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800 Independence Ave. S.W.
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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.

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distribution is unlimited.

92-05207



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
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Washington, DC 20591

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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)

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Research and Development Service
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Rotorwash Computer Model - User's Guide

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November 1991

Final Report

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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					
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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.

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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:

<u>OUTPUT OPTION</u>	<u>TYPING COMMAND</u>
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 ($0.0023769 \text{ slugs/ft}^3$). 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.

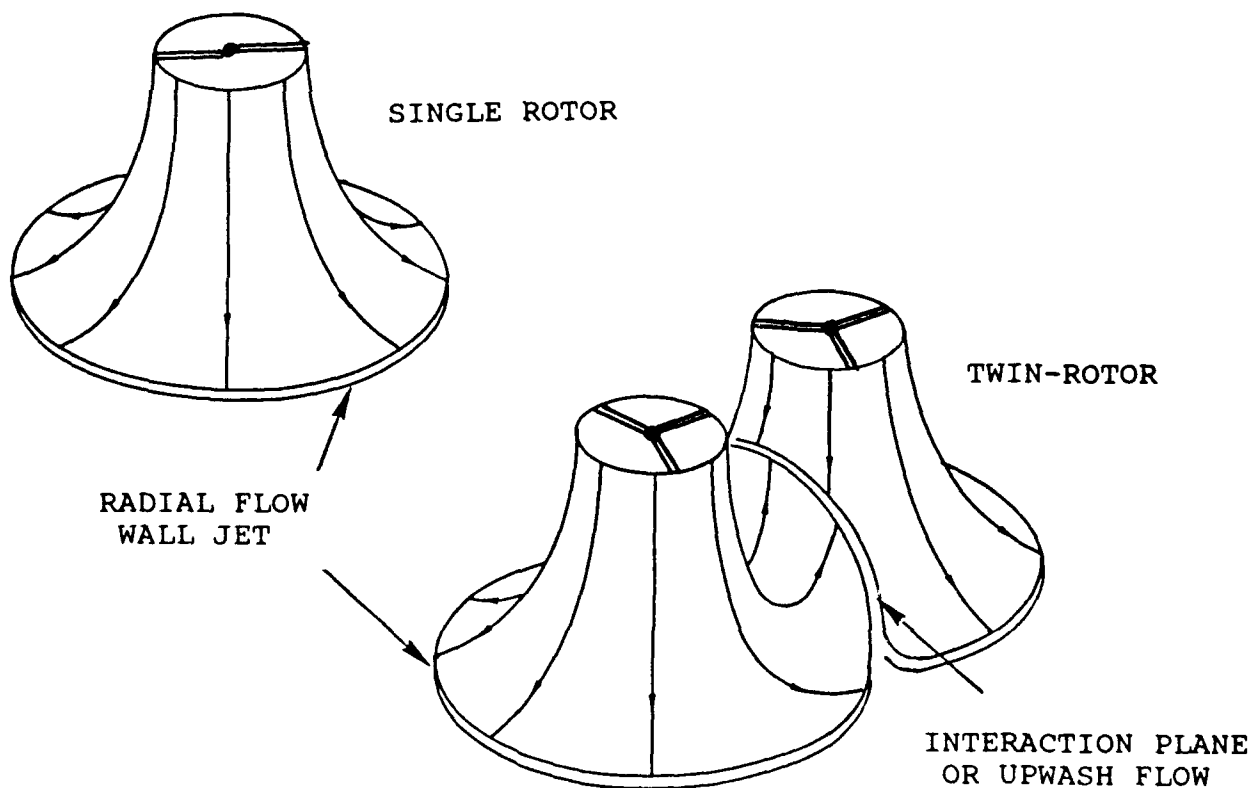


FIGURE 7 ROTORWASH FLOWFIELD CHARACTERISTICS OF SINGLE AND TWIN ROTOR CONFIGURATIONS OPERATING IN CLOSE PROXIMITY TO THE GROUND

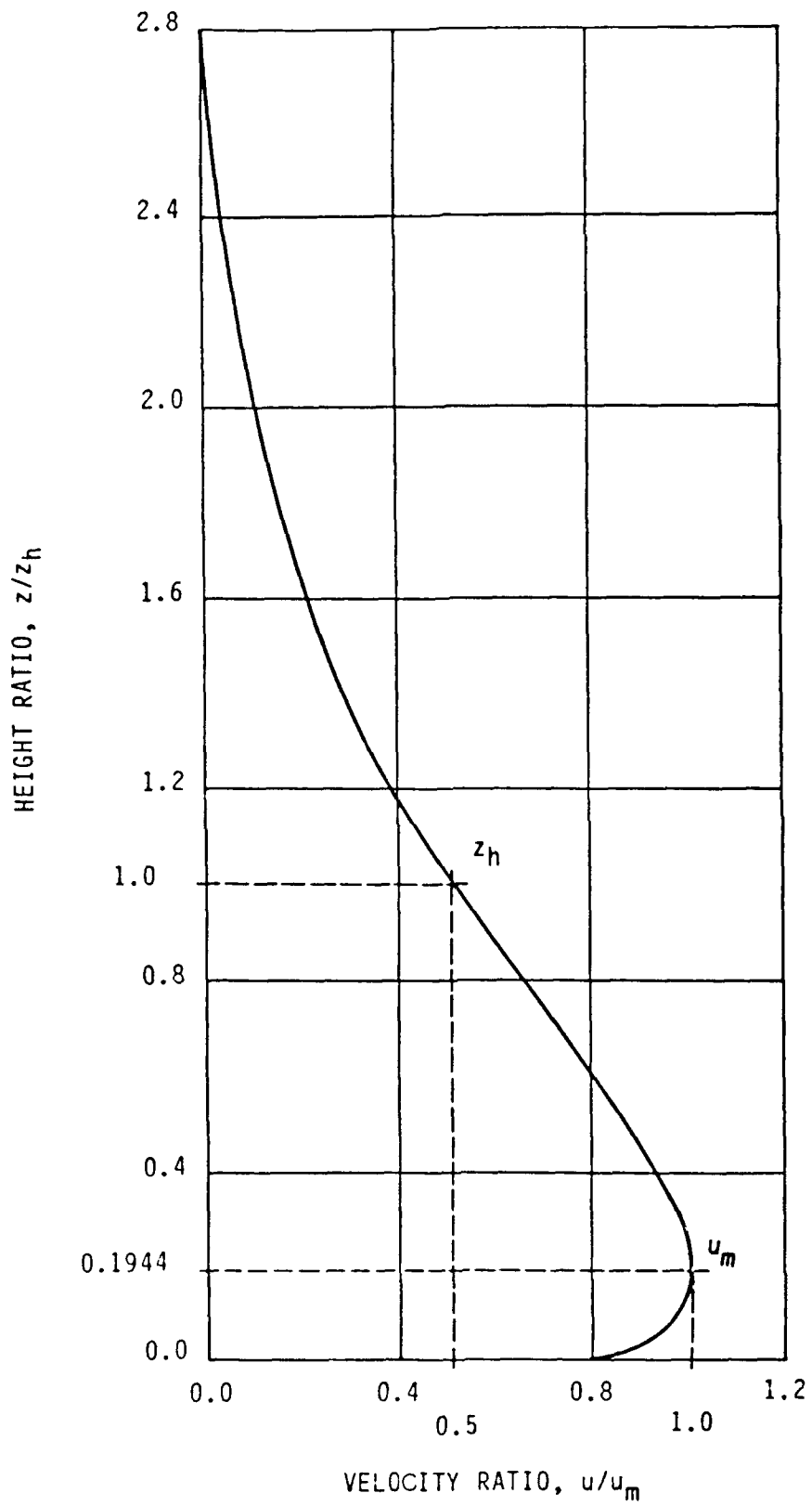


FIGURE 8 VERTICAL SECTION OF THE NONDIMENSIONAL WALL JET VELOCITY PROFILE

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 center 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).

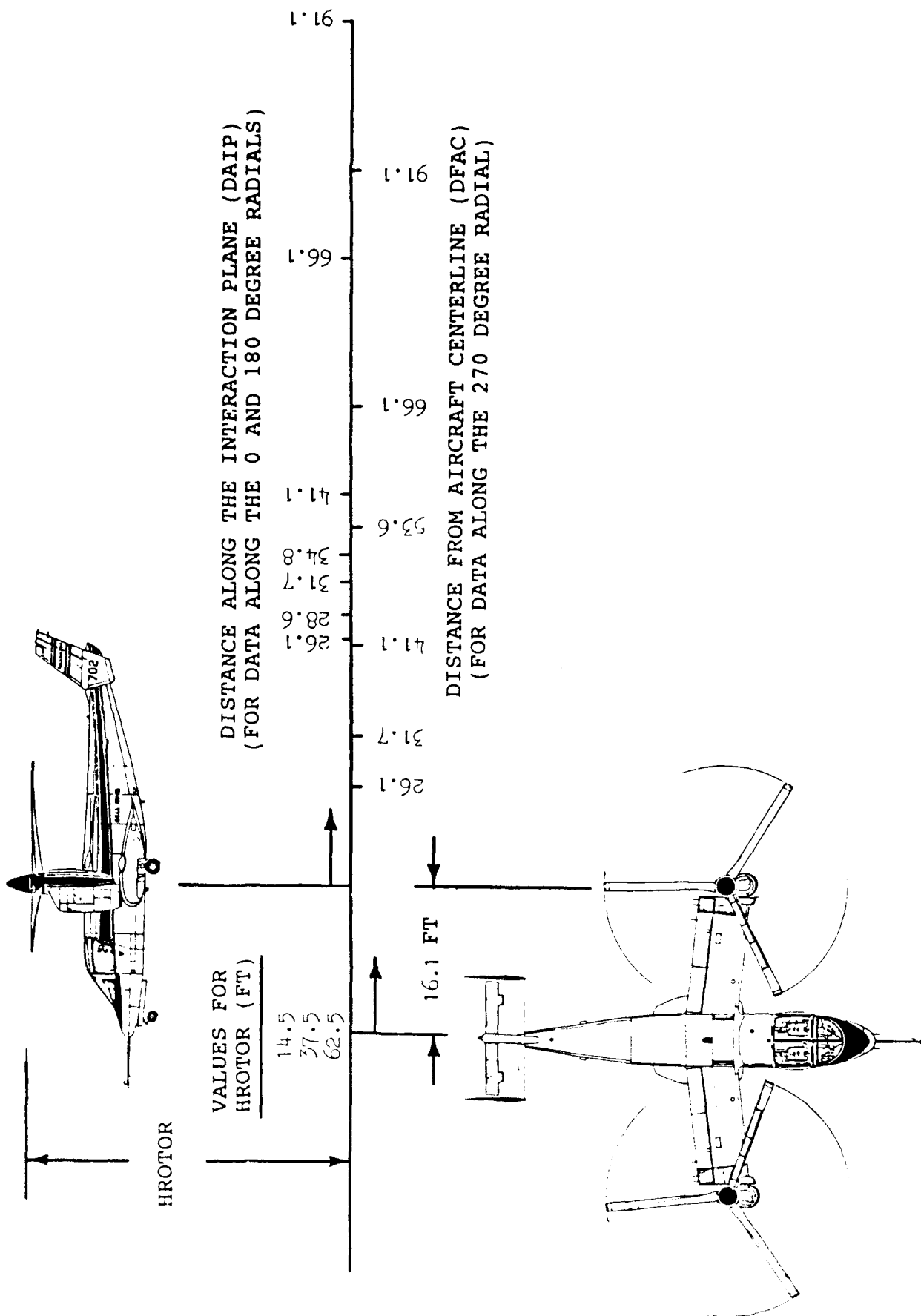


FIGURE 10 XV-15 FLIGHT TEST DATA MEASUREMENT LOCATIONS

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		PEAK VELOCITY		MEAN Q (PSF)	PEAK Q (PSF)
	(FPS)	(KN)	(FPS)	(KN)		
.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

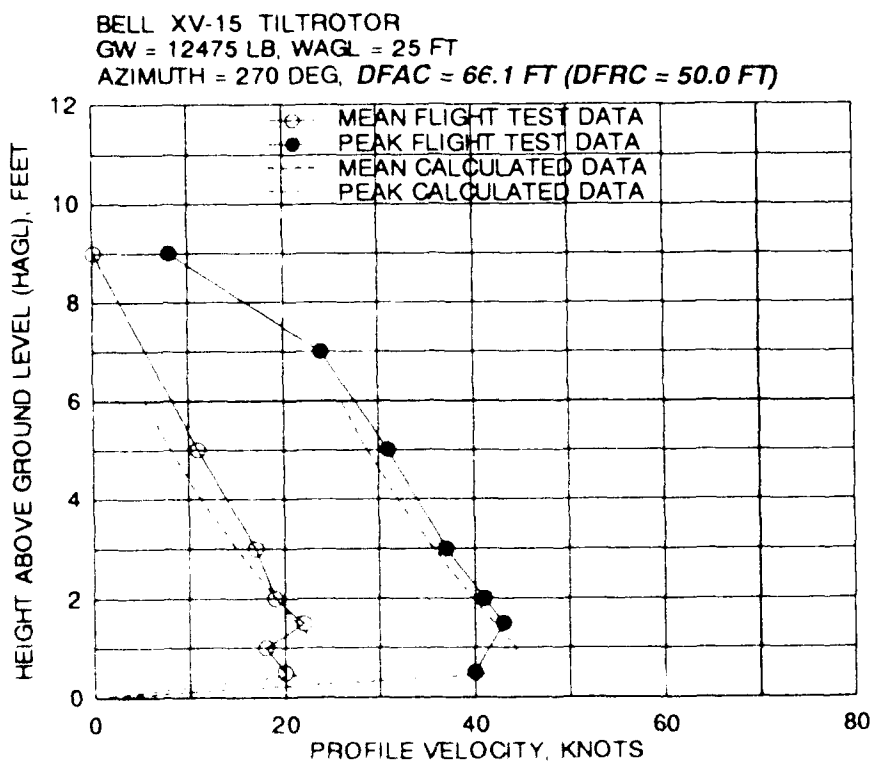


FIGURE 12 XV-15 VELOCITY PROFILE CORRELATION

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 media 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		PEAK VELOCITY		MEAN Q	PEAK Q
		(FPS)	(KN)	(FPS)	(KN)	(PSF)	(PSF)
.00	H	.000	.000	.000	.000	.000	.000
	V	.000	.000	.000	.000	.000	.000
1.00	H	59.870	35.489	106.420	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.

BELL XV-15 TILTROTOR
 GW = 12475 LB, WAGL = 25 FT
 AZIMUTH = 0 DEG, DAIP = 34.8 FT

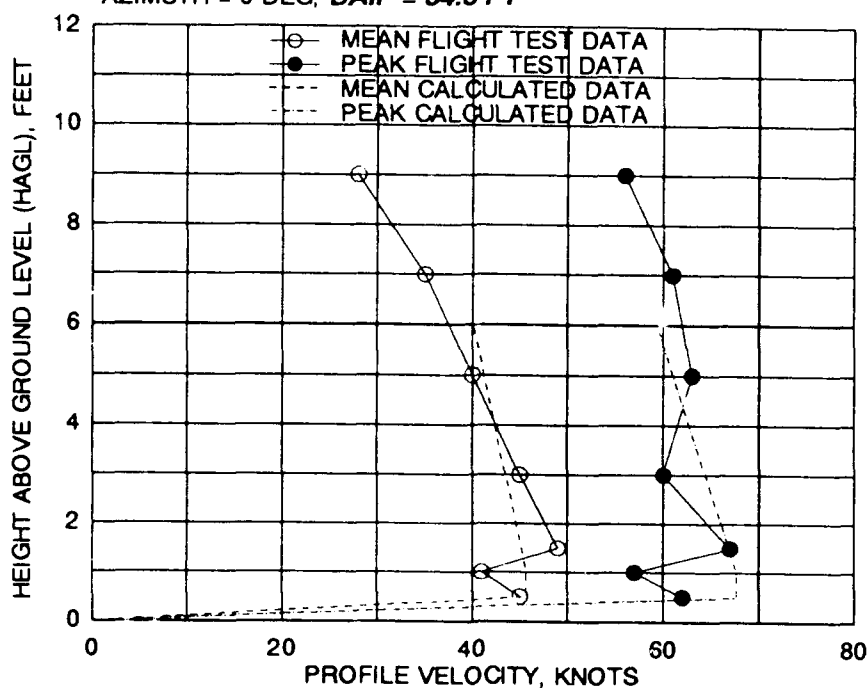


FIGURE 14 XV-15 INTERACTION PLANE VELOCITY
 PROFILE CORRELATION

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

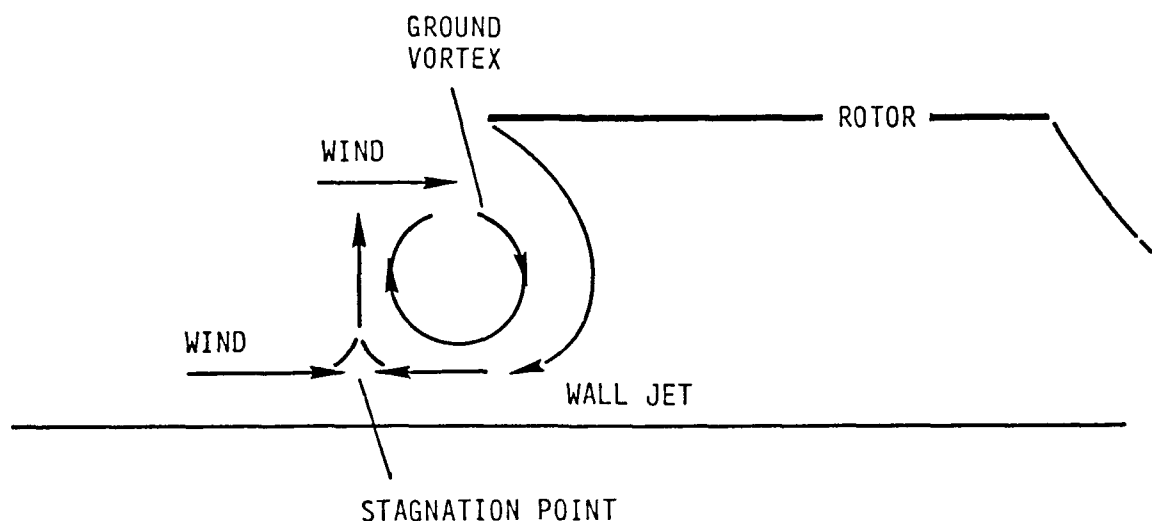


FIGURE 15 DIAGRAM OF THE GROUND VORTEX STRUCTURE

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 discussed.

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.

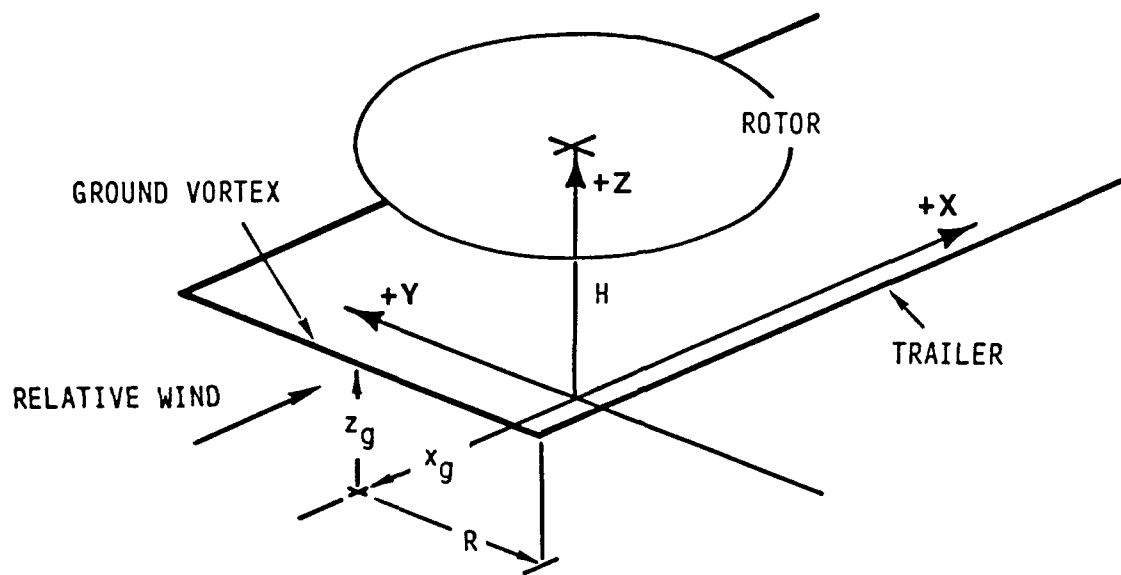


FIGURE 18 HORSE SHOE VORTEX GEOMETRY FOR THE GROUND VORTEX ANALYSIS OPTION

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

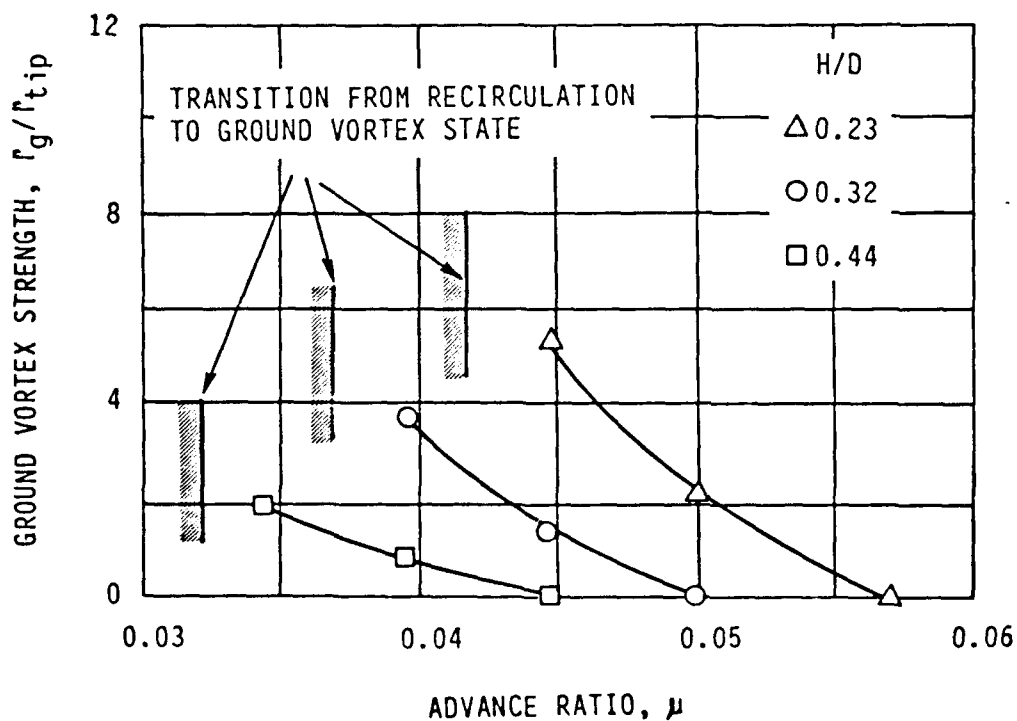


FIGURE 20 GROUND VORTEX CIRCULATION STRENGTH AS A FUNCTION OF ADVANCE RATIO

HEIGHT		MEAN VELOCITY		MEAN Q
(FT)		(FPS)	(KN)	(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.

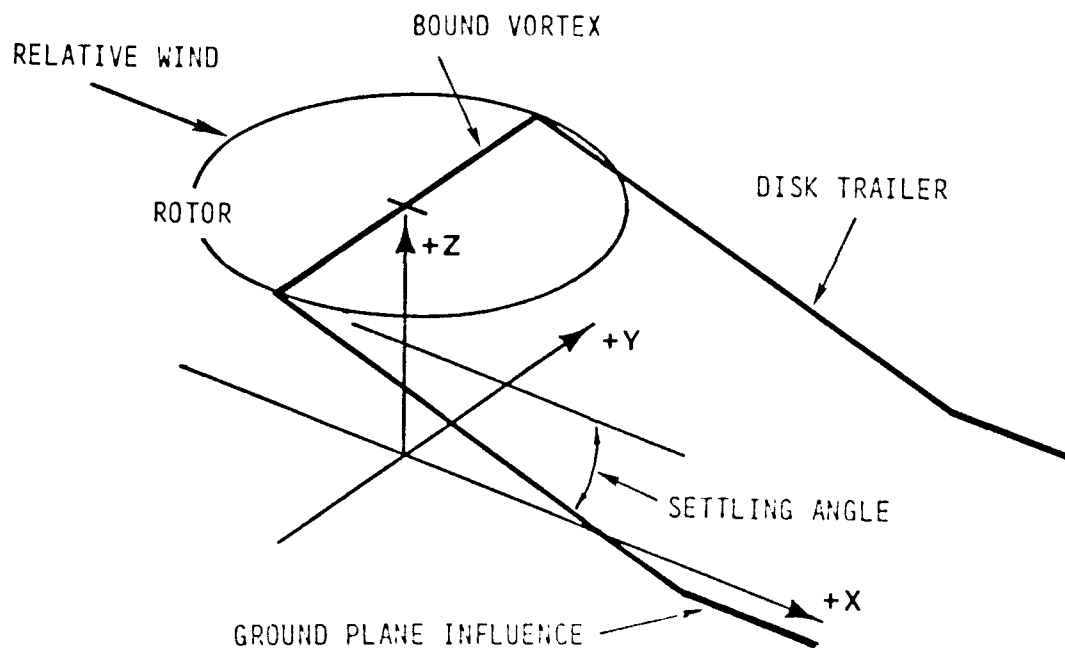


FIGURE 22 DISK EDGE VORTEX GEOMETRY DEFINITION

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 ==>

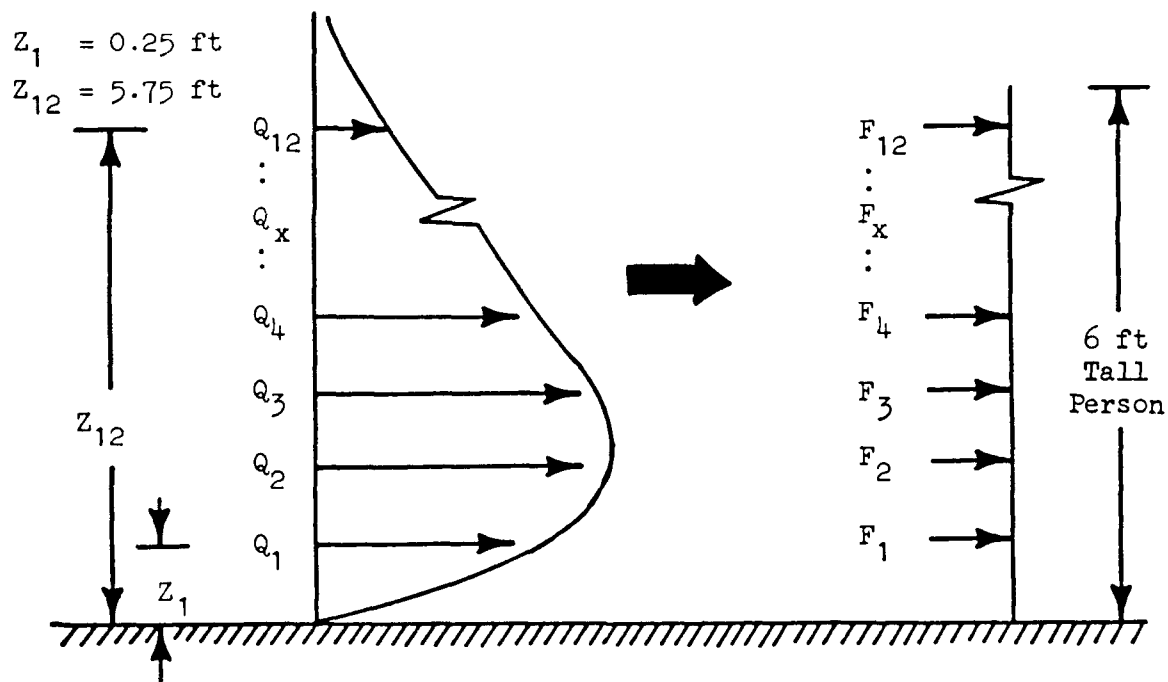
FIGURE 24 VELOCITY FIELD OUTPUT DATA FROM
THE DISK EDGE VORTEX OPTION

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 calculations 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.

