROTWASH program) are documented in reference 2.

The technical approach used to modify the reference 1 mathematical model to include tilted tip path plane effects is generally based upon work documented in reference 3. This technical approach was developed using experimental results which are referenced in the memorandum. Unfortunately, no effort was made to document any correlation of results with the mentioned experimental data. This mathematical modeling approach is graphically described using figures 1 through 3. A hovering helicopter at a given gross weight, rotor radius of R feet, and rotor height of H feet (figure 1) generates a mean induced velocity v_i or dynamic pressure q_A across the rotor disk. If the plane of the rotor is parallel to the ground, the stream tube of air is turned 90 degrees upon impact with the ground and a circular wall jet flowfield forms at position x_o. A three-dimensional view of this process is presented in figure 2. As the horizontal position of the wall jet is increased to a value of x_m, the peak velocity V_m in the wall jet slowly decays. If the rotor tip path plane is tilted slightly, the effect depicted in figure 3 must be modeled. In this scenario, assuming the center of the rotor is in the same position, the impingement point of the stream tube moves further aft as the rotor tip path plane is tilted further forward. This shift of the impingement point also increases the distance x_o, the location where the wall jet begins. Therefore, for any fixed distance x_m, the maximum profile velocity V_m is increased when the tilt angle is increased.

Modifications required to add the improvements to the reference 1 mathematical model are easy to implement. The user first defines the angle that the tip path plane will be tilted. This angle, ϕ , is then used to calculate the shift in the impingement point of the mean value of the rotor downwash. The corrected length to the impingement point, H_ϕ , is:

$$H_\phi = H / \cos\phi$$

The horizontal shift in the location of the point is:

$$\Delta x_o = H * \tan\phi$$

Analytically, the effect of the parameter H_ϕ is the same as a change in the altitude of the rotor above ground level when the tip path plane is not tilted. The effect of the parameter Δx_o is to shift the location of the formation (and strength) of the wall jet further away from the rotor.

Two practical constraints exist with respect to the use of the tilted tip path plane mathematical model improvements. The first of these constraints is related to a lack of available test data for correlation with the model. At some as yet undetermined impingement angle, the wall jet flowfield will cease to form as a circular three-dimensional flowfield. When this angle is exceeded, the mathematical model described reference 1 will cease to be valid. Since the critical angle is presently unknown, it is recommended that tilt angles greater than 30 degrees be avoided until flight test data become available for correlation. This recommendation is not based on any particular body of data, only experience in the analysis of rotorcraft.

A second model constraint exists due to the fact that the model is not designed for use in the analysis of dynamic maneuvers such as a takeoff. The model can only be used during very specific segments of these maneuvers where airspeed is essentially zero. Steady flow assumptions inherent to the model are "assumed" to be valid if the output data are viewed as snapshots of conditions generated during the maneuver. The model must also be used with <u>caution</u> since flight test data are not yet available for correlation. The segment of the takeoff maneuver which can be analyzed is the initial pushover from hover. At this point in the maneuver, airspeed is still essentially zero and the tip path plane is tilted forward to accelerate the rotorcraft. This phase of the maneuver also requires an increase in rotor thrust above that required to hover in order to avoid ground contact. Therefore, the user must know something about the gross weight of the rotorcraft and the thrust-power relationships involved to make practical use of the model for this segment of the takeoff maneuver. During a landing, the final phase of the flare manuever which is near zero airspeed can also be analyzed. During this phase of the maneuver, the rotor is tilted back very close to its maximum position and the thrust level used to maintain altitude while decelerating is at its maximum.

EXAMPLE CASE

The effect of adding the rotor tip path plane feature to the reference 1 mathematical model is demonstrated in this section through an example using a Bell UH-1H helicopter. A three-view of the UH-1H is presented in figure 4. The gross weight of the UH-1H in the example is 9500 pounds and the height above ground level of the rotor is 40 feet.

Results from calculations for hover and the initiation of a takeoff with a 20 degree forward tilt of the tip path plane are presented in figure 5. The hover rotorwash profile characteristics are depicted by the solid lines and are provided for distances of 50, 100, and 150 feet from the center of the rotor. Peak profile velocities vary from approximately 48 knots at 0.5 feet above the ground to 22 knots at 2 feet for the 50 and 150 feet radial positions respectively. If the UH-1H accelerates from hover at a tip path plane of 20 degrees, then the pilot must increase thrust (through the collective stick) to approximately 10500 pounds to maintain at least a constant altitude above the ground. Calculated results at the instant the rotor stabilizes at the 20 degree position are represented by the dashed lines. Peak profile velocities at the 50 and 150 feet radial positions are increased by approximately 9 and 4 knots respectively.

CONCLUSIONS

A simple model has been developed to approximate the effects of a tilt in the rotor tip path plane on rotorwash characteristics in close proximity to the ground. This model has been integrated into the ROTWASH computer program and tested with example cases. Unfortunately, at this time appropriate flight test data do not exist which can be used for correlation purposes. These data will have to be acquired and correlated with the improved mathematical model before any further improvements can be made.

Sam Ferguson

Samuel W. Ferguson, EMA

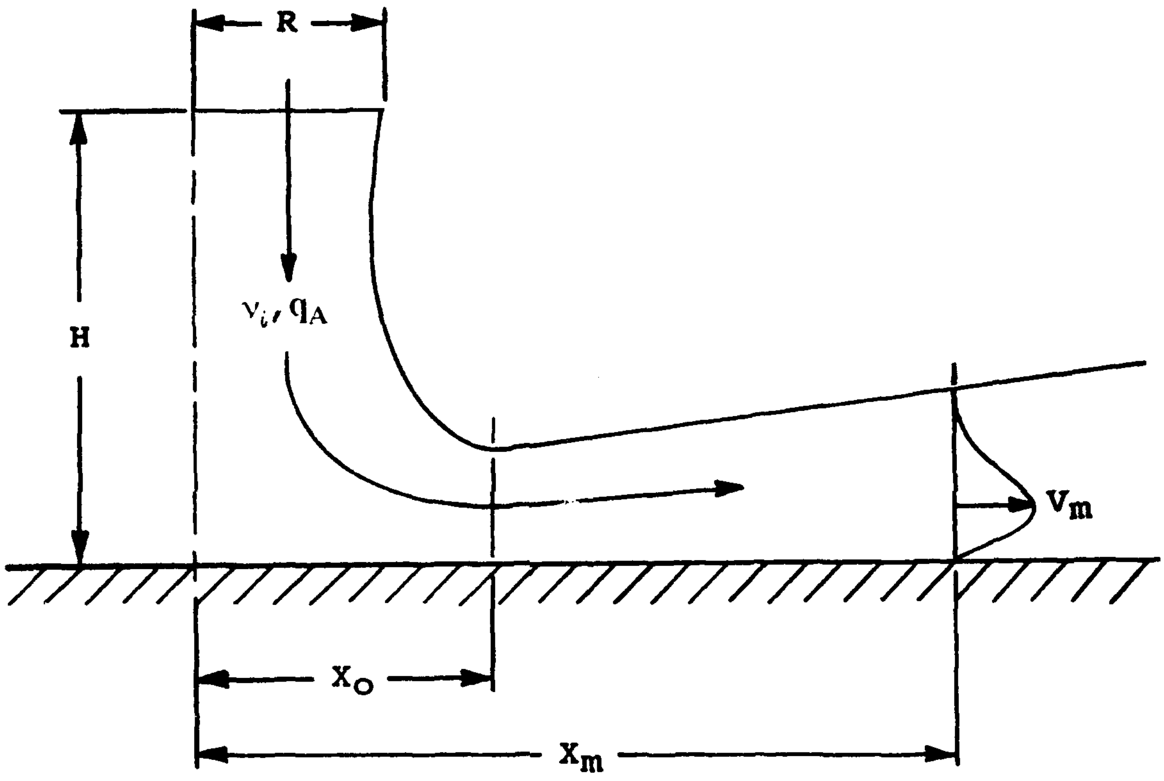


FIGURE 1 ROTORWASH FLOW FIELD CHARACTERISTICS FOR A ROTOR TIP PATH PLANE PARALLEL TO THE GROUND

SINGLE ROTOR CONFIGURATION

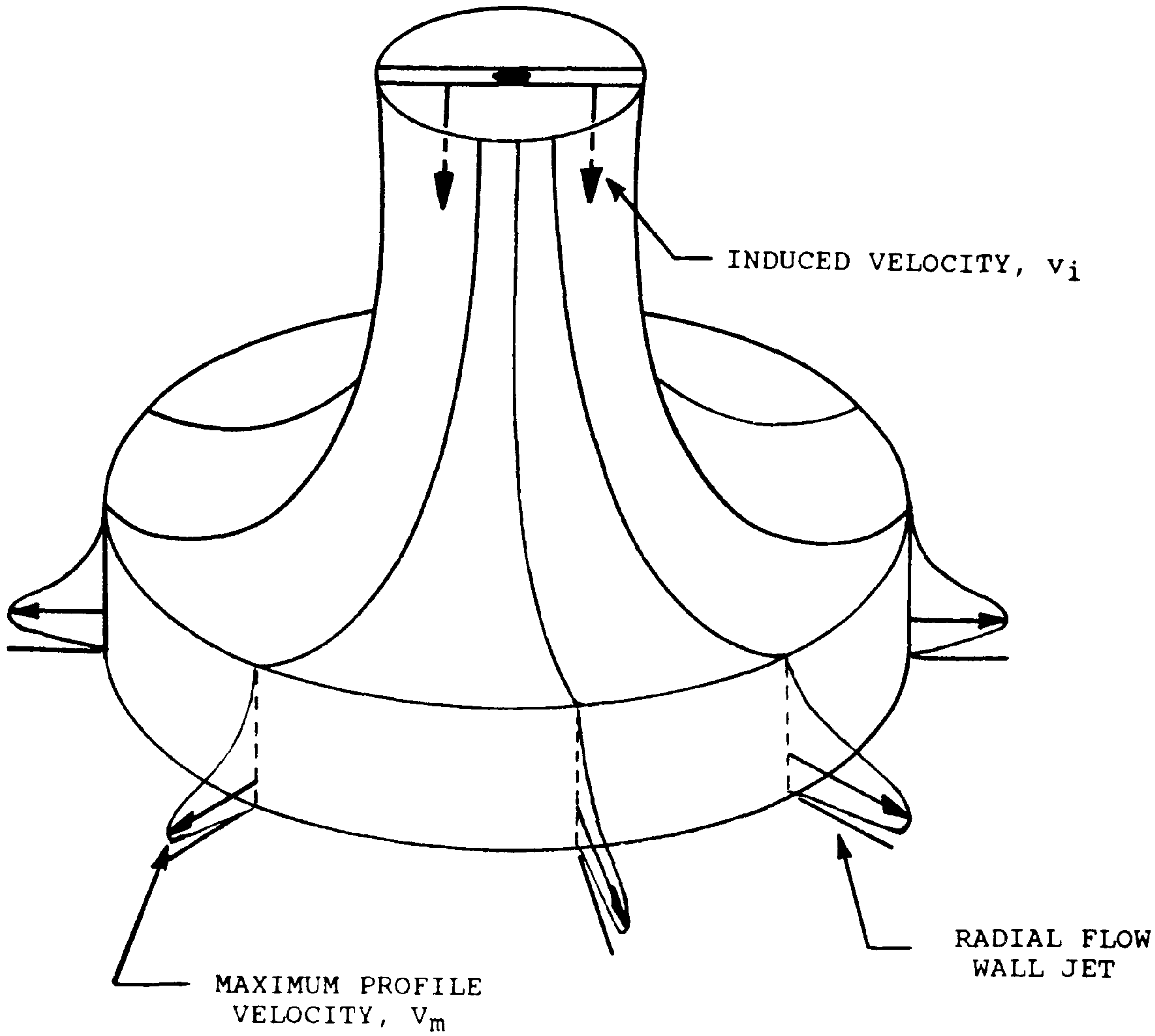


FIGURE 2 THREE-DIMENSIONAL ROTORWASH FLOW FIELD CHARACTERISTICS FOR A ROTOR TIP PATH PLANE PARALLEL TO THE GROUND

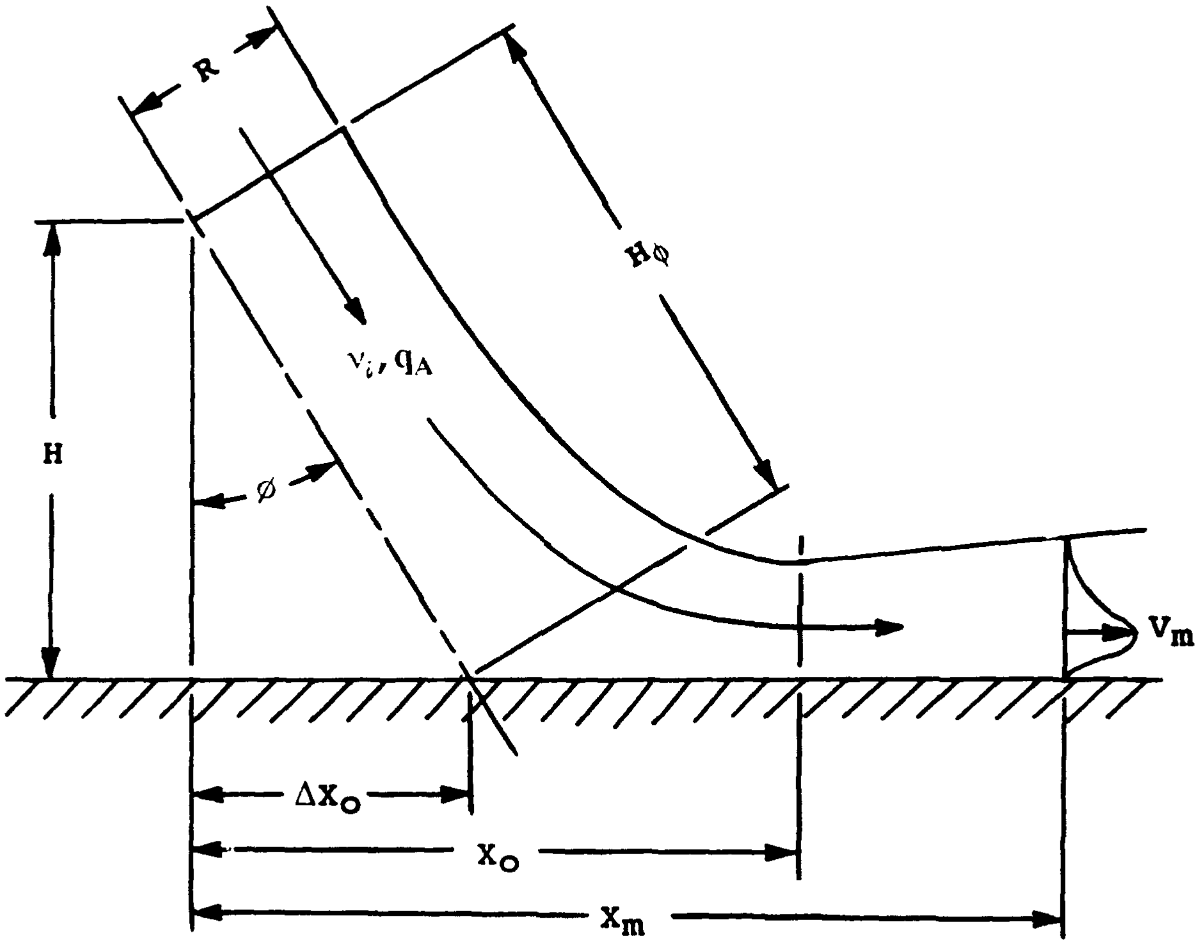


FIGURE 3 ROTORWASH FLOW FIELD CHARACTERISTICS FOR A ROTOR TIP PATH PLANE WHICH IS TILTED FORWARD WITH RESPECT TO A PLANE PARALLEL TO THE GROUND

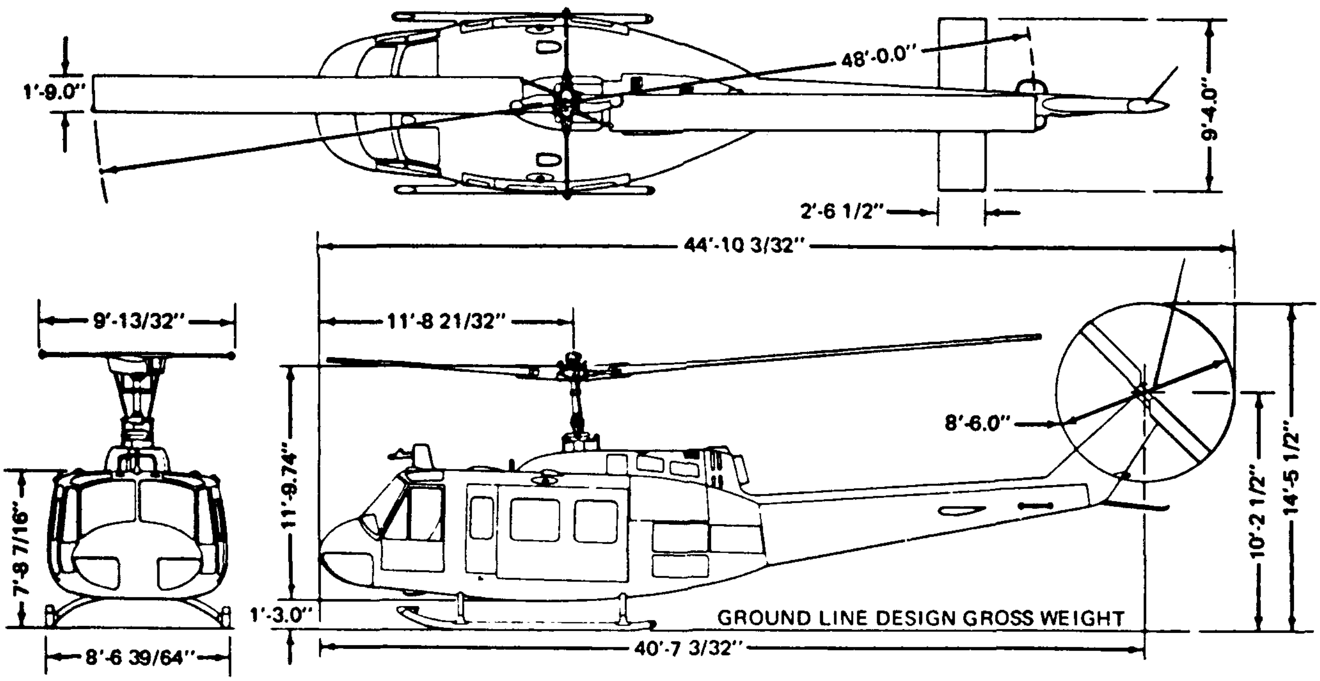


FIGURE 4 THREE-VIEW OF A BELL UH-1H UTILITY HELICOPTER

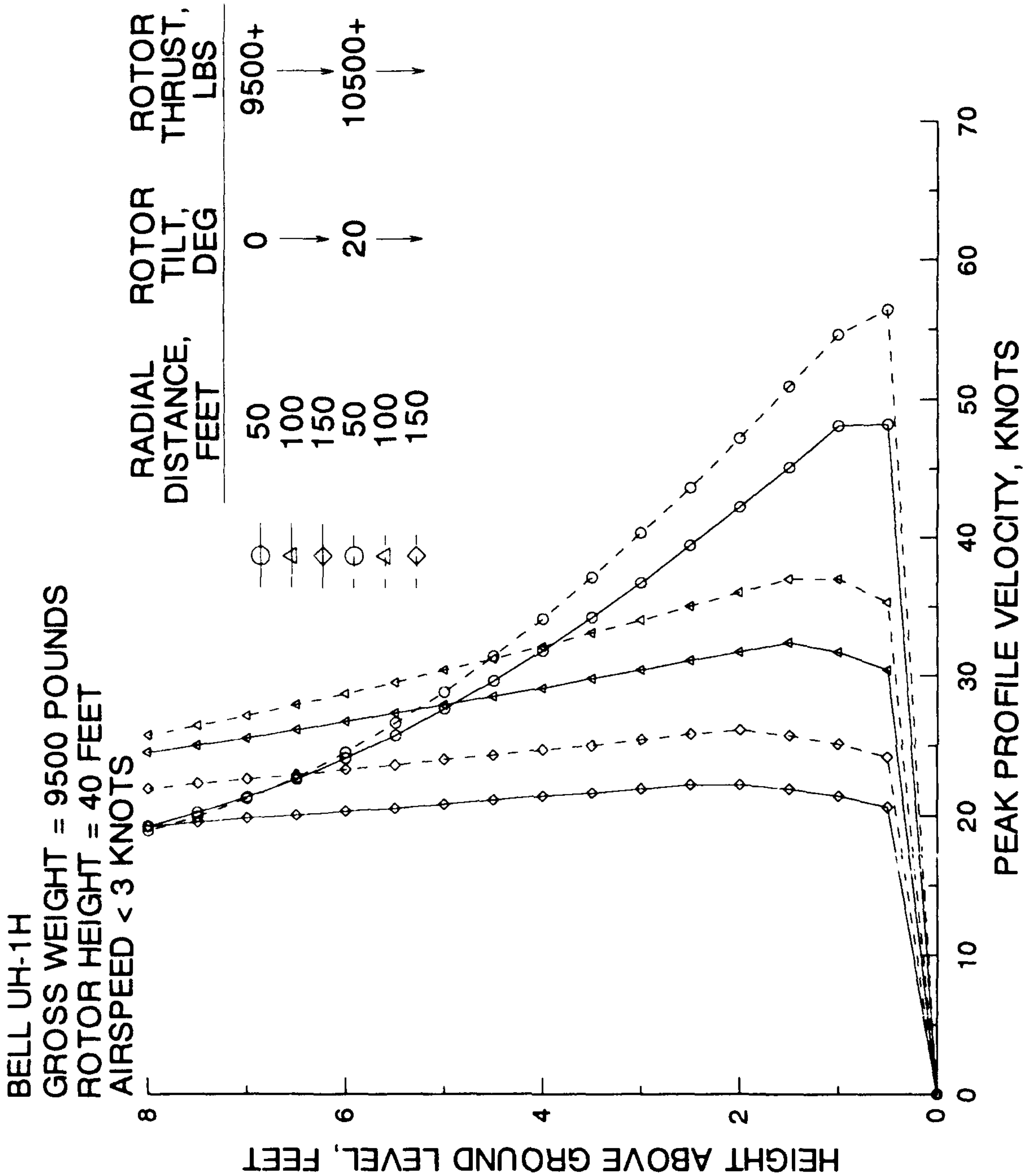


FIGURE 5 UH-1H ROTORWASH CHARACTERISTICS AT RADIAL DISTANCES OF 50, 100, AND 150 FEET FOR TIP PATH PLANE ANGLES OF 0 AND 20 DEGREES

