FORTRAN PROGRAMS FOR CALCULATING
WIND-TUNNEL BOUNDARY INTERFERENCE

by Harry H. Heyson
Langley Research Center
Langley Station, Hampton, Va.

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FORTRAN PROGRAMS FOR CALCULATING WIND-TUNNEL
BOUNDARY INTERFERENCE

By Harry H. Heyson
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SUMMARY

Boundary-interference programs, developed in NASA TR R-302, are presented without comment. These programs should be utilized only after careful consideration of the assumptions and procedures given in that report.

INTRODUCTION

Reference 1 develops a systematic computer procedure for calculating the wind-tunnel interference factors for arbitrary configurations from the interference calculations for a vanishingly small model. The method is not limited to any one tunnel configuration since it is necessary only to substitute a subroutine appropriate to the tunnel for that given herein.

The underlying theory (subroutine DLTAS) in the present computer programs is that of reference 2. It is directly applicable to models which produce large wake deflections, such as V/STOL models. These programs may also be used directly for more conventional testing at moderate lift coefficients by means of the few simple modifications described in reference 1.

No sample calculations or check cases are provided herewith. The numerical values provided in reference 1 should be adequate for this purpose. The reader is cautioned against using these programs without first carefully considering the assumptions, limitations, and procedures given in reference 1.
COMPUTER PROGRAMS

The programs are given in the appendixes. The following table should aid in locating the program of interest:

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Model</th>
<th>Interference</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Small</td>
<td>At point</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>Wing</td>
<td>Average</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>Wing</td>
<td>Span distribution</td>
<td>9</td>
</tr>
<tr>
<td>D</td>
<td>Wing</td>
<td>At tail</td>
<td>12</td>
</tr>
<tr>
<td>E</td>
<td>Jet</td>
<td>At wing</td>
<td>16</td>
</tr>
<tr>
<td>F</td>
<td>Jet</td>
<td>Wing distribution</td>
<td>20</td>
</tr>
<tr>
<td>G</td>
<td>Jet</td>
<td>At tail</td>
<td>24</td>
</tr>
<tr>
<td>H</td>
<td>Rotor</td>
<td>Average</td>
<td>28</td>
</tr>
<tr>
<td>I</td>
<td>Rotor</td>
<td>Lateral axis</td>
<td>31</td>
</tr>
<tr>
<td>J</td>
<td>Rotor</td>
<td>Longitudinal axis</td>
<td>34</td>
</tr>
<tr>
<td>K</td>
<td>Rotor</td>
<td>At tail</td>
<td>37</td>
</tr>
<tr>
<td>L</td>
<td>Tandem rotors</td>
<td>Average</td>
<td>41</td>
</tr>
<tr>
<td>M</td>
<td>Unloaded rotors</td>
<td>Average</td>
<td>46</td>
</tr>
<tr>
<td>N</td>
<td>Unloaded rotors</td>
<td>At tail</td>
<td>52</td>
</tr>
<tr>
<td>O</td>
<td>Side-by-side rotors</td>
<td>Average</td>
<td>57</td>
</tr>
<tr>
<td>P</td>
<td>Side-by-side rotors</td>
<td>At tail</td>
<td>64</td>
</tr>
<tr>
<td>Q</td>
<td>Subroutine DLTAS</td>
<td></td>
<td>70</td>
</tr>
</tbody>
</table>

Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., December 11, 1968,
721-01-00-20-23.
REFERENCES


FORTRAN PROGRAM FOR CALCULATING WIND-TUNNEL INTERFERENCE NEAR A VANISHINGLY SMALL MODEL

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

THIS IS THE BASIC WIND-TUNNEL INTERFERENCE PROGRAM FOR WHICH THE DERIVATIONS ARE GIVEN IN NASA TR R-124 (REF 2). THE SUCCEEDING PROGRAMS ARE ALL DEVELOPED FROM THIS ONE PROGRAM. INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. THE REQUIRED INPUT VARIABLES ARE

ZETA SEMIHEIGHT OF WIND TUNNEL DIVIDED BY HEIGHT OF MODEL ABOVE FLOOR
ETA DISTANCE FROM MODEL TO RIGHT-HAND WALL DIVIDED BY WIND-TUNNEL SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
XOVERH LONGITUDINAL POSITION OF POINT AT WHICH INTERFERENCE IS NEEDED, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
YOVERH LATERAL POSITION OF POINT AT WHICH INTERFERENCE IS NEEDED, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
ZOVERH VERTICAL POSITION OF POINT AT WHICH INTERFERENCE IS NEEDED, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT