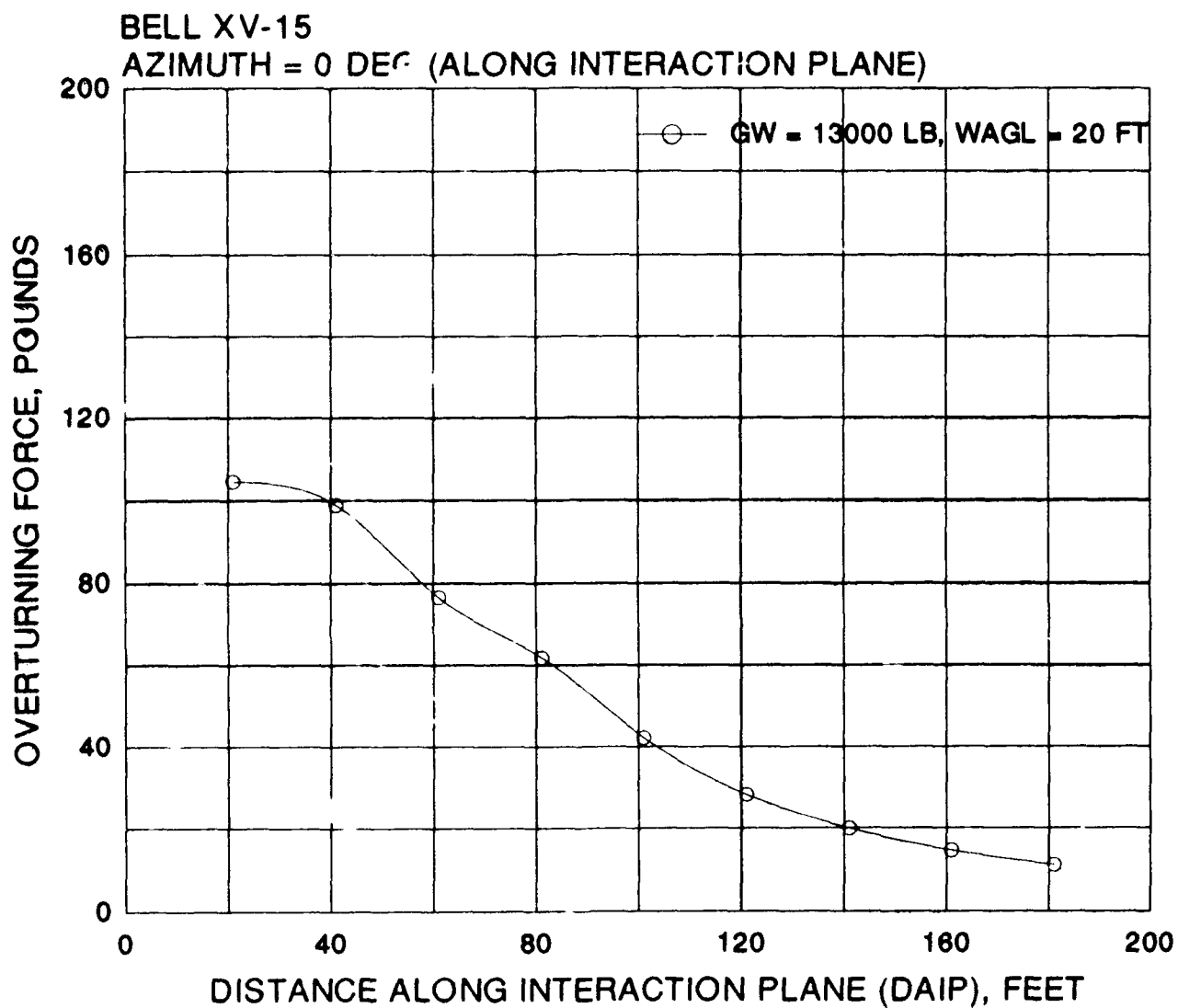


FIGURE 28 BELL XV-15 OVERTURNING FORCE AS A FUNCTION OF DISTANCE ALONG THE INTERACTION PLANE (0 DEGREE AZIMUTH)

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		PEAK VELOCITY		MEAN Q	PEAK Q
	(FPS)	(KN)	(FPS)	(KN)	(PSF)	(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

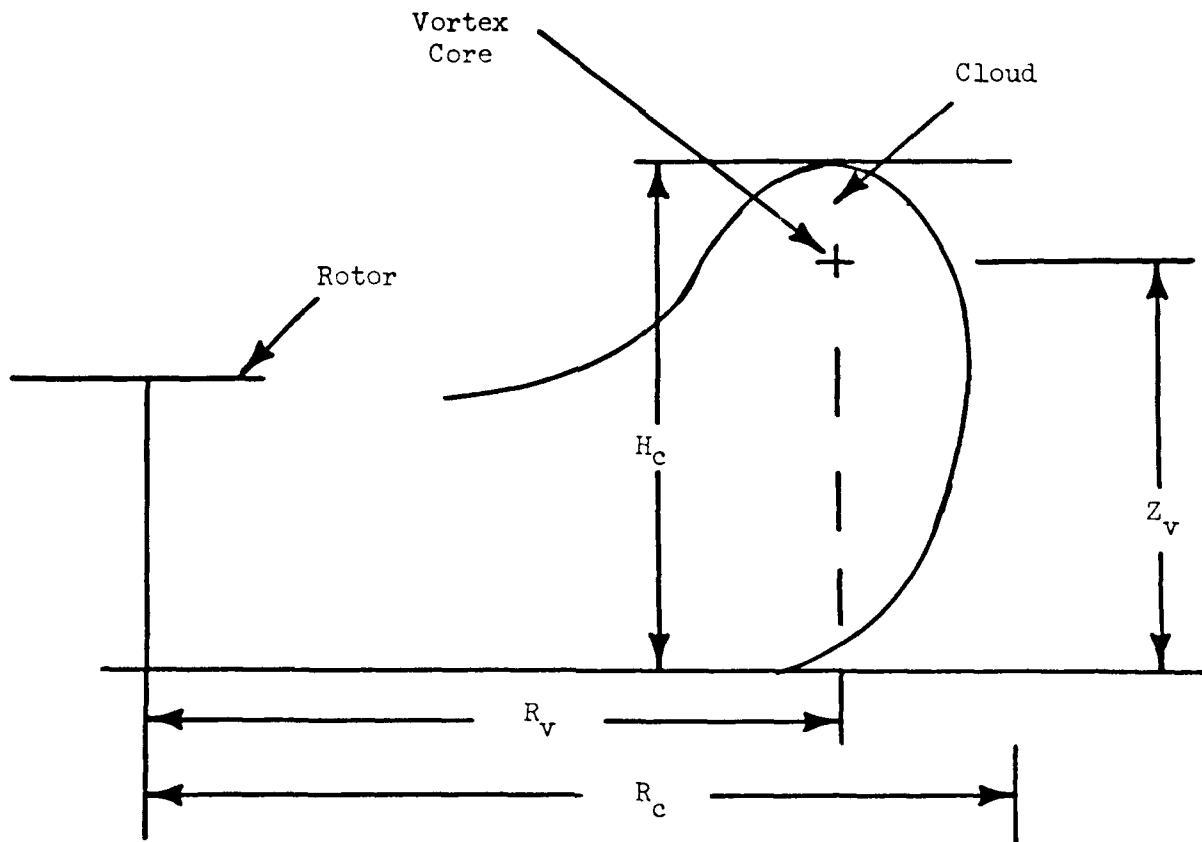


FIGURE 32 PARTICULATE CLOUD ANALYSIS GEOMETRY DEFINITION

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.

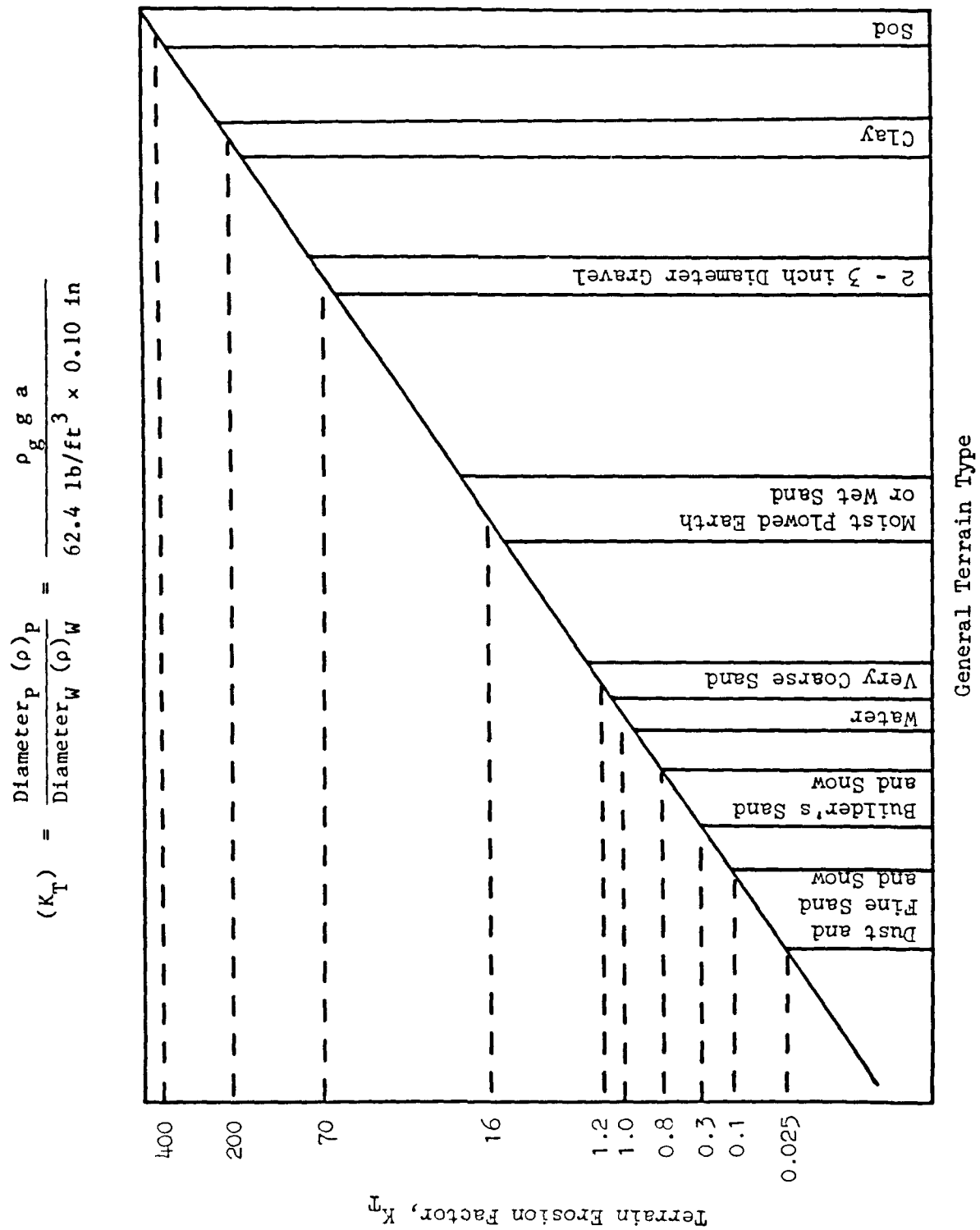


FIGURE 33 APPROXIMATE VALUES FOR THE TERRAIN EROSION FACTOR AS A FUNCTION OF TERRAIN TYPE

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

<u>FILE OUTPUT TYPE</u>	<u>FIGURE</u>	<u>SOURCE CODE LOCATION</u>
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., Fluid-Dynamic Drag, Published by Author, 1958.

APPENDIX A

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

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July 20, 1990

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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_0 . 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_0 , 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:

$$\Delta x_0 = H * \tan \phi$$

Analytically, the effect of the parameter $H\phi$ 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_0 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 caution 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 maneuver 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.



Samuel W. Ferguson, EMA

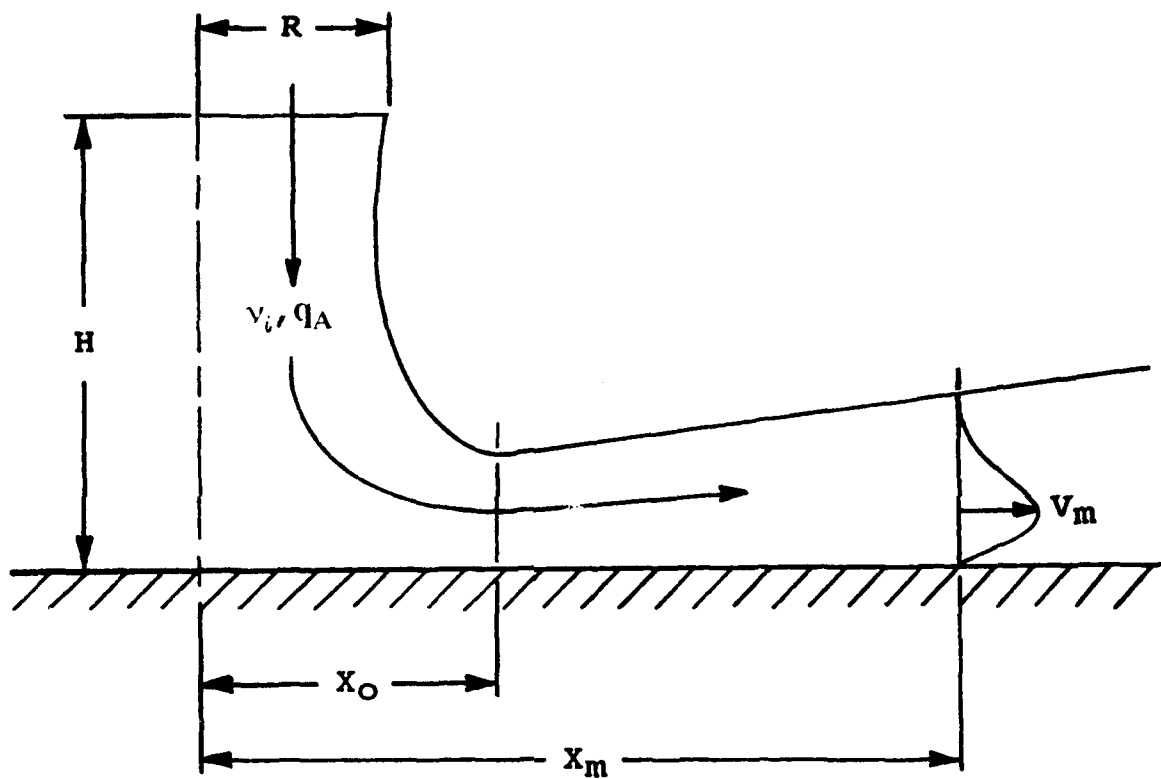


FIGURE 1 ROTORWASH FLOW FIELD CHARACTERISTICS FOR A ROTOR TIP PATH PLANE PARALLEL TO THE GROUND

SINGLE ROTOR CONFIGURATION

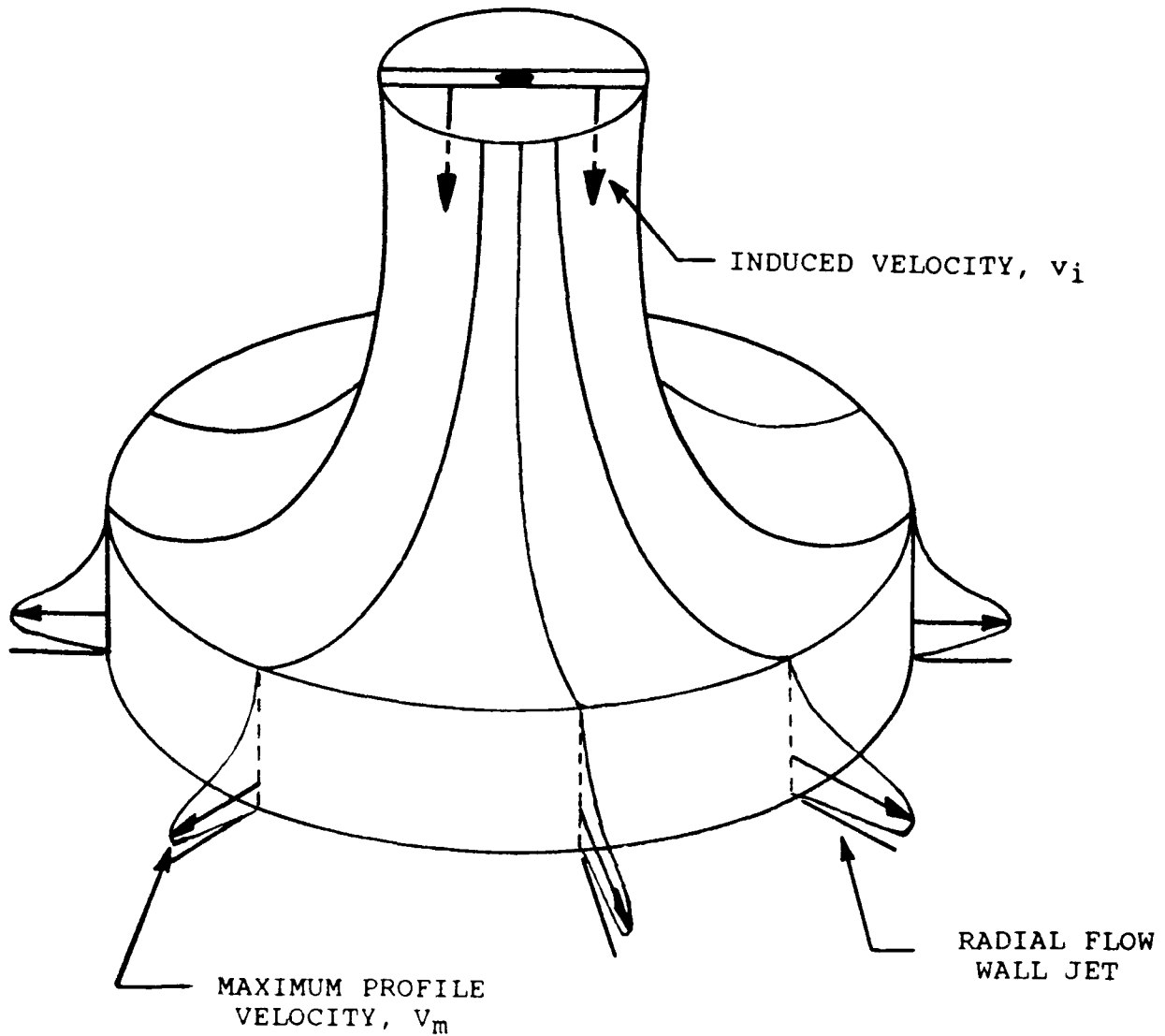


FIGURE 2 THREE-DIMENSIONAL ROTORWASH FLOW FIELD CHARACTERISTICS FOR A ROTOR TIP PATH PLANE PARALLEL TO THE GROUND

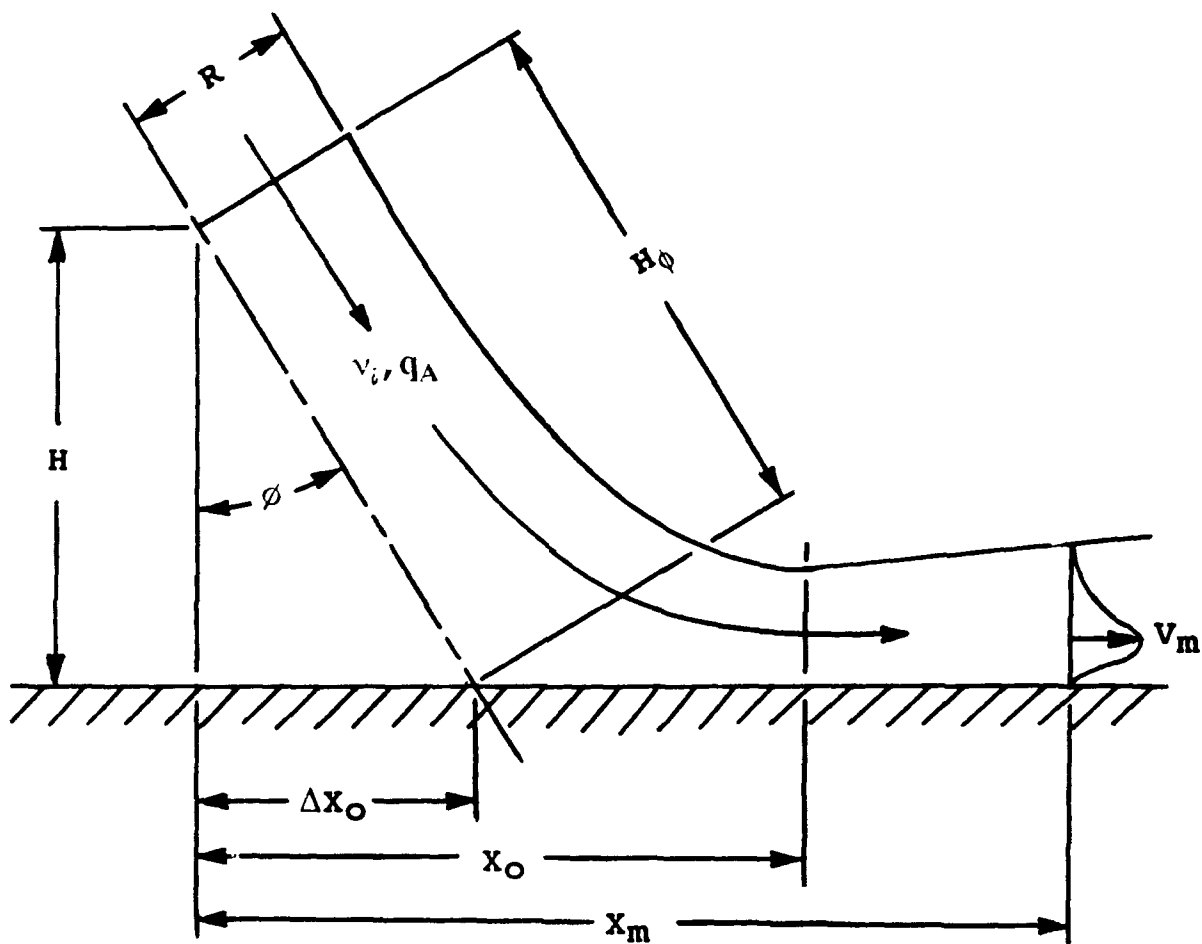


FIGURE 3 ROTORWASH FLOW FIELD CHARACTERISTICS FOR A ROTOR TIP PATH PLANE WHICH IS TILTED FORWARD WITH RESPECT TO A PLANE PARALLEL TO THE GROUND