APPENDIX B

ROTORCRAFT DESIGN DATA IN ROTWASH FORMAT

TABLE B-1 ROTORCRAFT DATA SUMMARY

Rotorcraft Manufacturer /Type	Maximum Gross Weight, lb	Main Rotor Radius, ft	Estimated Fuselage Download, PCT	Disk Loading, PSF	Number of Rotors/Blades per Rotor	Rotor Tip Speed, fps	Rotor Height Above Ground, ft	Twin Rotor Separation, ft
Agusta								
A109	5,730	18.05	1.5	5.60	1/4	727	10.0	--
Aerospatiale								
SA341G	3,970	17.25	1.5	4.24	1/3	683	8.9	--
AS350	4,299	17.55	2.0	4.44	1/3	698	10.3	--
AS355	5,291	17.55	2.0	5.47	1/3		10.7	--
SA315B	5,070	18.05	1.5	4.95	1/3		10.1	--
SA319B	4,960	18.05	1.5	4.84	1/3		9.8	--
SA360	6,615	18.85	2.0	5.92	1/4	690	11.5	--
SA365N	8,900	19.55	2.0	7.41	1/4	715	11.4	--
SA330	16,315	24.75	5.0	8.48	1/4	687	14.4	--
SA332	19,840	25.60	5.0	9.64	1/4	711	15.0	--
SA321	28,660	31.00	5.0	9.49	1/6	688	16.3	--
Bell								
47	2,850	18.50	1.0	2.65	1/2	645-716	9.5	--
206	3,200	16.65	1.5	3.67	1/2	688	9.5	--
OH-58A	3,200	17.65	1.5	3.26	1/2	654	9.5	--
OH-58D	4,300	17.5	1.5	4.47	1/4	724	8.5	--
206L	4,150	18.5	1.5	3.86	1/2	763	10.1	--
222B	8,250	21.0	4.0	5.95	1/2	765	10.8	--
204	8,500	22.0	2.0	5.59	1/2	746	11.8	--

TABLE B-1 ROTORCRAFT DATA SUMMARY (Continued)

Rotorcraft Manufacturer /Type	Maximum Gross Weight, lb	Main Rotor Radius, ft	Estimated Fuselage Download, PCT	Disk Loading, PSF	Number of Rotors/Blades per Rotor	Rotor Tip Speed, fps	Rotor Height Above Ground, ft	Twin Rotor Separation, ft
Bell (Concluded)								
UH-1M	9,500	22.0	2.0	6.25	1/2	746	11.8	--
205	9,500	24.0	2.0	5.25	1/2	814	11.8	--
212	11,200	24.0	2.0	6.19	1/2	814	13.4	--
412	11,900	23.0	2.0	7.16	1/4	780	12.8	--
214B	13,800	25.0	2.0	7.03	1/2	785	14.0	--
214ST	17,500	26.0	2.0	8.24	1/2	781	14.2	--
AH-1S	10,000	22.0	2.0	6.58	1/2	746	12.3	--
AH-1T	14,750	24.0	2.0	8.15	1/2	781		--
XV-15	13,200	12.5	13.0	13.44	2/3	771	12.5	32.2
Bell/Boeing								
V-22	47,500	19.0	10.0	17.63	2/3	790	20.1	46.5
Boeing/Vertol								
CH-46E	24,300	25.5	7.0	5.95	2/3	705	16.6	33.3
CH-47C	46,000	30.0	8.0	8.13	2/3	723	18.6	39.2
CH-47D	54,000	30.0	8.0	9.55	2/3	707	18.6	39.2
Enstrom								
F28F	2,600	16.0	1.5	3.23	1/3		9.1	--

TABLE B-1 ROTORCRAFT DATA SUMMARY (Continued)

Rotorcraft Manufacturer /Type	Maximum Gross Weight, lb	Main Rotor Radius, ft	Estimated Fuselage Download, PCT	Disk Loading, PSF	Number of Rotors/Blades per Rotor	Rotor Tip Speed, fps	Rotor Height Above Ground, ft	Twin Rotor Separation, ft
Hiller								
UH-12	2,800	17.7	1.0	2.84	1/2		10.1	--
FH-1100	2,750	17.7	1.5	2.79	1/2		10.2	--
								--
								--
Hughes								
300	2,050	13.4	1.0	3.63	1/3	662	8.8	--
500D	3,000	13.2	1.5	5.48	1/4	665	8.5	--
500E	3,000	13.2	1.5	5.48	1/5	680	8.7	--
500F	3,100	13.7	1.5	5.26	1/5		8.6	--
AH-64	14,694	24.0	2.0	8.12	1/4	726	12.6	--
Kaman								
SH-2	12,800	22.0	2.0	8.42	1/4	687	13.6	--
MBB								
BK105	5,512	16.11	1.5	6.81	1/4	715	9.7	--
BK117	6,834	18.05	2.0	6.68	1/4	725	11.0	--
Robinson								
R22	1,370	12.6	1.0	2.75	1/2	699	8.8	--

TABLE B-1 ROTORCRAFT DATA SUMMARY (Concluded)

Rotorcraft Manufacturer /Type	Maximum Gross Weight, lb	Main Rotor Radius, ft	Estimated Fuselage Download, PCT	Disk Loading, PSF	Number of Rotors/Blades per Rotor	Rotor Tip Speed, fps	Rotor Height Above Ground, ft	Twin Rotor Separation, ft
Sikorsky								
S-62	7,900	26.5	5.0	3.58	1/3			--
S-76	10,300	22.0	3.0	6.77	1/4	675	10.0	--
S-76B	11,400	22.0	3.0	7.49	1/4	675	10.0	--
UH-60A	20,250	26.85	3.0	8.94	1/4	725	12.3	--
UH-60L	22,000	26.85	3.0	9.71	1/4	725	12.3	--
S-61	20,500	31.0	5.0	6.79	1/5		17.0	--
SH-3	20,500	31.0	5.0	6.79	1/5	660	15.5	--
CH-3E	22,500	31.0	5.0	7.45	1/5		16.2	--
CH-54A	42,000	36.1	5.0	10.23	1/6		18.6	--
S-64E	42,000	36.1	5.0	10.23	1/6		18.6	--
CH-54B	47,000	36.1	5.0	11.54	1/6	700	17.6	--
CH-53D	36,400	36.1	5.0	8.89	1/6	700	17.0	--
HH-53	38,275	36.1	5.0	9.35	1/6		17.0	--
RH-53D	41,126	36.1	5.0	10.04	1/6		17.0	--
CH-53E	70,000	39.5	5.0	14.28	1/7	733	17.0	--
Westland								
Lynx	10,500	21.0	2.0	7.58	1/4		9.8	--
Lynx(3)	12,000	21.0	2.0	8.66	1/4		10.0	--
W-30-200	12,800	21.8	2.0	8.57	1/4	745	12.5	--
W-30-300	15,500	21.8	2.0	10.38	1/4			--
EH-101	31,500	30.5	5.0	10.78	1/5		21.3	--

APPENDIX C

ROTWASH PROGRAM FORTRAN 77 LISTINGS

ROTWASH program listings are presented in this appendix for the ROTWASH main program and its 24 subroutines. The listings are for a version of the program that is run on IBM PC / PC-compatible computers using MICROSOFT FORTRAN 77, Version 5.0. The tabular listing below indexes subroutine names and briefly describes functionality for user reference.