PROGRAM WINWTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT) (A 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28) (A 2)
DIMENSION C(8) (A 3)
DATA (C(1),I=1,8)/*20.,30.,40.,50.,60.,70.,80.,90.*/ (A 4)
I READ (5,103) ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH (A 5)
IF (EOF,5) 999,2 (A 6)
2 WRITE (6,148) GAMMA,ZETA,ETA,XOVERH,YOVERH,ZOVERH (A 7)
WRITE (6,210) (A 8)
WRITE (6,211) (A 9)
WRITE (6,212) (A 10)
WRITE (6,213) (A 11)
WRITE (6,214) (A 12)
WRITE (6,215) (A 13)
WRITE (6,216) (A 14)
WRITE (6,217) (A 15)
Appendix A – Concluded

WRITE (6,218)                     (A 16)
DO 41 K=1,8                      (A 17)
CALL DLTAS (C(K))              (A 18)

**********************************************************************
** SEE APPENDIX Q FOR SUBROUTINE DLTAS ******
**********************************************************************
WRITE (6,149) C(K)            (A 19)
WRITE (6,150) (DETA(I),I=1,25,4)  (A 20)
WRITE (6,151) (DETA(I),I=2,26,4)  (A 21)
WRITE (6,152) (DETA(I),I=3,27,4)  (A 22)
WRITE (6,153) (DETA(I),I=4,28,4)  (A 23)
41 CONTINUE                       (A 24)
GO TO 1                         (A 25)

103 FORMAT (6F10.3)               (A 26)
148 FORMAT (1H/35X*INTERFERENCE FACTORS AT A POINT NEAR A VANISHING L
1Y SMALL MODEL/*35X*GAMMA =*F8.3,9X*ZETA =*F8.3,11X*ETA =*
2F8.3//35X*X/H =*F8.3,9X*Y/H =*F8.3,11X*Z/H =*F8.3//)   (A 27)
149 FORMAT (/5X6H CHI =F6.2/)   (A 28)
150 FORMAT (3X5HW,L17(F17.4))    (A 29)
151 FORMAT (3X5HU,L17(F17.4))    (A 30)
152 FORMAT (3X5HW,D17(F17.4))    (A 31)
153 FORMAT (3X5HU,D17(F17.4))    (A 32)
210 FORMAT (1X131(1H-))        (A 33)
211 FORMAT (1X1H111X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
1WIND TUNNEL WHICH IS25X1HI)   (A 34)
212 FORMAT (1X1H111X1HI17(1H-1HI) (A 35)
213 FORMAT (1X1H111X1HI16X1HI5X6CLOSED5X1HI16X1HI2X12HCLOSED FLO02X1
1HI6X4HOPN5X1HI6X1HI5X6CLOSED4X1HI) (A 36)
214 FORMAT (1X1HI3X5FDELT4X1HI5X6CLOSED5X1HI4X1HON BOTTOM3X1HI6X4HOP
1EN6X1HI6X4HONLY6X1HI5X6HFL006X1HI5X6CLOSED5X1HI3X9HON BOTTOM3X1H
21)                       (A 37)
215 FORMAT (1X1H111X1HI16X1HI6X4HONLY6X1HI16X1HI16X1HI(GROUND EFFECT) I6X4H
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (A 38)
216 FORMAT (1X1H111X1HI84(1H-1HI32(1H-1HI) (A 39)
217 FORMAT (1X1H111X1HI36X1HNO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1
1HI)                  (A 40)
218 FORMAT (1X131(1H-1))       (A 41)
999 STOP                  (A 42)
END                      (A 43)

5
APPENDIX B

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A SWEP'T WING

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 4160 SERIES COMPUTERS WITH THE SCOPE 3.0 (OPERATING SYSTEM AND LIBRARY TAPE). MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE OLTA5 WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE APEX OF THE SWEP'T LIFTING LINE. THE REQUIRED INPUT VARIABLES ARE

L1 LOAD INDICATOR, L1=1 FOR UNIFORM LOADING, L1=2 FOR ELLIPTIC LOADING
ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETAL DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDAX WING SWEEP ANGLE, DEG
ALPHAX ANGLE OF ATTACK OF WING, DEG