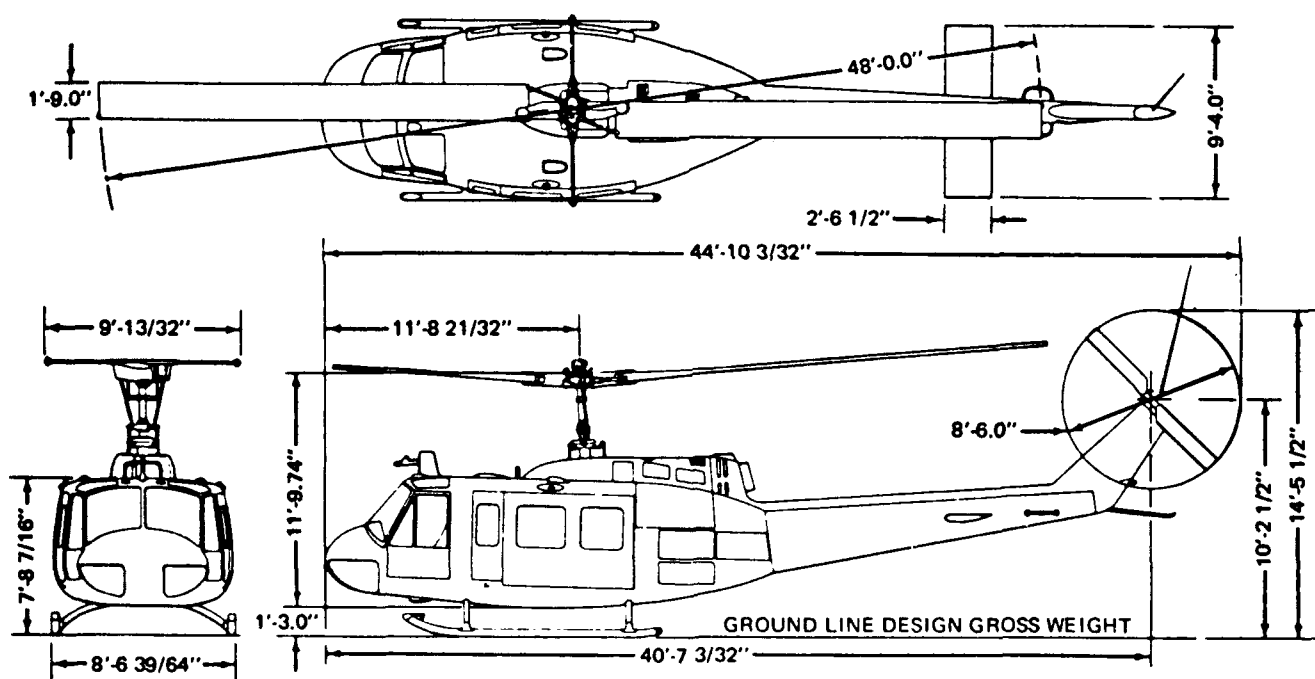


FIGURE 4 THREE-VIEW OF A BELL UH-1H UTILITY HELICOPTER

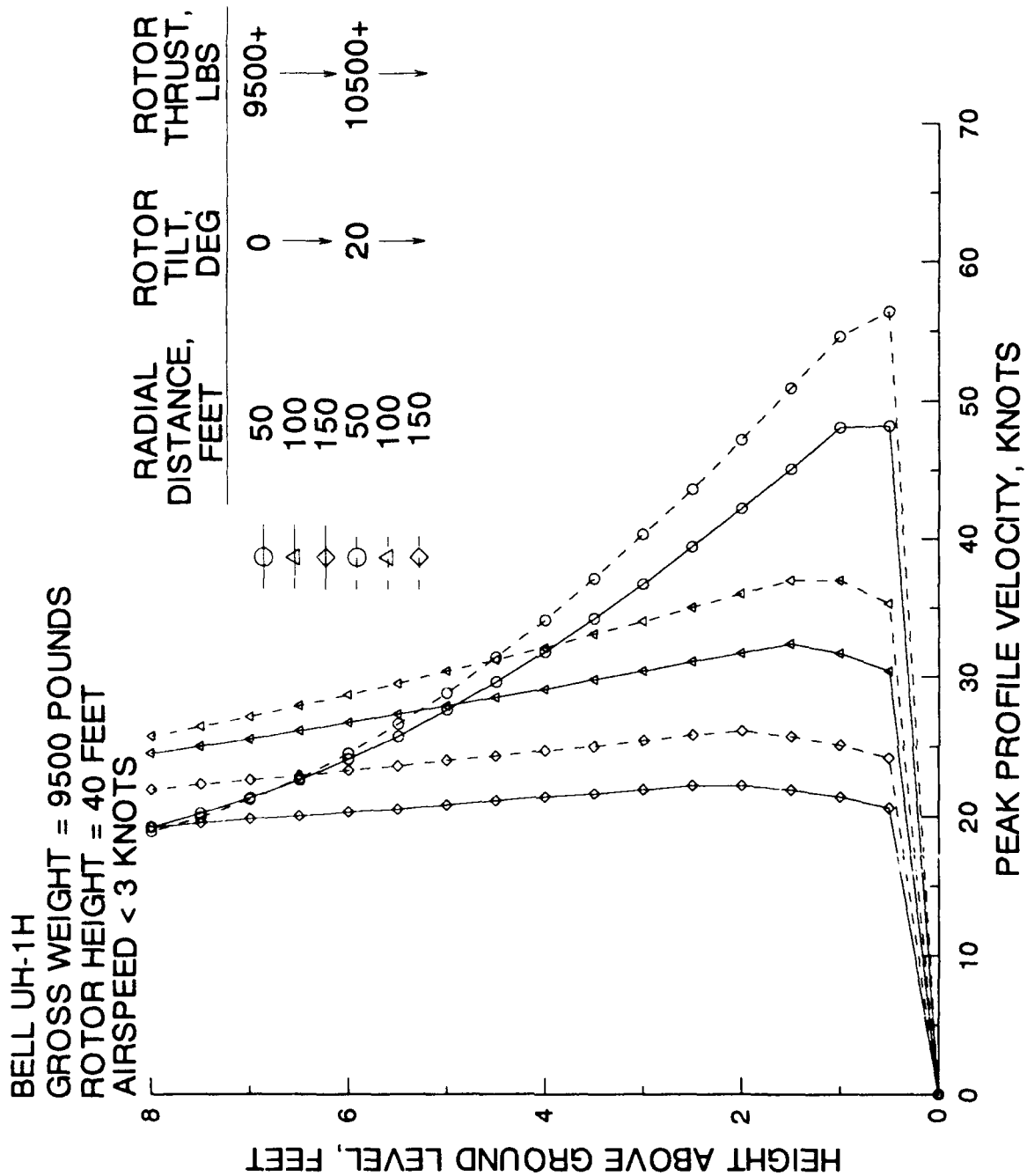


FIGURE 5 UH-1H ROTORWASH CHARACTERISTICS AT RADIAL DISTANCES OF 50, 100, AND 150 FEET FOR TIP PATH PLANE ANGLES OF 0 AND 20 DEGREES

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.

<u>SUBROUTINE</u>	<u>FUNCTION</u>
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

PROGRAM ROTWASH

```

1  C
2  C
3  PROGRAM ROTWASH
4  C
5  C *****
6  C ROTORCRAFT DOWNWASH HAZARD ANALYSIS PROGRAM
7  C
8  C EMA / COMPUTATIONAL METHODOLOGY ASSOCIATES
9  C SAMUEL W. FERGUSON / J. DAVID KOCUREK
10 C
11 C 1 APRIL 1991
12 C
13 C PROGRAM VERSION 2.0
14 C
15 C THIS PROGRAM WAS DEVELOPED USING MICROSOFT FORTRAN 77 FOR
16 C THE DOS OPERATING SYSTEM. CONSOLE DISPLAY CONTROL IS
17 C PROVIDED WITH THIS PROGRAM IN SEVERAL SPECIAL SUBROUTINES.
18 C *****
19 C
20 C PARAMETER(NUM = 10)
21 C
22 C CHARACTER*1 OKLIST(NUM)
23 C CHARACTER*1 KEY,KKEY,FLOW,VELHAZ,HAZTYP
24 C CHARACTER*1 ICONT(5)
25 C CHARACTER*1 TEMCHAR
26 C CHARACTER*12 PTSFIL(4)
27 C CHARACTER*50 COMM(2)
28 C
29 C DIMENSION CONT(9),CONTV(7),CONTX(8)
30 C
31 C COMMON / CKEY/ KEY,KKEY
32 C COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
33 C COMMON /HELGEO/ H,DL,YSEP,WSPD,RADIUS,SHFTAN,DXO
34 C COMMON /INPUTC/ ICONT,COMM,PTSFIL
35 C COMMON /INPUTD/ CONT,CONTV,CONTX
36 C COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
37 C COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
38 C
39 C DATA CONT/2.0,32.2,12.5,13000.0,13.0,37.0,0.0,1.0,0.0/
40 C DATA ICONT/'V','N','N','W','L'/
41 C DATA CONTV/50.0,1.0,10.0,50.0,10.0,100.0,0.0/
42 C DATA CONTX/733.0,7.0,18.0,200.0,0.0,20.0,100.0,0.0/
43 C DATA PTSFIL/'DFRC.PTS','DAIP.PTS','OTDFRC.PTS','OTDAIP.PTS'/
44 C DATA COMM/
45 C 1 'BELL XV-15 CHARACTERISTICS ARE ED AS INPUT DATA ',
46 C 2 'GROSS WEIGHT MIGHT BE ONE OF THE COMMENT STRINGS '/
47 C
48 C DATA OKLIST /'W','w','I','i','G','g','D','d','X','x'/
49 C
50 C *****
51 C
52 C -----
53 C INITIALIZE I/O SYSTEM
54 C -----

```

PROGRAM ROTWASH

```

55  C
56      CALL IOINIT
57  C
58  C -----
59  C  INITIALIZE MISCELLANEOUS CONSTANTS
60  C -----
61  C
62      PI      = ACOS(-1.0)
63      RHOSL   = 0.0023769
64      FPSPKN  = 1.687
65      DRC     = 0.01745329252
66  C
67      50 CONTINUE
68  C
69      KEY = ' '
70      KKEY= ' '
71  C
72  C -----
73  C  OBTAIN INPUT DATA PARAMETERS FROM STATUS SCREEN
74  C -----
75  C
76      CALL INPUT
77  C
78  C -----
79  C  DEFINE PARAMETERS OBTAINED FROM SUBROUTINE INPUT
80  C -----
81  C
82      ROTORS = CONT(1)
83      YYSEP  = CONT(2)
84      RADIUS = CONT(3)
85      HELGW  = CONT(4)
86      DWNLD  = CONT(5)
87      HAGL   = CONT(6)
88      SHFTAN = CONT(7)
89      SIGPR  = CONT(8)
90      WSPD   = CONT(9)
91  C
92      VELHAZ = ICONT(1)
93  C
94  C -----
95  C  ADJUST GEOMETRY IF SHAFT ANGLE > 0.0 DEGREES
96  C -----
97  C
98      RSHFT  = SHFTAN*DRC
99      CSHFTA = COS(RSHFT)
100     DXO    = HAGL*TAN(RSHFT)
101  C
102  C -----
103  C  NON-DIMENSIONALIZE SOME OF THE INPUT PARAMETERS
104  C -----
105  C
106     H      = HAGL/RADIUS/CSHFTA
107     YSEP   = YYSEP/2.0/RADIUS
108     EFFGW  = HELGW*(1.0 + (DWNLD/100.0))

```

PROGRAM ROTWASH

```

109      DL      = EFFGW/ROTORS/PI/RADIUS**2
110      RHO      = SIGPR*RHOSL
111      RHOD2 = 0.5*RHO
112      C
113      C
114      C      -----
115      C      SWITCHING CALLS HAZARD PROGRAM AND ALLOWS RETURN (IF DESIRED)
116      C      TO THE MAINLINE ROUTINE TO CHANGE ROTORCRAFT INPUT PARAMETERS
117      C      -----
118      C      IF(VELHAZ.EQ.'H')THEN
119      C
120      C          KKEY = 'H'
121      C          CALL HAZARD(HAZTYP)
122      C
123      C          IF(KEY.EQ.'X')GOTO 999
124      C          IF(FLOW.EQ.'X')GOTO 999
125      C          IF(HAZTYP.EQ.'X')GOTO 999
126      C          GOTO 50
127      C
128      C      ELSE
129      C
130      C          KKEY = 'V'
131      C
132      C      END IF
133      C
134      C      -----
135      C      SELECT FLOWFIELD OPTION
136      C      -----
137      C
138      C      10 CONTINUE
139      C
140      C      -----
141      C      HOME CURSOR AND CLEAR SCREEN
142      C      -----
143      C
144      C      ICD = 0
145      C      CALL HOMCLS(ICD)
146      C      CALL LOCATE(3,1)
147      C
148      C      WRITE(IOU1,11)
149      C      11 FORMAT ( 20X,' SELECT TYPE OF FLOW TO BE ESTIMATED',///,
150      C          1      20X,'WALL JET PROFILE,          TYPE <W>',/,
151      C          2      20X,'INTERACTION PLANE PROFILE,   TYPE <I>',/,
152      C          2      20X,'GROUND VORTEX,              TYPE <G>',/,
153      C          2      20X,'DISK VORTEX,                TYPE <D>',/,
154      C          3      20X,'TO EXIT PROGRAM',           TYPE <X>',//)
155      C
156      C      -----
157      C      PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT
158      C      -----
159      C
160      C      40 CONTINUE
161      C
162      C      WRITE(IOU1,'(23X,A,$)')
```

PROGRAM ROTWASH

```

163      1 ' ENTER DATA ENTRY CODE  ==> '
164      C
165      READ(IOU1,'(A1)') FLOW
166      C
167      IF(LEGAL(FLOW,IOU1,OKLIST,NUM).EQ.1)GOTO 40
168      C
169      C -----
170      C MAKE LEGAL LOWERCASE INPUTS UPPER CASE BEFORE BRANCHING
171      C -----
172      C
173      IF(FLOW.EQ.'w') FLOW = 'W'
174      IF(FLOW.EQ.'i') FLOW = 'I'
175      IF(FLOW.EQ.'g') FLOW = 'G'
176      IF(FLOW.EQ.'d') FLOW = 'D'
177      IF(FLOW.EQ.'x') FLOW = 'X'
178      C
179      C -----
180      C HOME CURSOR AND CLEAR SCREEN
181      C -----
182      C
183      ICD = 0
184      CALL HOMCLS(ICD)
185      C
186      C -----
187      C BRANCH BASED ON CHOSEN OPTION, ALSO
188      C CHECK NUMBER OF ROTORS TO LIMIT SOME OPTIONS
189      C -----
190      C
191      IF(FLOW.EQ.'X')GOTO 999
192      IF(FLOW.EQ.'W')GOTO 12
193      C
194      IF(FLOW.EQ.'I')THEN
195          IF(ROTORS.GT.1.0)GOTO 12
196          WRITE(IOU1,'(////,14X,A,$)')
197      1 ' REQUIRES TWO ROTORS, TYPE <RETURN> TO CONTINUE '
198          READ(IOU1,'(A1)') TEMCHAR
199          GOTO 10
200      ENDIF
201      C
202      IF(FLOW.EQ.'G')THEN
203          IF(ROTORS.LT.2.0)GOTO 1000
204          WRITE(IOU1,'(////,14X,A,$)')
205      1 ' REQUIRES ONE ROTOR, TYPE <RETURN> TO CONTINUE '
206          READ(IOU1,'(A1)') TEMCHAR
207          GOTO 10
208      ENDIF
209      C
210      IF(FLOW.EQ.'D')THEN
211          IF(ROTORS.LT.2.0)GOTO 1000
212          WRITE(IOU1,'(////,14X,A,$)')
213      1 ' REQUIRES ONE ROTOR, TYPE <RETURN> TO CONTINUE '
214          READ(IOU1,'(A1)') TEMCHAR
215          GOTO 10
216      ENDIF

```

PROGRAM ROTWASH

```

217 C
218 GOTO 10
219 C
220 12 CONTINUE
221 C
222 C *****
223 C RADIAL WALL JET FLOWS
224 C *****
225 C
226 C -----
227 C ACCELERATED SLIPSTREAM MEAN VELOCITY
228 C -----
229 C
230 UN = SQRT(2.0*DL/RHO)
231 C
232 C -----
233 C GROUND EFFECT CORRECTION
234 C -----
235 C
236 AKG = 1.0 - 0.9*EXP(-2.0*H)
237 C
238 C -----
239 C MEAN VELOCITY AT ROTOR DISK (RATIOED TO UN)
240 C -----
241 C
242 UB = AKG/2.0
243 C
244 C -----
245 C FIND INITIAL RADIUS OF WALL JET
246 C -----
247 C
248 CALL WALJET(H,UB,UN,UMB)
249 C
250 500 CONTINUE
251 C
252 IF(KEY.EQ.'X')GOTO 999
253 IF(KEY.EQ.'N')GOTO 50
254 IF(FLOW.EQ.'I')GOTO 700
255 C
256 600 CONTINUE
257 C
258 C -----
259 C WALL JET REGION
260 C
261 C OBTAIN INPUT DATA FOR THE WALL JET OPTION
262 C -----
263 C
264 CALL INPUTV(FLOW)
265 C
266 RVZ = (CONTV(1) - DXO)/RADIUS
267 DELZ = CONTV(2)/RADIUS
268 ZMAX = CONTV(3)/RADIUS
269 C
270 C -----

```

PROGRAM ROTWASH

```

271 C    GENERATE VELOCITY PROFILE AT RVZ IN WALL JET REGION
272 C    -----
273 C
274 C    CALL WJVEL(H,UN,UMB,RVZ,RADIUS,WSPD,DELZ,ZMAX,DXO)
275 C
276 C    GOTO 500
277 C
278 C    700 CONTINUE
279 C
280 C    -----
281 C    INTERACTION PLANE UPWASH DEFLECTION ZONE
282 C
283 C    OBTAIN INPUT DATA FOR THE IPLANE OPTION
284 C    -----
285 C
286 C    CALL INPUTV(FLOW)
287 C
288 C    XIP = (CONTV(1) - DXO)/RADIUS
289 C    DELZ = CONTV(2)/RADIUS
290 C    ZMAX = CONTV(3)/RADIUS
291 C
292 C    -----
293 C    GENERATE VELOCITY PROFILE AT XIP IN INTERACTION PLANE
294 C    -----
295 C
296 C    CALL IPVEL(H,UN,RADIUS,UMB,XIP,YSEP,WSPD,DELZ,ZMAX,DXO)
297 C
298 C    GOTO 500
299 C
300 C    1100 CONTINUE
301 C
302 C    IF(KEY.EQ.'X')GOTO 999
303 C    IF(KEY.EQ.'N')GOTO 50
304 C
305 C    1000 CONTINUE
306 C
307 C    *****
308 C    HORSESHOE VORTEX FLOWS
309 C    *****
310 C
311 C    -----
312 C    OBTAIN INPUT DATA FOR VORTEX OPTIONS
313 C    -----
314 C
315 C    CALL INPUTX
316 C
317 C    OMEGAR = CONTX(1)
318 C    B      = CONTX(2)
319 C    VF     = CONTX(3)
320 C    XT     = CONTX(4)/RADIUS
321 C    YT     = CONTX(5)/RADIUS
322 C    DELZ   = CONTX(6)/RADIUS
323 C    ZMAX   = CONTX(7)/RADIUS
324 C

```

PROGRAM ROTWASH

```

325      VF = VF*FPSPKN
326      AMU = VF/OMEGAR
327      CT = DL/RHO/OMEGAR**2
328      C
329      C -----
330      C ITERATE TO GET INFLOW RATIO
331      C -----
332      C
333      ALOLD = SQRT(CT/2.0)
334      C
335      DO 1300 ITER=1,100
336      C
337      ALNEW = CT/2.0/SQRT(ALOLD**2 + AMU**2)
338      C
339      IF(ABS(ALNEW - ALOLD).LE.1.0E-05)GOTO 1301
340      C
341      ALOLD = ALNEW
342      C
343      1300 CONTINUE
344      C
345      C -----
346      C HOME CURSOR AND CLEAR SCREEN
347      C -----
348      C
349      ICD = 0
350      CALL HOMCLS(ICD)
351      CALL LOCATE(5,1)
352      C
353      WRITE(10U1,20)
354      20 FORMAT( '*****',/
355      1          , 'ITERATIONS EXCEEDED FOR INFLOW RATIO',/
356      2          , '*****')
357      C
358      STOP ' '
359      C
360      1301 CONTINUE
361      C
362      ALAMDA = ALNEW
363      AMUS = AMU/SQRT(CT/2.0)
364      GAMT = OMEGAR*RADIUS*2.0*PI*CT/B
365      CHI = ATAN(ALAMDA/AMU)/2.0
366      GAMW = PI*RADIUS*OMEGAR**2*CT/VF/2.0
367      HOD = H/2.0
368      C
369      C -----
370      C HOME CURSOR AND CLEAR SCREEN
371      C -----
372      C
373      ICD = 0
374      CALL HOMCLS(ICD)
375      CALL LOCATE(3,1)
376      C
377      IF(FLOW.EQ.'D')GOTO 1200
378      C

```

PROGRAM ROTWASH

```

379 C -----
380 C GROUND VORTEX
381 C -----
382 C
383 WRITE(IOU1,1001) HOD,AMUS,AMU
384 1001 FORMAT( 18X,'ROTOR HEIGHT ABOVE GROUND H/D ',2X,F8.4,/
385 1 ,18X,'ADVANCE RATIO MU-STAR ',2X,F8.4,/
386 2 ,18X,'ADVANCE RATIO MU ',2X,F8.4,/)
387 C
388 C -----
389 C THE VALUE INPUT HERE REQUIRES USE OF THE CHART IN FIGURE 18
390 C OF THE ACCOMPANYING DOCUMENTATION FOR THE GROUND VORTEX
391 C -----
392 C
393 30 CONTINUE
394 C
395 WRITE(IOU1,31)
396 31 FORMAT( 18X,'ENTER GROUND VORTEX STRENGTH RATIO',/,
397 1 25X,'(SEE FIGURE 18) ==> '$)
398 C
399 READ(IOU1,*,ERR=30) GAMG
400 C
401 IF(GAMG.LT.0.0) GAMG = 0.0
402 C
403 C -----
404 C CONTINUE ANALYSIS
405 C -----
406 C
407 GAMG = GAMG*GAMT
408 C
409 CALL GDVTX(H,RADIUS,AMU,CT,GAMG,XT,YT,DELZ,ZMAX)
410 C
411 GOTO 1100
412 C
413 1200 CONTINUE
414 C
415 C -----
416 C DISK VORTEX
417 C -----
418 C
419 CALL DEVTX(H,RADIUS,GAMW,CHI,XT,YT,DELZ,ZMAX)
420 C
421 GOTO 1100
422 C
423 C -----
424 C NORMAL PROGRAM EXIT
425 C -----
426 C
427 999 CONTINUE
428 C
429 END
430 C
431

```

SUBROUTINE CLOUD

```

1  C
2  C
3  SUBROUTINE CLOUD(UN,UMB)
4  C
5  C *****
6  C SUBROUTINE CLOUD
7  C
8  C THIS SUBROUTINE MAKES THE CALCULATIONS REQUIRED IN ESTIMATING
9  C THE PARTICLE CLOUD BOUNDARIES ( NO DENSITIES ) FOR SINGLE AND
10 C TWIN ROTOR CONFIGURATIONS
11 C *****
12 C
13 CHARACTER*1 KEY,KKEY
14 CHARACTER*1 ICONT(5)
15 CHARACTER*12 PTSFIL(4)
16 CHARACTER*50 COMM(2)
17 C
18 COMMON / CKEY/ KEY,KKEY
19 COMMON /CLOUDK/ QSMAX
20 COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
21 COMMON /HELGEO/ H,DL,YSEP,WSPD,RADIUS,SHFTAN,DXO
22 COMMON /INPUTC/ ICONT,COMM,PTSFIL
23 COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CY,CY
24 COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
25 C
26 C *****
27 C
28 C -----
29 C CLEAR SCREEN AND HOME CURSOR
30 C -----
31 C
32 ICD = 0
33 CALL HOMCLS(ICD)
34 CALL LOCATE(3,1)
35 C
36 C -----
37 C READ IN THE TERRAIN FACTOR CONSTANT
38 C (SEE FIGURE 30 OF USER'S GUIDE)
39 C -----
40 C
41 10 CONTINUE
42 C
43 WRITE(IOU1,20)
44 20 FORMAT( 15X,'ENTER TERRAIN EROSION FACTOR (-ND-) ==> ',5)
45 C
46 READ(IOU1,*,ERR=10) XKT
47 C
48 C -----
49 C VALIDATE REAL INPUT VALUE
50 C -----
51 C
52 IF(XKT.LE.0.0.OR.XKT.GT.500.0)GOTO 10
53 C
54 C -----

```

SUBROUTINE CLOUD

```

55 C      DEFINE CLOUD BOUNDARY CONSTANTS
56 C      -----
57 C
58      XKT = SQRT(XKT)
59 C
60      QSMX = RHOD2*((SQRT(QSMAX)*UN)**2)
61      ERC = -0.437
62      XUM = (UMB*UN)**2
63      XCU = CU*CU
64      C1 = 1.0
65      C2 = 2.2
66 C
67 C      -----
68 C      SINGLE ROTOR CLOUD BOUNDARY CALCULATIONS
69 C      -----
70 C
71      RCR = RADIUS*((XKT/(C1*RHOD2*XUM*XCU))**ERC)
72      RVR = 0.785*RCR
73      ZVR = 0.329*RCR
74      RCVR = RCR - RVR
75      AR = (2.0/PI)*ALOG(ZVR/RCVR)
76      PHIR = (PI/2.0)*ALOG(RCVR)/ALOG(ZVR/RCVR)
77      AXLV = AR*((-PI/2.0) + PHIR)
78      XLV = EXP(AXLV)
79      HCR = XLV + ZVR
80 C
81 C      -----
82 C      INITIALIZE INTERACTION PLANE BOUNDARIES
83 C      -----
84 C
85      RCI = 0.0
86      RVI = 0.0
87      ZVI = 0.0
88      HCI = 0.0
89      IF(YSEP.LE.0.1)GOTO 30
90 C
91 C      -----
92 C      INTERACTION PLANE CLOUD BOUNDARY CALCULATIONS
93 C      -----
94 C
95      RCI = RADIUS*((XKT/(C2*RHOD2*XUM*XCU))**ERC)
96      RVI = 0.785*RCI
97      ZVI = 0.329*RCI
98      RCVR = RCI - RVI
99      AR = (2.0/PI)*ALOG(ZVI/RCVR)
100     PHIR = (PI/2.0)*ALOG(RCVR)/ALOG(ZVI/RCVR)
101     AXLV = AR*((-PI/2.0) + PHIR)
102     XLV = EXP(AXLV)
103     HCI = XLV + ZVI
104 C
105     30 CONTINUE
106 C
107 C      -----
108 C      PRINTOUT OF BOUNDARY LIMITS

```

SUBROUTINE CLOUD

```

109 C -----
110 C
111 C IF(IOUS.NE.IOUS) WRITE(IOUS,('1'))
112 C
113 C -----
114 C WRITE "40 FORMAT" IF OUTPUT TO GRAPHICS FILE
115 C -----
116 C
117 C IF(IOUS.EQ.6) WRITE(IOUS,40) COMM(1),COMM(2)
118 40 FORMAT( 10X,A50,/,10X,A50,/)
119 C
120 C WRITE(IOUS,50)
121 50 FORMAT( //,
122 1 20X,' SUMMARY OF CLOUD BOUNDARIES',//,
123 2 20X,' RC AND RV ARE FROM ROTOR CENTER (FT)',//,
124 3 20X,' RC ',7X,' RV ',7X,' ZV ',7X,' HC ',/)
125 C
126 C WRITE(IOUS,60) RCR,RVR,ZVR,HCR
127 60 FORMAT( 13X,'SR',F10.1,3F11.1)
128 C
129 C WRITE(IOUS,70) RCI,RVI,ZVI,HCI
130 70 FORMAT( 13X,'IP',F10.1,3F11.1)
131 C
132 C WRITE(IOUS,80) QSMX
133 80 FORMAT( /,12X,' QSMAX =',F7.1,' PSF',/)
134 C
135 C -----
136 C DECIDE NEXT OPTION WITH INKEY
137 C -----
138 C
139 C CALL INKEY
140 C
141 C RETURN
142 C END
143 C
144

```

SUBROUTINE DEVTX

```

1  C
2  C
3  SUBROUTINE DEVTX(H,RADIUS,GAMW,CHI,XT,YT,DELZ,ZMAX)
4  C
5  C *****
6  C SUBROUTINE DEVTX
7  C
8  C THIS SUBROUTINE LOCATES THE DISK EDGE VORTEX SYSTEM, AND
9  C DIRECTS THE CALCULATION OF ITS INDUCED VELOCITY FIELD
10 C *****
11 C
12 CHARACTER*1 TEMCHAR
13 CHARACTER*1 KEY,KKEY
14 CHARACTER*1 ICONT(5)
15 CHARACTER*12 PTSFIL(4)
16 CHARACTER*50 COMM(2)
17 C
18 COMMON / CKEY/ KEY,KKEY
19 COMMON /CHSVTX/ XL1,YL1,ZL1,XL2,YL2,ZL2,XL3,YL3,ZL3,
20 1 XR1,YR1,ZR1,XR2,YR2,ZR2,XR3,YR3,ZR3
21 COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
22 COMMON /INPUTC/ ICONT,COMM,PTSFIL
23 COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
24 C
25 C *****
26 C
27 C -----
28 C ASSUME HORSESHOE SHAPE - ASSIGN LEFT AND RIGHT CORNERS
29 C -----
30 C
31 XL1 = 0.0
32 YL1 = -1.0
33 ZL1 = H
34 C
35 XR1 = 0.0
36 YR1 = 1.0
37 ZR1 = H
38 C
39 C -----
40 C SET UP DIRECTION POINTERS FOR TRAILER ELEMENTS
41 C POINT 2 IS AT GROUND IMPINGEMENT
42 C -----
43 C
44 XL2 = XL1 + H/TAN(CHI)
45 YL2 = YL1
46 ZL2 = 0.0
47 C
48 XR2 = XR1 + H/TAN(CHI)
49 YR2 = YR1
50 ZR2 = 0.0
51 C
52 C -----
53 C POINT THREE EXTENDS TRAILER PARALLEL TO GROUND
54 C -----