SUBROUTINE	FUNCTION
ROTWASH	Main Program Driver and Initialization
CLOUD	Calculates Particle Cloud Boundaries
DEVTX	Locates Disk Edge Vortex System and Calculates Induced Velocity Field
FREAD	Prompt/Validate for Floating Point Input Data
GDVTX	Locates Ground Vortex System and Calculates Induced Velocity Field
HAZARD	Driver Subroutine for Hazard Analysis
HIPVEL	Twin Rotor Overturning Forces and Moments
HOMCLS	Home Cursor and Clear Screen
HSVTX	Calculates Induced Velocity Field of a Horseshoe Vortex System
HWJVEL	Single Rotor Overturning Forces and Moments
INKEY	Menu Input Data Control
INPUT	Rotorcraft Characteristics Input Data Menu
INPUTV	Velocity Profile Status Menu
INPUTX	Ground/Disk Vortex Input Data Menu
IOFNSH	Close Disk I/O Files
IOINIT	File I/O Management Menu
IPVEL	Calculates Interaction Plane Velocity Profile
IREAD	Prompt/Validate for Integer Input Data
LEGAL	Check Validity of Input Data Selection Codes
LOCATE	Locate Cursor Position
MOMENT	Calculates Personnel Overturning Forces and Moments
PROPRM	Calculates Radial Wall Jet Velocity Profile
VLINE	Calculates Induced Velocity from a Line Vortex Field
WALJET	Defines Initial Wall Jet Position and Growth Parameters
WJVEL	Calculates Single Rotor Velocity Profile

```
C
C
      PROGRAM ROTWASH
C
C     ************************************************************
C     ROTORCRAFT DOWNWASH HAZARD ANALYSIS PROGRAM
C
C     EMA / COMPUTATIONAL METHODOLOGY ASSOCIATES
C     SAMUEL W. FERGUSON / J. DAVID KOCUREK
C
C     1 APRIL 1991
C
C     PROGRAM VERSION 2.0
C
C     THIS PROGRAM WAS DEVELOPED USING MICROSOFT FORTRAN 77 FOR
C     THE DOS OPERATING SYSTEM.  CONSOLE DISPLAY CONTROL IS
C     PROVIDED WITH THIS PROGRAM IN SEVERAL SPECIAL SUBROUTINES.
C     ************************************************************
C
      PARAMETER(NUM = 10)
C
      CHARACTER*1 OKLIST(NUM)
      CHARACTER*1 KEY,KKEY,FLOW,VELHAZ,HAZTYP
      CHARACTER*1 ICONT(5)
      CHARACTER*1 TEMCHAR
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
C
      DIMENSION CONT(9),CONTV(7),CONTX(8)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /HELGEO/ H,DL,YSEP,WSPD,RADIUS,SHFTAN,DXO
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /INPUTD/ CONT,CONTV,CONTX
      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
      DATA CONT/2.0,32.2,12.5,13000.0,13.0,37.0,0.0,1.0,0.0/
      DATA ICONT/'V','N','N','W','L'/
      DATA CONTV/50.0,1.0,10.0,50.0,10.0,100.0,0.0/
      DATA CONTX/733.0,7.0,18.0,200.0,0.0,20.0,100.0,0.0/
      DATA PTSFIL/'DFRC.PTS','DAIP.PTS','OTDFRC.PTS','OTDAIP.PTS'/
      DATA COMM/
     1 'BELL XV-15 CHARACTERISTICS ARE USED AS INPUT DATA ',
     2 'GROSS WEIGHT MIGHT BE ONE OF THE COMMENT STRINGS  '/
C
      DATA OKLIST /'W','w','I','i','G','g','D','d','X','x'/
C
C     **************************************************************
C
C     ----------------------
C     INITIALIZE I/O SYSTEM
C     ----------------------
```

```
C
      CALL IOINIT
C
C     ----------------------------------
C     INITIALIZE MISCELLANEOUS CONSTANTS
C     ----------------------------------
C
      PI     = ACOS(-1.0)
      RHOSL  = 0.0023769
      FPSPKN = 1.687
      DRC    = 0.01745329252
C
   50 CONTINUE
C
      KEY = ' '
      KKEY= ' '
C
C     -----------------------------------------------
C     OBTAIN INPUT DATA PARAMETERS FROM STATUS SCREEN
C     -----------------------------------------------
C
      CALL INPUT
C
C     ------------------------------------------------
C     DEFINE PARAMETERS OBTAINED FROM SUBROUTINE INPUT
C     ------------------------------------------------
C
      ROTORS = CONT(1)
      YYSEP  = CONT(2)
      RADIUS = CONT(3)
      HELGW  = CONT(4)
      DWNLD  = CONT(5)
      HAGL   = CONT(6)
      SHFTAN = CONT(7)
      SIGPR  = CONT(8)
      WSPD   = CONT(9)
C
      VELHAZ = ICONT(1)
C
C     ---------------------------------------------
C     ADJUST GEOMETRY IF SHAFT ANGLE > 0.0 DEGREES
C     ---------------------------------------------
C
      RSHFT  = SHFTAN*DRC
      CSHFTA = COS(RSHFT)
      DXO    = HAGL*TAN(RSHFT)
C
C     -----------------------------------------------
C     NON-DIMENSIONALIZE SOME OF THE INPUT PARAMETERS
C     -----------------------------------------------
C
      H     = HAGL/RADIUS/CSHFTA
      YSEP  = YYSEP/2.0/RADIUS
      EFFGW = HELGW*(1.0 + (DWNLD/100.0))
```

```
      DL    = EFFGW/ROTORS/PI/RADIUS**2
      RHO   = SIGPR*RHOSL
      RHOD2 = 0.5*RHO
C
C     ------------------------------------------------------------
C     SWITCHING CALLS HAZARD PROGRAM AND ALLOWS RETURN (IF DESIRED)
C     TO THE MAINLINE ROUTINE TO CHANGE ROTORCRAFT INPUT PARAMETERS
C     ------------------------------------------------------------
C
      IF(VELHAZ.EQ.'H')THEN
C
         KKEY = 'H'
         CALL HAZARD(HAZTYP)
C
         IF(KEY.EQ.'X')GOTO 999
         IF(FLOW.EQ.'X')GOTO 999
         IF(HAZTYP.EQ.'X')GOTO 999
         GOTO 50
C
      ELSE
C
         KKEY = 'V'
C
      END IF
C
C     ------------------------
C     SELECT FLOWFIELD OPTION
C     ------------------------
C
   10 CONTINUE
C
C     -----------------------------
C     HOME CURSOR AND CLEAR SCREEN
C     -----------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
      CALL LOCATE(3,1)
C
      WRITE(IOU1,11)
   11 FORMAT ( 20X,' SELECT TYPE OF FLOW TO BE ESTIMATED',///,
     1     20X,'WALL JET PROFILE,                TYPE <W>',/,
     2     20X,'INTERACTION PLANE PROFILE,       TYPE <I>',/,
     2     20X,'GROUND VORTEX,                   TYPE <G>',/,
     2     20X,'DISK VORTEX,                     TYPE <D>',/,
     3     20X,'TO EXIT PROGRAM,                 TYPE <X>',//)
C
C     ---------------------------------------------
C     PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT
C     ---------------------------------------------
C
   40 CONTINUE
C
      WRITE(IOU1,'(23X,A,$)')
```

```
         1 ' ENTER DATA ENTRY CODE   ==> '
C
          READ(IOU1,'(A1)') FLOW
C
          IF(LEGAL(FLOW,IOU1,OKLIST,NUM).EQ.1)GOTO 40
C
C         --------------------------------------------------------
C         MAKE LEGAL LOWERCASE INPUTS UPPER CASE BEFORE BRANCHING
C         --------------------------------------------------------
C
          IF(FLOW.EQ.'w') FLOW = 'W'
          IF(FLOW.EQ.'i') FLOW = 'I'
          IF(FLOW.EQ.'g') FLOW = 'G'
          IF(FLOW.EQ.'d') FLOW = 'D'
          IF(FLOW.EQ.'x') FLOW = 'X'
C
C         -----------------------------
C         HOME CURSOR AND CLEAR SCREEN
C         -----------------------------
C
          ICD = 0
          CALL HOMCLS(ICD)
C
C         ---------------------------------------------
C         BRANCH BASED ON CHOSEN OPTION, ALSO
C         CHECK NUMBER OF ROTORS TO LIMIT SOME OPTIONS
C         ---------------------------------------------
C
          IF(FLOW.EQ.'X')GOTO 999
          IF(FLOW.EQ.'W')GOTO 12
C
          IF(FLOW.EQ.'I')THEN
             IF(ROTORS.GT.1.0)GOTO 12
             WRITE(IOU1,'(////,14X,A,$)')
         1   ' REQUIRES TWO ROTORS, TYPE <RETURN> TO CONTINUE '
             READ(IOU1,'(A1)') TEMCHAR
             GOTO 10
          ENDIF
C
          IF(FLOW.EQ.'G')THEN
             IF(ROTORS.LT.2.0)GOTO 1000
             WRITE(IOU1,'(////,14X,A,$)')
         1   ' REQUIRES ONE ROTOR, TYPE <RETURN> TO CONTINUE '
             READ(IOU1,'(A1)') TEMCHAR
             GOTO 10
          ENDIF
C
          IF(FLOW.EQ.'D')THEN
             IF(ROTORS.LT.2.0)GOTO 1000
             WRITE(IOU1,'(////,14X,A,$)')
         1   ' REQUIRES ONE ROTOR, TYPE <RETURN> TO CONTINUE '
             READ(IOU1,'(A1)') TEMCHAR
             GOTO 10
          ENDIF
```

```
C
      GOTO 10
C
   12 CONTINUE
C
C     *********************
C     RADIAL WALL JET FLOWS
C     *********************
C
C     -------------------------------------
C     ACCELERATED SLIPSTREAM MEAN VELOCITY
C     -------------------------------------
C
      UN = SQRT(2.0*DL/RHO)
C
C     ------------------------
C     GROUND EFFECT CORRECTION
C     ------------------------
C
      AKG = 1.0 - 0.9*EXP(-2.0*H)
C
C     --------------------------------------------
C     MEAN VELOCITY AT ROTOR DISK (RATIOED TO UN)
C     --------------------------------------------
C
      UB = AKG/2.0
C
C     ------------------------------
C     FIND INITIAL RADIUS OF WALL JET
C     ------------------------------
C
      CALL WALJET(H,UB,UN,UMB)
C
  500 CONTINUE
C
      IF(KEY.EQ.'X')GOTO 999
      IF(KEY.EQ.'N')GOTO 50
      IF(FLOW.EQ.'I')GOTO 700
C
  600 CONTINUE
C
C     ------------------------------------------
C     WALL JET REGION
C
C     OBTAIN INPUT DATA FOR THE WALL JET OPTION
C     ------------------------------------------
C
      CALL INPUTV(FLOW)
C
      RVZ  = (CONTV(1) - DXO)/RADIUS
      DELZ = CONTV(2)/RADIUS
      ZMAX = CONTV(3)/RADIUS
C
C     ----------------------------------------------------
```

```
C     GENERATE VELOCITY PROFILE AT RVZ IN WALL JET REGION
C     -----------------------------------------------------
C
      CALL WJVEL(H,UN,UMB,RVZ,RADIUS,WSPD,DELZ,ZMAX,DXO)
C
      GOTO 500
C
  700 CONTINUE
C
C     -----------------------------------------
C     INTERACTION PLANE UPWASH DEFLECTION ZONE
C
C     OBTAIN INPUT DATA FOR THE IPLANE OPTION
C     -----------------------------------------
C
      CALL INPUTV(FLOW)
C
      XIP  = (CONTV(1) - DXO)/RADIUS
      DELZ = CONTV(2)/RADIUS
      ZMAX = CONTV(3)/RADIUS
C
C     -------------------------------------------------------
C     GENERATE VELOCITY PROFILE AT XIP IN INTERACTION PLANE
C     -------------------------------------------------------
C
      CALL IPVEL(H,UN,RADIUS,UMB,XIP,YSEP,WSPD,DELZ,ZMAX,DXO)
C
      GOTO 500
C
 1100 CONTINUE
C
      IF(KEY.EQ.'X')GOTO 999
      IF(KEY.EQ.'N')GOTO 50
C
 1000 CONTINUE
C
C     **********************
C     HORSESHOE VORTEX FLOWS
C     **********************
C
C     -------------------------------------
C     OBTAIN INPUT DATA FOR VORTEX OPTIONS
C     -------------------------------------
C
      CALL INPUTX
C
      OMEGAR = CONTX(1)
      B      = CONTX(2)
      VF     = CONTX(3)
      XT     = CONTX(4)/RADIUS
      YT     = CONTX(5)/RADIUS
      DELZ   = CONTX(6)/RADIUS
      ZMAX   = CONTX(7)/RADIUS
C
```

```
      VF  = VF*FPSPKN
      AMU = VF/OMEGAR
      CT  = DL/RHO/OMEGAR**2
C
C     ----------------------------
C     ITERATE TO GET INFLOW RATIO
C     ----------------------------
C
      ALOLD = SQRT(CT/2.0)
C
      DO 1300 ITER=1,100
C
      ALNEW  = CT/2.0/SQRT(ALOLD**2 + AMU**2)
C
      IF(ABS(ALNEW - ALOLD).LE.1.0E-05)GOTO 1301
C
      ALOLD = ALNEW
C
 1300 CONTINUE
C
C     -----------------------------
C     HOME CURSOR AND CLEAR SCREEN
C     -----------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
      CALL LOCATE(5,1)
C
      WRITE(IOU1,20)
   20 FORMAT( '***************************************',/
     1        ,'ITERATIONS EXCEEDED FOR INFLOW RATIO',/
     2        ,'***************************************')
C
      STOP ' '
C
 1301 CONTINUE
C
      ALAMDA = ALNEW
      AMUS   = AMU/SQRT(CT/2.0)
      GAMT   = OMEGAR*RADIUS*2.0*PI*CT/B
      CHI    = ATAN(ALAMDA/AMU)/2.0
      GAMW   = PI*RADIUS*OMEGAR**2*CT/VF/2.0
      HOD    = H/2.0
C
C     ----------- -----------------
C     HOME CURSOR AND CLEAR SCREEN
C     -----------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
      CALL LOCATE(3,1)
C
      IF(FLOW.EQ.'D')GOTO 1200
C
```

```
C     --------------
C     GROUND VORTEX
C     --------------
C
      WRITE(IOU1,1001) HOD,AMUS,AMU
 1001 FORMAT( 18X,'ROTOR HEIGHT ABOVE GROUND H/D  ',2X,F8.4,/
     1       ,18X,'ADVANCE RATIO MU-STAR          ',2X,F8.4,/
     2       ,18X,'ADVANCE RATIO MU               ',2X,F8.4,//)
C
C     ---------------------------------------------------------------
C     THE VALUE INPUT HERE REQUIRES USE OF THE CHART IN FIGURE 18
C     OF THE ACCOMPANYING DOCUMENTATION FOR THE GROUND VORTEX
C     ---------------------------------------------------------------
C
   30 CONTINUE
C
      WRITE(IOU1,31)
   31 FORMAT( 18X,'ENTER GROUND VORTEX STRENGTH RATIO',/,
     1     25X,'(SEE FIGURE 18)            ==> '$)
C
      READ(IOU1,*,ERR=30) GAMG
C
      IF(GAMG.LT.0.0) GAMG = 0.0
C
C     ------------------
C     CONTINUE ANALYSIS
C     ------------------
C
      GAMG = GAMG*GAMT
C
      CALL GDVTX(H,RADIUS,AMU,CT,GAMG,XT,YT,DELZ,ZMAX)
C
      GOTO 1100
C
 1200 CONTINUE
C
C     ------------
C     DISK VORTEX
C     ------------
C
      CALL DEVTX(H,RADIUS,GAMW,CHI,XT,YT,DELZ,ZMAX)
C
      GOTO 1100
C
C     --------------------
C     NORMAL PROGRAM EXIT
C     --------------------
C
  999 CONTINUE
C
      END
C
```

```
C
C
      SUBROUTINE CLOUD(UN,UMB)
C
C     ****************************************************************
C     SUBROUTINE CLOUD
C
C     THIS SUBROUTINE MAKES THE CALCULATIONS REQUIRED IN ESTIMATING
C     THE PARTICLE CLOUD BOUNDARIES ( NO DENSITIES ) FOR SINGLE AND
C     TWIN ROTOR CONFIGURATIONS
C     ****************************************************************
C
      CHARACTER*1 KEY,KKEY
      CHARACTER*1 ICONT(5)
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON /CLOUDK/ QSMAX
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /HELGEO/ H,DL,YSEP,WSPD,RADIUS,SHFTAN,DXO
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     ****************************************************************
C
C     -----------------------------
C     CLEAR SCREEN AND HOME CURSOR
C     -----------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
      CALL LOCATE(3,1)
C
C     ------------------------------------
C     READ IN THE TERRAIN FACTOR CONSTANT
C     (SEE FIGURE 30 OF USER'S GUIDE)
C     ------------------------------------
C
   10 CONTINUE
C
      WRITE(IOU1,20)
   20 FORMAT( 15X,'ENTER TERRAIN EROSION FACTOR (-ND-) ==> ',$)
C
      READ(IOU1,*,ERR=10) XKT
C
C     --------------------------
C     VALIDATE REAL INPUT VALUE
C     --------------------------
C
      IF(XKT.LE.0.0.OR.XKT.GT.500.0)GOTO 10
C
C     --------------------------------
```

```
C     DEFINE CLOUD BOUNDARY CONSTANTS
C     -------------------------------
C
      XKT  = SQRT(XKT)
C
      QSMX = RHOD2*((SQRT(QSMAX)*UN)**2)
      ERC  = -0.437
      XUM  = (UMB*UN)**2
      XCU  = CU*CU
      C1   = 1.0
      C2   = 2.2
C
C     ----------------------------------------
C     SINGLE ROTOR CLOUD BOUNDARY CALCULATIONS
C     ----------------------------------------
C
      RCR  = RADIUS*((XKT/(C1*RHOD2*XUM*XCU))**ERC)
      RVR  = 0.785*RCR
      ZVR  = 0.329*RCR
      RCVR = RCR - RVR
      AR   = (2.0/PI)*ALOG(ZVR/RCVR)
      PHIR = (PI/2.0)*ALOG(RCVR)/ALOG(ZVR/RCVR)
      AXLV = AR*((-PI/2.0) + PHIR)
      XLV  = EXP(AXLV)
      HCR  = XLV + ZVR
C
C     ---------------------------------------
C     INITIALIZE INTERACTION PLANE BOUNDARIES
C     ---------------------------------------
C
      RCI = 0.0
      RVI = 0.0
      ZVI = 0.0
      HCI = 0.0
      IF(YSEP.LE.0.1)GOTO 30
C
C     ---------------------------------------------
C     INTERACTION PLANE CLOUD BOUNDARY CALCULATIONS
C     ---------------------------------------------
C
      RCI  = RADIUS*((XKT/(C2*RHOD2*XUM*XCU))**ERC)
      RVI  = 0.785*RCI
      ZVI  = 0.329*RCI
      RCVR = RCI - RVI
      AR   = (2.0/PI)*ALOG(ZVI/RCVR)
      PHIR = (PI/2.0)*ALOG(RCVR)/ALOG(ZVI/RCVR)
      AXLV = AR*((-PI/2.0) + PHIR)
      XLV  = EXP(AXLV)
      HCI  = XLV + ZVI
C
   30 CONTINUE
C
C     --------------------------
C     PRINTOUT OF BOUNDARY LIMITS
```

```
C       ---------------------------
C
        IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
C       --------------------------------------------
C       WRITE "40 FORMAT" IF OUTPUT TO GRAPHICS FILE
C       --------------------------------------------
C
        IF(IOU6.EQ.6) WRITE(IOU6,40) COMM(1),COMM(2)
     40 FORMAT( 10X,A50,/,10X,A50,//)
C
        WRITE(IOU6,50)
     50 FORMAT( //,
       1        20X,'      SUMMARY OF CLOUD BOUNDARIES',//,
       2        20X,'  RC AND RV ARE FROM ROTOR CENTER (FT)',//,
       3        20X,' RC ',7X,' RV ',7X,' ZV ',7X,' HC ',/)
C
        WRITE(IOU6,60) RCR,RVR,ZVR,HCR
     60 FORMAT( 13X,'SR',F10.1,3F11.1)
C
        WRITE(IOU6,70) RCI,RVI,ZVI,HCI
     70 FORMAT( 13X,'IP',F10.1,3F11.1)
C
        WRITE(IOU6,80) QSMX
     80 FORMAT( /,12X,' QSMAX =',F7.1,' PSF',//)
C
C       -----------------------------
C       DECIDE NEXT OPTION WITH INKEY
C       -----------------------------
C
        CALL INKEY
C
        RETURN
        END
C
```

```
C
C
      SUBROUTINE DEVTX(H,RADIUS,GAMW,CHI,XT,YT,DELZ,ZMAX)
C
C     **********************************************************
C     SUBROUTINE DEVTX
C
C     THIS SUBROUTINE LOCATES THE DISK EDGE VORTEX SYSTEM, AND
C     DIRECTS THE CALCULATION OF ITS INDUCED VELOCITY FIELD
C     **********************************************************
C
      CHARACTER*1 TEMCHAR
      CHARACTER*1 KEY,KKEY
      CHARACTER*1 ICONT(5)
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON /CHSVTX/ XL1,YL1,ZL1,XL2,YL2,ZL2,XL3,YL3,ZL3,
     1                XR1,YR1,ZR1,XR2,YR2,ZR2,XR3,YR3,ZR3
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     **********************************************************
C
C     ------------------------------------------------------
C     ASSUME HORSESHOE SHAPE - ASSIGN LEFT AND RIGHT CORNERS
C     ------------------------------------------------------
C
      XL1 = 0.0
      YL1 = -1.0
      ZL1 = H
C
      XR1 = 0.0
      YR1 = 1.0
      ZR1 = H
C
C     ---------------------------------------------
C     SET UP DIRECTION POINTERS FOR TRAILER ELEMENTS
C     POINT 2 IS AT GROUND IMPINGEMENT
C     ---------------------------------------------
C
      XL2 = XL1 + H/TAN(CHI)
      YL2 = YL1
      ZL2 = 0.0
C
      XR2 = XR1 + H/TAN(CHI)
      YR2 = YR1
      ZR2 = 0.0
C
C     ---------------------------------------------
C     POINT THREE EXTENDS TRAILER PARALLEL TO GROUND
C     ---------------------------------------------
```

```
C
      XL3 = XL2 + 1.0
      YL3 = YL2
      ZL  = ZL2
C
      XR3 = XR2 + 1.0
      YR3 = YR2
      ZR3 = ZR2
C
      XT = XT*RADIUS
      YT = YT*RADIUS
C
C     -----------------------------
C     CLEAR SCREEN AND HOME CURSOR
C     -----------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
      CALL LOCATE(4,1)
C
C     --------------------
C     WRITE OUTPUT HEADER
C     --------------------
C
      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
      WRITE(IOU6,1000) XT,YT
 1000 FORMAT( 21X,'DISK VORTEX VELOCITY PROFILE DATA',
     1 ///,14X,' X-LOCATION (XT)     = ',2X,F8.2,2X,'FT',
     2   /,14X,' Y-LOCATION (YT)     = ',2X,F8.2,2X,'FT',/)
C
      WRITE(IOU6,1001) GAMW
 1001 FORMAT( 15X,'VORTEX CIRCULATION = ',F10.2,2X,'FT**2/SEC')
C
      CHID = CHI*180.0/PI
C
      WRITE(IOU6,1005) CHID
 1005 FORMAT( 15X,'SETTLING ANGLE     = ',F10.2,2X,'DEG',////)
C