PROGRAM WINOUTUN(INPUT,OUTPUT,TAPES=INPUT,TAPES=OUTPUT) (R 1)
COMMON ZETA,ETAL,GAMMA,XOFFSET,YOFFSET,ZOFFSET,DELTA(28) (R 2)
DIMENSION XDELTA(28),XLOAD(19),XLE(19),XLE(19) (R 3)
REAL LAMDA (R 4)
REAL C(11),C(11),L(11),L(11),L(11) (R 5)
REAL XLE(11),XLE(11),XLE(11),XLE(11) (R 6)
REAL XLE(11),XLE(11),XLE(11),XLE(11) (R 7)
REAL XLE(11),XLE(11),XLE(11),XLE(11) (R 8)
REAL XLE(11),XLE(11),XLE(11),XLE(11) (R 9)
REAL XLE(11),XLE(11),XLE(11),XLE(11) (R 10)
REAL D0(83) D0(83) (R 11)
REAL XDELTA(D0) XDELTA(D0) (R 12)
REAL PI(3) PI(3) (R 13)
REAL RAD(3) RAD(3) (R 14)
1 READ (5,999) L1,ZETA1,ETAL1,GAMMA1,SIGMA1,LAMDA1,ALPHAX (R 15)
IF (EOF,5) 999,47 (R 16)
47 IF (L1.EQ.1) GO TO 814
  IALPHA=8HELLEPTIC
  SUML=0.*1261.4
  DO 808 M2=1,10
  808 XLOAD(M2)=XLE(M2)
  GO TO 160
  804 SUML=0.*1
  IALPHA=RHUVIFORM
  DO 809 M2=1,10
  809 XLOAD(M2)=1.0
  160 WRITE (6,901) IALPHA,GAMMA,ETA1,SIGMA,ZETA1,ALPHA,LAMBDA
  WRITE (6,210)
  WRITE (6,211)
  WRITE (6,212)
  WRITE (6,213)
  WRITE (6,214)
  WRITE (6,215)
  WRITE (6,216)
  WRITE (6,217)
  WRITE (6,218)
  CONST1=1.
  LAMBDA=LAMBDA*RAD
  ALPH=ALPHA*RAD
  DO 41 K=1,10
  IF (SIGMA.NE.0.0) GO TO 811
  M6=M7=M6=M7=1
  811 IF (ETA1.NE.1.) GO TO 813
  N6=1
  M6=6
  N7=N7=10
  CONST2=2.
  GO TO 812
  813 M6=M6=1
  M7=N7=10
  812 DO 801 M1=M5,M7
    DO 802 N1=N6,N7
    XSTAR=(11.2.*FLOAT(M1))/10.
    YSTAR=(2.*FLOAT(N1)-11.)/10.
    ZSTAR=(11.2.*FLOAT(N1))/10.
    ETA1=ETA1*SIGMA
    ZETA1=ZETA1/(1.-ABS(XSTAR)*SIGMA+GAMMA*ZETA1*TAN(LAMBDA)*SIN(ALPHA))
  1)
    XOVERH=SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)*(ABS(XSTAR)-ABS(ZSTAR))
    YOVERH=(FLOAT(M1)-FLOAT(N1))*SIGMA+GAMMA*(-.2)
    ZOVERH=SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)*(ABS(ZSTAR)-ABS(XSTAR))
    CALL OLTAS (C(K))
  801 CONTINUE
  802 CONTINUE
  901 CONTINUE
  DO 807 L3=1,28
  807 DELTA(L3)=XDELTA(L1)*DELTA(L1)*XLOAD(N1)
  CONTINUE
  805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)
  806 WRITE (6,149) (K)
  WRITE (6,150) (DELTA(I),I=1,28)
  WRITE (6,151) (DELTA(I),I=2,28)
  WRITE (6,152) (DELTA(I),I=3,27)
  WRITE (6,153) (DELTA(I),I=4,28)

*** SEE APPENDIX Q FOR SUBROUTINE OLTAS ****************************
DO 814 L4=1,29
  814 XDELTA(L4)=0.
  41 CONTINUE
  GO TO 1
145 FORMAT (1X*CHI =*F7.3/)
150 FORMAT (3X5H(W,L)7(F17.4))
151 FORMAT (3X5H(U,L)7(F17.4))
152 FORMAT (3X9H(W,D)7(F17.4))
153 FORMAT (3X5H(U,D)7(F17.4))/
210 FORMAT (1X131(1H-))
211 FORMAT (1X1H111X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
       1WIND TUNNEL WHICH IS25X1HI)
212 FORMAT (1X1H111X1HI1171H-1H1)
213 FORMAT (1X1H111X1HI16X1H15X6HCLOSED5X1HI16X1HI2X12HCLOSED FLJDR2X1
       1H16X4HOPENX1HI16X1HI5X6HCLOSED4X1HI)
214 FORMAT (1X1H13X5HDELTA3X1HI5X6HCLOSED5X1HI4X94ON BOTTOM3X1HI6X4HOP
       1EN6X1HI6X4HONLY6X1HI5X5HFLDOR6X1HI5X6HCLOSED5X1HI3X94ON BOTTOM3X1H
       2I)
215 FORMAT (1X1H111X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 16X4H
       1ONLY6X1HI16X1HI6X4HONLY5X1HI)
216 FORMAT (1X1H111X1HI81H-1H132(1H-1HI)
217 FORMAT (1X1H111X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1
       1HI)
218 FORMAT (1X131(1H-/)
900 FORMAT (11,F9.3,5F10.3)
901 FORMAT (1H1///42X*AVERAGE INTERFERENCE OF SWEPT WING OF FINITE SPA
       1N*/58XAB,* LOADING#/36X*GAMMA ==F6.3,10X*ETA  ==F7.3,10X
       2*SIGMA  ==F7.3/36X*ZETA  ==F6.3,10X*ALPHA  ==F7.3,10X
       3*L4H10A  ==F7.3//)
999 STOP
END