```

SUBROUTINE DEVTX

```

55  C
56      XL3 = XL2 + 1.0
57      YL3 = YL2
58      ZL  = ZL2
59  C
60      XR3 = XR2 + 1.0
61      YR3 = YR2
62      ZR3 = ZR2
63  C
64      XT = XT*RADIUS
65      YT = YT*RADIUS
66  C
67  C -----
68  C CLEAR SCREEN AND HOME CURSOR
69  C -----
70  C
71      ICD = 0
72      CALL HOMCLS(ICD)
73      CALL LOCATE(4,1)
74  C
75  C -----
76  C WRITE OUTPUT HEADER
77  C -----
78  C
79      IF(IOUS6.NE.IOUS1) WRITE(IOUS6,('( '1' '))')
80  C
81      WRITE(IOUS6,1000) XT,YT
82  1000 FORMAT( 21X,'DISK VORTEX VELOCITY PROFILE DATA',
83      1 ///,14X,' X-LOCATION (XT)      = ',2X,F8.2,2X,'FT',
84      2  /,14X,' Y-LOCATION (YT)      = ',2X,F8.2,2X,'FT',/)
85  C
86      WRITE(IOUS6,1001) GAMW
87  1001 FORMAT( 15X,'VORTEX CIRCULATION = ',F10.2,2X,'FT**2/SEC')
88  C
89      CHID = CHI*180.0/PI
90  C
91      WRITE(IOUS6,1005) CHID
92  1005 FORMAT( 15X,'SETTLING ANGLE      = ',F10.2,2X,'DEG',////)
93  C
94      WRITE(IOUS1,'(23X,A,$)')
95      1  ' PRESS <RETURN> TO CONTINUE  '
96  C
97      READ(IOUS1,'(A1)') TEMCHAR
98  C
99      CALL HOMCLS(ICD)
100  C
101      IF(IOUS6.EQ.6) WRITE(IOUS6,93) COMM(1),COMM(2)
102  93  FORMAT( 14X,A50,/,10X,A50,/)
103  C
104      WRITE(IOUS6,1100)
105  1100 FORMAT( 12X,'HEIGHT',8X,'MEAN VELOCITY',5X,'MEAN Q',/,
106      1  '0',12X,'(FT)',8X,'(FPS)',6X,'(KN)',5X,'(PSF)',/)
107  C
108  C -----

```

SUBROUTINE DEVTX

```

109  C      SET UP SWEEP OF Z AT SPECIFIED X,Y
110  C      DELZ AND ZMAX COME FROM A MAINLINE STATUS MENU
111  C      -----
112  C
113      XT    = XT/RADIUS
114      YT    = YT/RADIUS
115      NPTS  = IFIX(ZMAX/DELZ) + 2
116      LINES = 0
117  C
118      DO 200 I=1,NPTS
119  C
120      LINES = LINES + 4
121      ZT    = (I - 1)*DELZ
122  C
123      CALL HSVTX(XT,YT,ZT,VXF,VYF,VZF,GAMW,RADIUS)
124  C
125      ZZ    = ZT*RADIUS
126      VTF   = SQRT(VXF**2 + VYF**2 + VZF**2)
127      VXK   = VXF/FPSPKN
128      VYK   = VYF/FPSPKN
129      VZK   = VZF/FPSPKN
130      VTK   = VTF/FPSPKN
131  C
132      QX    = RHOD2*VXF**2
133      QY    = RHOD2*VYF**2
134      QZ    = RHOD2*VZF**2
135      QT    = RHOD2*VTF**2
136  C
137  C      -----
138  C      KEEP OUTPUT PAGE LENGTH TO SIZE OF SCREEN
139  C      -----
140  C
141      IF(IOUS.EQ.IOUS1)THEN
142          IF(LINES.LE.12)GOTO 100
143          LINES = 4
144          CALL INKEY
145          IF(KEY.NE.'C')GOTO 999
146          WRITE(IOUS,1100)
147      ENDIF
148  C
149      100 CONTINUE
150  C
151  C      -----
152  C      REPORT X COMPONENT OF VELOCITY
153  C      -----
154  C
155      WRITE(IOUS,1101) ZZ,VXF,VXK,QX
156      1101 FORMAT( 9X,F8.2,2X,'X',3F10.3)
157  C
158  C      -----
159  C      REPORT Y COMPONENT OF VELOCITY
160  C      -----
161  C
162      WRITE(IOUS,1102) VYF,VYK,QY

```

SUBROUTINE DEVTX

```

163      1102 FORMAT( 19X,'Y',3F10.3)
164      C
165      C -----
166      C      REPORT Z COMPONENT OF VELOCITY
167      C      -----
168      C
169      WRITE(IOU6,1103) VZF,VZK,QZ
170      1103 FORMAT( 19X,'Z',3F10.3)
171      C
172      C -----
173      C      REPORT TOTAL VELOCITY
174      C      -----
175      C
176      WRITE(IOU6,1104) VTF,VTK,QT
177      1104 FORMAT( 19X,'T',3F10.3)
178      C
179      200 CONTINUE
180      C
181      CALL INKEY
182      C
183      999 CONTINUE
184      C
185      RETURN
186      END
187      C
188

```

SUBROUTINE FREAD

```

1  C
2  C
3  SUBROUTINE FREAD(IOU1,PROMPT,VALUE,CONST)
4  C
5  C *****
6  C SUBROUTINE FREAD PROMPTS USER FOR A FLOATING
7  C POINT DATA ENTRY AND CHECKS VALIDITY OF ENTRY
8  C *****
9  C
10  C
11  C
12  C CHARACTER*50 PROMPT,SHOWIT
13  C CHARACTER*15 ENTRY,BLANK
14  C
15  C DATA BLANK /' /
16  C
17  C *****
18  C
19  C -----
20  C PROMPT USER FOR SCALED FLOATING POINT ENTRY.
21  C FIND POSITION OF LAST NON-BLANK CHARACTER IN PROMPT,
22  C THEN STORE RIGHT JUSTIFIED IN SHOWIT.
23  C -----
24  C
25  C N = LAST + 1
26  C
27  C 10 IF(N.EQ.1)GOTO 20
28  C
29  C N = N - 1
30  C
31  C IF(PROMPT(N:N).EQ.' ')GOTO 10
32  C
33  C 20 JS = LAST - N
34  C
35  C WRITE(SHOWIT,'(50A1)') (' ',J=1,JS),(PROMPT(I:I),I=1,N)
36  C
37  C -----
38  C NOW ASK USER FOR DATA ENTRY
39  C -----
40  C
41  C 30 WRITE(IOU1,'(/,1X,A,G13.6)') SHOWIT,VALUE*CONST
42  C
43  C WRITE(IOU1,'(/,8X,A,$)')
44  C 1 ' ENTER NEW VALUE OR <RETURN> TO LEAVE AS IS ==> '
45  C
46  C READ(IOU1,'(A)') ENTRY
47  C
48  C IF(ENTRY.EQ.BLANK)RETURN
49  C
50  C READ(ENTRY,'(BN,F15.0)',EPR=30) TEMP
51  C
52  C -----
53  C CONSTANT CAN BE USED TO SCALE OR
54  C OR CONVERT UNITS OF AN INPUT VALUE

```

SUBROUTINE FREAD

```
55 C -----  
56 C  
57 VALUE = TEMP/CONST  
58 C  
59 RETURN  
60 END  
61 C  
62
```

SUBROUTINE GDVTX

```

1  C
2  C
3  SUBROUTINE GDVTX(H,RADIUS,AMU,CT,GAMG,XT,YT,DELZ,ZMAX)
4  C
5  C *****
6  C SUBROUTINE GDVTX
7  C
8  C THIS SUBROUTINE LOCATES THE GROUND VORTEX BASED ON THE
9  C EXPERIMENTS BY SUN AND CURTIS (PRINCETON UNIV.), AND THEN
10 C DIRECTS THE CALCULATION OF ITS INDUCED VELOCITY FIELD
11 C
12 C THE OUTPUT FROM THIS SUBROUTINE SHOULD BE USED CAREFULLY
13 C FOR GROSS ESTIMATION PURPOSES ONLY
14 C *****
15 C
16 CHARACTER*1 ICONT(5)
17 CHARACTER*1 TEMCHAR
18 CHARACTER*1 KEY,KKEY
19 CHARACTER*12 PTSFIL(4)
20 CHARACTER*50 COMM(2)
21 C
22 COMMON / CKEY/ KEY,KKEY
23 COMMON /CHSVTX/ XL1,YL1,ZL1,XL2,YL2,ZL2,XL3,YL3,ZL3,
24 1 XR1,YR1,ZR1,XR2,YR2,ZR2,XR3,YR3,ZR3
25 COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
26 COMMON /INPUTC/ ICONT,COMM,PTSFIL
27 COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
28 C
29 C *****
30 C
31 HOD = H/2.0
32 C1 = 1.0 + 1.2086*HOD**0.4374
33 C2 = -0.2786*HOD**0.6757
34 ZGV = -10.0*AMU + 0.6
35 XGV = -(C1 + C2*(AMU/CT))**2
36 XXGV = XGV*RADIUS
37 ZZGV = ZGV*RADIUS
38 C
39 C -----
40 C ASSUME HORSESHOE SHAPE - ASSIGN LEFT AND RIGHT CORNERS
41 C -----
42 C
43 XL1 = XGV
44 YL1 = -1.0
45 ZL1 = ZGV
46 C
47 XR1 = XGV
48 YR1 = 1.0
49 ZR1 = ZGV
50 C
51 C -----
52 C SET UP DIRECTION POINTERS FOR TRAILER ELEMENTS
53 C -----
54 C

```

SUBROUTINE GDVTX

```

55      XL2 = XL1 + 1.0
56      YL2 = YL1
57      ZL2 = ZL1
58      C
59      XR2 = XR1 + 1.0
60      YR2 = YR1
61      ZR2 = ZR1
62      C
63      XL3 = XL2 + 1.0
64      YL3 = YL2
65      ZL3 = ZL2
66      C
67      XR3 = XR2 + 1.0
68      YR3 = YR2
69      ZR3 = ZR2
70      C
71      C -----
72      C WRITE OUT GROUND VORTEX POSITION/STRENGTH DATA
73      C -----
74      C
75      IF(IOU6.NE.IOU1) WRITE(IOU6,(''1''))
76      C
77      WRITE(IOU6,1001) XXGV,ZZGV
78      1001 FORMAT( //,24X,'GROUND VORTEX CORE POSITION',//,
79      1 18X,'X-LOCATION (XXGV)          = ',1X,F8.2,2X,'FT',/
80      2 18X,'Y-LOCATION (ZZGV)          = ',1X,F8.2,2X,'FT')
81      C
82      WRITE(IOU6,1002) GAMG
83      1002 FORMAT( /,18X,'GROUND VORTEX CIRCULATION = ',1X,
84      1      F8.2,2X,'FT**2/SEC',//)
85      C
86      WRITE(IOU1,'(23X,A,$)')
87      1 ' PRESS <RETURN> TO CONTINUE '
88      C
89      READ(IOU1,'(A1)') TEMCHAR
90      C
91      ICD = 0
92      CALL HOMCLS(ICD)
93      C
94      C -----
95      C WRITE OUTPUT HEADER
96      C -----
97      C
98      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
99      93 FORMAT( 14X,A50,/,10X,A50,/)
100     C
101     WRITE(IOU6,1100)
102     1100 FORMAT( 12X,'HEIGHT',8X,'MEAN VELOCITY',5X,'MEAN Q',/,
103     1      '0',12X,'(FT)',8X,'(FPS)',6X,'(KN)',5X,'(PSF)',/)
104     C
105     C -----
106     C SET UP SWEEP OF Z AT SPECIFIED X,Y
107     C DELZ AND ZMAX COME FROM MAINLINE STATUS SCREEN
108     C -----

```

SUBROUTINE CDVTX

```

109  C
110      NPTS = IFIX(ZMAX/DELZ) + 2
111      LINES = 0
112  C
113      DO 200 I=1,NPTS
114  C
115          LINES = LINES + 4
116          ZT = (I - 1)*DELZ
117  C
118          CALL HSVTX(XT,YT,ZT,VXF,VYF,VZF,GAMG,RADIUS)
119  C
120          ZZ = ZT*RADIUS
121          VTF = SQRT(VXF**2 + VYF**2 + VZF**2)
122          VXK = VXF/FPSPKN
123          VYK = VYF/FPSPKN
124          VZK = VZF/FPSPKN
125          VTK = VTF/FPSPKN
126  C
127          QX = RHOD2*VXF**2
128          QY = RHOD2*VYF**2
129          QZ = RHOD2*VZF**2
130          QT = RHOD2*VTF**2
131  C
132          IF (IOU6.EQ.IOU1)THEN
133              IF(LINES.LE.12)GOTO 100
134              LINES = 4
135              CALL INKEY
136              IF(KEY.NE.'C')GOTO 999
137              WRITE(IOU6,1100)
138          ENDIF
139  C
140      100 CONTINUE
141  C
142  C      -----
143  C      REPORT X COMPONENT OF VELOCITY
144  C      -----
145  C
146          WRITE(IOU6,1101) ZZ,VXF,VXK,QX
147      1101 FORMAT( 9X,F8.2,2X,'X',3F10.3)
148  C
149  C      -----
150  C      REPORT Y COMPONENT OF VELOCITY
151  C      -----
152  C
153          WRITE(IOU6,1102) VYF,VYK,QY
154      1102 FORMAT( 19X,'Y',3F10.3)
155  C
156  C      -----
157  C      REPORT Z COMPONENT OF VELOCITY
158  C      -----
159  C
160          WRITE(IOU6,1103) VZF,VZK,QZ
161      1103 FORMAT( 19X,'Z',3F10.3)
162  C

```

SUBROUTINE GDVTX

```

163 C -----
164 C REPORT TOTAL VELOCITY
165 C -----
166 C
167 WRITE(10U6,1104) VTF,VTK,QT
168 1104 FORMAT( 19X,'T',3F10.3)
169 C
170 200 CONTINUE
171 C
172 CALL INKEY
173 C
174 999 CONTINUE
175 C
176 RETURN
177 END
178 C
179

```

SUBROUTINE HAZARD

```

1  C
2  C
3  SUBROUTINE HAZARD(HAZTYP)
4  C
5  C *****
6  C SUBROUTINE HAZARD IS THE MAINLINE DRIVER FOR THE
7  C CALCULATION OF SPECIFIC HAZARDS
8  C *****
9  C
10  C PARAMETER(NUM1 = 6)
11  C PARAMETER(NUM2 = 13)
12  C PARAMETER(NUM3 = 4)
13  C PARAMETER(NUM4 = 4)
14  C
15  C CHARACTER*1 OKLST1(NUM1)
16  C CHARACTER*1 OKLST2(NUM2)
17  C CHARACTER*1 OKLST3(NUM3)
18  C CHARACTER*1 OKLST4(NUM4)
19  C
20  C CHARACTER*1 KEY,KKEY,HAZTYP,HUMTYP
21  C CHARACTER*1 CHDOL,CVALUE
22  C CHARACTER*1 ICONT(5)
23  C CHARACTER*12 PTSFIL(4)
24  C CHARACTER*12 TMPFIL
25  C CHARACTER*50 COMM(2)
26  C CHARACTER*50 PROMPT
27  C
28  C DIMENSION CONT(9),CONTV(7),CONTX(8)
29  C
30  C COMMON / CKEY/ KEY,KKEY
31  C COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
32  C COMMON /HELGEO/ H,DL,YSEP,WSPD,RADIUS,SHFTAN,DXO
33  C COMMON /INPUTC/ ICONT,COMM,PTSFIL
34  C COMMON /INPUTD/ CONT,CONTV,CONTX
35  C COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CY
36  C COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,ICRAPH
37  C
38  C *****
39  C
40  C DATA OKLST1 /'C','c','M','m','X','x'/
41  C DATA OKLST2 /' ','A','a','B','b','C','c','D','d',
42  C 1 'E','e','F','f'/
43  C DATA OKLST3 /'W','w','I','i'/
44  C DATA OKLST4 /'L','l','S','s'/
45  C
46  C -----
47  C CLEAR SCREEN AND HOME CURSOR
48  C -----
49  C
50  C ICD = 0
51  C CALL HOMCLS(ICD)
52  C CALL LOCATE(4,1)
53  C
54  C -----

```

SUBROUTINE HAZARD

```

55 C      DETERMINE THE TYPE OF HAZARD ANALYSIS
56 C      OPTION THAT WILL BE EXECUTED
57 C      -----
58 C
59 C      WRITE(IOU1,10)
60 C      10 FORMAT ( 25X,' SELECT TYPE OF HAZARD',///,
61 C          1      18X,'OVERTURNING FORCE/MOMENT,      TYPE <M>',/,
62 C          2      18X,'PARTICULATE CLOUDS,           TYPE <C>',/,
63 C          3      18X,'TO EXIT PROGRAM,               TYPE <X>',/)
64 C
65 C      -----
66 C      INQUIRE, OBTAIN, AND CHECK FOR VALID MENU CODE
67 C      -----
68 C
69 C      11 CONTINUE
70 C
71 C      WRITE(IOU1,'(23X,A,$)') ' ENTER HAZARD CODE ==> '
72 C
73 C      READ(IOU1,'(A1)') HAZTYP
74 C
75 C      IF(LEGAL(HAZTYP,IOU1,OKLST1,NUM1).EQ.1)GOTO 11
76 C
77 C      -----
78 C      CORRECT LOWER CASE LETTERS TO UPPER CASE
79 C      TO USE AS VALID FLAGS IN PARENT SUBROUTINE
80 C      -----
81 C
82 C      IF(HAZTYP.EQ.'c') HAZTYP = 'C'
83 C      IF(HAZTYP.EQ.'m') HAZTYP = 'M'
84 C      IF(HAZTYP.EQ.'x') HAZTYP = 'X'
85 C
86 C      -----
87 C      BRANCH IF EXIT OPTION CHOSEN
88 C      -----
89 C
90 C      IF(HAZTYP.EQ.'M')GOTO 18
91 C      IF(HAZTYP.EQ.'C')GOTO 18
92 C      IF(HAZTYP.EQ.'X')GOTO 999
93 C
94 C      GOTO 11
95 C
96 C      18 CONTINUE
97 C
98 C      *****
99 C      RADIAL WALL JET FLOW INFORMATION
100 C      *****
101 C
102 C      -----
103 C      ACCELERATED SLIPSTREAM MEAN VELOCITY
104 C      -----
105 C
106 C      UN = SQRT(2.0*DL/RHO)
107 C
108 C      -----

```

SUBROUTINE HAZARD

```

109 C      GROUND EFFECT CORRECTION
110 C      -----
111 C
112 C       $AKG = 1.0 - 0.9 * \exp(-2.0 * H)$ 
113 C
114 C      -----
115 C      MEAN VELOCITY AT ROTOR DISK (RATIOED TO UN)
116 C      -----
117 C
118 C       $UB = AKG / 2.0$ 
119 C
120 C      -----
121 C      FIND INITIAL RADIUS OF WALL JET
122 C      -----
123 C
124 C      CALL WALJET(H,UB,UN,UMB)
125 C
126 C      500 CONTINUE
127 C
128 C      IF(KEY.EQ.'X')GOTO 999
129 C      IF(KEY.EQ.'N')GOTO 999
130 C
131 C      -----
132 C      BRANCH IF CLOUD OPTION CHOSEN
133 C      -----
134 C
135 C      IF(HAZTYP.EQ.'C')GOTO 800
136 C
137 C      *****
138 C      OVERTURNING FORCES/MOMENTS
139 C      *****
140 C
141 C      -----
142 C      DETERMINE:
143 C
144 C          1. THE AXIS ALONG WHICH THE OVERTURNING
145 C             FORCES/MOMENTS WILL BE CALCULATED
146 C
147 C          2. THE SIZE OF THE PERSON AFFECTED
148 C
149 C          3. THE DISTANCES AT WHICH THE OVERTURNING
150 C             FORCES/MOMENTS WILL BE CALCULATED
151 C      -----
152 C
153 C      20 CONTINUE
154 C
155 C      ICD = 0
156 C      CALL HOMCLS(ICD)
157 C      CALL LOCATE(2,1)
158 C
159 C      WRITE(IOU1,12)
160 C      12 FORMAT( 20X,' OVERTURNING FORCE/MOMENT DATA MENU',//,
161 C          1    10X,'CODE'           PARAMETER           VALUE',
162 C          2    ' UNITS',',')

```

SUBROUTINE HAZARD

```

163 C
164 C -----
165 C PRINT OUT MENU VARIABLES AS BASED ON THE WALL JET
166 C OPTION OR INTERACTION PLANE OPTION SWITCH SETTING
167 C -----
168 C
169 C IF(ICONT(4).EQ.'W')THEN
170 C
171 C     WRITE(IOU1,14) ICONT(4),ICONT(5),PTSFIL(3),
172 1         CONTV(4),CONTV(5),CONTV(6)
173 C
174 C     ELSE
175 C
176 C     WRITE(IOU1,14) ICONT(4),ICONT(5),PTSFIL(4),
177 1         CONTV(4),CONTV(5),CONTV(6)
178 C
179 C     ENDIF
180 C
181 C 14 FORMAT( 11X,'A    <W>ALL JET OR <I>INTERACTION PLANE',5X,A2,/,
182 1 11X,'B    <L>ARGE OR <S>MALL PERSON          ',5X,A2,/,
183 2 11X,'C    DATA OUTPUT FILENAME              ',2X,A12,/,
184 3 11X,'                                           ',/,
185 4 11X,'D    INITIAL STATION POSITION              ',5X,F7.2,4X,'FT',/,
186 5 11X,'E    HORIZONTAL INCREMENT                  ',5X,F7.2,4X,'FT',/,
187 6 11X,'F    MAXIMUM STATION POSITION              ',5X,F7.2,4X,'FT',//)
188 C
189 C -----
190 C PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT DATA
191 C -----
192 C
193 C 16 CONTINUE
194 C
195 C     WRITE(IOU1,'(8X,A,$)')
196 1' ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> '
197 C
198 C     READ(IOU1,'(A1)') CHDOL
199 C
200 C     IF(LEGAL(CHDOL,IOU1,OKLST2,NUM2).EQ.1)GOTO 16
201 C
202 C -----
203 C DIRECT OPTIONS BASED ON CHOICE FOR "CHDOL"
204 C -----
205 C
206 C     IF(CHDOL.EQ.' ')GOTO 30
207 C
208 C -----
209 C CHOOSE WALLJET OR IPLANE OPTION
210 C -----
211 C
212 C     IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
213 C
214 40 CONTINUE
215 C
216 C     WRITE(IOU1,'(/,35X,A,1X,A2/)') ' ANALYSIS TYPE = ',ICONT(4)

```

SUBROUTINE HAZARD

```

217      WRITE(IOU1,'(37X,A,$)') ' ENTER NEW CODE ==> '
218      READ(IOU1,'(A1)') CVALUE
219      C
220      IF(LEGAL(CVALUE,IOU1,OKLST3,NUM3).EQ.1)GOTO 40
221      C
222      ICONT(4) = CVALUE
223      IF(ICONT(4).EQ.'w') ICONT(4) = 'W'
224      IF(ICONT(4).EQ.'i') ICONT(4) = 'I'
225      GOTO 20
226      C
227      ENDIF
228      C
229      C -----
230      CHOOSE LARGE OR SMALL PERSON
231      C -----
232      C
233      IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
234      C
235      41  CONTINUE
236      C
237      WRITE(IOU1,'(/,35X,A,1X,A2/)') ' PERSON TYPE = ',ICONT(5)
238      WRITE(IOU1,'(37X,A,$)') ' ENTER NEW CODE ==> '
239      READ(IOU1,'(A1)') CVALUE
240      C
241      IF(LEGAL(CVALUE,IOU1,OKLST4,NUM4).EQ.1)GOTO 41
242      C
243      ICONT(5) = CVALUE
244      IF(ICONT(5).EQ.'l') ICONT(5) = 'L'
245      IF(ICONT(5).EQ.'s') ICONT(5) = 'S'
246      GOTO 20
247      C
248      ENDIF
249      C
250      C -----
251      CHOOSE GRAPHICS FILENAME
252      C -----
253      C
254      IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
255      C
256      IF(ICONT(4).EQ.'W')THEN
257      WRITE(IOU1,'(/,25X,A,1X,A12/)')
258      1  ' FILENAME = ',PTSFIL(3)
259      ELSE
260      WRITE(IOU1,'(/,25X,A,1X,A12/)')
261      1  ' FILENAME = ',PTSFIL(4)
262      ENDIF
263      C
264      WRITE(IOU1,'(20X,A,$)')
265      1  ' ENTER NEW FILENAME (xxxxxxxxx.xxx) ==> '
266      C
267      READ(IOU1,'(A12)') TMPFIL
268      C
269      IF(ICONT(4).EQ.'W') PTSFIL(3) = TMPFIL
270      IF(ICONT(4).EQ.'I') PTSFIL(4) = TMPFIL

```

SUBROUTINE HAZARD

```

271      GOTO 20
272      C
273      ENDIF
274      C
275      C -----
276      C CHOOSE INITIAL STATION POSITION
277      C -----
278      C
279      IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
280      C
281          PROMPT = 'INITIAL STATION POSITION = '
282          CALL FREAD(IOU1,PROMPT,CONTV(4),1.0)
283      C
284          IF(CONTV(4).LT.0.0) CONTV(4) = 0.0
285          GOTO 20
286      C
287      ENDIF
288      C
289      C -----
290      C CHOOSE HORIZONTAL INCREMENT
291      C -----
292      C
293      IF(CHDOL.EQ.'E'.OR.CHDOL.EQ.'e')THEN
294      C
295          PROMPT = 'HORIZONTAL INCREMENT = '
296          CALL FREAD(IOU1,PROMPT,CONTV(5),1.0)
297      C
298          IF(CONTV(5).LT.0.0) CONTV(5) = 0.0
299          GOTO 20
300      C
301      ENDIF
302      C
303      C -----
304      C CHOOSE HORIZONTAL INCREMENT
305      C -----
306      C
307      IF(CHDOL.EQ.'F'.OR.CHDOL.EQ.'f')THEN
308      C
309          PROMPT = 'MAXIMUM STATION POSITION = '
310          CALL FREAD(IOU1,PROMPT,CONTV(6),1.0)
311      C
312          IF(CONTV(6).LT.CONTV(4)) CONTV(6) = CONTV(4)
313          GOTO 20
314      C
315      ENDIF
316      C
317      GOTO 20
318      C
319      30 CONTINUE
320      C
321      ICD = 0
322      CALL HOMCLS(ICD)
323      C
324      IF(ICONT(4).EQ.'I')GOTO 700