      WRITE(IOU1,'(23X,A,$)')
     1  ' PRESS <RETURN> TO CONTINUE   '
C
      READ(IOU1,'(A1)') TEMCHAR
C
      CALL HOMCLS(ICD)
C
      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
   93 FORMAT( 14X,A50,/,10X,A50,//)
C
      WRITE(IOU6,1100)
 1100 FORMAT( 12X,'HEIGHT',8X,'MEAN VELOCITY',5X,'MEAN Q',/,
     1     '0',12X,'(FT)',8X,'(FPS)',6X,'(KN)',5X,'(PSF)',/)
C
C     ----------------------------------------------
```

```
C     SET UP SWEEP OF Z AT SPECIFIED X,Y
C     DELZ AND ZMAX COME FROM A MAINLINE STATUS MENU
C     ----------------------------------------------
C
      XT    = XT/RADIUS
      YT    = YT/RADIUS
      NPTS  = IFIX(ZMAX/DELZ) + 2
      LINES = 0
C
      DO 200 I=1,NPTS
C
      LINES = LINES + 4
      ZT    = (I - 1)*DELZ
C
      CALL HSVTX(XT,YT,ZT,VXF,VYF,VZF,GAMW,RADIUS)
C
      ZZ  = ZT*RADIUS
      VTF = SQRT(VXF**2 + VYF**2 + VZF**2)
      VXK = VXF/FPSPKN
      VYK = VYF/FPSPKN
      VZK = VZF/FPSPKN
      VTK = VTF/FPSPKN
C
      QX  = RHOD2*VXF**2
      QY  = RHOD2*VYF**2
      QZ  = RHOD2*VZF**2
      QT  = RHOD2*VTF**2
C
C     ----------------------------------------
C     KEEP OUTPUT PAGE LENGTH TO SIZE OF SCREEN
C     ----------------------------------------
C
      IF(IOU6.EQ.IOU1)THEN
        IF(LINES.LE.12)GOTO 100
        LINES = 4
        CALL INKEY
        IF(KEY.NE.'C')GOTO 999
        WRITE(IOU6,1100)
      ENDIF
C
  100 CONTINUE
C
C     ------------------------------
C     REPORT X COMPONENT OF VELOCITY
C     ------------------------------
C
      WRITE(IOU6,1101) ZZ,VXF,VXK,QX
 1101 FORMAT( 9X,F8.2,2X,'X',3F10.3)
C
C     ------------------------------
C     REPORT Y COMPONENT OF VELOCITY
C     ------------------------------
C
      WRITE(IOU6,1102) VYF,VYK,QY
```

```
 1102 FORMAT( 19X,'Y',3F10.3)
C
C     ------------------------------
C     REPORT Z COMPONENT OF VELOCITY
C     ------------------------------
C
      WRITE(IOU6,1103) VZF,VZK,QZ
 1103 FORMAT( 19X,'Z',3F10.3)
C
C     ---------------------
C     REPORT TOTAL VELOCITY
C     ---------------------
C
      WRITE(IOU6,1104) VTF,VTK,QT
 1104 FORMAT( 19X,'T',3F10.3)
C
  200 CONTINUE
C
      CALL INKEY
C
  999 CONTINUE
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE FREAD(IOU1,PROMPT,VALUE,CONST)
C
C     *********************************************
C     SUBROUTINE FREAD PROMPTS USER FOR A FLOATING
C     POINT DATA ENTRY AND CHECKS VALIDITY OF ENTRY
C     *********************************************
C
      PARAMETER(LAST=50)
C
      CHARACTER*50 PROMPT,SHOWIT
      CHARACTER*15 ENTRY,BLANK
C
      DATA BLANK /'               '/
C
C     *********************************************
C
C     -----------------------------------------------------
C     PROMPT USER FOR SCALED FLOATING POINT ENTRY.
C     FIND POSITION OF LAST NON-BLANK CHARACTER IN PROMPT,
C     THEN STORE RIGHT JUSTIFIED IN SHOWIT.
C     -----------------------------------------------------
C
      N = LAST + 1
C
   10 IF(N.EQ.1)GOTO 20
C
      N = N - 1
C
      IF(PROMPT(N:N).EQ.' ')GOTO 10
C
   20 JS = LAST - N
C
      WRITE(SHOWIT,'(50A1)') (' ',J=1,JS),(PROMPT(I:I),I=1,N)
C
C     ---------------------------
C     NOW ASK USER FOR DATA ENTRY
C     ---------------------------
C
   30 WRITE(IOU1,'(/,1X,A,G13.6)') SHOWIT,VALUE*CONST
C
      WRITE(IOU1,'(/,8X,A,$)')
     1 ' ENTER NEW VALUE OR <RETURN> TO LEAVE AS IS    ==> '
C
      READ(IOU1,'(A)') ENTRY
C
      IF(ENTRY.EQ.BLANK)RETURN
C
      READ(ENTRY,'(BN,F15.0)',ERR=30) TEMP
C
C     -----------------------------------
C     CONSTANT CAN BE USED TO SCALE OR
C     OR CONVERT UNITS OF AN INPUT VALUE
```

```
C     ----------------------------------
C
      VALUE = TEMP/CONST
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE GDVTX(H,RADIUS,AMU,CT,GAMG,XT,YT,DELZ,ZMAX)
C
C     ***********************************************************
C     SUBROUTINE GDVTX
C
C     THIS SUBROUTINE LOCATES THE GROUND VORTEX BASED ON THE
C     EXPERIMENTS BY SUN AND CURTIS (PRINCETON UNIV.), AND THEN
C     DIRECTS THE CALCULATION OF ITS INDUCED VELOCITY FIELD
C
C     THE OUTPUT FROM THIS SUBROUTINE SHOULD BE USED CAREFULLY
C     FOR GROSS ESTIMATION PURPOSES ONLY
C     ***********************************************************
C
      CHARACTER*1 ICONT(5)
      CHARACTER*1 TEMCHAR
      CHARACTER*1 KEY,KKEY
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON /CHSVTX/ XL1,YL1,ZL1,XL2,YL2,ZL2,XL3,YL3,ZL3,
     1                XR1,YR1,ZR1,XR2,YR2,ZR2,XR3,YR3,ZR3
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     ***********************************************************
C
      HOD   = H/2.0
      C1    = 1.0 + 1.2086*HOD**0.4374
      C2    = -0.2786*HOD**0.6757
      ZGV   = -10.0*AMU + 0.6
      XGV   = -(C1 + C2*(AMU/CT))**2
      XXGV  = XGV*RADIUS
      ZZGV  = ZGV*RADIUS
C
C     -------------------------------------------------------
C     ASSUME HORSESHOE SHAPE - ASSIGN LEFT AND RIGHT CORNERS
C     -------------------------------------------------------
C
      XL1 = XGV
      YL1 = -1.0
      ZL1 = ZGV
C
      XR1 = XGV
      YR1 = 1.0
      ZR1 = ZGV
C
C     -----------------------------------------------
C     SET UP DIRECTION POINTERS FOR TRAILER ELEMENTS
C     -----------------------------------------------
C
```

```
      XL2 = XL1 + 1.0
      YL2 = YL1
      ZL2 = ZL1
C
      XR2 = XR1 + 1.0
      YR2 = YR1
      ZR2 = ZR1
C
      XL3 = XL2 + 1.0
      YL3 = YL2
      ZL3 = ZL2
C
      XR3 = XR2 + 1.0
      YR3 = YR2
      ZR3 = ZR2
C
C     ----------------------------------------------
C     WRITE OUT GROUND VORTEX POSITION/STRENGTH DATA
C     ----------------------------------------------
C
      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
      WRITE(IOU6,1001) XXGV,ZZGV
 1001 FORMAT( //,24X,'GROUND VORTEX CORE POSITION',//,
     1 18X,'X-LOCATION (XXGV)         = ',1X,F8.2,2X,'FT',/
     2 18X,'Y-LOCATION (ZZGV)         = ',1X,F8.2,2X,'FT')
C
      WRITE(IOU6,1002) GAMG
 1002 FORMAT( /,18X,'GROUND VORTEX CIRCULATION = ',1X,
     1           F8.2,2X,'FT**2/SEC',//)
C
      WRITE(IOU1,'(23X,A,$)')
     1 ' PRESS <RETURN> TO CONTINUE '
C
      READ(IOU1,'(A1)') TEMCHAR
C
      ICD = 0
      CALL HOMCLS(ICD)
C
C     -------------------
C     WRITE OUTPUT HEADER
C     -------------------
C
      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
   93 FORMAT( 14X,A50,/,10X,A50,//)
C
      WRITE(IOU6,1100)
 1100 FORMAT( 12X,'HEIGHT',8X,'MEAN VELOCITY',5X,'MEAN Q',/,
     1       '0',12X,'(FT)',8X,'(FPS)',6X,'(KN)',5X,'(PSF)',/)
C
C     ----------------------------------------------
C     SET UP SWEEP OF Z AT SPECIFIED X,Y
C     DELZ AND ZMAX COME FROM MAINLINE STATUS SCREEN
C     ----------------------------------------------
```

```
C
      NPTS  = IFIX(ZMAX/DELZ) + 2
      LINES = 0
C
      DO 200 I=1,NPTS
C
      LINES = LINES + 4
      ZT    = (I - 1)*DELZ
C
      CALL HSVTX(XT,YT,ZT,VXF,VYF,VZF,GAMG,RADIUS)
C
      ZZ  = ZT*RADIUS
      VTF = SQRT(VXF**2 + VYF**2 + VZF**2)
      VXK = VXF/FPSPKN
      VYK = VYF/FPSPKN
      VZK = VZF/FPSPKN
      VTK = VTF/FPSPKN
C
      QX  = RHOD2*VXF**2
      QY  = RHOD2*VYF**2
      QZ  = RHOD2*VZF**2
      QT  = RHOD2*VTF**2
C
      IF (IOU6.EQ.IOU1)THEN
        IF(LINES.LE.12)GOTO 100
        LINES = 4
        CALL INKEY
        IF(KEY.NE.'C')GOTO 999
        WRITE(IOU6,1100)
      ENDIF
C
  100 CONTINUE
C
C     ------------------------------
C     REPORT X COMPONENT OF VELOCITY
C     ------------------------------
C
      WRITE(IOU6,1101) ZZ,VXF,VXK,QX
 1101 FORMAT( 9X,F8.2,2X,'X',3F10.3)
C
C     ------------------------------
C     REPORT Y COMPONENT OF VELOCITY
C     ------------------------------
C
      WRITE(IOU6,1102) VYF,VYK,QY
 1102 FORMAT( 19X,'Y',3F10.3)
C
C     ------------------------------
C     REPORT Z COMPONENT OF VELOCITY
C     ------------------------------
C
      WRITE(IOU6,1103) VZF,VZK,QZ
 1103 FORMAT( 19X,'Z',3F10.3)
C
```

```
C      ----------------------
C      REPORT TOTAL VELOCITY
C      ----------------------
C
       WRITE(IOU6,1104) VTF,VTK,QT
  1104 FORMAT( 19X,'T',3F10.3)
C
   200 CONTINUE
C
       CALL INKEY
C
   999 CONTINUE
C
       RETURN
       END
C
```

```
C
C
      SUBROUTINE HAZARD(HAZTYP)
C
C     ****************************************************
C     SUBROUTINE HAZARD IS THE MAINLINE DRIVER FOR THE
C     CALCULATION OF SPECIFIC HAZARDS
C     ****************************************************
C
      PARAMETER(NUM1 =  6)
      PARAMETER(NUM2 = 13)
      PARAMETER(NUM3 =  4)
      PARAMETER(NUM4 =  4)
C
      CHARACTER*1 OKLST1(NUM1)
      CHARACTER*1 OKLST2(NUM2)
      CHARACTER*1 OKLST3(NUM3)
      CHARACTER*1 OKLST4(NUM4)
C
      CHARACTER*1 KEY,KKEY,HAZTYP,HUMTYP
      CHARACTER*1 CHDOL,CVALUE
      CHARACTER*1 ICONT(5)
      CHARACTER*12 PTSFIL(4)
      CHARACTER*12 TMPFIL
      CHARACTER*50 COMM(2)
      CHARACTER*50 PROMPT
C
      DIMENSION CONT(9),CONTV(7),CONTX(8)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /HELGEO/ H,DL,YSEP,WSPD,RADIUS,SHFTAN,DXO
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /INPUTD/ CONT,CONTV,CONTX
      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     ****************************************************
C
      DATA OKLST1 /'C','c','M','m','X','x'/
      DATA OKLST2 /' ','A','a','B','b','C','c','D','d',
     1             'E','e','F','f'/
      DATA OKLST3 /'W','w','I','i'/
      DATA OKLST4 /'L','l','S','s'/
C
C     ----------------------------
C     CLEAR SCREEN AND HOME CURSOR
C     ----------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
      CALL LOCATE(4,1)
C
C     -------------------------------------
```

```
C     DETERMINE THE TYPE OF HAZARD ANALYSIS
C     OPTION THAT WILL BE EXECUTED
C     --------------------------------------
C
      WRITE(IOU1,10)
   10 FORMAT ( 25X,' SELECT TYPE OF HAZARD',///,
     1      18X,'OVERTURNING FORCE/MOMENT,    TYPE <M>',/,
     2      18X,'PARTICULATE CLOUDS,          TYPE <C>',/,
     3      18X,'TO EXIT PROGRAM,             TYPE <X>',//)
C
C     ---------------------------------------------
C     INQUIRE, OBTAIN, AND CHECK FOR VALID MENU CODE
C     ---------------------------------------------
C
   11 CONTINUE
C
      WRITE(IOU1,'(23X,A,$)') ' ENTER HAZARD CODE ==> '
C
      READ(IOU1,'(A1)') HAZTYP
C
      IF(LEGAL(HAZTYP,IOU1,OKLST1,NUM1).EQ.1)GOTO 11
C
C     -------------------------------------------
C     CORRECT LOWER CASE LETTERS TO UPPER CASE
C     TO USE AS VALID FLAGS IN PARENT SUBROUTINE
C     -------------------------------------------
C
      IF(HAZTYP.EQ.'c') HAZTYP = 'C'
      IF(HAZTYP.EQ.'m') HAZTYP = 'M'
      IF(HAZTYP.EQ.'x') HAZTYP = 'X'
C
C     -----------------------------
C     BRANCH IF EXIT OPTION CHOSEN
C     -----------------------------
C
      IF(HAZTYP.EQ.'M')GOTO 18
      IF(HAZTYP.EQ.'C')GOTO 18
      IF(HAZTYP.EQ.'X')GOTO 999
C
      GOTO 11
C
   18 CONTINUE
C
C     *********************************
C     RADIAL WALL JET FLOW INFORMATION
C     *********************************
C
C     -------------------------------------
C     ACCELERATED SLIPSTREAM MEAN VELOCITY
C     -------------------------------------
C
      UN = SQRT(2.0*DL/RHO)
C
C     -------------------------
```

```
C      GROUND EFFECT CORRECTION
C      ------------------------
C
       AKG = 1.0 - 0.9*EXP(-2.0*H)
C
C      ---------------------------------------------
C      MEAN VELOCITY AT ROTOR DISK (RATIOED TO UN)
C      ---------------------------------------------
C
       UB = AKG/2.0
C
C      -------------------------------
C      FIND INITIAL RADIUS OF WALL JET
C      -------------------------------
C
       CALL WALJET(H,UB,UN,UMB)
C
   500 CONTINUE
C
       IF(KEY.EQ.'X')GOTO 999
       IF(KEY.EQ.'N')GOTO 999
C
C      -----------------------------
C      BRANCH IF CLOUD OPTION CHOSEN
C      -----------------------------
C
       IF(HAZTYP.EQ.'C')GOTO 800
C
C      ***************************
C      OVERTURNING FORCES/MOMENTS
C      ***************************
C
C      ---------------------------------------------
C      DETERMINE:
C
C         1. THE AXIS ALONG WHICH THE OVERTURNING
C            FORCES/MOMENTS WILL BE CALCULATED
C
C         2. THE SIZE OF THE PERSON AFFECTED
C
C         3. THE DISTANCES AT WHICH THE OVERTURNING
C            FORCES/MOMENTS WILL BE CALCULATED
C      ---------------------------------------------
C
    20 CONTINUE
C
       ICD = 0
       CALL HOMCLS(ICD)
       CALL LOCATE(2,1)
C
       WRITE(IOU1,12)
    12 FORMAT( 20X,' OVERTURNING FORCE/MOMENT DATA MENU',//,
     1   10X,'CODE           PARAMETER                       VALUE',
     2        '    UNITS',/)
```

```
C
C     ----------------------------------------------------
C     PRINT OUT MENU VARIABLES AS BASED ON THE WALL JET
C     OPTION OR INTERACTION PLANE OPTION SWITCH SETTING
C     ----------------------------------------------------
C
      IF(ICONT(4).EQ.'W')THEN
C
         WRITE(IOU1,14) ICONT(4),ICONT(5),PTSFIL(3),
     1                  CONTV(4),CONTV(5),CONTV(6)
C
      ELSE
C
         WRITE(IOU1,14) ICONT(4),ICONT(5),PTSFIL(4),
     1                  CONTV(4),CONTV(5),CONTV(6)
C
      ENDIF
C
   14 FORMAT( 11X,'A    <W>ALL JET OR <I>NTERACTION PLANE',5X,A2,/,
     1  11X,'B    <L>ARGE OR <S>MALL PERSON        ',5X,A2,/,
     2  11X,'C    DATA OUTPUT FILENAME             ',2X,A12,/,
     3  11X,'                                 ',/,
     4  11X,'D    INITIAL STATION POSITION     ',5X,F7.2,4X,'FT',/,
     5  11X,'E    HORIZONTAL INCREMENT         ',5X,F7.2,4X,'FT',/,
     6  11X,'F    MAXIMUM STATION POSITION     ',5X,F7.2,4X,'FT',//)
C
C     -----------------------------------------------------
C     PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT DATA
C     -----------------------------------------------------
C
   16 CONTINUE
C
      WRITE(IOU1,'(8X,A,$)')
     1' ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> '
C
      READ(IOU1,'(A1)') CHDOL
C
      IF(LEGAL(CHDOL,IOU1,OKLST2,NUM2).EQ.1)GOTO 16
C
C     ---------------------------------------------
C     DIRECT OPTIONS BASED ON CHOICE FOR "CHDOL"
C     ---------------------------------------------
C
      IF(CHDOL.EQ.' ')GOTO 30
C
C     ------------------------------
C     CHOOSE WALJET OR IPLANE OPTION
C     ------------------------------
C
      IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
C
   40   CONTINUE
C
        WRITE(IOU1,'(/,35X,A,1X,A2/)') ' ANALYSIS TYPE = ',ICONT(4)
```

```
            WRITE(IOU1,'(37X,A,$)') ' ENTER NEW CODE    ==> '
            READ(IOU1,'(A1)') CVALUE
C
            IF(LEGAL(CVALUE,IOU1,OKLST3,NUM3).EQ.1)GOTO 40
C
            ICONT(4) = CVALUE
            IF(ICONT(4).EQ.'w') ICONT(4) = 'W'
            IF(ICONT(4).EQ.'i') ICONT(4) = 'I'
            GOTO 20
C
          ENDIF
C
C         -----------------------------
C         CHOOSE LARGE OR SMALL PERSON
C         -----------------------------
C
          IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
C
   41       CONTINUE
C
            WRITE(IOU1,'(/,35X,A,1X,A2/)') ' PERSON TYPE = ',ICONT(5)
            WRITE(IOU1,'(37X,A,$)') ' ENTER NEW CODE    ==> '
            READ(IOU1,'(A1)') CVALUE
C
            IF(LEGAL(CVALUE,IOU1,OKLST4,NUM4).EQ.1)GOTO 41
C
            ICONT(5) = CVALUE
            IF(ICONT(5).EQ.'l') ICONT(5) = 'L'
            IF(ICONT(5).EQ.'s') ICONT(5) = 'S'
            GOTO 20
C
          ENDIF
C
C         -------------------------
C         CHOOSE GRAPHICS FILENAME
C         -------------------------
C
          IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
C
            IF(ICONT(4).EQ.'W')THEN
              WRITE(IOU1,'(/,25X,A,1X,A12/)')
     1              ' FILENAME = ',PTSFIL(3)
            ELSE
              WRITE(IOU1,'(/,25X,A,1X,A12/)')
     1              ' FILENAME = ',PTSFIL(4)
            ENDIF
C
            WRITE(IOU1,'(20X,A,$)')
     1 ' ENTER NEW FILENAME (xxxxxxxx.xxx) ==> '
C
            READ(IOU1,'(A12)') TMPFIL
C
            IF(ICONT(4).EQ.'W') PTSFIL(3) = TMPFIL
            IF(ICONT(4).EQ.'I') PTSFIL(4) = TMPFIL
```

```
            GOTO 20
C
          ENDIF
C
C         -------------------------------
C         CHOOSE INITIAL STATION POSITION
C         -------------------------------
C
          IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
C
            PROMPT = 'INITIAL STATION POSITION = '
            CALL FREAD(IOU1,PROMPT,CONTV(4),1.0)
C
            IF(CONTV(4).LT.0.0) CONTV(4) = 0.0
            GOTO 20
C
          ENDIF
C
C         ---------------------------
C         CHOOSE HORIZONTAL INCREMENT
C         ---------------------------
C
          IF(CHDOL.EQ.'E'.OR.CHDOL.EQ.'e')THEN
C
            PROMPT = 'HORIZONTAL INCREMENT = '
            CALL FREAD(IOU1,PROMPT,CONTV(5),1.0)
C
            IF(CONTV(5).LT.0.0) CONTV(5) = 0.0
            GOTO 20
C
          ENDIF
C
C         ---------------------------
C         CHOOSE HORIZONTAL INCREMENT
C         ---------------------------
C
          IF(CHDOL.EQ.'F'.OR.CHDOL.EQ.'f')THEN
C
            PROMPT = 'MAXIMUM STATION POSITION = '
            CALL FREAD(IOU1,PROMPT,CONTV(6),1.0)
C
            IF(CONTV(6).LT.CONTV(4)) CONTV(6) = CONTV(4)
            GOTO 20
C
          ENDIF
C
          GOTO 20
C
       30 CONTINUE
C
          ICD = 0
          CALL HOMCLS(ICD)
C
          IF(ICONT(4).EQ.'I')GOTO 700
```

```
C
  600 CONTINUE
C
C     ---------------------------------
C     WALL JET REGION
C
C     OBTAIN DATA FOR THE HWJVEL OPTION
C     ---------------------------------
C
      RVZ    = (CONTV(4) - DXO)/RADIUS
      DELH   = CONTV(5)
      HMAX   = CONTV(6)
      HUMTYP = ICONT(5)
C
C     ----------------------------------------------------
C     GENERATE VELOCITY PROFILE AT RVZ IN WALL JET REGION
C     ----------------------------------------------------
C
      CALL HWJVEL(H,UN,UMB,RVZ,RADIUS,WSPD,DELH,HMAX,HUMTYP,DXO)
C
      GOTO 500
C
  700 CONTINUE
C
C     ----------------------------------------
C     INTERACTION PLANE UPWASH DEFLECTION ZONE
C
C     OBTAIN INPUT DATA FOR THE HIPVEL OPTION
C     ----------------------------------------
C
      XIP    = (CONTV(4) - DXO)/RADIUS
      DELH   = CONTV(5)
      HMAX   = CONTV(6)
      HUMTYP = ICONT(5)
C
C     -----------------------------------------------------
C     GENERATE VELOCITY PROFILE AT XIP IN INTERACTION PLANE
C     -----------------------------------------------------
C
      CALL HIPVEL(H,UN,RADIUS,UMB,XIP,YSEP,WSPD,DELH,HMAX,
     *            HUMTYP,DXO)
C
      GOTO 500
C
  800 CONTINUE
C
C     ***************************************
C     CALCULATE PARTICULATE CLOUD BOUNDARIES
C     ***************************************
C
      CALL CLOUD(UN,UMB)
C
      GOTO 500
C
```

```
C     --------------------
C     NORMAL PROGRAM EXIT
C     --------------------
C
  999 CONTINUE
C
      RETURN
      END
C