Appendix B – Concluded
APPENDIX C
----------

FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF
WIND-TUNNEL INTERFERENCE OVER THE
SPAN OF A SWEPT WING

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 5000
SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR
MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM
HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY
THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRE-
CISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS
OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN
APPENDIX C.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE
THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE APEX OF THE SWEPT LIFTING LINE.
THE REQUIRED INPUT VARIABLES ARE

LI LOAD INDICATOR, LI=1 FOR UNIFORM LOADING, L=2 FOR ELLIPTIC
LOADING
ZETA SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETAE DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL
SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA WING SWEEP ANGLE, DEG
ALPHA ANGLE OF ATTACK OF WING, DEG
C EFFECTIVE WAKE SKEW-ANGLE, DEG

IN SYMMETRICAL CASES THIS PROGRAM COMPUTES THE INTERFERENCE DISTRIBUTION
OVER ONE SEMISPAW ONLY. THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH
CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PRO-
VIDED BY THE PROGRAM OF APPENDIX B.

PROGRAM WINTUN (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT) (C 1)
COMMON ZETA,ETA,GAMMA,XXOVERH,YYOVERH,ZOVERH,DELTA(28) (C 2)
DIMENSION XDELTAN(28),XLOAD(10),XLE(10) (C 3)
REAL LAMBDA (C 4)
XLE(1)=XLE(10)=.43579 (C 5)
XLE(2)=XLE(9)=.71422 (C 6)
Appendix C - Continued

\[ XLE(3) = XLE(8) = 0.86603 \]
\[ XLE(4) = XLE(7) = 0.95394 \]
\[ XLE(5) = XLE(6) = 0.99499 \]
\[ \text{DO } 805 \text{ N2} = 1, 28 \]
\[ 805 \text{ XDELTAN2} = 0. \]
\[ \text{RA0 = 0.017453295199} \]
\[ \text{READ (5, 103) L1, ZETA1, ETA1, GAMMA, SIGMA, LAMBD1A, ALPHA, C} \]
\[ \text{IF (EOF5) 999, 814} \]
\[ 814 \text{ IF (L1.EQ.1) GO TO 806} \]
\[ \text{I ALPHA = 8: ELLIPTIC} \]
\[ \text{SUML = 0.126104} \]
\[ \text{DO } 808 \text{ M2} = 1, 10 \]
\[ 808 \text{ XLOAD(M2) = XLE(M2)} \]
\[ \text{GO TO 803} \]
\[ 803 \text{ XOVERH} = ZOVERH = 0. \]
\[ \text{M1 = 0} \]
\[ \text{IF (ETA1.EQ.1.) M1 = 6} \]
\[ \text{WRITE (6, 900) GAMMA, ZETA1, I ALPHA, ALPH1A, SIGMA, ETA1, LAMBD1A, C} \]
\[ \text{WRITE (6, 210)} \]
\[ \text{WRITE (6, 211)} \]
\[ \text{WRITE (6, 212)} \]
\[ \text{WRITE (6, 213)} \]
\[ \text{WRITE (6, 214)} \]
\[ \text{WRITE (6, 215)} \]
\[ \text{WRITE (6, 216)} \]
\[ \text{WRITE (6, 217)} \]
\[ \text{WRITE (6, 218)} \]
\[ \text{IF (SIGMA.NE.0.) GO TO 813} \]
\[ \text{WRITE (6, 901)} \]
\[ \text{GO TO 1} \]
\[ 813 \text{ ALPHA = ALPHA.RAD} \]
\[ \text{LAMBD1A = LAMBD1A.RAD} \]
\[ \text{804 XSTAR = (11. - 2. * FLOAT(M1)) / 1.} \]
\[ \text{DO 800 N1 = 1, 10} \]
\[ \text{YSTAR = (2. * FLOAT(N1) - 11.) / 1.} \]
\[ \text{ZSTAR = (11. - 2. * FLOAT(N1)) / 12.} \]
\[ \text{ETA1 = ETA1 + YSTAR * SIGMA} \]
\[ \text{ZETA1 = ZETA1 + (1. - ABS(YSTAR)) * SIGMA * GAMMA * ZETA1 * TAN(LAMBDA) * SIN(ALPHA)} \]
\[ \text{11} \]
\[ \text{XOVERH = SIGMA * GAMMA * TAN(LAMBDA) * COS(ALPHA) * (ABS(XSTAR) - ABS(ZSTAR))} \]
\[ \text{YCOVER = (FLOAT(M1) - FLOAT(N1)) * SIGMA * GAMMA * (-2)} \]
\[ \text{ZOVERH = SIGMA * GAMMA * TAN(LAMBDA) * SIN(ALPHA) * (ABS(ZSTAR) - ABS(XSTAR))} \]
\[ \text{CALL DLTAS (C)} \]