```

SUBROUTINE HAZARD

```

325 C
326 C 600 CONTINUE
327 C
328 C -----
329 C WALL JET REGION
330 C
331 C OBTAIN DATA FOR THE HWJVEL OPTION
332 C -----
333 C
334 C RVZ = (CONTV(4) - DXO)/RADIUS
335 C DELH = CONTV(5)
336 C HMAX = CONTV(6)
337 C HUMTYP = ICONT(5)
338 C
339 C -----
340 C GENERATE VELOCITY PROFILE AT RVZ IN WALL JET REGION
341 C -----
342 C
343 C CALL HWJVEL(H,UN,UMB,RVZ,RADIUS,WSPD,DELH,HMAX,HUMTYP,DXO)
344 C
345 C GOTO 500
346 C
347 C 700 CONTINUE
348 C
349 C -----
350 C INTERACTION PLANE UPWASH DEFLECTION ZONE
351 C
352 C OBTAIN INPUT DATA FOR THE HIPVEL OPTION
353 C -----
354 C
355 C XIP = (CONTV(4) - DXO)/RADIUS
356 C DELH = CONTV(5)
357 C HMAX = CONTV(6)
358 C HUMTYP = ICONT(5)
359 C
360 C -----
361 C GENERATE VELOCITY PROFILE AT XIP IN INTERACTION PLANE
362 C -----
363 C
364 C CALL HIPVEL(H,UN,RADIUS,UMB,XIP,YSEP,WSPD,DELH,HMAX,
365 C * HUMTYP,DXO)
366 C
367 C GOTO 500
368 C
369 C 800 CONTINUE
370 C
371 C *****
372 C CALCULATE PARTICULATE CLOUD BOUNDARIES
373 C *****
374 C
375 C CALL CLOUD(UN,UMB)
376 C
377 C GOTO 500
378 C

```

SUBROUTINE HAZARD

```
379 C -----  
380 C  NORMAL PROGRAM EXIT  
381 C -----  
382 C  
383 999 CONTINUE  
384 C  
385  RETURN  
386  END  
387 C  
388
```

SUBROUTINE HIPVEL

```

1  C
2  C
3      SUBROUTINE HIPVEL(H,UN,RADIUS,UMB,XIP,YSEP,WSPD,DELH,
4      *                  HMAX,HUMTYP,DXO)
5  C
6  C
7  *****
8  C      SUBROUTINE HIPVEL GENERATES THE VELOCITY PROFILE AND THE FORCES
9  C      AND OVERTURNING MOMENTS FOR A HUMAN BEING ALONG THE INTERACTION
10 C      PLANE FOR THE TWIN ROTOR CASE
11 C
12 *****
13 C
14     CHARACTER*1 TEMCHAR
15     CHARACTER*1 KEY,KKEY,HUMTYP
16     CHARACTER*1 ICONT(5)
17     CHARACTER*12 PTSFIL(4)
18     CHARACTER*50 COMM(2)
19 C
20     COMMON / CKEY/ KEY,KKEY
21     COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
22     COMMON /INPUTC/ ICONT,COMM,PTSFIL
23     COMMON /PERSON/ QP(12),DSET
24     COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
25     COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
26 C
27 C
28 *****
29 C
30     ICD = 0
31     CALL HOMCLS(ICD)
32 C
33 C      -----
34 C      INPUT FOR DELH AND HMAX COMES FROM INPUTV STATUS MENU
35 C      -----
36 C
37     DSET = DELH
38     IF(DSET.EQ.0.)DELH = HMAX
39 C
40     DELH = DELH/RADIUS
41     HMAX = HMAX/RADIUS
42     NHPTS = IFIX((HMAX - XIP)/DELH) + 1
43 C
44     IF(DSET.EQ.0.)GOTO 33
45 C
46 C      -----
47 C      WRITE OUTPUT HEADER (FOR PLOT FILE, SEE BELOW)
48 C      -----
49 C
50     IF(IOU6.NE.IOU1) WRITE(IOU6,('( '1''))')
51 C
52     IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
53     93 FORMAT( 10X,A50,/,10X,A50,/)
54 C

```

SUBROUTINE HIPVEL

```

55      WRITE(IOU6,1001)
56      1001 FORMAT( 12X,' SUMMARY OF OVERTURNING FORCES AND MOMENTS',/,/,
57      1          19X,'RADIUS',6X,'TOTF',6X,'TOTM',/,/,
58      2          20X,'(FT)',7X,'(LB)',5X,'(FT-LB)',/,/)
59      33 CONTINUE
60      C
61      C -----
62      C WRITE OUT GRAPHICS FILES IF SWITCH IS SET BY USER
63      C -----
64      C
65      IF(IGRAPH.EQ.1)THEN
66      C
67      C -----
68      C OPEN GRAPHICS FILE AND WRITE FILE HEADER
69      C -----
70      C
71      OPEN(IOU8,FILE=PTSFIL(4),STATUS='NEW',ERR=2000)
72      C
73      WRITE(IOU8,83) COMM(1),COMM(2)
74      83 FORMAT( 10X,A50,/,10X,A50,/,/)
75      C
76      WRITE(IOU8,80)
77      80 FORMAT( 1X,'TITLE="TWIN ROTOR DAIP DATA"')
78      C
79      WRITE(IOU8,81)
80      81 FORMAT( 1X,'VARIABLES = DAIP,TOTF,TOTM')
81      C
82      WRITE(IOU8,88)
83      88 FORMAT( 1X,'ZONE T = "GW = xxxxx LB, WAGL = xx FT",',,
84      *          ' I=x, F=POINT')
85      C
86      ENDIF
87      C
88      C -----
89      C BEGIN LOOP INCREMENTING THE RADIAL POINTS AT WHICH
90      C THE OVERTURNING MOMENT CALCULATIONS ARE MADE
91      C -----
92      C
93      DO 565 K = 1,NHPTS
94      C
95      C -----
96      C TF IS INTERACTION PLANE AMPLIFICATION FACTOR
97      C -----
98      C
99      TF = 1.55 - (0.55)*EXP(-1.35*XIP)
100     C
101     C -----
102     C GET PARAMETERS AT BASE RADIUS FOR 'BOUNDARY LAYER'
103     C -----
104     C
105     RIP0 = SQRT(XIP**2 + YSEP**2)
106     C
107     C -----
108     C 'PROPRM' PROVIDES THE VELOCITY PROFILE PARAMETERS

```

SUBROUTINE HIPVEL

```

109 C      OF A RADIAL WALL JET (WITHOUT INTERACTION PLANE)
110 C      -----
111 C
112 C      CALL PROPRM(H,UMB,RIP0)
113 C
114 C      ZIPB = ZB
115 C      ZIPM = ZM
116 C      ZIPH = ZH
117 C
118 C      RIPM = SQRT(XIP**2 + (YSEP + ZIPM)**2)
119 C
120 C      CALL PROPRM(H,UMB,RIPM)
121 C
122 C      UMM = UM
123 C
124 C      -----
125 C      OUTPUT HEADER
126 C      -----
127 C
128 C      IF(DSET.NE.0.)GOTO 78
129 C
130 C      XXIP  = RADIUS*XIP
131 C      XIPOUT = XXIP + DXO
132 C
133 C      IF(IOUS.NE.IOUS1) WRITE(IOUS,'(''1'')')
134 C
135 C      IF(IOUS.EQ.6) WRITE(IOUS,93) COMM(1),COMM(2)
136 C
137 C      WRITE(IOUS,1000) XIPOUT
138 C      1000 FORMAT( 2X,'TWIN ROTOR INTERACTION PLANE VELOCITY PROFILE',
139 C      1          ' AT DISTANCE = ',F7.1,' FT',//)
140 C
141 C      WRITE(IOUS,1002)
142 C      1002 FORMAT( 3X,'HEIGHT',6X,'MEAN VELOCITY',7X,'PEAK VELOCITY',6X,
143 C      1          'MEAN Q',4X,'PEAK Q',/,
144 C      2          3X,'(FT)',7X,'(FPS)',6X,'(KN)',5X,'(FPS)',6X,'(KN)',5X,
145 C      3          '(PSF)',5X,'(PSF)',/)
146 C      78 CONTINUE
147 C
148 C      -----
149 C      'AN' IS ACTUALLY '= 1.0/7.0'
150 C      -----
151 C
152 C      AN = 0.142857142
153 C
154 C      DELZ = 0.5/RADIUS
155 C      NPTS = 12
156 C
157 C      DO 500 I = 1,NPTS
158 C
159 C      ZIP = DELZ*(I - 1) + (0.25/RADIUS)
160 C
161 C      -----
162 C      GET MAX WALL JET VELOCITY AT EFFECTIVE RADIUS

```

SUBROUTINE HIPVEL

```

163 C -----
164 C
165 RIP = SQRT(XIP**2 + (YSEP + ZIP)**2)
166 C
167 CALL PROPRM(H,UMB,RIP)
168 C
169 VN = UN
170 VZ = UM
171 C
172 C -----
173 C INTERACTION PLANE 'BOUNDARY LAYER'
174 C -----
175 C
176 IF(ZIP.LT.ZIPM)THEN
177     VZ = UMM*(ZIP/ZIPM)**AN
178 ENDIF
179 C
180 C -----
181 C DEVELOPED INTERACTION PLANE JET
182 C -----
183 C
184 VH = TF*VZ*XIP/RIP
185 VV = TF*VZ*(YSEP + ZIP)/RIP
186 C
187 ZZ = ZIP*RADIUS
188 C
189 C -----
190 C MEAN HORIZONTAL VELOCITIES AND DYNAMIC PRESSURE
191 C -----
192 C
193 VHMF = VH*UN
194 VHMK = VHMF/FPSPKN
195 C
196 C -----
197 C PEAK HORIZONTAL VELOCITIES AND DYNAMIC PRESSURE
198 C -----
199 C
200 VMFD3I = (XIP*0.2444) + 0.8
201 C
202 IF(VMFD3I.GT.2.5) VMFD3I = 2.5
203 VHPF = VMFD3I*VHMF
204 VHPK = VHPF/FPSPKN
205 C
206 C -----
207 C THE EFFECT OF WIND IS TO ADD (DOWNWIND SIDE) OR SUBTRACT
208 C (UPWIND SIDE) 'XKW' TIMES THE AMBIENT WIND VELOCITY TO
209 C THE HORIZONTAL PROFILE VELOCITY (EMPIRICAL, CH-53E BASED)
210 C -----
211 C
212 XKW = (-0.5*H) + 2.5
213 C
214 IF(XKW.LT.1.0)XKW = 1.0
215 C
216 WSPD2 = WSPD*XKW

```

SUBROUTINE HIPVEL

```

217      VHMK = VHMK + WSPD2
218      VHMF = VHMK*FPSPKN
219      VHPK = VHPK + WSPD2
220      VHPF = VHPK*FPSPKN
221      C
222      C -----
223      C DYNAMIC PRESSURE
224      C -----
225      C
226      QHM = RHOD2*VHMF**2
227      QP(I) = RHOD2*VHPF**2
228      C
229      IF(DSET.NE.0.)GOTC 77
230      C
231      C -----
232      C REPORT HORIZONTAL COMPONENTS
233      C -----
234      C
235      WRITE(IOU6,1003) ZZ,VHMF,VHMK,VHPF,VHPK,QHM,QP(I)
236      1003 FORMAT ( F8.2,2X,6F10.3)
237      77 CONTINUE
238      C
239      500 CONTINUE
240      C
241      IF(DSET.NE.0.)GOTO 520
242      WRITE(IOU1,73)
243      73 FORMAT( )
244      C
245      WRITE(IOU1,'(19X,A,$)')
246      1 ' TYPE <RETURN> TO CONTINUE '
247      C
248      READ(IOU1,'(A1)') TEMCHAR
249      C
250      ICD = 0
251      CALL HOMCLS(ICD)
252      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
253      C
254      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
255      C
256      WRITE(IOU6,1007) XIPOUT
257      1007 FORMAT( 12X,'TWIN ROTOR FORCE PROFILE AT DISTANCE = ',
258      1 F7.1,' FT',//)
259      WRITE(IOU6,1008)
260      1008 FORMAT( 2X,'HEIGHT',6X,'PEAK Q',6X,'FOVER',7X,'OVERM',7X,
261      1 'TOT F',7X,'TOT M',/,
262      2 3X,'(FT)',8X,'(PSF)',7X,'(LB)',6X,'(FT-LB)',7X,
263      3 '(LB)',6X,'(FT-LB)',/)
264      520 CONTINUE
265      C
266      C -----
267      C CALL SUBROUTINE TO CALCULATE THE
268      C FORCES AND MOMENTS ON A HUMAN BEING
269      C -----
270      C

```

SUBROUTINE HIPVEL

```

271      CALL MOMENT(NPTS,HUMTYP,TOTF,TOTM)
272      C
273      IF(DSET.EQ.0.)GOTO 545
274      C
275      HH      = XIP*RADIUS
276      HHOUT = HH + DXO
277      C
278      WRITE(IOU6,1014) HHOUT,TOTF,TOTM
279      1014 FORMAT( 18X,F8.2,2F10.3)
280      C
281      IF(IGRAPH.EQ.1)THEN
282      C
283          WRITE(IOU8,90) HHOUT,TOTF,TOTM
284          90  FORMAT( 1X,F7.2,1X,F7.2,1X,F8.2)
285      C
286      ENDIF
287      C
288      545 CONTINUE
289      C
290      XIP = XIP + DELH
291      C
292      565 CONTINUE
293      C
294      C -----
295      C CLOSE AN OPEN GRAPHICS FILE
296      C -----
297      C
298      IF(IGRAPH.EQ.1)THEN
299      C
300          CLOSE(IOU8,STATUS='KEEP')
301      C
302      ENDIF
303      C
304      CALL INKEY
305      C
306      GOTO 999
307      C
308      C -----
309      C THE ERROR LOGIC ALLOWS FOR THE HANDLING OF FILE
310      C OPEN ERRORS BY RETURNING THE USER TO A MENU
311      C -----
312      C
313      2000 CONTINUE
314      C
315      CALL HOMCLS(0)
316      WRITE(IOU1,2001)
317      2001 FORMAT( ////,8X,
318          1      ' *** ERROR *** PLEASE CHOOSE A NEW OUTPUT FILENAME',
319          2      ' ///,8X,' TYPE <RETURN> TO CONTINUE ', $)
320      READ(IOU1,'(A1)') TEMCHAR
321      KEY = 'P'
322      C
323      999 CONTINUE
324      C

```

SUBROUTINE HIPVEL

325 RETURN
326 END
327 C
328

SUBROUTINE HOMCLS

```

1  C
2  C
3      SUBROUTINE HOMCLS(CODE)
4  C
5  C      *****
6  C      SUBROUTINE HOMCLS
7  C
8  C      THIS SUBROUTINE HOMES THE CURSOR AND CLEARS THE TERMINAL
9  C      SCREEN (CODE=0) OR HOMES THE CURSOR ONLY (CODE=1)
10 C      *****
11 C
12     COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
13 C
14     INTEGER*4 CODE
15 C
16     CHARACTER*4 ED
17     CHARACTER*1 EED(4)
18     EQUIVALENCE (ED,EED(1))
19 C
20     CHARACTER*3 EE
21     CHARACTER*1 EEE(3)
22     EQUIVALENCE (EE,EEE(1))
23 C
24 C      *****
25 C
26     IF(CODE.EQ.1)GOTO 20
27 C
28 C      -----
29 C      HOME CURSOR AND CLEAR SCREEN
30 C      ANSI CONTROL SEQUENCE: ED = ESC[2J
31 C      -----
32 C
33     EED(1) = CHAR(27)
34     EED(2) = CHAR(91)
35     EED(3) = CHAR(50)
36     EED(4) = CHAR(74)
37 C
38     WRITE(IOU1,*) ED
39 C
40 20 CONTINUE
41 C
42 C      -----
43 C      HOME CURSOR ONLY
44 C      ANSI CONTROL SEQUENCE: EE = ESC[H
45 C      -----
46 C
47     EEE(1) = CHAR(27)
48     EEE(2) = CHAR(91)
49     EEE(3) = CHAR(72)
50 C
51     WRITE(IOU1,*) EE
52 C
53     RETURN
54     END

```

SUBROUTINE HOMCLS

55 C
56

SUBROUTINE HSVTX

```

1  C
2  C
3      SUBROUTINE HSVTX(XT,YT,ZT,VX,VY,VZ,GAMMA,RADIUS)
4  C
5  C *****
6  C SUBROUTINE HSVTX
7  C
8  C THIS SUBROUTINE DIRECTS THE CALCULATION OF THE INDUCED VELOCITY
9  C FIELD DUE TO A HORSESHOE VORTEX SYSTEM OF UNIT STRENGTH. POINT 1
10 C (LEFT = L1, RIGHT = R1) DEFINE THE EXTENT OF THE BOUND PORTION OF
11 C THE HORSESHOE. THE TRAILERS START AT POINT 1 AND EXTEND THROUGH
12 C POINT 2, AND THEN ON TO POINT 3. THIS ALLOWS TWO ELEMENTS FOR
13 C EACH TRAILER SO THAT IT CAN 'BEND' TO ACCOUNT FOR GROUND CONTACT.
14 C *****
15 C
16 COMMON /CHSVTX/ XL1,YL1,ZL1,XL2,YL2,ZL2,XL3,YL3,ZL3,
17 1      XR1,YR1,ZR1,XR2,YR2,ZR2,XR3,YR3,ZR3
18 COMMON /CVLINE/ IFI,XA,YA,ZA,XB,YB,ZB,XC,YC,ZC,Q1,Q2,Q3
19 C
20 C *****
21 C
22 C -----
23 C AT SPECIFIED (X,Y,Z) TARGET POINT IN VICINITY
24 C OF ROTOR, CALCULATE THE VECTOR VELOCITY
25 C -----
26 C
27 VX = 0.0
28 VY = 0.0
29 VZ = 0.0
30 C
31 XC = XT
32 YC = YT
33 ZC = ZT
34 C
35 C -----
36 C LEFT TRAILER CONTRIBUTION, POINT 1 TO POINT 2
37 C -----
38 C
39 IFI = 0
40 XA = XL1
41 YA = YL1
42 ZA = ZL1
43 XB = XL2
44 YB = YL2
45 ZB = ZL2
46 C
47 CALL VLINE
48 C
49 VX = VX - Q1
50 VY = VY - Q2
51 VZ = VZ - Q3
52 C
53 C -----
54 C LEFT TRAILER IMAGE

```

SUBROUTINE HSVTX

```

55 C -----
56 C
57     ZA = -ZA
58     ZB = -ZB
59 C
60     CALL VLINE
61 C
62     VX = VX + Q1
63     VY = VY + Q2
64     VZ = VZ + Q3
65 C
66 C -----
67 C     LEFT TRAILER CONTRIBUTION, POINT 2 TO POINT 3
68 C -----
69 C
70     IFI = 1
71     XA = XL2
72     YA = YL2
73     ZA = ZL2
74     XB = XL3
75     YB = YL3
76     ZB = ZL3
77 C
78     CALL VLINE
79 C
80     VX = VX - Q1
81     VY = VY - Q2
82     VZ = VZ - Q3
83 C
84 C -----
85 C     LEFT TRAILER IMAGE
86 C -----
87 C
88     ZA = -ZA
89     ZB = -ZB
90 C
91     CALL VLINE
92 C
93     VX = VX + Q1
94     VY = VY + Q2
95     VZ = VZ + Q3
96 C
97 C -----
98 C     SPANWISE VORTEX CONTRIBUTION
99 C -----
100 C
101     IFI = 0
102     XA = XL1
103     YA = YL1
104     ZA = ZL1
105     XB = XR1
106     YB = YR1
107     ZB = ZR1
108 C

```

SUBROUTINE HSVTX

```

109      CALL VLINE
110      C
111      VX = VX + Q1
112      VY = VY + Q2
113      VZ = VZ + Q3
114      C
115      C -----
116      C SPANWISE VORTEX IMAGE
117      C -----
118      C
119      ZA = -ZA
120      ZB = -ZB
121      C
122      CALL VLINE
123      C
124      VX = VX - Q1
125      VY = VY - Q2
126      VZ = VZ - Q3
127      C
128      C -----
129      C RIGHT TRAILER CONTRIBUTION, POINT 1 TO POINT 2
130      C -----
131      C
132      IFI = 0
133      XA = XR1
134      YA = YR1
135      ZA = ZR1
136      XB = XR2
137      YB = YR2
138      ZB = ZR2
139      C
140      CALL VLINE
141      C
142      VX = VX + Q1
143      VY = VY + Q2
144      VZ = VZ + Q3
145      C
146      C -----
147      C RIGHT TRAILER IMAGE
148      C -----
149      C
150      ZA = -ZA
151      ZB = -ZB
152      C
153      CALL VLINE
154      C
155      VX = VX - Q1
156      VY = VY - Q2
157      VZ = VZ - Q3
158      C
159      C -----
160      C RIGHT TRAILER CONTRIBUTION, POINT 2 TO POINT 3
161      C -----
162      C

```

SUBROUTINE HSVTX

```
163      IFI = 1
164      XA = XR2
165      YA = YR2
166      ZA = ZR2
167      XB = XR3
168      YB = YR3
169      ZB = ZR3
170      C
171      CALL VLINE
172      C
173      VX = VX + Q1
174      VY = VY + Q2
175      VZ = VZ + Q3
176      C
177      C -----
178      C RIGHT TRAILER IMAGE
179      C -----
180      C
181      ZA = -ZA
182      ZB = -ZB
183      C
184      CALL VLINE
185      C
186      VX = VX - Q1
187      VY = VY - Q2
188      VZ = VZ - Q3
189      C
190      C -----
191      C DIMENSIONALIZE
192      C -----
193      C
194      GDR= GAMMA/RADIUS
195      VX = VX*GDR
196      VY = VY*GDR
197      VZ = VZ*GDR
198      C
199      RETURN
200      END
201      C
```

SUBROUTINE HWJVEL

```

1  C
2  C
3      SUBROUTINE HWJVEL(H,UN,UMB,RVZ,RADIUS,WSPD,DELH,HMAX,
4      *                      HUMTYP,DXO)
5  C
6  C      *****
7  C      SUBROUTINE HWJVEL GENERATES THE VELOCITY PROFILE AND
8  C      THE FORCES AND OVERTURNING MOMENTS FOR A HUMAN BEING
9  C      AT A GIVEN RADIUS
10 C      *****
11 C
12      CHARACTER*1 ICONT(5)
13      CHARACTER*1 TEMCHAR
14      CHARACTER*1 KEY,KKEY,HUMTYP
15      CHARACTER*12 PTSFIL(4)
16      CHARACTER*50 COMM(2)
17  C
18      COMMON / CKEY/ KEY,KKEY
19      COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
20      COMMON /INPUTC/ ICONT,COMM,PTSFIL
21      COMMON /PERSON/ QP(12),DSET
22      COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
23      COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
24  C
25  C      *****
26  C
27      ICD = 0
28      CALL HOMCLS(ICD)
29  C
30  C      -----
31  C      INPUT FOR DELH AND HMAX COMES FROM INPUTV STATUS MENU
32  C      -----
33  C
34      DSET = DELH
35  C
36      IF(DSET.EQ.0.) DELH = HMAX
37  C
38      DELH = DELH/RADIUS
39      HMAX = HMAX/RADIUS
40      NHPTS = IFIX((HMAX - RVZ)/DELH) + 1
41  C
42      IF(DSET.EQ.0.)GOTO 50
43      IF(IOU6.NE.IOU1) WRITE(IOU6,('( '1 '))')
44  C
45      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
46      93 FORMAT( 10X,A50,/,10X,A50,/)
47  C
48      WRITE(IOU6,1001)
49      1001 FORMAT( 12X,' SUMMARY OF OVERTURNING FORCES AND MOMENTS',/,
50      1          19X,'RADIUS',6X,'TOTF',6X,'TOTM',/,
51      2          20X,'(FT)',7X,'(LB)',5X,'(FT-LB)',/,)
52      50 CONTINUE
53  C
54  C      -----

```

SUBROUTINE HWJVEL

```

55 C WRITE OUT GRAPHICS FILE IF SWITCH IS SET BY USER
56 C -----
57 C
58 C IF(IGRAPH.EQ.1)THEN
59 C
60 C -----
61 C OPEN GRAPHICS FILE AND WRITE FILE HEADER
62 C -----
63 C
64 C OPEN(IOUS,FILE=PTSFIL(3),STATUS='NEW',ERR=2000)
65 C
66 C WRITE(IOUS,83) COMM(1),COMM(2)
67 83 FORMAT( 10X,A50,/,10X,A50,/)
68 C
69 C WRITE(IOUS,80)
70 80 FORMAT( 1X,'TITLE="SINGLE ROTOR DFRC DATA"')
71 C
72 C WRITE(IOUS,81)
73 81 FORMAT( 1X,'VARIABLES = DFRC,TOTF,TOTM')
74 C
75 C WRITE(IOUS,88)
76 88 FORMAT( 1X,'ZONE T = "GW = xxxxx LB, WAGL = xx FT",',
77 * ' I=x, F=POINT')
78 C
79 C ENDIF
80 C
81 C -----
82 C BEGIN LOOP INCREMENTING THE RADIAL POINTS AT WHICH
83 C THE OVERTURNING MOMENT CALCULATIONS ARE MADE
84 C -----
85 C
86 C DO 565 K = 1,NHPTS
87 C
88 C -----
89 C 'PROPRM' PROVIDES THE VELOCITY PROFILE PARAMETERS
90 C OF A RADIAL WALL JET (WITHOUT INTERACTION PLANE)
91 C -----
92 C
93 C CALL PROPRM(H,UMB,RVZ)
94 C
95 C ZETAM = ZM/ZB
96 C
97 C -----
98 C BOUNDARY LAYER REGION EXPONENT
99 C -----
100 C
101 C -----
102 C 'AN' IS ACTUALLY '= 1.0/7.0'
103 C -----
104 C
105 C AN = 0.142857142
106 C
107 C -----
108 C SHEAR LAYER REGION EXPONENT, TO MEET EDGE CONDITIONS