```

```
C
C
      SUBROUTINE HIPVEL(H,UN,RADIUS,UMB,XIP,YSEP,WSPD,DELH,
     *                  HMAX,HUMTYP,DXO)
C
C
*****************************************************************
C     SUBROUTINE HIPVEL GENERATES THE VELOCITY PROFILE AND THE FORCES
C     AND OVERTURNING MOMENTS FOR A HUMAN BEING ALONG THE INTERACTION
C     PLANE FOR THE TWIN ROTOR CASE
C
*****************************************************************
C
      CHARACTER*1 TEMCHAR
      CHARACTER*1 KEY,KKEY,HUMTYP
      CHARACTER*1 ICONT(5)
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /PERSON/ QP(12),DSET
      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C
*****************************************************************
C
      ICD = 0
      CALL HOMCLS(ICD)
C
C     -------------------------------------------------------
C     INPUT FOR DELH AND HMAX COMES FROM INPUTV STATUS MENU
C     -------------------------------------------------------
C
      DSET = DELH
      IF(DSET.EQ.0.)DELH = HMAX
C
      DELH  = DELH/RADIUS
      HMAX  = HMAX/RADIUS
      NHPTS = IFIX((HMAX - XIP)/DELH) + 1
C
      IF(DSET.EQ.0.)GOTO 33
C
C     ------------------------------------------------
C     WRITE OUTPUT HEADER (FOR PLOT FILE, SEE BELOW)
C     ------------------------------------------------
C
      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
   93 FORMAT( 10X,A50,/,10X,A50,//)
C
```

```
      WRITE(IOU6,1001)
 1001 FORMAT( 12X,' SUMMARY OF OVERTURNING FORCES AND MOMENTS',//,
     1          19X,'RADIUS',6X,'TOTF',6X,'TOTM',/,
     2          20X,'(FT)',7X,'(LB)',5X,'(FT-LB)',/)
   33 CONTINUE
C
C     -----------------------------------------------
C     WRITE OUT GRAPHICS FILES IF SWITCH IS SET BY USER
C     -----------------------------------------------
C
      IF(IGRAPH.EQ.1)THEN
C
C     -----------------------------------------
C     OPEN GRAPHICS FILE AND WRITE FILE HEADER
C     -----------------------------------------
C
      OPEN(IOU8,FILE=PTSFIL(4),STATUS='NEW',ERR=2000)
C
      WRITE(IOU8,83) COMM(1),COMM(2)
   83 FORMAT( 10X,A50,/,10X,A50,//)
C
      WRITE(IOU8,80)
   80 FORMAT( 1X,'TITLE="TWIN ROTOR DAIP DATA"')
C
      WRITE(IOU8,81)
   81 FORMAT( 1X,'VARIABLES = DAIP,TOTF,TOTM')
C
      WRITE(IOU8,88)
   88 FORMAT( 1X,'ZONE T = "GW = xxxxx LB, WAGL = xx FT",',
     *            ' I=x, F=POINT')
C
      ENDIF
C
C     ------------------------------------------------
C     BEGIN LOOP INCREMENTING THE RADIAL POINTS AT WHICH
C     THE OVERTURNING MOMENT CALCULATIONS ARE MADE
C     ------------------------------------------------------
C
      DO 565 K = 1,NHPTS
C
C     ---------------------------------------------
C     TF IS INTERACTION PLANE AMPLIFICATION FACTOR
C     ---------------------------------------------
C
      TF = 1.55 - (0.55)*EXP(-1.35*XIP)
C
C     ------------------------------------------------
C     GET PARAMETERS AT BASE RADIUS FOR 'BOUNDARY LAYER'
C     ------------------------------------------------
C
      RIP0 = SQRT(XIP**2 + YSEP**2)
C
C     -----------------------------------------------
C     'PROPRM' PROVIDES THE VELOCITY PROFILE PARAMETERS
```

```
C      OF A RADIAL WALL JET (WITHOUT INTERACTION PLANE)
C      -------------------------------------------------
C
       CALL PROPRM(H,UMB,RIP0)
C
       ZIPB = ZB
       ZIPM = ZM
       ZIPH = ZH
C
       RIPM = SQRT(XIP**2 + (YSEP + ZIPM)**2)
C
       CALL PROPRM(H,UMB,RIPM)
C
       UMM = UM
C
C      --------------
C      OUTPUT HEADER
C      --------------
C
       IF(DSET.NE.0.)GOTO 78
C
       XXIP   = RADIUS*XIP
       XIPOUT = XXIP + DXO
C
       IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
       IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
C
       WRITE(IOU6,1000) XIPOUT
  1000 FORMAT( 2X,'TWIN ROTOR INTERACTION PLANE VELOCITY PROFILE',
      1           ' AT DISTANCE = ',F7.1,' FT',//)
C
       WRITE(IOU6,1002)
  1002 FORMAT( 3X,'HEIGHT',6X,'MEAN VELOCITY',7X,'PEAK VELOCITY',6X,
      1       'MEAN Q',4X,'PEAK Q',/,
      2       3X,'(FT)',7X,'(FPS)',6X,'(KN)',5X,'(FPS)',6X,'(KN)',5X,
      3       '(PSF)',5X,'(PSF)',/)
    78 CONTINUE
C
C      ----------------------------
C      'AN' IS ACTUALLY '= 1.0/7.0'
C      ----------------------------
C
       AN = 0.142857142
C
       DELZ = 0.5/RADIUS
       NPTS = 12
C
       DO 500 I = 1,NPTS
C
       ZIP = DELZ*(I - 1) + (0.25/RADIUS)
C
C      ---------------------------------------------
C      GET MAX WALL JET VELOCITY AT EFFECTIVE RADIUS
```

```
C      -----------------------------------------------
C
       RIP = SQRT(XIP**2 + (YSEP + ZIP)**2)
C
       CALL PROPRM(H,UMB,RIP)
C
       VN = UN
       VZ = UM
C
C      ----------------------------------
C      INTERACTION PLANE 'BOUNDARY LAYER'
C      ----------------------------------
C
       IF(ZIP.LT.ZIPM)THEN
         VZ = UMM*(ZIP/ZIPM)**AN
       ENDIF
C
C      -------------------------------
C      DEVELOPED INTERACTION PLANE JET
C      -------------------------------
C
       VH = TF*VZ*XIP/RIP
       VV = TF*VZ*(YSEP + ZIP)/RIP
C
       ZZ = ZIP*RADIUS
C
C      -----------------------------------------------
C      MEAN HORIZONTAL VELOCITIES AND DYNAMIC PRESSURE
C      -----------------------------------------------
C
       VHMF = VH*UN
       VHMK = VHMF/FPSPKN
C
C      -----------------------------------------------
C      PEAK HORIZONTAL VELOCITIES AND DYNAMIC PRESSURE
C      -----------------------------------------------
C
       VMFD3I = (XIP*0.2444) + 0.8
C
       IF(VMFD3I.GT.2.5) VMFD3I = 2.5
       VHPF = VMFD3I*VHMF
       VHPK = VHPF/FPSPKN
C
C      ---------------------------------------------------------
C      THE EFFECT OF WIND IS TO ADD (DOWNWIND SIDE) OR SUBTRACT
C      (UPWIND SIDE) 'XWK' TIMES THE AMBIENT WIND VELOCITY TO
C      THE HORIZONTAL PROFILE VELOCITY (EMPIRICAL, CH-53E BASED)
C      ---------------------------------------------------------
C
       XKW = (-0.5*H) + 2.5
C
       IF(XKW.LT.1.0)XKW = 1.0
C
       WSPD2 = WSPD*XKW
```

```
      VHMK  = VHMK + WSPD2
      VHMF  = VHMK*FPSPKN
      VHPK  = VHPK + WSPD2
      VHPF  = VHPK*FPSPKN
C
C     -----------------
C     DYNAMIC PRESSURE
C     -----------------
C
      QHM   = RHOD2*VHMF**2
      QP(I) = RHOD2*VHPF**2
C
      IF(DSET.NE.0.)GOTC 77
C
C     -----------------------------
C     REPORT HORIZONTAL COMPONENTS
C     -----------------------------
C
      WRITE(IOU6,1003) ZZ,VHMF,VHMK,VHPF,VHPK,QHM,QP(I)
 1003 FORMAT ( F8.2,2X,6F10.3)
   77 CONTINUE
C
  500 CONTINUE
C
      IF(DSET.NE.0.)GOTO 520
      WRITE(IOU1,73)
   73 FORMAT( )
C
      WRITE(IOU1,'(19X,A,$)')
     1  ' TYPE <RETURN> TO CONTINUE  '
C
      READ(IOU1,'(A1)') TEMCHAR
C
      ICD = 0
      CALL HOMCLS(ICD)
      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
C
      WRITE(IOU6,1007) XIPOUT
 1007 FORMAT( 12X,'TWIN ROTOR FORCE PROFILE AT DISTANCE = ',
     1       F7.1,' FT',//)
      WRITE(IOU6,1008)
 1008 FORMAT( 2X,'HEIGHT',6X,'PEAK Q',6X,'FOVER',7X,'OVERM',7X,
     1            'TOT F',7X,'TOT M',/,
     2         3X,'(FT)',8X,'(PSF)',7X,'(LB)',6X,'(FT-LB)',7X,
     3            '(LB)',6X,'(FT-LB)',/)
  520 CONTINUE
C
C     -----------------------------------
C     CALL SUBROUTINE TO CALCULATE THE
C     FORCES AND MOMENTS ON A HUMAN BEING
C     -----------------------------------
C
```

```
      CALL MOMENT(NPTS,HUMTYP,TOTF,TOTM)
C
      IF(DSET.EQ.0.)GOTO 545
C
      HH    = XIP*RADIUS
      HHOUT = HH + DXO
C
      WRITE(IOU6,1014) HHOUT,TOTF,TOTM
 1014 FORMAT( 18X,F8.2,2F10.3)
C
      IF(IGRAPH.EQ.1)THEN
C
        WRITE(IOU8,90) HHOUT,TOTF,TOTM
   90   FORMAT( 1X,F7.2,1X,F7.2,1X,F8.2)
C
      ENDIF
C
  545 CONTINUE
C
      XIP = XIP + DELH
C
  565 CONTINUE
C
C     ----------------------------
C     CLOSE AN OPEN GRAPHICS FILE
C     ----------------------------
C
      IF(IGRAPH.EQ.1)THEN
C
        CLOSE(IOU8,STATUS='KEEP')
C
      ENDIF
C
      CALL INKEY
C
      GOTO 999
C
C     -------------------------------------------------
C     THE ERROR LOGIC ALLOWS FOR THE HANDLING OF FILE
C     OPEN ERRORS BY RETURNING THE USER TO A MENU
C     -------------------------------------------------
C
 2000 CONTINUE
C
      CALL HOMCLS(0)
      WRITE(IOU1,2001)
 2001 FORMAT( ////,8X,
     1         ' *** ERROR ***  PLEASE CHOOSE A NEW OUTPUT FILENAME',
     2 ///,8X,'             TYPE <RETURN> TO CONTINUE   ',$)
      READ(IOU1,'(A1)') TEMCHAR
      KEY = 'P'
C
  999 CONTINUE
C
```

```
      RETURN
      END
C
```

```
C
C
      SUBROUTINE HOMCLS(CODE)
C
C     ********************************************************
C     SUBROUTINE HOMCLS
C
C     THIS SUBROUTINE HOMES THE CURSOR AND CLEARS THE TERMINAL
C     SCREEN (CODE=0) OR HOMES THE CURSOR ONLY (CODE=1)
C     ********************************************************
C
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
      INTEGER*4 CODE
C
      CHARACTER*4 ED
      CHARACTER*1 EED(4)
      EQUIVALENCE (ED,EED(1))
C
      CHARACTER*3 EE
      CHARACTER*1 EEE(3)
      EQUIVALENCE (EE,EEE(1))
C
C     ********************************************************
C
      IF(CODE.EQ.1)GOTO 20
C
C     -----------------------------------
C     HOME CURSOR AND CLEAR SCREEN
C     ANSI CONTROL SEQUENCE: ED = ESC[2J
C     -----------------------------------
C
      EED(1) = CHAR(27)
      EED(2) = CHAR(91)
      EED(3) = CHAR(50)
      EED(4) = CHAR(74)
C
      WRITE(IOU1,*) ED
C
   20 CONTINUE
C
C     ----------------------------------
C     HOME CURSOR ONLY
C     ANSI CONTROL SEQUENCE: EE = ESC[H
C     ----------------------------------
C
      EEE(1) = CHAR(27)
      EEE(2) = CHAR(91)
      EEE(3) = CHAR(72)
C
      WRITE(IOU1,*) EE
C
      RETURN
      END
```

```
C