*************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ***************

\[ \text{DO 801 N2} = 1, 28 \]
\[ 801 \text{ XDELTAN2} = \text{XDELTAN2} + \text{DELTA(N2)} * \text{XLOAD(N1)} \]
\[ \text{CONTINUE} \]
\[ \text{DO 802 N2} = 1, 28 \]
\[ 802 \text{ DELTA(N2) = XDELTAN2} \]
\[ \text{WRITE (6, 149) XSTAR} \]
\[ \text{WRITE (6, 150) (DELTA(I), I = 1, 25, 4)} \]
\[ \text{WRITE (6, 151) (DELTA(I), I = 2, 26, 4)} \]
\[ \text{WRITE (6, 152) (DELTA(I), I = 3, 27, 4)} \]
\[ \text{WRITE (6, 153) (DELTA(I), I = 4, 28, 4)} \]
\[ \text{DO 810 N2} = 1, 28 \]
\[ 810 \text{ XDELTAN2} = 0.0 \]
\[ \text{M1} = M1 + 1 \]
Appendix C – Concluded

IF (M1.LT.12) GO TO 804

GO TO 1

103 FORMAT (I1,F9.3,E9.3)
149 FORMAT (10X12HY/SEMISPAN =F4.1/)
150 FORMAT (3X5H(W1,7.4))
151 FORMAT (3X5H(U1,7.4))
152 FORMAT (3X5H(U1,7.4))/
153 FORMAT (3X5H(U1,7.4)/)
210 FORMAT (1X131(1H-))
211 FORMAT (1X1H11X1H131X61HCORRECTION FACTORS FOR CORRECTING FROM A
1WIND TUNNEL WHICH IS25X1H1)
212 FORMAT (1X1H11X1H117(1H-1H1)
213 FORMAT (1X1H11X1H116X1H5X6HCLOSED5X1H16X1H2X1HCLOSED FLOOR2X1
1H16X4HOPEN6X1H16X1H5X6HCLOSED4X1H)
214 FORMAT (1X1H13X5+DELT3X1H5X6HCLOSED5X1H14X9HON BOTTOM3X1H6X4HOP
1EN6X1H6X4HONLY6X1H5X6HFL0OR6X1H5X6HCLOSED5X1H13X9HON BOTTOM3X1H
21)
215 FORMAT (1X1H11X1H116X1H6X4HONLY6X1H16X1H8HI(GROUND EFFECT) 1S4H
1ONLY6X1H116X1H6X4HONLY5X1H)
216 FORMAT (1X1H11X1H184(1H-1H132(1H-1H1)
217 FORMAT (1X1H11X1H18X1H36X1H1HTO GROUND EFFECT8X1
1H1)
218 FORMAT (1X131(1H-1/)
900 FORMAT (1H1///38X*INTERFERENCE DISTRIBUTION OVER SWEPT WING OF FIN
1ITE SPAN///15X*GAMMA =*F7.3,15X*ZETA =*F7.3,15X*A8* LOADING*
215X*ALPHA =*F7.3///15X*SIGMA =*F7.3,15X*ETA =*F7.3,15X*LAMBDA =*
3F8.3,15X*CHI =*F7.3//)
901 FORMAT (///40X*SIGMA EQUALS ZERO - USE AVERAGE INTERFERENCE PROGR
1AM**///)
999 STOP
END
APPENDIX D

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL
INTERFERENCE OVER A TAIL
BEHIND A SWEPT WING

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE Apex CF THE SWEPT LIFTING LINE. THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE FIRST CARD, ARE