```

SUBROUTINE HWJVEL

```

109 C (FROM FIGURE 7, USAAVLABS TECHNICAL REPORT 68-52, JULY 1968)
110 C -----
111 C
112 C ALPW = ALOG(1.0 - 1.0/SQRT(2.0))/ALOG((ZH - ZM)/(ZB - ZM))
113 C
114 C VN = UN
115 C VMN = UM
116 C
117 C -----
118 C CALCULATION OF THE PEAK VELOCITY CORRECTION FACTOR
119 C IS MADE IN THE NEXT SECTION AT THE 3 FT POSITION
120 C -----
121 C
122 C VZ3 = 3.0/RADIUS
123 C ZETA3 = VZ3/ZB
124 C VZM3 = 0.0
125 C IF(ZETA3.GE.ZETAM)GOTO 51
126 C
127 C -----
128 C THE 3 FT HEIGHT IS IN THE BOUNDARY LAYER
129 C -----
130 C
131 C IF(ZETAM.GT.0.0) VZM3 = (ZETA3/ZETAM)**AN
132 C GOTO 52
133 C
134 C 51 CONTINUE
135 C
136 C -----
137 C THE 3 FT HEIGHT IS IN THE SHEAR LAYER
138 C -----
139 C
140 C IF(VZ3.LE.ZB)THEN
141 C VZM3 = (1.0 - ((ZETA3 - ZETAM)/(1.0 - ZETAM))**ALPW)**2
142 C ENDIF
143 C
144 C 52 CONTINUE
145 C
146 C -----
147 C THE DELTA VELOCITY TO ADD TO THE MEAN VELOCITY IS
148 C CALCULATED AS THE CONSTANT VMFD3 (FT/SEC)
149 C -----
150 C
151 C VZN3 = VZM3*VMN
152 C VMF3 = VZN3*VN
153 C VMFD3S = (RVZ*0.2444) + 0.4
154 C
155 C IF(VMFD3S.GT.1.5) VMFD3S = 1.5
156 C
157 C VMFD3 = VMFD3S*VMF3
158 C
159 C IF(DSET.NE.0.)GOTO 78
160 C
161 C RRVZ = RVZ*RADIUS
162 C RVZOUT = RRVZ + DXO

```

SUBROUTINE HWJVEL

```

163 C
164 IF(IOUS.NE.IOUS) WRITE(IOUS,('1'))
165 C
166 IF(IOUS.EQ.6) WRITE(IOUS,93) COMM(1),COMM(2)
167 C
168 WRITE(IOUS,1000) RVZOUT
169 1000 FORMAT( 10X,'SINGLE ROTOR VELOCITY PROFILE AT RADIUS = ',
170 1 F7.1,' FT',//)
171 WRITE(IOUS,1005)
172 1005 FORMAT( 2X,'HEIGHT',5X,'MEAN VELOCITY',7X,'PEAK VELOCITY',6X,
173 1 'MEAN Q',4X,'PEAK Q',/,
174 2 3X,'(FT)',5X,'(FPS)',6X,'(KN)',5X,'(FPS)',6X,'(KN)',5X,
175 3 '(PSF)',5X,'(PSF)',/)
176 78 CONTINUE
177 C
178 C -----
179 C SET UP ABILITY TO CALCULATE AT 0.5 FT.
180 C INCREMENTS UP THE VELOCITY PROFILE
181 C -----
182 C
183 DELZ = 0.5/RADIUS
184 NPTS = 12
185 C
186 DO 500 I = 1,NPTS
187 C
188 Z = DELZ*(I - 1) + (0.25/RADIUS)
189 ZETA = Z/ZB
190 C
191 IF(ZETA.GE.ZETAM)GOTO 300
192 C
193 C -----
194 C Z IS WITHIN BOUNDARY LAYER
195 C -----
196 C
197 VZM = 0.0
198 IF(ZETAM.GT.0.0) VZM = (ZETA/ZETAM)**AN
199 C
200 GOTO 400
201 C
202 300 CONTINUE
203 C
204 C -----
205 C Z IS WITHIN SHEAR LAYER
206 C -----
207 C
208 VZM = 0.0
209 C
210 IF(Z.LE.ZB)THEN
211 VZM = (1.0 - ((ZETA - ZETAM)/(1.0 - ZETAM))**ALPW)**2
212 ENDIF
213 C
214 400 CONTINUE
215 C
216 VZN = VZM*VMN

```

SUBROUTINE HWJVEL

```

217 C
218 C -----
219 C DIMENSIONAL HEIGHT
220 C -----
221 C
222 C ZZ = Z*RADIUS
223 C
224 C -----
225 C MEAN VELOCITIES
226 C -----
227 C
228 C VMF = VZN*VN
229 C VMK = VMF/FPSPKN
230 C
231 C -----
232 C PEAK VELOCITIES
233 C -----
234 C
235 C VPF = VMF + VMFD3
236 C VPK = VPF/FPSPKN
237 C
238 C -----
239 C THE EFFECT OF WIND IS TO ADD (DOWNWIND SIDE) OR SUBTRACT
240 C (UPWIND SIDE) 'XKW' TIMES THE AMBIENT WIND VELOCITY TO
241 C THE HORIZONTAL PROFILE VELOCITY (EMPIRICAL, CH-53E BASED)
242 C -----
243 C
244 C XKW = (-0.5*H) + 2.5
245 C
246 C IF(XKW.LT.1.0) XKW = 1.0
247 C
248 C WSPD2 = WSPD*XKW
249 C VMK = VMK + WSPD2
250 C VMF = VMK*FPSPKN
251 C VPK = VPK + WSPD2
252 C VPF = VPK*FPSPKN
253 C
254 C -----
255 C DYNAMIC PRESSURE
256 C -----
257 C
258 C QM = RHOD2*VMF**2
259 C QP(I) = RHOD2*VPF**2
260 C
261 C IF(DSET.NE.0.)GOTO 77
262 C
263 C WRITE(IOU6,1002) ZZ,VMF,VMK,VPF,VPK,QM,QP(I)
264 C 1002 FORMAT( F8.2,6F10.3)
265 C 77 CONTINUE
266 C
267 C 500 CONTINUE
268 C
269 C IF(DSET.NE.0.)GOTO 520
270 C

```

SUBROUTINE HWJVEL

```

271      WRITE(IOU1,73)
272      73 FORMAT( )
273      C
274      WRITE(IOU1,'(15X,A,$)')
275      1 ' TYPE <RETURN> TO CONTINUE '
276      C
277      READ(IOU1,'(A1)') TEMCHAR
278      C
279      ICD = 0
280      CALL HOMCLS(ICD)
281      IF(IOU6.NE.IOU1) WRITE(IOU6,'(''1'')')
282      C
283      IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
284      C
285      WRITE(IOU6,1007) RVZOUT
286      1007 FORMAT( 12X,'SINGLE ROTOR FORCE PROFILE AT RADIUS = ',
287      1          F7.1,' FT',//)
288      C
289      WRITE(IOU6,1008)
290      1008 FORMAT( 2X,'HEIGHT',6X,'PEAK Q',6X,'FOVER',7X,'OVERM',7X,
291      1          'TOT F',7X,'TOT M',/,
292      2          3X,'(FT)',8X,'(PSF)',7X,'(LB)',6X,'(FT-LB)',7X,
293      3          '(LB)',6X,'(FT-LB)',/,)
294      C
295      520 CONTINUE
296      C
297      C -----
298      C CALL SUBROUTINE TO CALCULATE THE
299      C FORCES AND MOMENTS ON A HUMAN BEING
300      C -----
301      C
302      CALL MOMENT(NPTS,HUMTYP,TOTF,TOTM)
303      C
304      IF(DSET.EQ.0.)GOTO 545
305      C
306      HH      = RVZ*RADIUS
307      HHOUT = HH + DXO
308      C
309      WRITE(IOU6,1014) HHOUT,TOTF,TOTM
310      1014 FORMAT( 18X,F8.2,2F10.3)
311      C
312      IF(IGRAPH.EQ.1)THEN
313      C
314          WRITE(IOU8,90) HHOUT,TOTF,TOTM
315      90  FORMAT( 1X,F7.2,1X,F7.2,1X,F8.2)
316      C
317      ENDIF
318      C
319      545 CONTINUE
320      C
321      RVZ = RVZ + DELH
322      C
323      565 CONTINUE
324      C

```

SUBROUTINE HWJVEL

```

325 C -----
326 C CLOSE AN OPEN GRAPHICS FILE
327 C -----
328 C
329 IF(IGRAPH.EQ.1) THEN
330 C
331 CLOSE(IOU8,STATUS='KEEP')
332 C
333 ENDIF
334 C
335 CALL INKEY
336 C
337 GOTO 999
338 C
339 C -----
340 C THE ERROR LOGIC ALLOWS FOR THE HANDLING OF FILE
341 C OPEN ERRORS BY RETURNING THE USER TO A MENU
342 C -----
343 C
344 2000 CONTINUE
345 C
346 CALL HOMCLS(0)
347 WRITE(IOU1,2001)
348 2001 FORMAT( ////,8X,
349 1 ' *** ERROR *** PLEASE CHOOSE A NEW OUTPUT FILENAME',
350 2 ///,8X,' TYPE <RETURN> TO CONTINUE ', $)
351 READ(IOU1,'(A1)') TEMCHAR
352 KEY = 'P'
353 C
354 999 CONTINUE
355 C
356 RETURN
357 END
358 C
359

```

SUBROUTINE INKEY

```

1  C
2  C
3      SUBROUTINE INKEY
4  C
5  C      *****
6  C      SUBROUTINE INKEY
7  C      *****
8  C
9      PARAMETER(NUM = 8)
10 C
11     CHARACTER*1 KEY,KKEY
12     CHARACTER*1 OKLIST(NUM)
13 C
14     COMMON / CKEY/ KEY,KKEY
15     COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
16 C
17 C      *****
18 C
19     DATA OKLIST / 'C','c','P','p','N','n','X','x'/
20 C
21 C      -----
22 C      INQUIRE, OBTAIN, AND CHECK FOR VALID MENU OPTION
23 C      -----
24 C
25     10 CONTINUE
26 C
27     WRITE(IOU1,20)
28     20 FORMAT( //,7X,' TYPE <C>ONTINUE, NEXT <P>OINT, <N>EW CASE, '
29         1      , ' E<X>IT ==> ', $)
30     READ(IOU1,'(A1)') KEY
31 C
32     IF(LEGAL(KEY,IOU1,OKLIST,NUM).EQ.1)GOTO 10
33 C
34 C      -----
35 C      CORRECT LOWER CASE LETTERS TO UPPER CASE
36 C      TO USE AS VALID FLAGS IN PARENT SUBROUTINE
37 C      -----
38 C
39     IF(KEY.EQ.'c') KEY = 'C'
40     IF(KEY.EQ.'p') KEY = 'P'
41     IF(KEY.EQ.'n') KEY = 'N'
42     IF(KEY.EQ.'x') KEY = 'X'
43 C
44 C      -----
45 C      CLEAR SCREEN AND HOME CURSOR
46 C      -----
47 C
48     ICD = 0
49     CALL HOMCLS(ICD)
50 C
51     RETURN
52     END
53 C
54

```

SUBROUTINE INPUT

```

1  C
2  C
3  SUBROUTINE INPUT
4  C
5  C *****
6  C SUBROUTINE INPUT
7  C
8  C THIS SUBROUTINE PRESENTS THE INPUT STATUS MENU
9  C AND MANIPULATES THE DATA FOR PROGRAM USE
10 C *****
11 C
12 C PARAMETER(NUM1 = 19)
13 C PARAMETER(NUM2 = 9)
14 C PARAMETER(NUM3 = 4)
15 C PARAMETER(NUM4 = 4)
16 C
17 C CHARACTER*1 CHDOL
18 C CHARACTER*1 CENTRY
19 C CHARACTER*1 OKLST1(NUM1)
20 C CHARACTER*1 OKLST2(NUM2)
21 C CHARACTER*1 OKLST3(NUM3)
22 C CHARACTER*1 OKLST4(NUM4)
23 C CHARACTER*1 ICONT(5)
24 C
25 C CHARACTER*12 PTSFIL(4)
26 C
27 C CHARACTER*50 COMM(2),LENTY
28 C CHARACTER*50 PROMPT
29 C
30 C DIMENSION CONT(9),CONTV(7),CONTX(8)
31 C
32 C COMMON /INPUTC/ ICONT,COMM,PTSFIL
33 C COMMON /INPUTD/ CONT,CONTV,CONTX
34 C COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
35 C
36 C *****
37 C
38 C -----
39 C SET DATA TO CHECK FOR ILLEGAL DATA INPUT
40 C -----
41 C
42 C DATA OKLST1 / ' ','A','a','B','b','C','c','D','d',
43 1 'E','e','F','f','G','g','H','h','I','i'/
44 C DATA OKLST2 / ' ','A','a','B','b','C','c','D','d'/
45 C DATA OKLST3 / 'V','v','H','h'/
46 C DATA OKLST4 / 'Y','y','N','n'/
47 C
48 C 10 CONTINUE
49 C
50 C -----
51 C CLEAR SCREEN AND HOME CURSOR
52 C -----
53 C
54 C CALL HOMCLS(0)

```

SUBROUTINE INPUT

```

55      CALL LOCATE(2,1)
56      C
57      C -----
58      C WRITE FIRST ENGINEERING DATA MENU
59      C -----
60      C
61      IROTOR = IFIX(CONT(1))
62      C
63      WRITE(IOU1,'(24X,A/)' ) ' ROTWASH USER INPUT DATA MENU'
64      WRITE(IOU1,'(T7,A,T25,A,T51,A,T61,A/)' ) ' CODE',' PARAMETER',
65      1 ' VALUE',' UNITS'
66      WRITE(IOU1,'(8X,A,T50,I5,8X,A)' )
67      1 ' A          NUMBER OF ROTORS (1 OR 2)  ',IROTOR,'-ND-'
68      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)' )
69      1 ' B          HUB TO HUB ROTOR SEPARATION',CONT(2),'FT'
70      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)' )
71      1 ' C          ROTOR RADIUS                ',CONT(3),'FT'
72      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)' )
73      1 ' D          GROSS WEIGHT                ',CONT(4),'LB'
74      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)' )
75      1 ' E          FUSELAGE DOWNLOAD FACTOR    ',CONT(5),'PCT'
76      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)' )
77      1 ' F          ROTOR HEIGHT ABOVE GROUND   ',CONT(6),'FT'
78      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A)' )
79      1 ' G          SHAFT TILT ANGLE (<20 DEG)  ',CONT(7),'DEG'
80      WRITE(IOU1,'(8X,A,T50,F8.4,6X,A)' )
81      1 ' H          AIR DENSITY RATIO          ',CONT(8),'ND'
82      WRITE(IOU1,'(8X,A,T50,F8.1,6X,A//)' )
83      1 ' I          AMBIENT WIND (-10 TO 10 KT)',CONT(9),'KT'
84      C
85      C -----
86      C PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT DATA
87      C -----
88      C
89      20 WRITE(IOU1,'(8X,A,$)' )
90      1 ' ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> '
91      C
92      READ(IOU1,'(A1)' ) CHDOL
93      C
94      IF(LEGAL(CHDOL,IOU1,OKLST1,NUM1).EQ.1)GOTO 20
95      C
96      IF(CHDOL.EQ.' ' )GOTO 30
97      C
98      IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
99      C
100         PROMPT = 'ROTORS = '
101         CALL IREAD(IOU1,PROMPT,IROTOR)
102      C
103         IF(IROTOR.LT.1) IROTOR = 1
104         IF(IROTOR.GT.2) IROTOR = 2
105         CONT(1) = FLOAT(IROTOR)
106      C
107         GOTO 10
108      C

```

SUBROUTINE INPUT

```

109      ENDIF
110      C
111      IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
112      C
113          PROMPT = 'ROTOR SEPARATION = '
114          CALL FREAD(IOU1,PROMPT,CONT(2),1.0)
115          GOTO 10
116      C
117      ENDIF
118      C
119      IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
120      C
121          PROMPT = 'ROTOR RADIUS = '
122          CALL FREAD(IOU1,PROMPT,CONT(3),1.0)
123          GOTO 10
124      C
125      ENDIF
126      C
127      IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
128      C
129          PROMPT = 'GROSS WEIGHT = '
130          CALL FREAD(IOU1,PROMPT,CONT(4),1.0)
131          GOTO 10
132      C
133      ENDIF
134      C
135      IF(CHDOL.EQ.'E'.OR.CHDOL.EQ.'e')THEN
136      C
137          PROMPT = 'DOWNLOAD FACTOR = '
138          CALL FREAD(IOU1,PROMPT,CONT(5),1.0)
139          GOTO 10
140      C
141      ENDIF
142      C
143      IF(CHDOL.EQ.'F'.OR.CHDOL.EQ.'f')THEN
144      C
145          PROMPT = 'HEIGHT ABOVE GROUND = '
146          CALL FREAD(IOU1,PROMPT,CONT(6),1.0)
147          GOTO 10
148      C
149      ENDIF
150      C
151      IF(CHDOL.EQ.'G'.OR.CHDOL.EQ.'g')THEN
152      C
153          PROMPT = 'SHAFT TILT = '
154          CALL FREAD(IOU1,PROMPT,CONT(7),1.0)
155      C
156          IF(CONT(7).LT. 0.0) CONT(7) = 0.0
157          IF(CONT(7).GT.20.0) CONT(7) = 20.0
158          GOTO 10
159      C
160      ENDIF
161      C
162      IF(CHDOL.EQ.'H'.OR.CHDOL.EQ.'h')THEN

```

SUBROUTINE INPUT

```

163 C
164     PROMPT = 'DENSITY RATIO = '
165     CALL FREAD(IOU1,PROMPT,CONT(8),1.0)
166     GOTO 10
167 C
168     ENDIF
169 C
170     IF(CHDOL.EQ.'I'.OR.CHDOL.EQ.'i')THEN
171 C
172         PROMPT = 'WIND VELOCITY = '
173         CALL FREAD(IOU1,PROMPT,CONT(9),1.0)
174 C
175         IF(CONT(9).LT.-10.0) CONT(9) = -10.0
176         IF(CONT(9).GT. 10.0) CONT(9) = 10.0
177         GOTO 10
178 C
179     ENDIF
180 C
181     GOTO 10
182 C
183 30 CONTINUE
184 C
185 C -----
186 C CLEAR SCREEN AND HOME CURSOR
187 C -----
188 C
189     CALL HOMCLS(0)
190     CALL LOCATE(2,1)
191 C
192 C -----
193 C WRITE SECOND ENGINEERING DATA MENU
194 C -----
195 C
196     WRITE(IOU1,40)
197 40 FORMAT( ' ',18X,' ROTWASH PROGRAM LOGIC/COMMENT MENU',//,
198 1         10X,'CODE          PARAMETER          VALUE'//)
199 C
200     WRITE(IOU1,50) ICONT(1),ICONT(2),COMM(1),COMM(2)
201 50 FORMAT( 12X,'A          ANALYSIS TYPE,      <V> OR <H>',5X,A4,/,
202 1         12X,'B          GRAPHICS FILE,      <Y> OR <N>',5X,A4,///,
203 2         15X,'USER INPUT COMMENTS (FOR "PRN" AND "PLT" OUTPUT)',
204 3         //,17X,'<---          50 SPACES          ---->',
205 4         /,12X,'C',4X,A50,/,
206 5         12X,'D',4X,A50,//)
207 C
208 C -----
209 C PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT DATA
210 C -----
211 C
212 60 WRITE(IOU1,'(8X,A,$)')
213 1 ' ENTER CODE FOR DATA INPUT OR <RETURN> TO CONTINUE ==> '
214 C
215     READ(IOU1,'(A1)') CHDOL
216 C

```

SUBROUTINE INPUT

```

217      IF(LEGAL(CHDOL,IOU1,OKLST2,NUM2).EQ.1)GOTO 60
218      C
219      IF(CHDOL.EQ.' ')GOTO 70
220      C
221      C -----
222      C CHOOSE VELOCITY OR HAZARD ANALYSIS OPTION
223      C -----
224      C
225      IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
226      C
227      80      CONTINUE
228      C
229      WRITE(IOU1,'(/,35X,A,1X,A2/)') ' ANALYSIS TYPE = ',ICONT(1)
230      WRITE(IOU1,'(40X,A,$)') ' ENTER NEW VALUE ==> '
231      READ(IOU1,'(A1)') CENTRY
232      C
233      IF(LEGAL(CENTRY,IOU1,OKLST3,NUM3).EQ.1)GOTO 80
234      C
235      ICONT(1) = CENTRY
236      IF(ICONT(1).EQ.'v') ICONT(1) = 'V'
237      IF(ICONT(1).EQ.'h') ICONT(1) = 'H'
238      GOTO 30
239      C
240      ENDIF
241      C
242      C -----
243      C CHOOSE OUTPUT TO A GRAPHICS FILE OR NOT
244      C -----
245      C
246      IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
247      C
248      90      CONTINUE
249      C
250      WRITE(IOU1,'(/,35X,A,1X,A2/)') ' GRAPHICS FLAG = ',ICONT(2)
251      WRITE(IOU1,'(40X,A,$)') ' ENTER NEW VALUE ==> '
252      READ(IOU1,'(A1)') CENTRY
253      C
254      IF(LEGAL(CENTRY,IOU1,OKLST4,NUM4).EQ.1)GOTO 90
255      C
256      ICONT(2) = CENTRY
257      IF(ICONT(2).EQ.'y') ICONT(2) = 'Y'
258      IF(ICONT(2).EQ.'n') ICONT(2) = 'N'
259      IF(ICONT(2).EQ.'Y') IGRAPH = 1
260      IF(ICONT(2).EQ.'N') IGRAPH = 0
261      GOTO 30
262      C
263      ENDIF
264      C
265      C -----
266      C CHOOSE COMMENT STRINGS FOR OUTPUT DATA
267      C -----
268      C
269      IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
270      C

```

SUBROUTINE INPUT

```

271      WRITE(IOU1,'(/,5X,A,A50/)') ' COMMENT STRING = ',COMM(1)
272      WRITE(IOU1,'(5X,A,$)') ' ENTER STRING ==> '
273      READ(IOU1,'(A50)') LENTRY
274      C
275      COMM(1) = LENTRY
276      GOTO 30
277      C
278      ENDIF
279      C
280      IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
281      C
282          WRITE(IOU1,'(/,5X,A,A50/)') ' COMMENT STRING = ',COMM(2)
283          WRITE(IOU1,'(5X,A,$)') ' ENTER STRING ==> '
284          READ(IOU1,'(A50)') LENTRY
285      C
286          COMM(2) = LENTRY
287          GOTO 30
288      C
289      ENDIF
290      C
291      GOTO 30
292      C
293      70 CONTINUE
294      C
295      RETURN
296      END
297      C
298

```

SUBROUTINE INPUTV

```

1  C
2  C
3      SUBROUTINE INPUTV(FLOW)
4  C
5  C      *****
6  C      SUBROUTINE INPUTV
7  C
8  C      THIS SUBROUTINE PRESENTS THE INPUT STATUS MENU AND MANIPULATES
9  C      DATA FOR FOR THE WALJET AND IPLANE PROGRAM OPTIONS
10 C      *****
11 C
12     PARAMETER(NUM = 9)
13 C
14     CHARACTER*1 OKLIST(NUM)
15     CHARACTER*1 CHDOL, FLOW
16     CHARACTER*1 ICONT(5)
17     CHARACTER*12 TMPFIL
18     CHARACTER*12 PTSFIL(4)
19     CHARACTER*50 COMM(2)
20     CHARACTER*50 PROMPT
21 C
22     DIMENSION CONT(9), CONTV(7), CONTX(8)
23 C
24     COMMON /INPUTC/ ICONT, COMM, PTSFIL
25     COMMON /INPUTD/ CONT, CONTV, CONTX
26     COMMON / UNITS/ IOU1, IOU4, IOU5, IOU6, IOU7, IOU8, IGRAPH
27 C
28 C      *****
29 C
30     DATA OKLIST / ' ', 'A', 'a', 'B', 'b', 'C', 'c', 'D', 'd' /
31 C
32 C      -----
33 C      CLEAR SCREEN AND HOME CURSOR
34 C      -----
35 C
36     ICD = 0
37 C
38     20 CONTINUE
39 C
40     CALL HOMCLS(ICD)
41     CALL LOCATE(1,1)
42 C
43     WRITE(IOU1,12)
44     12 FORMAT( 22X, ' VELOCITY PROFILE STATUS MENU', ///,
45             1      10X, 'CODE'          PARAMETER          VALUE',
46             2      3X, 'UNITS', /)
47 C
48 C      -----
49 C      PRINT OUT MENU VARIABLES AS BASED ON THE WALL JET
50 C      OPTION OR INTERACTION PLANE OPTION SWITCH SETTING
51 C      -----
52 C
53     IF(FLOW.EQ. 'W') THEN
54 C

```

SUBROUTINE INPUTV

```

55         WRITE(IOU1,14) (CONTV(I),I=1,3),PTSFIL(1)
56     C
57     ELSE
58     C
59         WRITE(IOU1,14) (CONTV(I),I=1,3),PTSFIL(2)
60     C
61     ENDIF
62     C
63     14 FORMAT( 12X,'A          PROFILE STATION POSITION ',5X,F7.2,
64         1      4X,'FT',/,
65         2      12X,'B          VERTICAL INCREMENT          ',5X,F7.2,4X,'FT',/,
66         3      12X,'C          MAXIMUM PROFILE HEIGHT      ',5X,F7.2,4X,'FT',/,
67         4      12X,'D          DATA OUTPUT FILENAME       ',7X,A12,/)
68     C
69     C -----
70     C PROMPT FOR, OBTAIN, AND CHECK FOR LEGAL INPUT DATA
71     C -----
72     C
73     10 CONTINUE
74     C
75     WRITE(IOU1,'(8X,A,$)')
76     1 ' ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> '
77     C
78     READ(IOU1,'(A1)') CHDOL
79     C
80     IF(LEGAL(CHDOL,IOU1,OKLIST,NUM).EQ.1)GOTO 10
81     C
82     IF(CHDOL.EQ.' ')GOTO 30
83     C
84     IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
85     C
86         PROMPT = 'PROFILE STATION POSITION = '
87         CALL FREAD(IOU1,PROMPT,CONTV(1),1.0)
88     C
89         IF(CONTV(1).LT.0.0) CONTV(1) = 0.0
90         GOTO 20
91     C
92     ENDIF
93     C
94     IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
95     C
96         PROMPT = 'VERTICAL INCREMENT = '
97         CALL FREAD(IOU1,PROMPT,CONTV(2),1.0)
98     C
99         IF(CONTV(2).LT.0.0) CONTV(2) = 0.0
100        GOTO 20
101    C
102    ENDIF
103    C
104    IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
105    C
106        PROMPT = 'MAXIMUM PROFILE HEIGHT = '
107        CALL FREAD(IOU1,PROMPT,CONTV(3),1.0)
108    C