```

```
C
C
      SUBROUTINE HSVTX(XT,YT,ZT,VX,VY,VZ,GAMMA,RADIUS)
C
C     ******************************************************************
C     SUBROUTINE HSVTX
C
C     THIS SUBROUTINE DIRECTS THE CALCULATION OF THE INDUCED VELOCITY
C     FIELD DUE TO A HORSESHOE VORTEX SYSTEM OF UNIT STRENGTH.  POINT 1
C     (LEFT = L1, RIGHT = R1) DEFINE THE EXTENT OF THE BOUND PORTION OF
C     THE HORSESHOE.  THE TRAILERS START AT POINT 1 AND EXTEND THROUGH
C     POINT 2, AND THEN ON TO POINT 3.  THIS ALLOWS TWO ELEMENTS FOR
C     EACH TRAILER SO THAT IT CAN 'BEND' TO ACCOUNT FOR GROUND CONTACT.
C     ******************************************************************
C
      COMMON /CHSVTX/ XL1,YL1,ZL1,XL2,YL2,ZL2,XL3,YL3,ZL3,
     1                XR1,YR1,ZR1,XR2,YR2,ZR2,XR3,YR3,ZR3
      COMMON /CVLINE/ IFI,XA,YA,ZA,XB,YB,ZB,XC,YC,ZC,Q1,Q2,Q3
C
C     ******************************************************************
C
C     ---------------------------------------------
C     AT SPECIFIED (X,Y,Z) TARGET POINT IN VICINITY
C     OF ROTOR, CALCULATE THE VECTOR VELOCITY
C     ---------------------------------------------
C
      VX = 0.0
      VY = 0.0
      VZ = 0.0
C
      XC = XT
      YC = YT
      ZC = ZT
C
C     ---------------------------------------------
C     LEFT TRAILER CONTRIBUTION, POINT 1 TO POINT 2
C     ---------------------------------------------
C
      IFI = 0
      XA = XL1
      YA = YL1
      ZA = ZL1
      XB = XL2
      YB = YL2
      ZB = ZL2
C
      CALL VLINE
C
      VX = VX - Q1
      VY = VY - Q2
      VZ = VZ - Q3
C
C     ------------------
C     LEFT TRAILER IMAGE
```

```
C     ------------------
C
      ZA = -ZA
      ZB = -ZB
C
      CALL VLINE
C
      VX = VX + Q1
      VY = VY + Q2
      VZ = VZ + Q3
C
C     --------------------------------------------
C     LEFT TRAILER CONTRIBUTION, POINT 2 TO POINT 3
C     --------------------------------------------
C
      IFI = 1
      XA = XL2
      YA = YL2
      ZA = ZL2
      XB = XL3
      YB = YL3
      ZB = ZL3
C
      CALL VLINE
C
      VX = VX - Q1
      VY = VY - Q2
      VZ = VZ - Q3
C
C     ------------------
C     LEFT TRAILER IMAGE
C     ------------------
C
      ZA = -ZA
      ZB = -ZB
C
      CALL VLINE
C
      VX = VX + Q1
      VY = VY + Q2
      VZ = VZ + Q3
C
C     ----------------------------
C     SPANWISE VORTEX CONTRIBUTION
C     ----------------------------
C
      IFI = 0
      XA = XL1
      YA = YL1
      ZA = ZL1
      XB = XR1
      YB = YR1
      ZB = ZR1
C
```

```
      CALL VLINE
C
      VX = VX + Q1
      VY = VY + Q2
      VZ = VZ + Q3
C
C     ---------------------
C     SPANWISE VORTEX IMAGE
C     ---------------------
C
      ZA = -ZA
      ZB = -ZB
C
      CALL VLINE
C
      VX = VX - Q1
      VY = VY - Q2
      VZ = VZ - Q3
C
C     ------------------------------------------------
C     RIGHT TRAILER CONTRIBUTION, POINT 1 TO POINT 2
C     ------------------------------------------------
C
      IFI = 0
      XA = XR1
      YA = YR1
      ZA = ZR1
      XB = XR2
      YB = YR2
      ZB = ZR2
C
      CALL VLINE
C
      VX = VX + Q1
      VY = VY + Q2
      VZ = VZ + Q3
C
C     -------------------
C     RIGHT TRAILER IMAGE
C     -------------------
C
      ZA = -ZA
      ZB = -ZB
C
      CALL VLINE
C
      VX = VX - Q1
      VY = VY - Q2
      VZ = VZ - Q3
C
C     ------------------------------------------------
C     RIGHT TRAILER CONTRIBUTION, POINT 2 TO POINT 3
C     ------------------------------------------------
C
```

```
      IFI = 1
      XA = XR2
      YA = YR2
      ZA = ZR2
      XB = XR3
      YB = YR3
      ZB = ZR3
C
      CALL VLINE
C
      VX = VX + Q1
      VY = VY + Q2
      VZ = VZ + Q3
C
C     --------------------
C     RIGHT TRAILER IMAGE
C     --------------------
C
      ZA = -ZA
      ZB = -ZB
C
      CALL VLINE
C
      VX = VX - Q1
      VY = VY - Q2
      VZ = VZ - Q3
C
C     ---------------
C     DIMENSIONALIZE
C     ---------------
C
      GDR= GAMMA/RADIUS
      VX = VX*GDR
      VY = VY*GDR
      VZ = VZ*GDR
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE HWJVEL(H,UN,UMB,RVZ,RADIUS,WSPD,DELH,HMAX,
     *                  HUMTYP,DXO)
C
C     ****************************************************
C     SUBROUTINE HWJVEL GENERATES THE VELOCITY PROFILE AND
C     THE FORCES AND OVERTURNING MOMENTS FOR A HUMAN BEING
C     AT A GIVEN RADIUS
C     ****************************************************
C
      CHARACTER*1 ICONT(5)
      CHARACTER*1 TEMCHAR
      CHARACTER*1 KEY,KKEY,HUMTYP
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /PERSON/ QP(12),DSET
      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     ****************************************************
C
      ICD = 0
      CALL HOMCLS(ICD)
C
C     ----------------------------------------------------
C     INPUT FOR DELH AND HMAX COMES FROM INPUTV STATUS MENU
C     ----------------------------------------------------
C
      DSET = DELH
C
      IF(DSET.EQ.0.) DELH = HMAX
C
      DELH  = DELH/RADIUS
      HMAX  = HMAX/RADIUS
      NHPTS = IFIX((HMAX - RVZ)/DELH) + 1
C
      IF(DSET.EQ.0.)GOTO 50
      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
   93 FORMAT( 10X,A50,/,10X,A50,//)
C
      WRITE(IOU6,1001)
 1001 FORMAT( 12X,' SUMMARY OF OVERTURNING FORCES AND MOMENTS',//,
     1        19X,'RADIUS',6X,'TOTF',6X,'TOTM',/,
     2        20X,'(FT)',7X,'(LB)',5X,'(FT-LB)',/)
   50 CONTINUE
C
C     -----------------------------------------------
```

```
C     WRITE OUT GRAPHICS FILE IF SWITCH IS SET BY USER
C     -------------------------------------------------
C
      IF(IGRAPH.EQ.1)THEN
C
C     ----------------------------------------
C     OPEN GRAPHICS FILE AND WRITE FILE HEADER
C     ----------------------------------------
C
      OPEN(IOU8,FILE=PTSFIL(3),STATUS='NEW',ERR=2000)
C
      WRITE(IOU8,83) COMM(1),COMM(2)
   83 FORMAT( 10X,A50,/,10X,A50,//)
C
      WRITE(IOU8,80)
   80 FORMAT( 1X,'TITLE="SINGLE ROTOR DFRC DATA"')
C
      WRITE(IOU8,81)
   81 FORMAT( 1X,'VARIABLES = DFRC,TOTF,TOTM')
C
      WRITE(IOU8,88)
   88 FORMAT( 1X,'ZONE T = "GW = xxxxx LB, WAGL = xx FT",',
     *             ' I=x, F=POINT')
C
      ENDIF
C
C     --------------------------------------------------
C     BEGIN LOOP INCREMENTING THE RADIAL POINTS AT WHICH
C     THE OVERTURNING MOMENT CALCULATIONS ARE MADE
C     --------------------------------------------------
C
      DO 565 K = 1,NHPTS
C
C     -------------------------------------------------
C     'PROPRM' PROVIDES THE VELOCITY PROFILE PARAMETERS
C     OF A RADIAL WALL JET (WITHOUT INTERACTION PLANE)
C     -------------------------------------------------
C
      CALL PROPRM(H,UMB,RVZ)
C
      ZETAM = ZM/ZB
C
C     ------------------------------
C     BOUNDARY LAYER REGION EXPONENT
C     ------------------------------
C
C     ----------------------------
C     'AN' IS ACTUALLY '= 1.0/7.0'
C     ----------------------------
C
      AN = 0.142857142
C
C     ---------------------------------------------------------
C     SHEAR LAYER REGION EXPONENT, TO MEET EDGE CONDITIONS
```

```
C     (FROM FIGURE 7, USAAVLABS TECHNICAL REPORT 68-52, JULY 1968)
C     ------------------------------------------------------------
C
      ALPW = ALOG(1.0 - 1.0/SQRT(2.0))/ALOG((ZH - ZM)/(ZB - ZM))
C
      VN  = UN
      VMN = UM
C
C     ---------------------------------------------------
C     CALCULATION OF THE PEAK VELOCITY CORRECTION FACTOR
C     IS MADE IN THE NEXT SECTION AT THE 3 FT POSITION
C     ---------------------------------------------------
C
      VZ3   = 3.0/RADIUS
      ZETA3 = VZ3/ZB
      VZM3  = 0.0
      IF(ZETA3.GE.ZETAM)GOTO 51
C
C     -----------------------------------------
C     THE 3 FT HEIGHT IS IN THE BOUNDARY LAYER
C     -----------------------------------------
C
      IF(ZETAM.GT.0.0) VZM3 = (ZETA3/ZETAM)**AN
      GOTO 52
C
   51 CONTINUE
C
C     --------------------------------------
C     THE 3 FT HEIGHT IS IN THE SHEAR LAYER
C     --------------------------------------
C
      IF(VZ3.LE.ZB)THEN
        VZM3 = (1.0 - ((ZETA3 - ZETAM)/(1.0 - ZETAM))**ALPW)**2
      ENDIF
C
   52 CONTINUE
C
C     -------------------------------------------------
C     THE DELTA VELOCITY TO ADD TO THE MEAN VELOCITY IS
C     CALCULATED AS THE CONSTANT VMFD3 (FT/SEC)
C     -------------------------------------------------
C
      VZN3    = VZM3*VMN
      VMF3    = VZN3*VN
      VMFD3S = (RVZ*0.2444) + 0.4
C
      IF(VMFD3S.GT.1.5) VMFD3S = 1.5
C
      VMFD3 = VMFD3S*VMF3
C
      IF(DSET.NE.0.)GOTO 78
C
      RRVZ    = RVZ*RADIUS
      RVZOUT = RRVZ + DXO
```

```
C
      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
C
      WRITE(IOU6,1000) RVZOUT
 1000 FORMAT( 10X,'SINGLE ROTOR VELOCITY PROFILE AT RADIUS = ',
     1       F7.1,' FT',//)
      WRITE(IOU6,1005)
 1005 FORMAT( 2X,'HEIGHT',5X,'MEAN VELOCITY',7X,'PEAK VELOCITY',6X,
     1        'MEAN Q',4X,'PEAK Q',/,
     2       3X,'(FT)',5X,'(FPS)',6X,'(KN)',5X,'(FPS)',6X,'(KN)',5X,
     3        '(PSF)',5X,'(PSF)',/)
   78 CONTINUE
C
C     ---------------------------------------
C     SET UP ABILITY TO CALCULATE AT 0.5 FT.
C     INCREMENTS UP THE VELOCITY PROFILE
C     ---------------------------------------
C
      DELZ = 0.5/RADIUS
      NPTS = 12
C
      DO 500 I = 1,NPTS
C
      Z    = DELZ*(I - 1) + (0.25/RADIUS)
      ZETA = Z/ZB
C
      IF(ZETA.GE.ZETAM)GOTO 300
C
C     --------------------------
C     Z IS WITHIN BOUNDARY LAYER
C     --------------------------
C
      VZM = 0.0
      IF(ZETAM.GT.0.0) VZM = (ZETA/ZETAM)**AN
C
      GOTO 400
C
  300 CONTINUE
C
C     -----------------------
C     Z IS WITHIN SHEAR LAYER
C     -----------------------
C
      VZM = 0.0
C
      IF(Z.LE.ZB)THEN
        VZM = (1.0 - ((ZETA - ZETAM)/(1.0 - ZETAM))**ALPW)**2
      ENDIF
C
  400 CONTINUE
C
      VZN = VZM*VMN
```

```
C
C      ------------------
C      DIMENSIONAL HEIGHT
C      ------------------
C
       ZZ   = Z*RADIUS
C
C      ---------------
C      MEAN VELOCITIES
C      ---------------
C
       VMF = VZN*VN
       VMK = VMF/FPSPKN
C
C      ---------------
C      PEAK VELOCITIES
C      ---------------
C
       VPF = VMF + VMFD3
       VPK = VPF/FPSPKN
C
C      -------------------------------------------------------
C      THE EFFECT OF WIND IS TO ADD (DOWNWIND SIDE) OR SUBTRACT
C      (UPWIND SIDE) 'XWK' TIMES THE AMBIENT WIND VELOCITY TO
C      THE HORIZONTAL PROFILE VELOCITY (EMPIRICAL, CH-53E BASED)
C      -------------------------------------------------------
C
       XKW = (-0.5*H) + 2.5
C
       IF(XKW.LT.1.0) XKW = 1.0
C
       WSPD2 = WSPD*XKW
       VMK   = VMK + WSPD2
       VMF   = VMK*FPSPKN
       VPK   = VPK + WSPD2
       VPF   = VPK*FPSPKN
C
C      ----------------
C      DYNAMIC PRESSURE
C      ----------------
C
       QM    = RHOD2*VMF**2
       QP(I) = RHOD2*VPF**2
C
       IF(DSET.NE.0.)GOTO 77
C
       WRITE(IOU6,1002) ZZ,VMF,VMK,VPF,VPK,QM,QP(I)
  1002 FORMAT( F8.2,6F10.3)
    77 CONTINUE
C
   500 CONTINUE
C
       IF(DSET.NE.0.)GOTO 520
C
```

```
      WRITE(IOU1,73)
   73 FORMAT( )
C
      WRITE(IOU1,'(15X,A,$)')
     1 ' TYPE <RETURN> TO CONTINUE '
C
      READ(IOU1,'(A1)') TEMCHAR
C
      ICD = 0
      CALL HOMCLS(ICD)
      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
C
      WRITE(IOU6,1007) RVZOUT
 1007 FORMAT( 12X,'SINGLE ROTOR FORCE PROFILE AT RADIUS = ',
     1       F7.1,' FT',//)
C
      WRITE(IOU6,1008)
 1008 FORMAT( 2X,'HEIGHT',6X,'PEAK Q',6X,'FOVER',7X,'OVERM',7X,
     1         'TOT F',7X,'TOT M',/,
     2         3X,'(FT)',8X,'(PSF)',7X,'(LB)',6X,'(FT-LB)',7X,
     3         '(LB)',6X,'(FT-LB)',/)
C
  520 CONTINUE
C
C     ------------------------------------
C     CALL SUBROUTINE TO CALCULATE THE
C     FORCES AND MOMENTS ON A HUMAN BEING
C     ------------------------------------
C
      CALL MOMENT(NPTS,HUMTYP,TOTF,TOTM)
C
      IF(DSET.EQ.0.)GOTO 545
C
      HH    = RVZ*RADIUS
      HHOUT = HH + DXO
C
      WRITE(IOU6,1014) HHOUT,TOTF,TOTM
 1014 FORMAT( 18X,F8.2,2F10.3)
C
      IF(IGRAPH.EQ.1)THEN
C
        WRITE(IOU8,90) HHOUT,TOTF,TOTM
   90   FORMAT( 1X,F7.2,1X,F7.2,1X,F8.2)
C
      ENDIF
C
  545 CONTINUE
C
      RVZ = RVZ + DELH
C
  565 CONTINUE
C
```

```
C     ----------------------------
C     CLOSE AN OPEN GRAPHICS FILE
C     ----------------------------
C
      IF(IGRAPH.EQ.1)THEN
C
        CLOSE(IOU8,STATUS='KEEP')
C
      ENDIF
C
      CALL INKEY
C
      GOTO 999
C
C     ------------------------------------------------
C     THE ERROR LOGIC ALLOWS FOR THE HANDLING OF FILE
C     OPEN ERRORS BY RETURNING THE USER TO A MENU
C     ------------------------------------------------
C
 2000 CONTINUE
C
      CALL HOMCLS(0)
      WRITE(IOU1,2001)
 2001 FORMAT( ////,8X,
     1         ' *** ERROR ***  PLEASE CHOOSE A NEW OUTPUT FILENAME',
     2 ///,8X,'              TYPE <RETURN> TO CONTINUE   ',$)
      READ(IOU1,'(A1)') TEMCHAR
      KEY = 'P'
C
  999 CONTINUE
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE INKEY
C
C     ****************************************************
C     SUBROUTINE INKEY
C     ****************************************************
C
      PARAMETER(NUM = 8)
C
      CHARACTER*1 KEY,KKEY
      CHARACTER*1 OKLIST(NUM)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     ****************************************************
C
      DATA OKLIST /'C','c','P','p','N','n','X','x'/
C
C     ------------------------------------------------
C     INQUIRE, OBTAIN, AND CHECK FOR VALID MENU OPTION
C     ------------------------------------------------
C
   10 CONTINUE
C
      WRITE(IOU1,20)
   20 FORMAT( //,7X,' TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE,'
     1           ,' E<X>IT ==> ',$)
      READ(IOU1,'(A1)') KEY
C
      IF(LEGAL(KEY,IOU1,OKLIST,NUM).EQ.1)GOTO 10
C
C     ------------------------------------------
C     CORRECT LOWER CASE LETTERS TO UPPER CASE
C     TO USE AS VALID FLAGS IN PARENT SUBROUTINE
C     ------------------------------------------
C
      IF(KEY.EQ.'c') KEY = 'C'
      IF(KEY.EQ.'p') KEY = 'P'
      IF(KEY.EQ.'n') KEY = 'N'
      IF(KEY.EQ.'x') KEY = 'X'
C
C     ----------------------------
C     CLEAR SCREEN AND HOME CURSOR
C     ----------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE INPUT
C
C     *******************************************************
C     SUBROUTINE INPUT
C
C     THIS SUBROUTINE PRESENTS THE INPUT STATUS MENU
C     AND MANIPULATES THE DATA FOR PROGRAM USE
C     *******************************************************
C
      PARAMETER(NUM1 = 19)
      PARAMETER(NUM2 =  9)
      PARAMETER(NUM3 =  4)
      PARAMETER(NUM4 =  4)
C
      CHARACTER*1 CHDOL
      CHARACTER*1 CENTRY
      CHARACTER*1 OKLST1(NUM1)
      CHARACTER*1 OKLST2(NUM2)
      CHARACTER*1 OKLST3(NUM3)
      CHARACTER*1 OKLST4(NUM4)
      CHARACTER*1 ICONT(5)
C
      CHARACTER*12 PTSFIL(4)
C
      CHARACTER*50 COMM(2),LENTRY
      CHARACTER*50 PROMPT
C
      DIMENSION CONT(9),CONTV(7),CONTX(8)
C
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /INPUTD/ CONT,CONTV,CONTX
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     *******************************************************
C
C     ----------------------------------------
C     SET DATA TO CHECK FOR ILLEGAL DATA INPUT
C     ----------------------------------------
C
      DATA OKLST1 /' ','A','a','B','b','C','c','D','d',
     1              'E','e','F','f','G','g','H','h','I','i'/
      DATA OKLST2 /' ','A','a','B','b','C','c','D','d'/
      DATA OKLST3 /'V','v','H','h'/
      DATA OKLST4 /'Y','y','N','n'/
C
   10 CONTINUE
C
C     ----------------------------
C     CLEAR SCREEN AND HOME CURSOR
C     ----------------------------
C
      CALL HOMCLS(0)
```

```
      CALL LOCATE(2,1)
C
C     ---------------------------------
C     WRITE FIRST ENGINEERING DATA MENU
C     ---------------------------------
C
      IROTOR = IFIX(CONT(1))
C
      WRITE(IOU1,'(24X,A/)') ' ROTWASH USER INPUT DATA MENU'
      WRITE(IOU1,'(T7,A,T25,A,T51,A,T61,A/)') ' CODE',' PARAMETER',
     1       ' VALUE',' UNITS'
      WRITE(IOU1,'(8X,A,T50,I5,8X,A)')
     1       ' A       NUMBER OF ROTORS (1 OR 2)  ',IROTOR,'-ND-'
      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)')
     1       ' B       HUB TO HUB ROTOR SEPARATION',CONT(2),'FT'
      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)')
     1       ' C       ROTOR RADIUS               ',CONT(3),'FT'
      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)')
     1       ' D       GROSS WEIGHT               ',CONT(4),'LB'
      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)')
     1       ' E       FUSELAGE DOWNLOAD FACTOR   ',CONT(5),'PCT'
      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)')
     1       ' F       ROTOR HEIGHT ABOVE GROUND  ',CONT(6),'FT'
      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)')
     1       ' G       SHAFT TILT ANGLE (<20 DEG) ',CONT(7),'DEG'
      WRITE(IOU1,'(8X,A,T50,F8.4,6X,A)')
     1       ' H       AIR DENSITY RATIO          ',CONT(8),'ND'
      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A//)')
     1       ' I       AMBIENT WIND (-10 TO 10 KT)',CONT(9),'KT'
C
C     --------------------------------------------------
C     PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT DATA
C     --------------------------------------------------
C
   20 WRITE(IOU1,'(8X,A,$)')
     1' ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> '
C
      READ(IOU1,'(A1)') CHDOL
C
      IF(LEGAL(CHDOL,IOU1,OKLST1,NUM1).EQ.1)GOTO 20
C
      IF(CHDOL.EQ.' ')GOTO 30
C
      IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
C
         PROMPT = 'ROTORS = '
         CALL IREAD(IOU1,PROMPT,IROTOR)
C
         IF(IROTOR.LT.1) IROTOR = 1
         IF(IROTOR.GT.2) IROTOR = 2
         CONT(1) = FLOAT(IROTOR)
C
         GOTO 10
C
```

```
      ENDIF
C
      IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
C
         PROMPT = 'ROTOR SEPARATION = '
         CALL FREAD(IOU1,PROMPT,CONT(2),1.0)
         GOTO 10
C
      ENDIF
C
      IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
C
         PROMPT = 'ROTOR RADIUS = '
         CALL FREAD(IOU1,PROMPT,CONT(3),1.0)
         GOTO 10
C
      ENDIF
C
      IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
C
         PROMPT = 'GROSS WEIGHT = '
         CALL FREAD(IOU1,PROMPT,CONT(4),1.0)
         GOTO 10
C
      ENDIF
C
      IF(CHDOL.EQ.'E'.OR.CHDOL.EQ.'e')THEN
C
         PROMPT = 'DOWNLOAD FACTOR = '
         CALL FREAD(IOU1,PROMPT,CONT(5),1.0)
         GOTO 10
C
      ENDIF
C
      IF(CHDOL.EQ.'F'.OR.CHDOL.EQ.'f')THEN
C
         PROMPT = 'HEIGHT ABOVE GROUND = '
         CALL FREAD(IOU1,PROMPT,CONT(6),1.0)
         GOTO 10
C
      ENDIF
C
      IF(CHDOL.EQ.'G'.OR.CHDOL.EQ.'g')THEN
C
         PROMPT = 'SHAFT TILT = '
         CALL FREAD(IOU1,PROMPT,CONT(7),1.0)
C
         IF(CONT(7).LT. 0.0) CONT(7) =  0.0
         IF(CONT(7).GT.20.0) CONT(7) = 20.0
         GOTO 10
C
      ENDIF
C
      IF(CHDOL.EQ.'H'.OR.CHDOL.EQ.'h')THEN
```

```
C
         PROMPT = 'DENSITY RATIO = '
         CALL FREAD(IOU1,PROMPT,CONT(8),1.0)
         GOTO 10
C
      ENDIF
C
      IF(CHDOL.EQ.'I'.OR.CHDOL.EQ.'i')THEN
C
         PROMPT = 'WIND VELOCITY = '
         CALL FREAD(IOU1,PROMPT,CONT(9),1.0)
C
         IF(CONT(9).LT.-10.0) CONT(9) = -10.0
         IF(CONT(9).GT. 10.0) CONT(9) =  10.0
         GOTO 10
C
      ENDIF
C
      GOTO 10
C
   30 CONTINUE
C
C     -----------------------------
C     CLEAR SCREEN AND HOME CURSOR
C     -----------------------------
C
      CALL HOMCLS(0)
      CALL LOCATE(2,1)
C
C     -----------------------------------
C     WRITE SECOND ENGINEERING DATA MENU
C     -----------------------------------
C
      WRITE(IOU1,40)
   40 FORMAT( ' ',18X,' ROTWASH PROGRAM LOGIC/COMMENT MENU',//,
     1       10X,'CODE              PARAMETER                        VALUE'/)
C
      WRITE(IOU1,50) ICONT(1),ICONT(2),COMM(1),COMM(2)
   50 FORMAT( 12X,'A       ANALYSIS TYPE,     <V> OR <H>',5X,A4,/,
     1          12X,'B       GRAPHICS FILE,     <Y> OR <N>',5X,A4,///,
     2          15X,'USER INPUT COMMENTS (FOR "PRN" AND "PLT" OUTPUT)',
     3     //,17X,'<---                50 SPACES                   --->',
     4        /,12X,'C',4X,A50,/,
     5          12X,'D',4X,A50,//)
C
C     ---------------------------------------------------
C     PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT DATA
C     ---------------------------------------------------
C
   60 WRITE(IOU1,'(8X,A,$)')
     1' ENTER CODE FOR DATA INPUT OR <RETURN> TO CONTINUE ==> '
C
      READ(IOU1,'(A1)') CHDOL
C
```

```
      IF(LEGAL(CHDOL,IOU1,OKLST2,NUM2).EQ.1)GOTO 60
C
      IF(CHDOL.EQ.' ')GOTO 70
C
C     -----------------------------------------
C     CHOOSE VELOCITY OR HAZARD ANALYSIS OPTION
C     -----------------------------------------
C
      IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
C
   80    CONTINUE
C
         WRITE(IOU1,'(/,35X,A,1X,A2/)') ' ANALYSIS TYPE = ',ICONT(1)
         WRITE(IOU1,'(40X,A,$)') ' ENTER NEW VALUE    ==> '
         READ(IOU1,'(A1)') CENTRY
C
         IF(LEGAL(CENTRY,IOU1,OKLST3,NUM3).EQ.1)GOTO 80
C
         ICONT(1) = CENTRY
         IF(ICONT(1).EQ.'v') ICONT(1) = 'V'
         IF(ICONT(1).EQ.'h') ICONT(1) = 'H'
         GOTO 30
C
      ENDIF
C