LI LOAD INDICATOR, LI=1 FOR UNIFORM LOADING, L=2 FOR ELLIPTIC LOADING
ZETA SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAW RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA WING SWEEP ANGLE, DEG
ALPHA ANGLE OF ATTACK OF WING, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, GIVEN ON THE SECOND CARD, ARE

SIGMAT RATIO OF TAIL SPAN TO TUNNEL WIDTH
TL TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
TL TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)
DIMENSION XDELT4(28),XLOAD(10),XLE(10),C(18)
REAL LAMBD4
DATA (C(I),I=1,8)/1,8/20.,30.,40.,50.,60.,70.,80.,90./
XLE(1)=XLE(10)-0.43579
XLE(2)=XLE(9)-0.71422
XLE(3)=XLE(8)-0.86603
XLE(4)=XLE(7)-0.95394
XLE(5)=XLE(6)-0.99499
DO 803 L1=1,28
803 XCELTA(L1)=0.
R0=.0174532925159
PI=3.14159265358979
1 READ (5,900) L1,ZETAI,ETA1,GAMMA,SIGMAW,LAMBD4,ALPHA,
1 SIGMAT,T,L,TH
47 IF (LI.EQ.1) GO TO 804
I ALPHA=8*ELLIP1C
SUML=0.031506
DO 808 M2=1,10
808 XLOAD(M2)=XLE(M2)
GO TO 48
48 WRITE (6,901) SIGMAW,TH,IALPHA,GAMMA,ZETAI,SIGMAT,T,L,LAMBD4,ALPHA,
LETAL
WRITE (6,210)
WRITE (6,211)
WRITE (6,212)
WRITE (6,213)
WRITE (6,214)
WRITE (6,215)
WRITE (6,216)
WRITE (6,217)
WRITE (6,218)
LAMBD4=LAMBD4*P4D
ALPHA=ALPHA*PI
DO 41 K=1,8
41 IF (SIGMAW.EQ.0..AND.SIGMAT.EQ.0.) GO TO 850
IF (SIGMAW.EQ.0..AND.SIGMAT.NE.0.) GO TO 855
IF (SIGMAW.NE.0..AND.SIGMAT.EQ.0.) GO TO 860
M7=4
M7=N7=1
XLOAD(1)=1.0
SUML=0.025
CONST1=40.0
GO TO 812
850 M7=N7=1
XLOAD(1)=1.0
SUML=0.025
CONST1=10.0
IF (ETA1.NE.1.) GO TO 812
M7=2
13
Appendix D – Continued

CONST1=20.0
GO TO 812
860 M7=1
N7=10
CONST1=4.0
IF (ETAl.NE.1.) GO TO 812
N7=5
CONST1=8.0
812 DC 801 M1=1,M7
DD 802 N1=1,N7
XSTAR=2.*FLOAT(N1)-1.0
YSTAR=-1.0.*FLOAT(N1)/10.
ZSTAR=5.0.*FLOAT(N1)/4.
ETA=ETAl*XSTAR*SIGMA
ZETA=ZETAl/(1.0.-ABS(YSTAR)*SIGMA*GAMMA*ZETA1*TAN(LAMBDA)*SIN(ALPHA)
1)
XCOVER=TL*COS(ALPHA)+TH*SIN(ALPHA)-SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)*ABS(YSTAR)
1
YOVER=ZSTAR*SIGMA-Gamma-YSTAR*SIGMA*GAMMA
ZOVER=TH*COS(ALPHA)-TL*SIN(ALPHA)+SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)
1
1PHAt=ABS(YSTAR)
CALL DLTAS (CK)

*************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ***************

DO 805 L1=1,28 (D 64)
805 XDELTAl(L1)=XDELTAl(L1)+(DELTAl(L1)*XLOAD(N1)) (D 65)
802 CONTINUE (D 66)
801 CONTINUE (D 67)

DO 807 L3=1,28 (D 68)
807 DELTAl(L3)=XDELTAl(L3)*SUML*CONST1 (D 69)
WRITE (6,149) (IK) (D 70)
WRITE (6,150) (DELTAl(I),I=1,25,4) (D 71)
WRITE (6,151) (DELTAl(I),I=2,26,4) (D 72)
WRITE (6,152) (DELTAl(I),I=3,27,4) (D 73)
WRITE (6,153) (DELTAl(I),I=4,28,4) (D 74)
GO TD 1 (D 75)
814 XDELTAl(L4)=0. (D 76)
41 CONTINUE (D 77)