```

SUBROUTINE INPUTV

```

109          IF(CONTV(3).LT.0.0) CONTV(3) = 0.0
110          GOTO 20
111      C
112      ENDIF
113      C
114      C -----
115      C CHOOSE GRAPHICS FILENAME
116      C -----
117      C
118      IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
119      C
120          IF(FLOW.EQ.'W')THEN
121              WRITE(IOU1,'(/,25X,A,1X,A12/)')
122          1      ' FILENAME = ',PTSFIL(1)
123          ELSE
124              WRITE(IOU1,'(/,25X,A,1X,A12/)')
125          1      ' FILENAME = ',PTSFIL(2)
126          ENDIF
127      C
128          WRITE(IOU1,'(20X,A,$)')
129      1  ' ENTER NEW FILENAME (xxxxxxxx.xxx) ==> '
130      C
131          READ(IOU1,'(A12)') TMPFIL
132      C
133          IF(FLOW.EQ.'W') PTSFIL(1) = TMPFIL
134          IF(FLOW.EQ.'I') PTSFIL(2) = TMPFIL
135          GOTO 20
136      C
137      ENDIF
138      C
139      GOTO 20
140      C
141      30 CONTINUE
142      C
143          ICD = 0
144          CALL HOMCLS(ICD)
145      C
146          RETURN
147          END
148      C
149

```

SUBROUTINE INPUTX

```

1  C
2  C
3  SUBROUTINE INPUTX
4  C
5  C *****
6  C SUBROUTINE INPUTX PRESENTS THE INPUT STATUS MENU AND
7  C MANIPULATES DATA FOR PROGRAM USE WITH THE GROUND AND
8  C DISC VORTEX OPTIONS
9  C *****
10 C
11 C PARAMETER(NUM = 15)
12 C
13 C CHARACTER*1 OKLIST(NUM)
14 C CHARACTER*1 CHDOL
15 C CHARACTER*1 ICONT(5)
16 C CHARACTER*12 PTSFIL(4)
17 C CHARACTER*50 COMM(2)
18 C CHARACTER*50 PROMPT
19 C
20 C DIMENSION CONT(9),CONTV(7),CONTX(8)
21 C
22 C COMMON /INPUTC/ ICONT,COMM,PTSFIL
23 C COMMON /INPUTD/ CONT,CONTV,CONTX
24 C COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
25 C
26 C *****
27 C
28 C DATA OKLIST / ' ','A','a','B','b','C','c','D','d',
29 1 'E','e','F','f','G','g'/
30 C
31 C -----
32 C CLEAR SCREEN AND HOME CURSOR
33 C -----
34 C
35 C ICD = 0
36 C
37 20 CONTINUE
38 C
39 C CALL HOMCLS(ICD)
40 C CALL LOCATE(1,1)
41 C
42 C WRITE(IOU1,10)
43 10 FORMAT( 18X,' GROUND/DISK VORTEX INPUT DATA MENU',/,
44 1 15X,' (FOR SINGLE MAIN ROTOR HELICOPTERS ONLY)',/,
45 1 8X,'CODE' PARAMETER VALUE',
46 2 4X,'UNITS',/)
47 C
48 C WRITE(IOU1,11)(CONTX(I),I=1,7)
49 11 FORMAT( 10X,'A ROTOR TIP SPEED ',5X,F8.2,
50 1 4X,'FPS',/,
51 2 10X,'B NUMBER OF ROTOR BLADES ',5X,F8.2,4X,'-ND-',/,
52 3 10X,'C TRANSLATIONAL SPEED ',5X,F8.2,4X,'FPS',/,
53 4 10X,'D XT POSITION ',5X,F8.2,4X,'FT',/,
54 5 10X,'E YT POSITION ',5X,F8.2,4X,'FT',/,

```

SUBROUTINE INPUTX

```

55      6      10X,'F      ZT CALCULATION INCREMENT  ',5X,F8.2,4X,'FT',/,
56      7      10X,'G      MAXIMUM CALCULATION HEIGHT',5X,F8.2,4X,'FT',///)
57      C
58      C      -----
59      C      INQUIRE, OBTAIN, AND CHECK FOR VALID MENU OPTION
60      C      -----
61      C
62      40 CONTINUE
63      C
64      WRITE(IOU1,'(8X,A,$)')
65      1 ' ENTER DATA ENTRY CODE OR <RETURN> TO CONTINUE ==> '
66      C
67      READ(IOU1,'(A1)') CHDOL
68      C
69      IF(LEGAL(CHDOL,IOU1,OKLIST,NUM).EQ.1)GOTO 40
70      C
71      IF(CHDOL.EQ.' ')GOTO 30
72      C
73      IF(CHDOL.EQ.'A'.OR.CHDOL.EQ.'a')THEN
74      C
75          PROMPT = 'ROTOR TIP SPEED = '
76          CALL FREAD(IOU1,PROMPT,CONTX(1),1.0)
77      C
78          IF(CONTX(1).LT.0.0) CONTX(1) = 0.0
79          GOTO 20
80      C
81      ENDIF
82      C
83      IF(CHDOL.EQ.'B'.OR.CHDOL.EQ.'b')THEN
84      C
85          PROMPT = 'NUMBER OF ROTOR BLADES = '
86          CALL FREAD(IOU1,PROMPT,CONTX(2),1.0)
87      C
88          IF(CONTX(2).LT.2.0) CONTX(2) = 2.0
89          GOTO 20
90      C
91      ENDIF
92      C
93      IF(CHDOL.EQ.'C'.OR.CHDOL.EQ.'c')THEN
94      C
95          PROMPT = 'TRANSLATIONAL SPEED = '
96          CALL FREAD(IOU1,PROMPT,CONTX(3),1.0)
97      C
98          IF(CONTX(3).LT.0.0) CONTX(3) = 0.0
99          GOTO 20
100     C
101     ENDIF
102     C
103     IF(CHDOL.EQ.'D'.OR.CHDOL.EQ.'d')THEN
104     C
105         PROMPT = 'XT POSITION = '
106         CALL FREAD(IOU1,PROMPT,CONTX(4),1.0)
107         GOTO 20
108     C

```

SUBROUTINE INPUTX

```

109      ENDIF
110      C
111      IF(CHDOL.EQ.'E'.OR.CHDOL.EQ.'e')THEN
112      C
113          PROMPT = 'YT POSITION = '
114          CALL FREAD(IOU1,PROMPT,CONTX(5),1.0)
115          GOTO 20
116      C
117      ENDIF
118      C
119      IF(CHDOL.EQ.'F'.OR.CHDOL.EQ.'f')THEN
120      C
121          PROMPT = 'ZT CALCULATION INCREMENT = '
122          CALL FREAD(IOU1,PROMPT,CONTX(6),1.0)
123      C
124          IF(CONTX(6).LT.0.0) CONTX(6) = 0.0
125          GOTO 20
126      C
127      ENDIF
128      C
129      IF(CHDOL.EQ.'G'.OR.CHDOL.EQ.'g')THEN
130      C
131          PROMPT = 'MAXIMUM CALCULATION HEIGHT = '
132          CALL FREAD(IOU1,PROMPT,CONTX(7),1.0)
133      C
134          IF(CONTX(7).LT.0.0) CONTX(7) = 0.0
135          GOTO 20
136      C
137      ENDIF
138      C
139      GOTO 20
140      C
141      30 CONTINUE
142      C
143          ICD = 0
144          CALL HOMCLS(ICD)
145      C
146          RETURN
147          END
148      C
149

```

SUBROUTINE IOFNSH

```
1  C
2  C
3  SUBROUTINE IOFNSH
4  C
5  C *****
6  C SUBROUTINE IOFNSH CLOSES FILES OPENED FOR DISK I/O
7  C *****
8  C
9  COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
10 C
11 C *****
12 C
13 C -----
14 C KEEP STANDARD I/O FILES IF ON DISK, ELSE DELETE
15 C -----
16 C
17 IF(IOU5.EQ.5) CLOSE(IOU5,STATUS='KEEP')
18 IF(IOU6.EQ.6) CLOSE(IOU6,STATUS='KEEP')
19 C
20 RETURN
21 END
22 C
```

SUBROUTINE IOINIT

```

1  C
2  C
3  SUBROUTINE IOINIT
4  C
5  C *****
6  C SUBROUTINE IOINIT DISPLAYS THE OPENING BANNER
7  C AND OPENS THE FILES FOR DISK I/O, FILENAMES
8  C ARE PROMPTED FROM THE TERMINAL
9  C *****
10 C
11 CHARACTER*3 IPFILE,OPFILE
12 CHARACTER*1 TEMCHAR
13 C
14 COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
15 C
16 C *****
17 C
18 C -----
19 C ASSIGN DEFAULT VALUES TO I/O UNIT POINTERS
20 C -----
21 C
22 IOU1 = 0
23 IOU4 = 0
24 IOU5 = 0
25 IOU6 = 6
26 IOU7 = 0
27 IOU8 = 8
28 IGRAPH = 0
29 C
30 C -----
31 C HOME CURSOR AND CLEAR THE DISPLAY
32 C -----
33 C
34 ICD = 0
35 CALL HOMCLS(ICD)
36 C
37 C -----
38 C DISPLAY BANNER
39 C -----
40 C
41 CALL LOCATE(5,1)
42 C
43 C -----
44 C ORIGINAL ROTHAZ PROGRAM WAS VERSION 1.0
45 C FIRST VAX MENU VERSION OF ROTHAZ WAS VERSION 1.1
46 C PROGRAM ROTWASH REPLACES ROTHAZ AT VERSION 2.0
47 C -----
48 C
49 WRITE(IOU1,10)
50 10 FORMAT( 27X,'ROTWASH PROGRAM',//
51 1 /,17X,'ROTORCRAFT DOWNWASH HAZARD ANALYSIS',/
52 2 /,15X,'EMA/COMPUTATIONAL METHODOLOGY ASSOCIATES',
53 3 /,15X,'*** PROGRAM VERSION 2.0, APRIL 1991 ***'
54 4 //)

```

SUBROUTINE IOINIT

```

55  C
56      WRITE(IOU1,'(A,$)')
57      1  '          PRESS <RETURN>
58      READ(IOU1,'(A1)') TEMCHAR
59  C
60  C      -----
61  C      HOME CURSOR AND CLEAR THE DISPLAY
62  C      -----
63  C
64      ICD = 0
65      CALL HOMCLS(ICD)
66      CALL LOCATE(3,1)
67  C
68  C      -----
69  C      PROMPT FOR I/O FILES AND READ USER RESPONSE
70  C      -----
71  C
72      WRITE(IOU1,12)
73      12 FORMAT( 14X,' I/O CAN BE DIRECTED TO FILES OR DEVICES',//,
74      1          19X,' VALID DEVICES ARE AS FOLLOWS:',//,
75      2          22X,' <CON> ==>  CONSOLE',/,
76      2          22X,' <PRN> ==>  PRINTER',/,
77      4          22X,' <PLT> ==>  GRAPHICS FILE',///)
78  C
79      16 CONTINUE
80  C
81      WRITE(IOU1,13)
82      13 FORMAT( 16X,' ENTER INPUT FILE/DEV NAME ==> ',$,)
83      11 FORMAT(A)
84      READ(IOU1,11) IPFILE
85  C
86  C      -----
87  C      CHECK FOR DATA ENTRY ERROR
88  C      -----
89  C
90      IF(IPFILE.NE.'CON'.AND.IPFILE.NE.'con')THEN
91          WRITE(IOU1,15)
92      15      FORMAT(/,16X,' ** INPUT ERROR, PLEASE REENTER **',//)
93          GOTO 16
94      ENDIF
95  C
96      17 CONTINUE
97  C
98      WRITE(IOU1,14)
99      14 FORMAT( 16X,' ENTER OUTPUT FILE/DEV NAME ==> ',$,)
100     READ(IOU1,11) OPFILE
101  C
102  C      -----
103  C      CHECK FOR DATA ENTRY ERROR
104  C      -----
105  C
106     IF(OPFILE.NE.'CON'.AND.OPFILE.NE.'con'.AND.
107     1  OPFILE.NE.'PRN'.AND.OPFILE.NE.'prn'.AND.
108     2  OPFILE.NE.'PLT'.AND.OPFILE.NE.'plt')THEN

```

SUBROUTINE IOINIT

```

109          WRITE(IOU1,15)
110          GOTO 17
111      ENDIF
112  C
113  C -----
114  C REDIRECT INPUT/OUTPUT FILES IF REQUESTED
115  C -----
116  C
117          IF(IPFILE.EQ.'CON'.OR.IPFILE.EQ.'con')IOU5 = IOU1
118          IF(OPFILE.EQ.'CON'.OR.OPFILE.EQ.'con')IOU6 = IOU1
119          IF(OPFILE.EQ.'PRN'.OR.OPFILE.EQ.'prn')IOU6 = 6
120  C
121          IF(OPFILE.EQ.'PLT'.OR.OPFILE.EQ.'plt')IGRAPH = 1
122          IF(OPFILE.EQ.'PLT'.OR.OPFILE.EQ.'plt')IOU6 = IOU1
123          IF(OPFILE.EQ.'PLT'.OR.OPFILE.EQ.'plt')IOU8 = 8
124  C
125  C -----
126  C OPEN STANDARD I/O FILES
127  C
128          IOU5 = STD. INPUT
129          IOU6 = STD. OUTPUT
130  C -----
131  C
132          IF(IOU5.EQ.5) OPEN(IOU5,FILE=IPFILE,STATUS='OLD')
133          IF(IOU6.EQ.6) OPEN(IOU6,FILE=OPFILE,STATUS='NEW')
134  C
135  C -----
136  C HOME CURSOR AND CLEAR THE DISPLAY
137  C -----
138  C
139          ICD = 0
140          CALL HOMCLS(ICD)
141  C
142          RETURN
143          END
144  C
145

```

SUBROUTINE IPVEL

```

1  C
2  C
3  SUBROUTINE IPVEL(H,UN,RADIUS,UMB,XIP,YSEP,WSPD,DELZ,ZMAX,DXO)
4  C
5  C *****
6  C SUBROUTINE IPVEL GENERATES THE VELOCITY PROFILE V(X,Z) AT
7  C XVZ ALONG THE INTERACTION PLANE FOR THE TWO ROTOR CASE
8  C *****
9  C
10 CHARACTER*1 TEMCHAR
11 CHARACTER*1 ICONT(5)
12 CHARACTER*1 KEY,KKEY
13 CHARACTER*12 PTSFIL(4)
14 CHARACTER*50 COMM(2)
15 C
16 DIMENSION ZZ(40),VHMF(40),VHMK(40),VHPF(40),VHPK(40),
17 1 QHM(40),QHP(40),VVMF(40),VVMK(40),VVPF(40),
18 2 VVPK(40),QVM(40),QVP(40)
19 C
20 COMMON / CKEY/ KEY,KKEY
21 COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
22 COMMON /INPUTC/ ICONT,COMM,PTSFIL
23 COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
24 COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
25 C
26 C *****
27 C
28 C -----
29 C TF IS THE INTERACTION PLANE AMPLIFICATION FACTOR
30 C -----
31 C
32 TF = 1.55 - (0.55)*EXP(-1.35*XIP)
33 C
34 C -----
35 C OBTAIN PAPAMETERS AT BASE RADIUS FOR THE 'BOUNDARY LAYER'
36 C -----
37 C
38 RIPO = SQRT(XIP**2 + YSEP**2)
39 C
40 C -----
41 C 'PROPRM' PROVIDES THE VELOCITY PROFILE PARAMETERS
42 C OF A RADIAL WALL JET (WITHOUT INTERACTION PLANE)
43 C -----
44 C
45 CALL PROPRM(H,UMB,RIPO)
46 C
47 ZIPB = ZB
48 ZIPM = ZM
49 ZIPH = ZH
50 C
51 RIPM = SQRT(XIP**2 + (YSEP + ZIPM)**2)
52 C
53 CALL PROPRM(H,UMB,RIPM)
54 C

```

SUBROUTINE IPVEL

```

55      UMM = UM
56      C
57      C -----
58      C INCREMENT AND HEIGHT ARE DELZ AND ZMAX
59      C -----
60      C
61      NPTS = IFIX(ZMAX/DELZ) + 2
62      IF(NPTS.GT.40) NPTS = 40
63      C
64      C -----
65      C DIMENSIONALIZE VELOCITY PROFILE PARAMETERS
66      C -----
67      C
68      XXIP = RADIUS*XIP
69      ZZB  = ZIPB*RADIUS
70      ZZH  = ZIPH*RADIUS
71      ZZM  = ZIPM*RADIUS
72      C
73      C -----
74      C OUTPUT THE VELOCITY AND DYNAMIC PRESSURE PROFILE HEADP
75      C -----
76      C
77      ICD = 0
78      CALL HOMCLS(ICD)
79      C
80      IF(IOUS.NE.IOUS) WRITE(IOUS, '(''1'')')
81      C
82      IF(IOUS.EQ.6) WRITE(IOUS,93) COMM(1),COMM(2)
83      93 FORMAT( 10X,A50,/,10X,A50,/)
84      C
85      XIPOLT = XXIP + DXO
86      C
87      WRITE(IOUS,1000) XIPOUT
88      1000 FORMAT( 2X,'TWIN ROTOR INTERACTION PLANE VELOCITY PROFILE',
89      1          ' AT STATION = ',F7.1,' FT',/)
90      C
91      WRITE(IOUS,1002)
92      1002 FORMAT( 2X,'HEIGHT',8X,'MEAN VELOCITY',7X,'PEAK VELOCITY',6X,
93      1          'MEAN Q',4X,'PEAK Q',/,
94      2          3X,'(FT)',8X,'(FPS)',6X,'(KN)',5X,'(FPS)',6X,'(KN)',5X,
95      3          '(PSF)',5X,'(PSF)',/)
96      C
97      LINES = 0
98      C
99      C -----
100     C 'AN' IS ACTUALLY '= 1.0/7.0'
101     C -----
102     C
103     AN = 0.142857142
104     C
105     C -----
106     C CALCULATE THE VELOCITY PROFILE POINTS FOR OUTPUT
107     C 'NPTS' IS THE NUMBER OF VERTICAL STATION POINTS
108     C -----

```

SUBROUTINE IPVEL

```

109  C
110      DO 500 I = 1,NPTS
111  C
112      LINES = LINES + 2
113      ZIP   = DELZ*FLOAT(I - 1)
114  C
115  C      -----
116  C      GET MAX WALL JET VELOCITY AT EFFECTIVE RADIUS
117  C      -----
118  C
119      RIP = SQRT(XIP**2 + (YSEP + ZIP)**2)
120  C
121      CALL PROPRM(H,UMB,RIP)
122  C
123      VN = UN
124      VZ = UM
125  C
126  C      -----
127  C      INTERACTION PLANE 'BOUNDARY LAYER'
128  C      -----
129  C
130      IF(ZIP.LT.ZIPM) VZ = UMM*(ZIP/ZIPM)**AN
131  C
132  C      -----
133  C      DEVELOPED INTERACTION PLANE JET
134  C      -----
135  C
136      VH = TF*VZ*XIP/RIP
137      VV = TF*VZ*(YSEP + ZIP)/RIP
138  C
139      ZZ(I) = ZIP*RADIUS
140  C
141  C      -----
142  C      MEAN VELOCITIES AND DYNAMIC PRESSURE
143  C      -----
144  C
145      VHMF(I) = VH*UN
146      VVMF(I) = VV*UN
147      VHMK(I) = VHMF(I)/FPSPKN
148      VVMK(I) = VVMF(I)/FPSPKN
149  C
150  C      -----
151  C      PEAK VELOCITIES AND DYNAMIC PRESSURE
152  C      -----
153  C
154      VMFD3I = (XIP*0.2444) + 0.8
155  C
156      IF(VMFD3I.GT.2.5) VMFD3I = 2.5
157  C
158      VHPF(I) = VMFD3I*VHMF(I)
159      VVPF(I) = VMFD3I*VVMF(I)
160      VHPK(I) = VHPF(I)/FPSPKN
161      VVPK(I) = VVPF(I)/FPSPKN
162  C

```

SUBROUTINE IPVEL

```

163      IF(VHMF(I).EQ.0.)GOTO 55
164      C
165      C -----
166      C THE EFFECT OF WIND IS TO ADD (DOWNWIND SIDE) OR SUBTRACT
167      C (UPWIND SIDE) 'XWK' TIMES THE AMBIENT WIND VELOCITY TO
168      C THE HORIZONTAL PROFILE VELOCITY (EMPIRICAL, CH-53E BASED)
169      C -----
170      C
171      XKW = (-0.5*H) + 2.5
172      C
173      IF(XKW.LT.1.0) XKW = 1.0
174      C
175      WSPD2      = WSPD*XKW
176      VHMK(I)    = VHMK(I) + WSPD2
177      VHMF(I)    = VHMF(I)*FPSPKN
178      VHPK(I)    = VHPK(I) + WSPD2
179      VHPF(I)    = VHPK(I)*FPSPKN
180      C
181      55  CONTINUE
182      C
183      C -----
184      C DYNAMIC PRESSURE
185      C -----
186      C
187      QHM(I) = RHOD2*VHMF(I)**2
188      QVM(I) = RHOD2*VVMF(I)**2
189      QHP(I) = RHOD2*VHPF(I)**2
190      QVP(I) = RHOD2*VVPF(I)**2
191      C
192      IF(IOUS.EQ.IOUS1)THEN
193      C
194          IF(LINES.LT.12)GOTO 450
195          LINES = 2
196          CALL INKEY
197          IF(KEY.NE.'C')GOTO 999
198          WRITE(IOUS,1002)
199      C
200      ENDIF
201      C
202      450  CONTINUE
203      C
204      C -----
205      C REPORT HORIZONTAL COMPONENTS OF VELOCITY PROFILE
206      C -----
207      C
208      WRITE(IOUS,1003) ZZ(I),VHMF(I),VHMK(I),VHPF(I),
209      *              VHPK(I),QHM(I),QHP(I)
210      1003  FORMAT ( F8.2,2X,'H',6F10.3)
211      C
212      C -----
213      C REPORT VERTICAL COMPONENTS OF VELOCITY PROFILE
214      C -----
215      C
216      WRITE(IOUS,1004) VVMF(I),VVMK(I),VVPF(I),VVPK(I),

```

SUBROUTINE IPVEL

```

217      *          QVM(I),QVP(I)
218      1004      FORMAT ( 10X,'V',6F10.3)
219      C
220      500 CONTINUE
221      C
222      C      -----
223      C      WRITE OUT GRAPHICS FILES IF SWITCH IS SET BY USER
224      C      -----
225      C
226      IF(IGRAPH.EQ.1)THEN
227      C
228      C      -----
229      C      OPEN GRAPHICS FILE
230      C      -----
231      C
232      OPEN(IOUS,FILE=PTSFIL(2),STATUS='NEW',ERR=2000)
233      C
234      WRITE(IOUS,89) COMM(1),COMM(2)
235      89      FORMAT( 10X,A50,/,10X,A50,/)
236      C
237      WRITE(IOUS,80) XIPOUT
238      80      FORMAT( 1X,'TITLE="TWIN ROTOR, DAIP =',F6.2,' FT,'
239      *          ' GW = xxxxx LB, WAGL = xx FT"')
240      C
241      C      -----
242      C      PRINT OUT MEAN VELOCITY, PEAK VELOCITY, AND PEAK
243      C      DYNAMIC PRESSURE PROFILES VERSUS PROFILE HEIGHT (AGL)
244      C      -----
245      C
246      WRITE(IOUS,88)
247      88      FORMAT( 1X,'VARIABLES = X,HT')
248      C
249      WRITE(IOUS,81)
250      81      FORMAT( 1X,'ZONE T = "MEAN PROFILE, KTS", I=xx, F=POINT')
251      DO 82 I = 1,NPTS
252      WRITE(IOUS,83) VHMK(I),ZZ(I)
253      83      FORMAT( 1X,F6.1,1X,F5.1)
254      82      CONTINUE
255      C
256      WRITE(IOUS,84)
257      84      FORMAT( 1X,'ZONE T = "PEAK PROFILE, KTS", I=xx, F=POINT')
258      DO 85 I = 1,NPTS
259      WRITE(IOUS,83) VHPK(I),ZZ(I)
260      85      CONTINUE
261      C
262      WRITE(IOUS,86)
263      86      FORMAT( 1X,'ZONE T = "PEAK Q, PSF", I=xx, F=POINT')
264      DO 87 I = 1,NPTS
265      WRITE(IOUS,83) QHP(I),ZZ(I)
266      87      CONTINUE
267      C
268      C      -----
269      C      CLOSE GRAPHICS FILE
270      C      -----

```

SUBROUTINE IPVEL

```

271  C
272      CLOSE( IOU8, STATUS= 'KEEP' )
273  C
274      ENDIF
275  C
276      CALL INKEY
277  C
278      GOTO 999
279  C
280  C      -----
281  C      THE ERROR LOGIC ALLOWS FOR THE HANDLING OF FILE
282  C      OPEN ERRORS BY RETURNING THE USER TO A MENU
283  C      -----
284  C
285      2000 CONTINUE
286  C
287      CALL HOMCLS(0)
288  C
289      WRITE( IOU1, 2001 )
290      2001 FORMAT( //, //, 8X,
291          1      ' *** ERROR *** PLEASE CHOOSE A NEW OUTPUT FILENAME',
292          2      //, 8X, '
293          C                                     TYPE <RETURN> TO CONTINUE ', $ )
294      READ( IOU1, ' (A1)' ) TEMCHAR
295  C
296      KEY = 'P'
297  C
298      999 CONTINUE
299  C
300      RETURN
301      END
302  C
303

```

SUBROUTINE IREAD

```

1  C
2  C
3      SUBROUTINE IREAD(IOU1,PROMPT,IVALUE)
4  C
5  C      *****
6  C      SUBROUTINE IREAD PROMPTS USER FOR AN INTEGER
7  C      DATA ENTRY AND CHECKS VALIDITY OF ENTRY
8  C      *****
9  C
10     PARAMETER(LAST=50)
11  C
12     CHARACTER*50 PROMPT,SHOWIT
13     CHARACTER*15 ENTRY,BLANK
14  C
15     DATA BLANK /'          '/'
16  C
17  C      *****
18  C
19  C      -----
20  C      PROMPT USER FOR INTEGER ENTRY.  FIND POSITION
21  C      OF LAST NON-BLANK CHARACTER IN PROMPT,
22  C      THEN STORE RIGHT JUSTIFIED IN SHOWIT
23  C      -----
24  C
25     N = LAST + 1
26  C
27     10 IF(N.EQ.1)GOTO 20
28  C
29     N = N - 1
30  C
31     IF(PROMPT(N:N).EQ.' ')GOTO 10
32  C
33     20 JS = LAST - N
34  C
35     WRITE(SHOWIT,'(50A1)') (' ',J=1,JS),(PROMPT(I:I),I=1,N)
36  C
37  C      -----
38  C      NOW ASK USER FOR DATA ENTRY
39  C      -----
40  C
41     30 WRITE(IOU1,'(/,1X,A,I3)') SHOWIT,IVALUE
42  C
43     WRITE(IOU1,'(/,8X,A,$)')
44     1 ' ENTER NEW VALUE OR <RETURN> TO LEAVE AS IS ==> '
45  C
46     READ(IOU1,'(A)') ENTRY
47  C
48     IF(ENTRY.EQ.BLANK)RETURN
49  C
50     READ(ENTRY,'(BN,I7)',ERR=30) ITEMP
51  C
52     IVALUE = ITEMP
53  C
54     RETURN