C     ----------------------------------------
C     CHOOSE OUTPUT TO A GRAPHICS FILE OR NOT
C     ----------------------------------------
C
      IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
C
   90    CONTINUE
C
         WRITE(IOU1,'(/,35X,A,1X,A2/)') ' GRAPHICS FLAG = ',ICONT(2)
         WRITE(IOU1,'(40X,A,$)') ' ENTER NEW VALUE    ==> '
         READ(IOU1,'(A1)') CENTRY
C
         IF(LEGAL(CENTRY,IOU1,OKLST4,NUM4).EQ.1)GOTO 90
C
         ICONT(2) = CENTRY
         IF(ICONT(2).EQ.'y') ICONT(2) = 'Y'
         IF(ICONT(2).EQ.'n') ICONT(2) = 'N'
         IF(ICONT(2).EQ.'Y') IGRAPH = 1
         IF(ICONT(2).EQ.'N') IGRAPH = 0
         GOTO 30
C
      ENDIF
C
C     ---------------------------------------
C     CHOOSE COMMENT STRINGS FOR OUTPUT DATA
C     ---------------------------------------
C
      IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
C
```

```
            WRITE(IOU1,'(/,5X,A,A50/)') ' COMMENT STRING = ',COMM(1)
            WRITE(IOU1,'(5X,A,$)') ' ENTER STRING ==> '
            READ(IOU1,'(A50)') LENTRY
C
            COMM(1) = LENTRY
            GOTO 30
C
         ENDIF
C
         IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
C
            WRITE(IOU1,'(/,5X,A,A50/)') ' COMMENT STRING = ',COMM(2)
            WRITE(IOU1,'(5X,A,$)') ' ENTER STRING ==> '
            READ(IOU1,'(A50)') LENTRY
C
            COMM(2) = LENTRY
            GOTO 30
C
         ENDIF
C
         GOTO 30
C
   70    CONTINUE
C
         RETURN
         END
C
```

```
C
C
      SUBROUTINE INPUTV(FLOW)
C
C     ****************************************************************
C     SUBROUTINE INPUTV
C
C     THIS SUBROUTINE PRESENTS THE INPUT STATUS MENU AND MANIPULATES
C     DATA FOR FOR THE WALJET AND IPLANE PROGRAM OPTIONS
C     ****************************************************************
C
      PARAMETER(NUM = 9)
C
      CHARACTER*1 OKLIST(NUM)
      CHARACTER*1 CHDOL,FLOW
      CHARACTER*1 ICONT(5)
      CHARACTER*12 TMPFIL
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
      CHARACTER*50 PROMPT
C
      DIMENSION CONT(9),CONTV(7),CONTX(8)
C
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /INPUTD/ CONT,CONTV,CONTX
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     ****************************************************************
C
      DATA OKLIST /' ','A','a','B','b','C','c','D','d'/
C
C     ----------------------------
C     CLEAR SCREEN AND HOME CURSOR
C     ----------------------------
C
      ICD = 0
C
   20 CONTINUE
C
      CALL HOMCLS(ICD)
      CALL LOCATE(1,1)
C
      WRITE(IOU1,12)
   12 FORMAT( 22X,' VELOCITY PROFILE STATUS MENU',///,
     1       10X,'CODE          PARAMETER                  VALUE',
     2        3X,'UNITS',/)
C
C     -----------------------------------------------
C     PRINT OUT MENU VARIABLES AS BASED ON THE WALL JET
C     OPTION OR INTERACTION PLANE OPTION SWITCH SETTING
C     -----------------------------------------------
C
      IF(FLOW.EQ.'W')THEN
C
```

```
            WRITE(IOU1,14)(CONTV(I),I=1,3),PTSFIL(1)
C
         ELSE
C
            WRITE(IOU1,14)(CONTV(I),I=1,3),PTSFIL(2)
C
         ENDIF
C
      14 FORMAT( 12X,'A      PROFILE STATION POSITION ',5X,F7.2,
        1     4X,'FT',/,
        2    12X,'B      VERTICAL INCREMENT       ',5X,F7.2,4X,'FT',/,
        3    12X,'C      MAXIMUM PROFILE HEIGHT   ',5X,F7.2,4X,'FT',//,
        4    12X,'D      DATA OUTPUT FILENAME     ',7X,A12,//)
C
C        ---------------------------------------------------
C        PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT DATA
C        ---------------------------------------------------
C
      10 CONTINUE
C
         WRITE(IOU1,'(8X,A,$)')
        1 ' ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> '
C
         READ(IOU1,'(A1)') CHDOL
C
         IF(LEGAL(CHDOL,IOU1,OKLIST,NUM).EQ.1)GOTO 10
C
         IF(CHDOL.EQ.' ')GOTO 30
C
         IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
C
            PROMPT = 'PROFILE STATION POSITION = '
            CALL FREAD(IOU1,PROMPT,CONTV(1),1.0)
C
            IF(CONTV(1).LT.0.0) CONTV(1) = 0.0
            GOTO 20
C
         ENDIF
C
         IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
C
            PROMPT = 'VERTICAL INCREMENT = '
            CALL FREAD(IOU1,PROMPT,CONTV(2),1.0)
C
            IF(CONTV(2).LT.0.0) CONTV(2) = 0.0
            GOTO 20
C
         ENDIF
C
         IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
C
            PROMPT = 'MAXIMUM PROFILE HEIGHT = '
            CALL FREAD(IOU1,PROMPT,CONTV(3),1.0)
C
```

```
         IF(CONTV(3).LT.0.0) CONTV(3) = 0.0
         GOTO 20
C
      ENDIF
C
C     -------------------------
C     CHOOSE GRAPHICS FILENAME
C     -------------------------
C
      IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
C
        IF(FLOW.EQ.'W')THEN
          WRITE(IOU1,'(/,25X,A,1X,A12/)')
     1              ' FILENAME = ',PTSFIL(1)
        ELSE
          WRITE(IOU1,'(/,25X,A,1X,A12/)')
     1              ' FILENAME = ',PTSFIL(2)
        ENDIF
C
        WRITE(IOU1,'(20X,A,$)')
     1 ' ENTER NEW FILENAME (xxxxxxxx.xxx) ==> '
C
        READ(IOU1,'(A12)') TMPFIL
C
        IF(FLOW.EQ.'W') PTSFIL(1) = TMPFIL
        IF(FLOW.EQ.'I') PTSFIL(2) = TMPFIL
        GOTO 20
C
      ENDIF
C
      GOTO 20
C
   30 CONTINUE
C
      ICD = 0
      CALL HOMCLS(ICD)
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE INPUTX
C
C     ******************************************************
C     SUBROUTINE INPUTX PRESENTS THE INPUT STATUS MENU AND
C     MANIPULATES DATA FOR PROGRAM USE WITH THE GROUND AND
C     DISC VORTEX OPTIONS
C     ******************************************************
C
      PARAMETER(NUM = 15)
C
      CHARACTER*1 OKLIST(NUM)
      CHARACTER*1 CHDOL
      CHARACTER*1 ICONT(5)
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
      CHARACTER*50 PROMPT
C
      DIMENSION CONT(9),CONTV(7),CONTX(8)
C
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /INPUTD/ CONT,CONTV,CONTX
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     ******************************************************
C
      DATA OKLIST /' ','A','a','B','b','C','c','D','d',
     1             'E','e','F','f','G','g'/
C
C     -----------------------------
C     CLEAR SCREEN AND HOME CURSOR
C     -----------------------------
C
      ICD = 0
C
   20 CONTINUE
C
      CALL HOMCLS(ICD)
      CALL LOCATE(1,1)
C
      WRITE(IOU1,10)
   10 FORMAT( 18X,' GROUND/DISK VORTEX INPUT DATA MENU',/,
     1        15X,' (FOR SINGLE MAIN ROTOR HELICOPTERS ONLY)',///,
     1        8X,'CODE          PARAMETER                    VALUE',
     2        4X,'UNITS',/)
C
      WRITE(IOU1,11)(CONTX(I),I=1,7)
   11 FORMAT( 10X,'A     ROTOR TIP SPEED           ',5X,F8.2,
     1      4X,'FPS',/,
     2     10X,'B     NUMBER OF ROTOR BLADES    ',5X,F8.2,4X,'-ND-',/,
     3     10X,'C     TRANSLATIONAL SPEED       ',5X,F8.2,4X,'FPS',/,
     4     10X,'D     XT POSITION               ',5X,F8.2,4X,'FT',/,
     5     10X,'E     YT POSITION               ',5X,F8.2,4X,'FT',/,
```

```
     6    10X,'F     ZT CALCULATION INCREMENT   ',5X,F8.2,4X,'FT',/,
     7    10X,'G     MAXIMUM CALCULATION HEIGHT',5X,F8.2,4X,'FT',///)
C
C      -------------------------------------------------
C      INQUIRE, OBTAIN, AND CHECK FOR VALID MENU OPTION
C      -------------------------------------------------
C
   40 CONTINUE
C
      WRITE(IOU1,'(8X,A,$)')
     1 ' ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> '
C
      READ(IOU1,'(A1)') CHDOL
C
      IF(LEGAL(CHDOL,IOU1,OKLIST,NUM).EQ.1)GOTO 40
C
      IF(CHDOL.EQ.' ')GOTO 30
C
      IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
C
         PROMPT = 'ROTOR TIP SPEED = '
         CALL FREAD(IOU1,PROMPT,CONTX(1),1.0)
C
         IF(CONTX(1).LT.0.0) CONTX(1) = 0.0
         GOTO 20
C
      ENDIF
C
      IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
C
         PROMPT = 'NUMBER OF ROTOR BLADES = '
         CALL FREAD(IOU1,PROMPT,CONTX(2),1.0)
C
         IF(CONTX(2).LT.2.0) CONTX(2) = 2.0
         GOTO 20
C
      ENDIF
C
      IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
C
         PROMPT = 'TRANSLATIONAL SPEED = '
         CALL FREAD(IOU1,PROMPT,CONTX(3),1.0)
C
         IF(CONTX(3).LT.0.0) CONTX(3) = 0.0
         GOTO 20
C
      ENDIF
C
      IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
C
         PROMPT = 'XT POSITION = '
         CALL FREAD(IOU1,PROMPT,CONTX(4),1.0)
         GOTO 20
C
```

```
      ENDIF
C
      IF(CHDOL.EQ.'E'.OR.CHDOL.EQ.'e')THEN
C
         PROMPT = 'YT POSITION = '
         CALL FREAD(IOU1,PROMPT,CONTX(5),1.0)
         GOTO 20
C
      ENDIF
C
      IF(CHDOL.EQ.'F'.OR.CHDOL.EQ.'f')THEN
C
         PROMPT = 'ZT CALCULATION INCREMENT = '
         CALL FREAD(IOU1,PROMPT,CONTX(6),1.0)
C
         IF(CONTX(6).LT.0.0) CONTX(6) = 0.0
         GOTO 20
C
      ENDIF
C
      IF(CHDOL.EQ.'G'.OR.CHDOL.EQ.'g')THEN
C
         PROMPT = 'MAXIMUM CALCULATION HEIGHT = '
         CALL FREAD(IOU1,PROMPT,CONTX(7),1.0)
C
         IF(CONTX(7).LT.0.0) CONTX(7) = 0.0
         GOTO 20
C
      ENDIF
C
      GOTO 20
C
   30 CONTINUE
C
      ICD = 0
      CALL HOMCLS(ICD)
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE IOFNSH
C
C     ****************************************************
C     SUBROUTINE IOFNSH CLOSES FILES OPENED FOR DISK I/O
C     ****************************************************
C
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     ****************************************************
C
C     -------------------------------------------------
C     KEEP STANDARD I/O FILES IF ON DISK, ELSE DELETE
C     -------------------------------------------------
C
      IF(IOU5.EQ.5) CLOSE(IOU5,STATUS='KEEP')
      IF(IOU6.EQ.6) CLOSE(IOU6,STATUS='KEEP')
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE IOINIT
C
C     **************************************************
C     SUBROUTINE IOINIT DISPLAYS THE OPENING BANNER
C     AND OPENS THE FILES FOR DISK I/O, FILENAMES
C     ARE PROMPTED FROM THE TERMINAL
C     **************************************************
C
      CHARACTER*3 IPFILE,OPFILE
      CHARACTER*1 TEMCHAR
C
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     **************************************************
C
C     ------------------------------------------
C     ASSIGN DEFAULT VALUES TO I/O UNIT POINTERS
C     ------------------------------------------
C
      IOU1   = 0
      IOU4   = 0
      IOU5   = 0
      IOU6   = 6
      IOU7   = 0
      IOU8   = 8
      IGRAPH = 0
C
C     ---------------------------------
C     HOME CURSOR AND CLEAR THE DISPLAY
C     ---------------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
C
C     --------------
C     DISPLAY BANNER
C     --------------
C
      CALL LOCATE(5,1)
C
C     -----------------------------------------------
C     ORIGINAL ROTHAZ PROGRAM WAS VERSION 1.0
C     FIRST VAX MENU VERSION OF ROTHAZ WAS VERSION 1.1
C     PROGRAM ROTWASH REPLACES ROTHAZ AT VERSION 2.0
C     -----------------------------------------------
C
      WRITE(IOU1,10)
   10 FORMAT( 27X,'ROTWASH PROGRAM',//
     1 /,17X,'ROTORCRAFT DOWNWASH HAZARD ANALYSIS',/
     2 /,15X,'EMA/COMPUTATIONAL METHODOLOGY ASSOCIATES',
     3 /,15X,'*** PROGRAM VERSION 2.0,  APRIL 1991 ***'
     4 ///////)
```

```
C
      WRITE(IOU1,'(A,$)')
     1 '                              PRESS <RETURN>
      READ(IOU1,'(A1)') TEMCHAR
C
C     ----------------------------------
C     HOME CURSOR AND CLEAR THE DISPLAY
C     ----------------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
      CALL LOCATE(3,1)
C
C     --------------------------------------------
C     PROMPT FOR I/O FILES AND READ USER RESPONSE
C     --------------------------------------------
C
      WRITE(IOU1,12)
   12 FORMAT( 14X,' I/O CAN BE DIRECTED TO FILES OR DEVICES',//,
     1        19X,' VALID DEVICES ARE AS FOLLOWS:',//,
     2        22X,'  <CON>  ==>  CONSOLE',/,
     2        22X,'  <PRN>  ==>  PRINTER',/,
     4        22X,'  <PLT>  ==>  GRAPHICS FILE',///)
C
   16 CONTINUE
C
      WRITE(IOU1,13)
   13 FORMAT( 16X,' ENTER INPUT FILE/DEV NAME  ==> ',$)
   11 FORMAT(A)
      READ(IOU1,11) IPFILE
C
C     ---------------------------
C     CHECK FOR DATA ENTRY ERROR
C     ---------------------------
C
      IF(IPFILE.NE.'CON'.AND.IPFILE.NE.'con')THEN
          WRITE(IOU1,15)
   15     FORMAT(/,16X,' ** INPUT ERROR, PLEASE REENTER **',//)
          GOTO 16
      ENDIF
C
   17 CONTINUE
C
      WRITE(IOU1,14)
   14 FORMAT( 16X,' ENTER OUTPUT FILE/DEV NAME ==> ',$)
      READ(IOU1,11) OPFILE
C
C     ---------------------------
C     CHECK FOR DATA ENTRY ERROR
C     ---------------------------
C
      IF(OPFILE.NE.'CON'.AND.OPFILE.NE.'con'.AND.
     1   OPFILE.NE.'PRN'.AND.OPFILE.NE.'prn'.AND.
     2   OPFILE.NE.'PLT'.AND.OPFILE.NE.'plt')THEN
```

```
            WRITE(IOU1,15)
            GOTO 17
        ENDIF
C
C       ----------------------------------------
C       REDIRECT INPUT/OUTPUT FILES IF REQUESTED
C       ----------------------------------------
C
        IF(IPFILE.EQ.'CON'.OR.IPFILE.EQ.'con')IOU5 = IOU1
        IF(OPFILE.EQ.'CON'.OR.OPFILE.EQ.'con')IOU6 = IOU1
        IF(OPFILE.EQ.'PRN'.OR.OPFILE.EQ.'prn')IOU6 = 6
C
        IF(OPFILE.EQ.'PLT'.OR.OPFILE.EQ.'plt')IGRAPH = 1
        IF(OPFILE.EQ.'PLT'.OR.OPFILE.EQ.'plt')IOU6 = IOU1
        IF(OPFILE.EQ.'PLT'.OR.OPFILE.EQ.'plt')IOU8 = 8
C
C       ------------------------
C       OPEN STANDARD I/O FILES
C
C         IOU5 = STD. INPUT
C         IOU6 = STD. OUTPUT
C       ------------------------
C
        IF(IOU5.EQ.5) OPEN(IOU5,FILE=IPFILE,STATUS='OLD')
        IF(IOU6.EQ.6) OPEN(IOU6,FILE=OPFILE,STATUS='NEW')
C
C       ---------------------------------
C       HOME CURSOR AND CLEAR THE DISPLAY
C       ---------------------------------
C
        ICD = 0
        CALL HOMCLS(ICD)
C
        RETURN
        END
C
```

```
C
C
      SUBROUTINE IPVEL(H,UN,RADIUS,UMB,XIP,YSEP,WSPD,DELZ,ZMAX,DXO)
C
C     **********************************************************
C     SUBROUTINE IPVEL GENERATES THE VELOCITY PROFILE V(X,Z) AT
C     XVZ ALONG THE INTERACTION PLANE FOR THE TWO ROTOR CASE
C     **********************************************************
C
      CHARACTER*1 TEMCHAR
      CHARACTER*1 ICONT(5)
      CHARACTER*1 KEY,KKEY
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
C
      DIMENSION ZZ(40),VHMF(40),VHMK(40),VHPF(40),VHPK(40),
     1          QHM(40),QHP(40),VVMF(40),VVMK(40),VVPF(40),
     2          VVPK(40),QVM(40),QVP(40)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     **********************************************************
C
C     ------------------------------------------------
C     TF IS THE INTERACTION PLANE AMPLIFICATION FACTOR
C     ------------------------------------------------
C
      TF = 1.55 - (0.55)*EXP(-1.35*XIP)
C
C     ----------------------------------------------------------
C     OBTAIN PAPAMETERS AT BASE RADIUS FOR THE 'BOUNDARY LAYER'
C     ----------------------------------------------------------
C
      RIPO = SQRT(XIP**2 + YSEP**2)
C
C     -------------------------------------------------
C     'PROPRM' PROVIDES THE VELOCITY PROFILE PARAMETERS
C     OF A RADIAL WALL JET (WITHOUT INTERACTION PLANE)
C     -------------------------------------------------
C
      CALL PROPRM(H,UMB,RIPO)
C
      ZIPB = ZB
      ZIPM = ZM
      ZIPH = ZH
C
      RIPM = SQRT(XIP**2 + (YSEP + ZIPM)**2)
C
      CALL PROPRM(H,UMB,RIPM)
C
```

```
      UMM = UM
C
C     ------------------------------------
C     INCREMENT AND HEIGHT ARE DELZ AND ZMAX
C     ------------------------------------
C
      NPTS = IFIX(ZMAX/DELZ) + 2
      IF(NPTS.GT.40) NPTS = 40
C
C     ------------------------------------------
C     DIMENSIONALIZE VELOCITY PROFILE PARAMETERS
C     ------------------------------------------
C
      XXIP = RADIUS*XIP
      ZZB  = ZIPB*RADIUS
      ZZH  = ZIPH*RADIUS
      ZZM  = ZIPM*RADIUS
C
C     -------------------------------------------------------
C     OUTPUT THE VELOCITY AND DYNAMIC PRESSURE PROFILE HEADER
C     -------------------------------------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
C
      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
   93 FORMAT( 10X,A50,/,10X,A50,//)
C
      XIPOUT = XXIP + DXO
C
      WRITE(IOU6,1000) XIPOUT
 1000 FORMAT( 2X,'TWIN ROTOR INTERACTION PLANE VELOCITY PROFILE',
     1           ' AT STATION = ',F7.1,' FT',//)
C
      WRITE(IOU6,1002)
 1002 FORMAT( 2X,'HEIGHT',8X,'MEAN VELOCITY',7X,'PEAK VELOCITY',6X,
     1       'MEAN Q',4X,'PEAK Q',/,
     2     3X,'(FT)',8X,'(FPS)',6X,'(KN)',5X,'(FPS)',6X,'(KN)',5X,
     3       '(PSF)',5X,'(PSF)',/)
C
      LINES = 0
C
C     ----------------------------
C     'AN' IS ACTUALLY '= 1.0/7.0'
C     ----------------------------
C
      AN = 0.142857142
C
C     ----------------------------------------------
C     CALCULATE THE VELOCITY PROFILE POINTS FOR OUTPUT
C     'NPTS' IS THE NUMBER OF VERTICAL STATION POINTS
C     ----------------------------------------------
```

```
C
      DO 500 I = 1,NPTS
C
        LINES = LINES + 2
        ZIP   = DELZ*FLOAT(I - 1)
C
C       ---------------------------------------------
C       GET MAX WALL JET VELOCITY AT EFFECTIVE RADIUS
C       ---------------------------------------------
C
        RIP = SQRT(XIP**2 + (YSEP + ZIP)**2)
C
        CALL PROPRM(H,UMB,RIP)
C
        VN = UN
        VZ = UM
C
C       -----------------------------------
C       INTERACTION PLANE 'BOUNDARY LAYER'
C       -----------------------------------
C
        IF(ZIP.LT.ZIPM) VZ = UMM*(ZIP/ZIPM)**AN
C
C       -------------------------------
C       DEVELOPED INTERACTION PLANE JET
C       -------------------------------
C
        VH = TF*VZ*XIP/RIP
        VV = TF*VZ*(YSEP + ZIP)/RIP
C
        ZZ(I) = ZIP*RADIUS
C
C       -------------------------------------
C       MEAN VELOCITIES AND DYNAMIC PRESSURE
C       -------------------------------------
C
        VHMF(I) = VH*UN
        VVMF(I) = VV*UN
        VHMK(I) = VHMF(I)/FPSPKN
        VVMK(I) = VVMF(I)/FPSPKN
C
C       -------------------------------------
C       PEAK VELOCITIES AND DYNAMIC PRESSURE
C       -------------------------------------
C
        VMFD3I = (XIP*0.2444) + 0.8
C
        IF(VMFD3I.GT.2.5) VMFD3I = 2.5
C
        VHPF(I) = VMFD3I*VHMF(I)
        VVPF(I) = VMFD3I*VVMF(I)
        VHPK(I) = VHPF(I)/FPSPKN
        VVPK(I) = VVPF(I)/FPSPKN
C
```

```
            IF(VHMF(I).EQ.0.)GOTO 55
C
C           ---------------------------------------------------------
C           THE EFFECT OF WIND IS TO ADD (DOWNWIND SIDE) OR SUBTRACT
C           (UPWIND SIDE) 'XWK' TIMES THE AMBIENT WIND VELOCITY TO
C           THE HORIZONTAL PROFILE VELOCITY (EMPIRICAL, CH-53E BASED)
C           ---------------------------------------------------------
C
            XKW = (-0.5*H) + 2.5
C
            IF(XKW.LT.1.0) XKW = 1.0
C
            WSPD2    = WSPD*XKW
            VHMK(I)  = VHMK(I) + WSPD2
            VHMF(I)  = VHMK(I)*FPSPKN
            VHPK(I)  = VHPK(I) + WSPD2
            VHPF(I)  = VHPK(I)*FPSPKN
C
       55   CONTINUE
C
C           -----------------
C           DYNAMIC PRESSURE
C           -----------------
C
            QHM(I) = RHOD2*VHMF(I)**2
            QVM(I) = RHOD2*VVMF(I)**2
            QHP(I) = RHOD2*VHPF(I)**2
            QVP(I) = RHOD2*VVPF(I)**2
C
            IF(IOU6.EQ.IOU1)THEN
C
              IF(LINES.LT.12)GOTO 450
              LINES = 2
              CALL INKEY
              IF(KEY.NE.'C')GOTO 999
              WRITE(IOU6,1002)
C
            ENDIF
C
      450   CONTINUE
C
C           ------------------------------------------------
C           REPORT HORIZONTAL COMPONENTS OF VELOCITY PROFILE
C           ------------------------------------------------
C
            WRITE(IOU6,1003) ZZ(I),VHMF(I),VHMK(I),VHPF(I),
     *                          VHPK(I),QHM(I),QHP(I)
     1003   FORMAT ( F8.2,2X,'H',6F10.3)
C
C           ----------------------------------------------
C           REPORT VERTICAL COMPONENTS OF VELOCITY PROFILE
C           ----------------------------------------------
C
            WRITE(IOU6,1004) VVMF(I),VVMK(I),VVPF(I),VVPK(I),
```

```
     *                   QVM(I),QVP(I)
 1004   FORMAT ( 10X,'V',6F10.3)
C
  500 CONTINUE
C
C     ------------------------------------------------
C     WRITE OUT GRAPHICS FILES IF SWITCH IS SET BY USER
C     ------------------------------------------------
C
      IF(IGRAPH.EQ.1)THEN
C
C       -------------------
C       OPEN GRAPHICS FILE
C       -------------------
C
        OPEN(IOU8,FILE=PTSFIL(2),STATUS='NEW',ERR=2000)
C
        WRITE(IOU8,89) COMM(1),COMM(2)
   89   FORMAT( 10X,A50,/,10X,A50,//)
C
        WRITE(IOU8,80) XIPOUT
   80   FORMAT( 1X,'TITLE="TWIN ROTOR, DAIP =',F6.2,' FT,'
     *             ' GW = xxxxx LB, WAGL = xx FT"')
C
C       -----------------------------------------------------
C       PRINT OUT MEAN VELOCITY, PEAK VELOCITY, AND PEAK
C       DYNAMIC PRESSURE PROFILES VERSUS PROFILE HEIGHT (AGL)
C       -----------------------------------------------------
C
        WRITE(IOU8,88)
   88   FORMAT( 1X,'VARIABLES = X,HT')
C
        WRITE(IOU8,81)
   81   FORMAT( 1X,'ZONE T = "MEAN PROFILE, KTS", I=xx, F=POINT')
        DO 82 I = 1,NPTS
        WRITE(IOU8,83) VHMK(I),ZZ(I)