169 FORMAT (5X5HCHI=F7.3/1) (D 78)
150 FORMAT (3X5H(ww,17)7(F17.4)) (D 79)
151 FORMAT (3X5H(wu,17)17(F17.4)) (D 80)
152 FORMAT (3X5H(wu,17)17(F17.4)) (D 81)
153 FORMAT (3X5H(wu,17)17(F17.4)) (D 82)
210 FORMAT (1X131(1H-1)) (D 83)
211 FORMAT (1X1H111X1H131X61H4CORRECTION FACTORS FOR CORRECTING FROM A (D 84)
1WIND TUNNEL WHICH IS 25X1H1) (D 85)
212 FORMAT (1X1H111X1H1171H-11H) (D 86)
213 FORMAT (1X1H111X1H116X1H15X6HCLOSED5X1H16X1H2X12HCLOSEDFLOOR2X1 (D 87)
1H16X4HOPEN5X1H116X1H5X6HCLOSED4X1H1) (D 88)
214 FORMAT (1X1H13X5HDelta3X1H15X6HCLOSED5X1H14X4HON BC3X1H16X4HDP (D 89)
1X6X1H16X4HONLY6X1H15XHFLR6X1H15XHCLOSED5X1H13X9HON BC3X1M (D 90)
21) (D 91)
215 FORMAT (1X1H111X1H116X1H16X4HONLY6X1H16X8H1H11H1H1H1H1H1H1H1H (D 92)
1ONLY6X1H16X1H6X4HONLY5X1H1) (D 93)
216 FORMAT (1X1H111X1H1841H-11H321H-11H1) (D 94)
217 FORMAT (1X1H111X1H136X11HTF FREE AIR37X1H8X16HTGROUNDEFFECT8X1 (D 95)
1H1) (D 96)
218 FORMAT (1X131(1H-1)) (D 97)
900 FORMAT (11,F9.3,5F10.3/3F10.3) (D 98)
901 FORMAT (1H1///39*INTERFERENCE AT TAIL BEHIND SWEPT WING OF FINITE (D 99)
1SPAN///10X*SIGMA (WING) =F7.3,7X*TAIL HEIGHT =F7.3,8X8,A,* LOAD (D 100)

1
2ING*7X*GAMMA =*F8.3,7X*ZETA=*F7.3//10X*SIGMA (TAIL) =*F7.3,7X*TAIL (D 124)
3 LENGTH =*F7.3,8X*LAMBDAX =*F8.3,7X*ALPHA =*F8.3,7X*ETA =*F7.3///) (D 125)
999 STOP (D 126)
END (D 127)
APPENDIX E

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL
INTERFERENCE OVER A SWEEP WING
CAUSED BY THE PRESENCE OF LIFTING JETS

This program was written in CDC FORTRAN, version 2.1, to run on CDC 6000 series computers with the SCOPE 3.0 operating system and library tape. Minor modifications may be required prior to use in other computers. This program has been found to be satisfactory on the aforementioned computers which carry the equivalent of approximately 15 decimal digits. Computers of lesser precision may require modification to double precision in order to obtain results of equal accuracy.

This program requires the use of subroutine DLTAS which is given in Appendix Q.

Input will be found at, and above, address 1. Note that the reference origin has been chosen at the apex of the swept lifting line. Only one configuration of jets can be treated per run. Any number of wing configurations, may, however, be treated in one run for this one jet configuration. The first variable required (in format 103) is

NJ TOTAL NUMBER OF JETS IN CONFIGURATION

As many as 13 jets can be considered by the program as listed herein. If more jets are required, as many as 99 can be obtained by suitable increases in XH1, YH1, ZH1, and XLOAD in the dimension statement. Further increases require alteration of format 103.

The next variables required are the locations and the relative strengths of the jets. As many cards may be used as needed, however, the total number of sets of data must agree with NJ. Input variables for the jets (in format 904) are

XH1 X-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
YH1 Y-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
ZH1 Z-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
XLOAD RELATIVE PORTION OF LOAD CARRIED BY JET

Subsequent to specification of the jets, model configurations are given (one card per case) in format 909. The required input variables are
Appendix E – Continued

ZETA1  SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1  DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH

GAMMA  WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA  RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA  WING SWEEP ANGLE, DEG
ALPHA  ANGLE OF ATTACK OF WING, DEG

PROGRAM WINTUN INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT)
COMMON ZETA, ETA, GAMMA, XOVERH, YOVERH, ZOVERH, DELTA (28)
DIMENSION XDELTA (28), XLOAD (10), XH1(10), YH1(10), ZH1(10), C(8)
REAL LAMBDA
CATA (C(I), I=1, 18 / 20, 30, 40, 50, 60, 70, 80, 90,)
DO 803 1 I=1, 28

803 XDELTA (I) = 0.
READ (.0, 174532925199)
IFIRST = 0
READ (5, 103) NJ
READ (5, 904) (XH1(I), YH1(I), ZH1(I), XLOAD(I), I=1, NJ)