```

SUBROUTINE IREAD

55 END
56 C
57

SUBROUTINE LEGAL

```

1  C
2  C
3  FUNCTION LEGAL(CHDOL,IOU1,OKLIST,NUM)
4  C
5  C *****
6  C FUNCTION LEGAL DETERMINES IF THE VALUE
7  C FOR CHDOL IS A VALID INPUT. THIS VALUE
8  C IS CHECKED AGAINST THE LIST OF LEGAL
9  C VALUE IN ARRAY OKLIST(NUM)
10 C *****
11 C
12 CHARACTER*1 CHDOL,OKLIST(NUM)
13 C
14 C *****
15 C
16 LEGAL = 0
17 C
18 DO 10 I=1,NUM
19 IF(CHDOL.EQ.OKLIST(I)) RETURN
20 10 CONTINUE
21 C
22 LEGAL = 1
23 C
24 WRITE(IOU1, '(/,T9,A,A1,A/)' ) ' *** ',CHDOL,
25 1 ' IS NOT A VALID INPUT ***'
26 C
27 RETURN
28 END
29 C
30

```

SUBROUTINE LOCATE

```

1  C
2  C
3  SUBROUTINE LOCATE(IROW,ICOL)
4  C
5  C *****
6  C SUBROUTINE LOCATE LOCATES THE CURSOR POSITION
7  C *****
8  C
9  COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRADE
10 C
11 CHARACTER*8 CUP
12 CHARACTER*1 ECUP(8)
13 EQUIVALENCE (CUP,ECUP(1))
14 C
15 CHARACTER*10 FMT
16 CHARACTER*1 EFMT(10)
17 EQUIVALENCE (FMT,EFMT(1))
18 C
19 DATA FMT / '( " ",A? \)' /
20 C
21 C *****
22 C
23 C -----
24 C ANSI CONTROL SEQUENCE: CUP = ESC['ROW';'COLUMN'H
25 C -----
26 C
27 IR1 = IROW/10
28 IR2 = IROW - IR1*10
29 IC1 = ICOL/10
30 IC2 = ICOL - IC1*10
31 C
32 ECUP(1) = CHAR(27)
33 ECUP(2) = CHAR(91)
34 IPOS = 3
35 C
36 IF(IR1.GT.0)THEN
37 ECUP(IPOS) = CHAR(IR1 + 48)
38 IPOS = IPOS + 1
39 ENDIF
40 C
41 ECUP(IPOS) = CHAR(IR2 + 48)
42 IPOS = IPOS + 1
43 C
44 ECUP(IPOS) = CHAR(59)
45 IPOS = IPOS + 1
46 C
47 IF(IC1.GT.0)THEN
48 ECUP(IPOS) = CHAR(IC1 + 48)
49 IPOS = IPOS + 1
50 ENDIF
51 C
52 ECUP(IPOS) = CHAR(IC2 + 48)
53 IPOS = IPOS + 1
54 C

```

SUBROUTINE LOCATE

```
55      ECUP(IPOS) = CHAR(72)
56      C
57      EFMT(7) = CHAR(IPOS + 48)
58      C
59      WRITE(10U1,*) CUP
60      C
61      RETURN
62      END
63      C
64
```

SUBROUTINE MOMENT

```

1  C
2  C
3  SUBROUTINE MOMENT(NPTS,HUMTYP,TOTF,TOTM)
4  C
5  C *****
6  C SUBROUTINE MOMENT CALCULATES THE TOTAL OVERTURNING
7  C FORCE AND MOMENT ON A MAN OR YOUNG PERSON AND PRINTS
8  C OUT THE RESULTS.
9  C *****
10 C
11 CHARACTER*1 HUMTYP
12 C
13 COMMON /PERSON/ QP(12),DSET
14 COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
15 C
16 C *****
17 C
18 C -----
19 C IN THE SUBROUTINE TO CALCULATE FORCES AND MOMENTS:
20 C
21 C "CDP" IS THE COEFFICIENT OF DRAG OF THE PERSON
22 C "WIDTHP" IS THE WIDTH OF THE PERSON WHERE:
23 C WIDTHP IS 'L' TYPE IF 1.1 FT
24 C WIDTHP IS 'S' TYPE IF 0.7 FT
25 C -----
26 C
27 WIDTHP = 1.1
28 CDP = 1.1
29 C
30 C -----
31 C INITIALIZE INTEGRATION STEP SIZE AND ZERO SUMMATION VARIABLES
32 C -----
33 C
34 DELZZ = 0.5
35 TOTM = 0.0
36 TOTF = 0.0
37 C
38 C -----
39 C CHOOSE HUMAN SIZE TYPE
40 C -----
41 C
42 IF(HUMTYP.EQ.'S')THEN
43 WIDTHP = 0.7
44 NPTS = 8
45 END IF
46 C
47 C -----
48 C INTEGRATE DYNAMIC PRESSURE PROFILE OVER
49 C THE HEIGHT OF THE PERSON CHOSEN
50 C -----
51 C
52 DO 10 J = 1,NPTS
53 C
54 FOVER = QP(J)*DELZZ*WIDTHP*CDP

```

SUBROUTINE MOMENT

```

55      ZZ      = 0.5*(J - 1) + 0.25
56      OVERM = FOVER*ZZ
57      TOTF   = TOTF + FOVER
58      TOTM   = TOTM + OVERM
59      C
60      C      -----
61      C      PRINT OUT RESULTS
62      C      -----
63      C
64      IF(DSET.NE.0.)GOTO 10
65      C
66      WRITE(10U6,20) ZZ,QP(J),FOVER,OVERM,TOTF,TOTM
67      20 FORMAT( F8.2,5(2X,F10.3))
68      C
69      10 CONTINUE
70      C
71      RETURN
72      END
73      C

```

SUBROUTINE PROPRM

```

1  C
2  C
3  SUBROUTINE PROPRM(H,UMB,RVZ)
4  C
5  C *****
6  C SUBROUTINE PROPRM
7  C
8  C THIS SUBROUTINE CALCULATES THE VELOCITY PROFILE V(R,Z) PARAMETERS
9  C OF THE RADIAL WALL JET FOR THE NON-INTERACTING ROTOR CASE
10 C *****
11 C
12 COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
13 C
14 C *****
15 C
16 IF(RVZ.GE.RJ)GOTO 600
17 C
18 C -----
19 C RVZ .LT. RJ ==> TRANSITION REGION
20 C -----
21 C
22 UM = UMJ*RVZ
23 IF(RVZ.GT.1.0) UM = UMJ
24 C
25 ZH = ZHJ*RVZ
26 IF(RVZ.GT.1.0) ZH = ZHJ
27 C
28 ZM = ZMJ*RVZ
29 IF(RVZ.GT.1.0) ZM = ZMJ
30 C
31 C -----
32 C BOUNDARY GROWTH IN TRANSITION REGION
33 C -----
34 C
35 ZB0 = 1.5
36 IF(H.LT.1.5) ZB0 = H
37 C
38 ZH0 = ZB0/2.8
39 ZH = (ZH0 - ZHJ)/RJ**2*(RJ - RVZ)**2 + ZHJ
40 ZB = 2.8*ZH
41 C
42 GOTO 700
43 C
44 C -----
45 C RVZ .GE. RJ ==> DEVELOPED WALL JET REGION
46 C -----
47 C
48 600 CONTINUE
49 C
50 UM = CU*RVZ**(-1.143)*UMB
51 ZH = CY*RVZ**(1.028)
52 ZB = 2.8*ZH
53 ZM = 0.1944*ZH
54 C

```

SUBROUTINE PROPRM

```
55      700 CONTINUE
56      C
57          RETURN
58          END
59      C
```

SUBROUTINE VLINE

```

1  C
2  C
3  SUBROUTINE VLINE
4  C
5  C *****
6  C SUBROUTINE VLINE
7  C
8  C THIS SUBROUTINE APPLIES THE BIOT-SAVORT LAW TO
9  C CALCULATE THE VELOCITY INDUCED BY A LINE VORTEX
10 C
11 C XA,YA,ZA = STARTING POINT OF VORTEX
12 C XB,YB,ZB = ENDING POINT, OR DIRECTION POINTER
13 C XC,YC,ZC = TARGET POINT WHERE VELOCITY IS INDUCED
14 C
15 C IFI = 0      VORTEX IS FINITE, FROM POINT A TO POINT B
16 C IFI = 1      VORTEX IS SEMI-INFINITE FROM POINT A THROUGH B
17 C
18 C *****
19 C
20 C COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
21 C COMMON /CVLINE/ IFI,XA,YA,ZA,XB,YB,ZB,XC,YC,ZC,Q1,Q2,Q3
22 C
23 C *****
24 C
25 C A = (XA-XC)**2 + (YA-YC)**2 + (ZA-ZC)**2
26 C B = 2.0*( (XA-XB)*(XC-XA) + (YA-YB)*(YC-YA) + (ZA-ZB)*(ZC-ZA) )
27 C C = (XA-XB)**2 + (YA-YB)**2 + (ZA-ZB)**2
28 C
29 C C1 = (YC-YB)*ZA + (YA-YC)*ZB + (YB-YA)*ZC
30 C C2 = (ZC-ZB)*XA + (ZA-ZC)*XB + (ZB-ZA)*XC
31 C C3 = (XC-XB)*YA + (XA-XC)*YB + (XB-XA)*YC
32 C
33 C Q = 4.0*A*C - B**2
34 C
35 C -----
36 C CHECK FOR COLINEAR TARGET POINT
37 C -----
38 C
39 C QB = 0.0
40 C IF(ABS(Q).LT.1.0E-06)GOTO 100
41 C
42 C -----
43 C FINITE LENGTH VORTEX
44 C -----
45 C
46 C IF(IFI.EQ.0)THEN
47 C   QB = 1.0/Q*((2.0*C + B)/SQRT(A + B + C) - B/SQRT(A))/2.0/PI
48 C ENDIF
49 C
50 C -----
51 C SEMI-INFINITE VORTEX
52 C -----
53 C
54 C IF(IFI.EQ.1)THEN

```

SUBROUTINE VLINE

```

55         QB = 1.0/Q*(2.0*SQRT(C) - B/SQRT(A))/2.0/PI
56     ENDIF
57     C
58     100 CONTINUE
59     C
60     C -----
61     C     VELOCITY COMPONENTS
62     C -----
63     C
64         Q1 = C1*QB
65         Q2 = C2*QB
66         Q3 = C3*QB
67     C
68     RETURN
69     END
70     C

```

SUBROUTINE WALJET

```

1  C
2  C
3  SUBROUTINE WALJET(H,UB,UN,UMB)
4  C
5  C *****
6  C SUBROUTINE WALJET
7  C
8  C THIS SUBROUTINE DEFINES THE START OF THE WALL JET AND ITS GROWTH
9  C *****
10 C
11 COMMON /CLOUDK/ QSMAX
12 COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
13 COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
14 C
15 C *****
16 C
17 C -----
18 C INITIALIZATION OF EXPONENTS
19 C -----
20 C
21 EXU = -1.143
22 EXY = 1.028
23 EXM = 1.0 + EXU + EXY
24 CQ = 0.52
25 CZM = 0.1944
26 CZB = 2.8
27 C
28 C -----
29 C ITERATE TO FIND INITIAL RADIUS OF WALL JET, RJ
30 C -----
31 C
32 TOL = 1.0E-05
33 RJ = 2.0
34 C
35 QSMAX0 = 1.0
36 C
37 DO 100 I=1,20
38 C
39 C -----
40 C EQUIVALENT JET LENGTH T/R
41 C -----
42 C
43 TR = H + (RJ - 1.0)
44 TDE = 0.707*TR
45 C
46 C -----
47 C QSMAX CURVEFIT TO FIG. 8, USAAVLABS TECHNICAL
48 C REPORT 68-52, JULY 1968
49 C -----
50 C
51 IF(TDE.LE.4.0) QSMAX = QSMAX0 + (0.6 - QSMAX0)/16.0*TDE**2
52 IF(TDE.GT.4.0) QSMAX = 2.4/TDE
53 UM = SQRT(QSMAX)
54 C

```

SUBROUTINE WALJET

```

55      RJNEW = 2.508078*(UB/UM)**(0.486)
56      C
57      IF(ABS(RJNEW - RJ).LE.TOL)GOTO 200
58      RJ = RJNEW
59      C
60      100 CONTINUE
61      C
62      WRITE(IOU1,10)
63      10 FORMAT( '*****',/
64      1          , 'ITERATIONS EXCEEDED FOR WALL JET INITIAL RADIUS',/
65      2          , '*****')
66      C
67      STOP ' '
68      C
69      200 CONTINUE
70      C
71      RJ = RJNEW
72      C
73      C -----
74      C VELOCITY GROWTH FUNCTION CONSTANTS
75      C -----
76      C
77      UMB = ((0.3586*RJ**EXM*(UM*UN)*(UB*UN)**(0.14))**(0.88))/UN
78      ZHJ = 0.654/(UM/UMB)**2/RJ
79      CU = UM/UMB*RJ**(-EXU)
80      CY = ZHJ*RJ**(-EXY)
81      C
82      C -----
83      C MAX VELOCITY AND BOUNDARY PARAMETERS AT RJ
84      C -----
85      C
86      UMJ = CU*RJ**(EXU)*UMB
87      ZHJ = CY*RJ**(EXY)
88      ZMJ = CZM*ZHJ
89      ZBJ = CZB*ZHJ
90      C
91      RETURN
92      END
93      C
94

```

SUBROUTINE WJVEL

```

1  C
2  C
3      SUBROUTINE WJVEL(H,UN,UMB,RVZ,RADIUS,WSPD,DELZ,ZMAX,DXO)
4  C
5  C      *****
6  C      SUBROUTINE WJVEL GENERATES THE VELOCITY PROFILE V(R,Z)
7  C      AT RVZ FOR THE NON-INTERACTING ROTOR CASE
8  C      *****
9  C
10     CHARACTER*1 TEMCHAR
11     CHARACTER*1 ICONT(5)
12     CHARACTER*1 KEY,KKEY
13     CHARACTER*12 PTSFIL(4)
14     CHARACTER*50 COMM(2)
15  C
16     DIMENSION ZZ(40),VMF(40),VMK(40),VPF(40),
17 1      VPK(40),QM(40),QP(40)
18  C
19     COMMON / CKEY/ KEY,KKEY
20     COMMON /CONSTS/ PI,RHO,FPSPKN,RHOD2,DRC
21     COMMON /INPUTC/ ICONT,COMM,PTSFIL
22     COMMON /PROFIL/ RJ,ZBJ,ZHJ,ZMJ,UMJ,ZB,ZH,ZM,UM,CU,CY
23     COMMON / UNITS/ IOU1,IOU4,IOU5,IOU6,IOU7,IOU8,IGRAPH
24  C
25  C      *****
26  C
27  C      -----
28  C      'PROPRM' PROVIDES THE VELOCITY PROFILE PARAMETERS
29  C      OF A RADIAL WALL JET (WITHOUT INTERACTION PLANE)
30  C      -----
31  C
32     CALL PROPRM(H,UMB,RVZ)
33  C
34  C      -----
35  C      DIMENSIONALIZE VELOCITY PROFILE PARAMETERS
36  C      -----
37  C
38     RRVZ = RADIUS*RVZ
39     ZZB = ZB*RADIUS
40     ZZH = ZH*RADIUS
41     ZZM = ZM*RADIUS
42     ZETAM = ZM/ZB
43  C
44  C      -----
45  C      OUTPUT THE VELOCITY AND DYNAMIC PRESSURE PROFILE HEADER
46  C      -----
47  C
48     ICD = 0
49     CALL HOMCLS(ICD)
50     IF(IOU6.NE.IOU1) WRITE(IOU6,(''1''))
51  C
52     IF(IOU6.EQ.6) WRITE(IOU6,93) COMM(1),COMM(2)
53 93  FORMAT( 10X,A50,/,10X,A50,/)
54  C

```

SUBROUTINE WJVEL

```

55      RVZOUT = RRVZ + DXO
56      C
57      WRITE(IOU6,1000) RVZOUT
58      1000 FORMAT( 9X,'SINGLE ROTOR VELOCITY PROFILE AT RADIUS = ',
59      1      F7.1,' FT',/)
60      C
61      WRITE(IOU6,1001) ZZB,ZZH,ZZM
62      1001 FORMAT( 15X,'PROFILE BOUNDARY HEIGHT = ',F7.2,' FT',/
63      1      ,15X,'      HALF-VEL.HEIGHT = ',F7.2,' FT',/
64      2      ,15X,'      MAX-VEL HEIGHT = ',F7.2,' FT',/)
65      C
66      C
67      C -----
68      C INCREMENTS AND HEIGHT ARE FROM DELZ AND ZMAX
69      C -----
70      C
71      NPTS = IFIX(ZMAX/DELZ) + 1
72      C
73      C -----
74      C BOUNDARY LAYER REGION EXPONENT
75      C 'AN' IS ACTUALLY = 1.0/7.0
76      C -----
77      C
78      AN = 0.142857142
79      C
80      C -----
81      C SHEAR LAYER REGION EXPONENT, TO MEET EDGE CONDITIONS
82      C (FROM FIGURE 7, USAAVLABS TECHNICAL REPORT 68-52, JULY 1968)
83      C -----
84      C
85      ALPW = ALOG(1.0 - 1.0/SQRT(2.0))/ALOG((ZH - ZM)/(ZB - ZM))
86      C
87      VN = UN
88      VMN = UM
89      C
90      C -----
91      C CALCULATION OF THE PEAK VELOCITY CORRECTION FACTOR
92      C IS MADE IN THE NEXT SECTION AT THE 3 FT POSITION
93      C -----
94      C
95      VZ3 = 3.0/RADIUS
96      ZETA3 = VZ3/ZB
97      VZM3 = 0.0
98      C
99      IF(ZETA3.GE.ZETAM)GOTO 51
100      C
101      C -----
102      C THE 3 FT HEIGHT IS IN THE BOUNDARY LAYER
103      C -----
104      C
105      IF(ZETAM.GT.0.0) VZM3 = (ZETA3/ZETAM)**AN
106      C
107      GOTO 52
108      51 CONTINUE

```

SUBROUTINE WJVEL

```

109 C -----
110 C THE 3 FT HEIGHT IS IN THE SHEAR LAYER
111 C -----
112 C
113 C IF(VZ3.LE.ZB)THEN
114 C     VZM3 = (1.0 - ((ZETA3 - ZETAM)/(1.0 - ZETAM))**ALPW)**2
115 C ENDIF
116 C
117 C 52 CONTINUE
118 C
119 C -----
120 C THE VELOCITY TO ADD TO THE MEAN VELOCITY TO OBTAIN THE PEAK
121 C VELOCITY IS CALCULATED AS THE CONSTANT VMFD3 (FT/SEC)
122 C -----
123 C
124 C     VZN3 = VZM3*VMN
125 C     VMF3 = VZN3*VN
126 C     VMFD3S = (RVZ*0.2444) + 0.4
127 C     IF(VMFD3S.GT.1.5) VMFD3S = 1.5
128 C     VMFD3 = VMFD3S*VMF3
129 C
130 C -----
131 C OUTPUT THE VELOCITY AND DYNAMIC PRESSURE PROFILE HEADER
132 C -----
133 C
134 C     WRITE(1005,1005)
135 C 1005 FORMAT( 2X,'HEIGHT',5X,'MEAN VELOCITY',7X,'PEAK VELOCITY',6X,
136 C 1      'MEAN Q',4X,'PEAK Q',/,
137 C 2      3X,'(FT)',5X,'(FPS)',6X,'(KN)',5X,'(FPS)',6X,'(KN)',5X,
138 C 3      '(PSF)',5X,'(PSF)',/)
139 C
140 C -----
141 C CALCULATE THE VELOCITY PROFILE POINTS FOR OUTPUT
142 C -----
143 C
144 C     LINES = 0
145 C
146 C     DO 500 I = 1,NPTS
147 C
148 C         LINES = LINES + 1
149 C         Z = DELZ*FLOAT(I - 1)
150 C         ZETA = Z/ZB
151 C         IF(ZETA.GE.ZETAM)GOTO 300
152 C
153 C -----
154 C Z IS WITHIN BOUNDARY LAYER
155 C -----
156 C
157 C     VZM = 0.0
158 C     IF(ZETAM.GT.0.0) VZM = (ZETA/ZETAM)**AN
159 C     GOTO 400
160 C
161 C 300 CONTINUE
162 C

```

SUBROUTINE WJVEL

```

163 C -----
164 C Z IS WITHIN SHEAR LAYER
165 C -----
166 C
167 C VZM = 0.0
168 C
169 C IF(Z.LE.ZB)THEN
170 C     VZM = (1.0 - ((ZETA - ZETAM)/(1.0 - ZETAM))**ALPW)**2
171 C ENDIF
172 C
173 C 400 CONTINUE
174 C
175 C VZN = VZM*VMN
176 C
177 C -----
178 C DIMENSIONAL HEIGHT
179 C -----
180 C
181 C ZZ(I) = Z*RADIUS
182 C
183 C -----
184 C MEAN VELOCITIES
185 C -----
186 C
187 C VMF(I) = VZN*VN
188 C VMK(I) = VMF(I)/FPSPKN
189 C
190 C -----
191 C PEAK VELOCITIES
192 C -----
193 C
194 C VPF(I) = VMF(I) + VMFD3
195 C IF(VMF(I).EQ.0.) VPF(I) = 0.0
196 C VPK(I) = VPF(I)/FPSPKN
197 C
198 C IF(VPK(I).EQ.0.0)GOTO 55
199 C
200 C -----
201 C THE EFFECT OF WIND IS TO ADD (DOWNWIND SIDE) OR SUBTRACT
202 C (UPWIND SIDE) 'XKW' TIMES THE AMBIENT WIND VELOCITY TO
203 C THE HORIZONTAL PROFILE VELOCITY (EMPIRICAL, CH-53E BASED)
204 C -----
205 C
206 C XKW = (-0.5*H) + 2.5
207 C IF(XKW.LT.1.0)XKW = 1.0
208 C WSPD2 = WSPD*XKW
209 C VMK(I) = VMK(I) + WSPD2
210 C VMF(I) = VMK(I)*FPSPKN
211 C VPK(I) = VPK(I) + WSPD2
212 C VPF(I) = VPK(I)*FPSPKN
213 C
214 C 55 CONTINUE
215 C
216 C -----

```

SUBROUTINE WJVEL

```

217 C      DYNAMIC PRESSURE
218 C      -----
219 C
220 C      QM(I) = RHOD2*VMF(I)**2
221 C      QP(I) = RHOD2*VPF(I)**2
222 C
223 C      IF (IOU6.EQ.IOU1) THEN
224 C          IF (LINES.LT.12) GOTO 450
225 C          LINES = 1
226 C          CALL INKEY
227 C          IF (KEY.NE.'C') GOTO 999
228 C          WRITE(IOU6,1005)
229 C      ENDIF
230 C
231 C      450 CONTINUE
232 C
233 C      -----
234 C      OUTPUT THE VELOCITY AND DYNAMIC PRESSURE PROFILES
235 C      -----
236 C
237 C      WRITE(IOU6,1002) ZZ(I),VMF(I),VMK(I),VPF(I),
238 C          *          VPK(I),QM(I),QP(I)
239 C      1002 FORMAT( F8.2,6F10.3)
240 C
241 C      500 CONTINUE
242 C
243 C      -----
244 C      WRITE OUT GRAPHICS FILES IF SWITCH IS SET BY USER
245 C      -----
246 C
247 C      IF (IGRAPH.EQ.1) THEN
248 C
249 C          -----
250 C          OPEN GRAPHICS FILE
251 C          -----
252 C
253 C
254 C          OPEN(IOU8,FILE=PTSFIL(1),STATUS='NEW',ERR=2000)
255 C
256 C          WRITE(IOU8,89) COMM(1),COMM(2)
257 C      89 FORMAT( 10X,A50,/,10X,A50,/)
258 C
259 C          WRITE(IOU8,80) RVZOUT
260 C      80 FORMAT( 1X,'TITLE="SINGLE ROTOR, DFRC =',F6.2,' FT,'
261 C          *      ' GW = xxxxx LB, WAGL = xx FT"')
262 C
263 C          -----
264 C          PRINT OUT MEAN VELOCITY, PEAK VELOCITY, AND PEAK
265 C          DYNAMIC PRESSURE PROFILES VERSUS PROFILE HEIGHT (AGL)
266 C          -----
267 C
268 C          WRITE(IOU8,88)
269 C      88 FORMAT( 1X,'VARIABLES = X,HT')
270 C

```

SUBROUTINE WJVEL

```

271      WRITE(IOUS,81)
272      81  FORMAT( 1X,'ZONE T = "MEAN PROFILE, KTS", I=xx, F=POINT')
273      C
274      DO 82 I = 1,NPTS
275      WRITE(IOUS,83) VMK(I),ZZ(I)
276      83  FORMAT( 1X,F6.1,1X,F5.1)
277      82  CONTINUE
278      C
279      WRITE(IOUS,84)
280      84  FORMAT( 1X,'ZONE T = "PEAK PROFILE, KTS", I=xx, F=POINT')
281      C
282      DO 85 I = 1,NPTS
283      WRITE(IOUS,83) VPK(I),ZZ(I)
284      85  CONTINUE
285      C
286      WRITE(IOUS,86)
287      86  FORMAT( 1X,'ZONE T = "PEAK Q, PSF", I=xx, F=POINT')
288      C
289      DO 87 I = 1,NPTS
290      WRITE(IOUS,83) QP(I),ZZ(I)
291      87  CONTINUE
292      C
293      C      -----
294      C      CLOSE GRAPHICS FILE
295      C      -----
296      C
297      CLOSE(IOUS,STATUS='KEEP')
298      C
299      ENDIF
300      C
301      CALL INKEY
302      C
303      GOTO 999
304      C
305      C      -----
306      C      THE ERROR LOGIC ALLOWS FOR THE HANDLING OF FILE
307      C      OPEN ERRORS BY RETURNING THE USER TO A MENU
308      C      -----
309      C
310      2000 CONTINUE
311      C
312      CALL HOMCLS(0)
313      WRITE(IOUS,2001)
314      2001 FORMAT( //,8X,
315      1      ' *** ERROR *** PLEASE CHOOSE A NEW OUTPUT FILENAME',
316      2      //,8X, ' TYPE <RETURN> TO CONTINUE ', $)
317      READ(IOUS,'(A1)') TEMCHAR
318      KEY = 'P'
319      C
320      999 CONTINUE
321      C
322      RETURN
323      END
324      C

```