   83   FORMAT( 1X,F6.1,1X,F5.1)
   82   CONTINUE
C
        WRITE(IOU8,84)
   84   FORMAT( 1X,'ZONE T = "PEAK PROFILE, KTS", I=xx, F=POINT')
        DO 85 I = 1,NPTS
        WRITE(IOU8,83) VHPK(I),ZZ(I)
   85   CONTINUE
C
        WRITE(IOU8,86)
   86   FORMAT( 1X,'ZONE T = "PEAK Q, PSF", I=xx, F=POINT')
        DO 87 I = 1,NPTS
        WRITE(IOU8,83) QHP(I),ZZ(I)
   87   CONTINUE
C
C       -------------------
C       CLOSE GRAPHICS FILE
C       -------------------
```

```
C
        CLOSE(IOU8,STATUS='KEEP')
C
      ENDIF
C
      CALL INKEY
C
      GOTO 999
C
C     ---------------------------------------------
C     THE ERROR LOGIC ALLOWS FOR THE HANDLING OF FILE
C     OPEN ERRORS BY RETURNING THE USER TO A MENU
C     ---------------------------------------------
C
 2000 CONTINUE
C
      CALL HOMCLS(0)
C
      WRITE(IOU1,2001)
 2001 FORMAT( ////,8X,
     1        ' *** ERROR ***  PLEASE CHOOSE A NEW OUTPUT FILENAME',
     2  //,8X,'              TYPE <RETURN> TO CONTINUE   ',$)
C
      READ(IOU1,'(A1)') TEMCHAR
C
      KEY = 'P'
C
  999 CONTINUE
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE IREAD(IOU1,PROMPT,IVALUE)
C
C     *********************************************
C     SUBROUTINE IREAD PROMPTS USER FOR AN INTEGER
C     DATA ENTRY AND CHECKS VALIDITY OF ENTRY
C     *********************************************
C
      PARAMETER(LAST=50)
C
      CHARACTER*50 PROMPT,SHOWIT
      CHARACTER*15 ENTRY,BLANK
C
      DATA BLANK /'               '/
C
C     *********************************************
C
C     ---------------------------------------------
C     PROMPT USER FOR INTEGER ENTRY.  FIND POSITION
C     OF LAST NON-BLANK CHARACTER IN PROMPT,
C     THEN STORE RIGHT JUSTIFIED IN SHOWIT
C     ---------------------------------------------
C
      N = LAST + 1
C
   10 IF(N.EQ.1)GOTO 20
C
      N = N - 1
C
      IF(PROMPT(N:N).EQ.' ')GOTO 10
C
   20 JS = LAST - N
C
      WRITE(SHOWIT,'(50A1)') (' ',J=1,JS),(PROMPT(I:I),I=1,N)
C
C     ---------------------------
C     NOW ASK USER FOR DATA ENTRY
C     ---------------------------
C
   30 WRITE(IOU1,'(/,1X,A,I3)') SHOWIT,IVALUE
C
      WRITE(IOU1,'(/,8X,A,$)')
     1 ' ENTER NEW VALUE OR <RETURN> TO LEAVE AS IS    ==> '
C
      READ(IOU1,'(A)') ENTRY
C
      IF(ENTRY.EQ.BLANK)RETURN
C
      READ(ENTRY,'(BN,I7)',ERR=30) ITEMP
C
      IVALUE = ITEMP
C
      RETURN
```

```
      END
C
```

```
C
C
      FUNCTION LEGAL(CHDOL,IOU1,OKLIST,NUM)
C
C     ****************************************
C     FUNCTION LEGAL DETERMINES IF THE VALUE
C     FOR CHDOL IS A VALID INPUT.  THIS VALUE
C     IS CHECKED AGAINST THE LIST OF LEGAL
C     VALUE IN ARRAY OKLIST(NUM)
C     ****************************************
C
      CHARACTER*1 CHDOL,OKLIST(NUM)
C
C     ****************************************
C
      LEGAL = 0
C
      DO 10 I=1,NUM
      IF(CHDOL.EQ.OKLIST(I)) RETURN
   10 CONTINUE
C
      LEGAL = 1
C
      WRITE(IOU1,'(/,T9,A,A1,A/)') ' ***   ',CHDOL,
     1 ' IS NOT A VALID INPUT ***'
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE LOCATE(IROW,ICOL)
C
C     ******************************************************
C     SUBROUTINE LOCATE LOCATES THE CURSOR POSITION
C     ******************************************************
C
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
      CHARACTER*8 CUP
      CHARACTER*1 ECUP(8)
      EQUIVALENCE (CUP,ECUP(1))
C
      CHARACTER*10 FMT
      CHARACTER*1  EFMT(10)
      EQUIVALENCE (FMT,EFMT(1))
C
      DATA FMT / '(" ",A? \)' /
C
C     ******************************************************
C
C     --------------------------------------------------
C     ANSI CONTROL SEQUENCE: CUP = ESC['ROW';'COLUMN'H
C     --------------------------------------------------
C
      IR1 = IROW/10
      IR2 = IROW - IR1*10
      IC1 = ICOL/10
      IC2 = ICOL - IC1*10
C
      ECUP(1) = CHAR(27)
      ECUP(2) = CHAR(91)
      IPOS    = 3
C
      IF(IR1.GT.0)THEN
        ECUP(IPOS) = CHAR(IR1 + 48)
        IPOS       = IPOS + 1
      ENDIF
C
      ECUP(IPOS) = CHAR(IR2 + 48)
      IPOS       = IPOS + 1
C
      ECUP(IPOS) = CHAR(59)
      IPOS       = IPOS + 1
C
      IF(IC1.GT.0)THEN
        ECUP(IPOS) = CHAR(IC1 + 48)
        IPOS       = IPOS + 1
      ENDIF
C
      ECUP(IPOS) = CHAR(IC2 + 48)
      IPOS       = IPOS + 1
C
```

```
      ECUP(IPOS) = CHAR(72)
C
      EFMT(7) = CHAR(IPOS + 48)
C
      WRITE(IOU1,*) CUP
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE MOMENT(NPTS,HUMTYP,TOTF,TOTM)
C
C     *****************************************************
C     SUBROUTINE MOMENT CALCULATES THE TOTAL OVERTURNING
C     FORCE AND MOMENT ON A MAN OR YOUNG PERSON AND PRINTS
C     OUT THE RESULTS.
C     *****************************************************
C
      CHARACTER*1 HUMTYP
C
      COMMON /PERSON/ QP(12),DSET
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     *****************************************************
C
C     ---------------------------------------------------
C     IN THE SUBROUTINE TO CALCULATE FORCES AND MOMENTS:
C
C       "CDP" IS THE COEFFICIENT OF DRAG OF THE PERSON
C       "WIDTHP" IS THE WIDTH OF THE PERSON WHERE:
C         WIDTHP IS 'L' TYPE IF 1.1 FT
C         WIDTHP IS 'S' TYPE IF 0.7 FT
C     ---------------------------------------------------
C
      WIDTHP = 1.1
      CDP    = 1.1
C
C     ---------------------------------------------------------------
C     INITIALIZE INTEGRATION STEP SIZE AND ZERO SUMMATION VARIABLES
C     ---------------------------------------------------------------
C
      DELZZ = 0.5
      TOTM  = 0.0
      TOTF  = 0.0
C
C     -----------------------
C     CHOOSE HUMAN SIZE TYPE
C     -----------------------
C
      IF(HUMTYP.EQ.'S')THEN
         WIDTHP = 0.7
         NPTS   = 8
      END IF
C
C     ----------------------------------------
C     INTEGRATE DYNAMIC PRESSURE PROFILE OVER
C     THE HEIGHT OF THE PERSON CHOSEN
C     ----------------------------------------
C
      DO 10 J = 1,NPTS
C
      FOVER = QP(J)*DELZZ*WIDTHP*CDP
```

```
      ZZ    = 0.5*(J - 1) + 0.25
      OVERM = FOVER*ZZ
      TOTF  = TOTF + FOVER
      TOTM  = TOTM + OVERM
C
C     ------------------
C     PRINT OUT RESULTS
C     ------------------
C
      IF(DSET.NE.0.)GOTO 10
C
      WRITE(IOU6,20) ZZ,QP(J),FOVER,OVERM,TOTF,TOTM
   20 FORMAT( F8.2,5(2X,F10.3))
C
   10 CONTINUE
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE PROPRM(H,UMB,RVZ)
C
C     ******************************************************************
C     SUBROUTINE PROPRM
C
C     THIS SUBROUTINE CALCULATES THE VELOCITY PROFILE V(R,Z) PARAMETERS
C     OF THE RADIAL WALL JET FOR THE NON-INTERACTING ROTOR CASE
C     ******************************************************************
C
      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
C
C     ******************************************************************
C
      IF(RVZ.GE.RJ)GOTO 600
C
C     ---------------------------------
C     RVZ .LT. RJ ==> TRANSITION REGION
C     ---------------------------------
C
      UM = UMJ*RVZ
      IF(RVZ.GT.1.0) UM = UMJ
C
      ZH = ZHJ*RVZ
      IF(RVZ.GT.1.0) ZH = ZHJ
C
      ZM = ZMJ*RVZ
      IF(RVZ.GT.1.0) ZM = ZMJ
C
C     ------------------------------------
C     BOUNDARY GROWTH IN TRANSITION REGION
C     ------------------------------------
C
      ZB0 = 1.5
      IF(H.LT.1.5) ZB0 = H
C
      ZH0 = ZB0/2.8
      ZH  = (ZH0 - ZHJ)/RJ**2*(RJ - RVZ)**2 + ZHJ
      ZB  = 2.8*ZH
C
      GOTO 700
C
C     -----------------------------------------
C     RVZ .GE. RJ ==> DEVELOPED WALL JET REGION
C     -----------------------------------------
C
  600 CONTINUE
C
      UM = CU*RVZ**(-1.143)*UMB
      ZH = CY*RVZ**(1.028)
      ZB = 2.8*ZH
      ZM = 0.1944*ZH
C
```

```
  700 CONTINUE
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE VLINE
C
C     ****************************************************************
C     SUBROUTINE VLINE
C
C     THIS SUBROUTINE APPLIES THE BIOT-SAVORT LAW TO
C     CALCULATE THE VELOCITY INDUCED BY A LINE VORTEX
C
C     XA,YA,ZA = STARTING POINT OF VORTEX
C     XB,YB,ZB = ENDING POINT, OR DIRECTION POINTER
C     XC,YC,ZC = TARGET POINT WHERE VELOCITY IS INDUCED
C
C     IFI = 0     VORTEX IS FINITE, FROM POINT A TO POINT B
C     IFI = 1     VORTEX IS SEMI-INFINITE FROM POINT A THROUGH B
C
C     ****************************************************************
C
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /CVLINE/ IFI,XA,YA,ZA,XB,YB,ZB,XC,YC,ZC,Q1,Q2,Q3
C
C     ****************************************************************
C
      A  = (XA-XC)**2 + (YA-YC)**2 + (ZA-ZC)**2
      B  = 2.0*( (XA-XB)*(XC-XA) + (YA-YB)*(YC-YA) + (ZA-ZB)*(ZC-ZA) )
      C  = (XA-XB)**2 + (YA-YB)**2 + (ZA-ZB)**2
C
      C1 = (YC-YB)*ZA + (YA-YC)*ZB + (YB-YA)*ZC
      C2 = (ZC-ZB)*XA + (ZA-ZC)*XB + (ZB-ZA)*XC
      C3 = (XC-XB)*YA + (XA-XC)*YB + (XB-XA)*YC
C
      Q  = 4.0*A*C - B**2
C
C     -------------------------------
C     CHECK FOR COLINEAR TARGET POINT
C     -------------------------------
C
      QB = 0.0
      IF(ABS(Q).LT.1.0E-06)GOTO 100
C
C     --------------------
C     FINITE LENGTH VORTEX
C     --------------------
C
      IF(IFI.EQ.0)THEN
        QB = 1.0/Q*((2.0*C + B)/SQRT(A + B + C) - B/SQRT(A))/2.0/PI
      ENDIF
C
C     --------------------
C     SEMI-INFINITE VORTEX
C     --------------------
C
      IF(IFI.EQ.1)THEN
```

```
           QB = 1.0/Q*(2.0*SQRT(C) - B/SQRT(A))/2.0/PI
        ENDIF
C
    100 CONTINUE
C
C       --------------------
C       VELOCITY COMPONENTS
C       --------------------
C
        Q1 = C1*QB
        Q2 = C2*QB
        Q3 = C3*QB
C
        RETURN
        END
C
```

```
C
C
      SUBROUTINE WALJET(H,UB,UN,UMB)
C
C     ****************************************************************
C     SUBROUTINE WALJET
C
C     THIS SUBROUTINE DEFINES THE START OF THE WALL JET AND ITS GROWTH
C     ****************************************************************
C
      COMMON /CLOUDK/ QSMAX
      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     ****************************************************************
C
C     ----------------------------
C     INITIALIZATION OF EXPONENTS
C     ----------------------------
C
      EXU = -1.143
      EXY = 1.028
      EXM = 1.0 + EXU + EXY
      CQ  = 0.52
      CZM = 0.1944
      CZB = 2.8
C
C     -----------------------------------------------
C     ITERATE TO FIND INITIAL RADIUS OF WALL JET, RJ
C     -----------------------------------------------
C
      TOL = 1.0E-05
      RJ  = 2.0
C
      QSMAX0 = 1.0
C
      DO 100 I=1,20
C
C     --------------------------
C     EQUIVALENT JET LENGTH T/R
C     --------------------------
C
      TR  = H + (RJ - 1.0)
      TDE = 0.707*TR
C
C     ----------------------------------------------
C     QSMAX CURVEFIT TO FIG. 8, USAAVLABS TECHNICAL
C     REPORT 68-52, JULY 1968
C     ----------------------------------------------
C
      IF(TDE.LE.4.0) QSMAX = QSMAX0 + (0.6 - QSMAX0)/16.0*TDE**2
      IF(TDE.GT.4.0) QSMAX = 2.4/TDE
      UM  = SQRT(QSMAX)
C
```

```
      RJNEW = 2.508078*(UB/UM)**(0.486)
C
      IF(ABS(RJNEW - RJ).LE.TOL)GOTO 200
      RJ = RJNEW
C
  100 CONTINUE
C
      WRITE(IOU1,10)
   10 FORMAT( '*************************************************',/
     1        ,'ITERATIONS EXCEEDED FOR WALL JET INITIAL RADIUS',/
     2        ,'*************************************************')
C
      STOP ' '
C
  200 CONTINUE
C
      RJ = RJNEW
C
C     -----------------------------------
C     VELOCITY GROWTH FUNCTION CONSTANTS
C     -----------------------------------
C
      UMB = ((0.3586*RJ**EXM*(UM*UN)*(UB*UN)**(0.14))**(0.88))/UN
      ZHJ = 0.654/(UM/UMB)**2/RJ
      CU  = UM/UMB*RJ**(-EXU)
      CY  = ZHJ*RJ**(-EXY)
C
C     -------------------------------------------
C     MAX VELOCITY AND BOUNDARY PARAMETERS AT RJ
C     -------------------------------------------
C
      UMJ = CU*RJ**(EXU)*UMB
      ZHJ = CY*RJ**(EXY)
      ZMJ = CZM*ZHJ
      ZBJ = CZB*ZHJ
C
      RETURN
      END
C
```

```
C
C
      SUBROUTINE WJVEL(H,UN,UMB,RVZ,RADIUS,WSPD,DELZ,ZMAX,DXO)
C
C     *******************************************************
C     SUBROUTINE WJVEL GENERATES THE VELOCITY PROFILE V(R,Z)
C     AT RVZ FOR THE NON-INTERACTING ROTOR CASE
C     *******************************************************
C
      CHARACTER*1 TEMCHAR
      CHARACTER*1 ICONT(5)
      CHARACTER*1 KEY,KKEY
      CHARACTER*12 PTSFIL(4)
      CHARACTER*50 COMM(2)
C
      DIMENSION ZZ(40),VMF(40),VMK(40),VPF(40),
     1          VPK(40),QM(40),QP(40)
C
      COMMON /  CKEY/ KEY,KKEY
      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
      COMMON /INPUTC/ ICONT,COMM,PTSFIL
      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
C
C     *******************************************************
C
C     --------------------------------------------------
C     'PROPRM' PROVIDES THE VELOCITY PROFILE PARAMETERS
C     OF A RADIAL WALL JET (WITHOUT INTERACTION PLANE)
C     --------------------------------------------------
C
      CALL PROPRM(H,UMB,RVZ)
C
C     -------------------------------------------
C     DIMENSIONALIZE VELOCITY PROFILE PARAMETERS
C     -------------------------------------------
C
      RRVZ  = RADIUS*RVZ
      ZZB   = ZB*RADIUS
      ZZH   = ZH*RADIUS
      ZZM   = ZM*RADIUS
      ZETAM = ZM/ZB
C
C     --------------------------------------------------------
C     OUTPUT THE VELOCITY AND DYNAMIC PRESSURE PROFILE HEADER
C     --------------------------------------------------------
C
      ICD = 0
      CALL HOMCLS(ICD)
      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
C
      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
   93 FORMAT( 10X,A50,/,10X,A50,//)
C
```

```
      RVZOUT = RRVZ + DXO
C
      WRITE(IOU6,1000) RVZOUT
 1000 FORMAT( 9X,'SINGLE ROTOR VELOCITY PROFILE AT RADIUS = ',
     1   F7.1,' FT',/)
C
      WRITE(IOU6,1001) ZZB,ZZH,ZZM
 1001 FORMAT( 15X,'PROFILE BOUNDARY HEIGHT = ',F7.2,' FT',/
     1       ,15X,'        HALF-VEL.HEIGHT = ',F7.2,' FT',/
     2       ,15X,'        MAX-VEL  HEIGHT = ',F7.2,' FT',/)
C
C     ---------------------------------------------
C     INCREMENTS AND HEIGHT ARE FROM DELZ AND ZMAX
C     ---------------------------------------------
C
      NPTS = IFIX(ZMAX/DELZ) + 1
C
C     ------------------------------
C     BOUNDARY LAYER REGION EXPONENT
C     'AN' IS ACTUALLY = 1.0/7.0
C     ------------------------------
C
      AN = 0.142857142
C
C     ---------------------------------------------------------------
C     SHEAR LAYER REGION EXPONENT, TO MEET EDGE CONDITIONS
C     (FROM FIGURE 7, USAAVLABS TECHNICAL REPORT 68-52, JULY 1968)
C     ---------------------------------------------------------------
C
      ALPW = ALOG(1.0 - 1.0/SQRT(2.0))/ALOG((ZH - ZM)/(ZB - ZM))
C
      VN  = UN
      VMN = UM
C
C     ---------------------------------------------------
C     CALCULATION OF THE PEAK VELOCITY CORRECTION FACTOR
C     IS MADE IN THE NEXT SECTION AT THE 3 FT POSITION
C     ---------------------------------------------------
C
      VZ3   = 3.0/RADIUS
      ZETA3 = VZ3/ZB
      VZM3  = 0.0
C
      IF(ZETA3.GE.ZETAM)GOTO 51
C
C     ----------------------------------------
C     THE 3 FT HEIGHT IS IN THE BOUNDARY LAYER
C     ----------------------------------------
C
      IF(ZETAM.GT.0.0) VZM3 = (ZETA3/ZETAM)**AN
C
      GOTO 52
   51 CONTINUE
C
```

```
C     -------------------------------------
C     THE 3 FT HEIGHT IS IN THE SHEAR LAYER
C     -------------------------------------
C
      IF(VZ3.LE.ZB)THEN
        VZM3 = (1.0 - ((ZETA3 - ZETAM)/(1.0 - ZETAM))**ALPW)**2
      ENDIF
C
   52 CONTINUE
C
C     -----------------------------------------------------------
C     THE VELOCITY TO ADD TO THE MEAN VELOCITY TO OBTAIN THE PEAK
C     VELOCITY IS CALCULATED AS THE CONSTANT VMFD3 (FT/SEC)
C     -----------------------------------------------------------
C
      VZN3    = VZM3*VMN
      VMF3    = VZN3*VN
      VMFD3S = (RVZ*0.2444) + 0.4
      IF(VMFD3S.GT.1.5) VMFD3S = 1.5
      VMFD3   = VMFD3S*VMF3
C
C     -------------------------------------------------------
C     OUTPUT THE VELOCITY AND DYNAMIC PRESSURE PROFILE HEADER
C     -------------------------------------------------------
C
      WRITE(IOU6,1005)
 1005 FORMAT( 2X,'HEIGHT',5X,'MEAN VELOCITY',7X,'PEAK VELOCITY',6X,
     1       'MEAN Q',4X,'PEAK Q',/,
     2       3X,'(FT)',5X,'(FPS)',6X,'(KN)',5X,'(FPS)',6X,'(KN)',5X,
     3       '(PSF)',5X,'(PSF)',/)
C
C     ------------------------------------------------
C     CALCULATE THE VELOCITY PROFILE POINTS FOR OUTPUT
C     ------------------------------------------------
C
      LINES = 0
C
      DO 500 I = 1,NPTS
C
        LINES = LINES + 1
        Z     = DELZ*FLOAT(I - 1)
        ZETA  = Z/ZB
        IF(ZETA.GE.ZETAM)GOTO 300
C
C       --------------------------
C       Z IS WITHIN BOUNDARY LAYER
C       --------------------------
C
        VZM = 0.0
        IF(ZETAM.GT.0.0) VZM = (ZETA/ZETAM)**AN
        GOTO 400
C
  300   CONTINUE
C
```

```
C       -----------------------
C       Z IS WITHIN SHEAR LAYER
C       -----------------------
C
        VZM = 0.0
C
        IF(Z.LE.ZB)THEN
          VZM = (1.0 - ((ZETA - ZETAM)/(1.0 - ZETAM))**ALPW)**2
        ENDIF
C
   400  CONTINUE
C
        VZN = VZM*VMN
C
C       ------------------
C       DIMENSIONAL HEIGHT
C       ------------------
C
        ZZ(I) = Z*RADIUS
C
C       ---------------
C       MEAN VELOCITIES
C       ---------------
C
        VMF(I) = VZN*VN
        VMK(I) = VMF(I)/FPSPKN
C
C       ---------------
C       PEAK VELOCITIES
C       ---------------
C
        VPF(I) = VMF(I) + VMFD3
        IF(VMF(I).EQ.0.) VPF(I) = 0.0
        VPK(I) = VPF(I)/FPSPKN
C
        IF(VPK(I).EQ.0.0)GOTO 55
C
C       ----------------------------------------------------------
C       THE EFFECT OF WIND IS TO ADD (DOWNWIND SIDE) OR SUBTRACT
C       (UPWIND SIDE) 'XWK' TIMES THE AMBIENT WIND VELOCITY TO
C       THE HORIZONTAL PROFILE VELOCITY (EMPIRICAL, CH-53E BASED)
C       ----------------------------------------------------------
C
        XKW   = (-0.5*H) + 2.5
        IF(XKW.LT.1.0)XKW = 1.0
        WSPD2 = WSPD*XKW
        VMK(I) = VMK(I) + WSPD2
        VMF(I) = VMK(I)*FPSPKN
        VPK(I) = VPK(I) + WSPD2
        VPF(I) = VPK(I)*FPSPKN
C
    55  CONTINUE
C
C       ----------------
```

```
C        DYNAMIC PRESSURE
C        ----------------
C
         QM(I) = RHOD2*VMF(I)**2
         QP(I) = RHOD2*VPF(I)**2
C
         IF (IOU6.EQ.IOU1)THEN
           IF(LINES.LT.12)GOTO 450
           LINES = 1
           CALL INKEY
           IF(KEY.NE.'C')GOTO 999
           WRITE(IOU6,1005)
         ENDIF
C
  450    CONTINUE
C
C        --------------------------------------------------
C        OUTPUT THE VELOCITY AND DYNAMIC PRESSURE PROFILES
C        --------------------------------------------------
C
         WRITE(IOU6,1002) ZZ(I),VMF(I),VMK(I),VPF(I),
     *                    VPK(I),QM(I),QP(I)
 1002    FORMAT( F8.2,6F10.3)
C
  500 CONTINUE
C
C      --------------------------------------------------
C      WRITE OUT GRAPHICS FILES IF SWITCH IS SET BY USER
C      --------------------------------------------------
C
       IF(IGRAPH.EQ.1)THEN
C
C        -------------------
C        OPEN GRAPHICS FILE
C        -------------------
C
C
         OPEN(IOU8,FILE=PTSFIL(1),STATUS='NEW',ERR=2000)
C
         WRITE(IOU8,89) COMM(1),COMM(2)
   89    FORMAT( 10X,A50,/,10X,A50,//)
C
         WRITE(IOU8,80) RVZOUT
   80    FORMAT( 1X,'TITLE="SINGLE ROTOR, DFRC =',F6.2,' FT,'
     *              ' GW = xxxxx LB, WAGL = xx FT"')
C
C        ------------------------------------------------------
C        PRINT OUT MEAN VELOCITY, PEAK VELOCITY, AND PEAK
C        DYNAMIC PRESSURE PROFILES VERSUS PROFILE HEIGHT (AGL)
C        ------------------------------------------------------
C
         WRITE(IOU8,88)
   88    FORMAT( 1X,'VARIABLES = X,HT')
C
```

```
           WRITE(IOU8,81)
   81      FORMAT( 1X,'ZONE T = "MEAN PROFILE, KTS", I=xx, F=POINT')
C
           DO 82 I = 1,NPTS
           WRITE(IOU8,83) VMK(I),ZZ(I)
   83      FORMAT( 1X,F6.1,1X,F5.1)
   82      CONTINUE
C
           WRITE(IOU8,84)
   84      FORMAT( 1X,'ZONE T = "PEAK PROFILE, KTS", I=xx, F=POINT')
C
           DO 85 I = 1,NPTS
           WRITE(IOU8,83) VPK(I),ZZ(I)
   85      CONTINUE
C
           WRITE(IOU8,86)
   86      FORMAT( 1X,'ZONE T = "PEAK Q, PSF", I=xx, F=POINT')
C
           DO 87 I = 1,NPTS
           WRITE(IOU8,83) QP(I),ZZ(I)
   87      CONTINUE
C
C          -------------------
C          CLOSE GRAPHICS FILE
C          -------------------
C
           CLOSE(IOU8,STATUS='KEEP')
C
        ENDIF
C
        CALL INKEY
C
        GOTO 999
C
C       ------------------------------------------------
C       THE ERROR LOGIC ALLOWS FOR THE HANDLING OF FILE
C       OPEN ERRORS BY RETURNING THE USER TO A MENU
C       ------------------------------------------------
C
 2000   CONTINUE
C
        CALL HOMCLS(0)
        WRITE(IOU1,2001)
 2001   FORMAT( ////,8X,
     1          ' *** ERROR ***  PLEASE CHOOSE A NEW OUTPUT FILENAME',
     2   //,8X,'            TYPE <RETURN> TO CONTINUE   ',$)
        READ(IOU1,'(A1)') TEMCHAR
        KEY = 'P'
C
  999   CONTINUE
C
        RETURN
        END
C
```

★U.S. GOVERNMENT PRINTING OFFICE 1992