1 READ (5, 903) ZETA1, ETA1, GAMMA, SIGMA, LAMBDA, ALPHA
IF (EOF, 5) 999,48
48 IF (IFIRST .NE. 0) GO TO 47
WRITE (6, 503) (XH1(I), YH1(I), ZH1(I), XLOAD(I), I=1, NJ)
47 WRITE (6, 901) GAMMA, ZETA1, LAMBDA, SIGMA, ETA1, ALPHA
WRITE (6, 210)
WRITE (6, 211)
WRITE (6, 212)
WRITE (6, 213)
WRITE (6, 214)
WRITE (6, 215)
WRITE (6, 216)
WRITE (6, 217)
WRITE (6, 218)
IFIRST = 1
LAMBDA = LAMBDA * RAD
ALPHA = ALPHA * RAD
SUML = 0.
DO 820 M2 = 1, NJ
SUML = SUML * XLOAD (M2)
820 CONTINUE
SUML = 1. / (10. * SUML)
DO 41 K = 1, 8
IF (ETA1, NE, 1.) GO TO 813
M3 = 0
DO 815 M4 = 1, NJ
IF (YH1(M4), EQ, 0.) GO TO 817
M3 = 0
DO 815 M4 = 1, NJ
IF (M4, EQ, 0) GO TO 816
IF (M4, EQ, XH1(M5), AND, ZH1(M4), EQ, ZH1(M5), ANC. YH1(M4), EQ, YH1(M5), I=1, M5)
IM5) GO TO 821
GO TO 816
821 M3 = M3 +1
816 CONTINUE
GO TO 815

817 M3=M3+1

815 CONTINUE
   IF (M3.NE.NJ) GO TO 813
   IALPHA=1CH SYMMETRIC
   M6=N6=1
   M7=5
   N7=NJ
   CONST1=2.
   IF (SIGMA.NE.0.) GO TO 812
   M7=1
   CONST1=10.
   GO TO 812

813 M6=N6=1
   M7=10
   N7=NJ
   CONST1=1.
   IALPHA=10HASYMMETRIC
   IF (SIGMA.NE.0.) GO TO 812
   M7=10
   CONTINUE

812 CO 801 M1=M6,M7
   DO 802 N1=N6,N7
   YSTAR(I1,-2.*FLOAT(M1))/I7.
   ZETA=ZETA1/ (1.+ZETA1*(ZHI(N1)*COS(ALPHA)-XHI(N1)*SIN(ALPHA)))
   ETA=ETA1-(((1./GAMMA)*YHI(N1)))
   XOVERH=ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)-(XHI(N1)*COS(1ALPHA)-(ZHI(N1)*SIN(ALPHA))
   YOVERT=ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)-(XHI(N1)*COS(IALPHA))+(XHI(N1)*SIN(ALPHA))
   CALL DLTAS (C(K))

******************************************************************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ********************************************************************
   DO 805 L1=1,28
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)

802 CONTINUE
801 CONTINUE
   DO 807 L3=1,28
807 DELTA(L3)=XDELTA(L3)*SUML*CONST1
   WRITE (6,149) C(K),IALPHA
   WRITE (6,150) (DELTA(I),I=1,25,4)
   WRITE (6,151) (DELTA(I),I=2,26,4)
   WRITE (6,152) (DELTA(I),I=3,27,4)
   WRITE (6,153) (DELTA(I),I=4,28,4)
   DO 814 L4=1,28
814 XDELTA(L4)=0.

41 CONTINUE
   GO TO 1

103 FORMAT (I2)
149 FORMAT (1X*CHI =#F7.3,6XA10,* JET CONFIGURATION*)/)
150 FORMAT (3X5H(W,L)7(F17.4))
151 FORMAT (3X5H(U,L)7(F17.4))
152 FORMAT (3X5H(W,D)7(F17.4))
153 FORMAT (3X5H(U,D)7(F17.4))/
210 FORMAT (1X111(IH-))
211 FORMAT (1X1111X1XH)3X6XH1MCORRECTION FACTORS FOR CORRECTING FROM A WIND TUNNEL WHICH IS5X1H)
1WIND TUNNEL WHICH IS25X1H1)
212 FORMAT (1X1111X1XH)117(IH-1)IH1)
213 FORMAT (1X1111X1XH)6XH15X6MCLOSED5X1XH)16X1H2X12HCLOSEDFLOOR2X1
11H15X4OPEN6X12XH15X6MCLOSED3X4141)
214 FORMAT (1X1111X5HDDELTA3X1XH)5X6HCLOSE35X1H)4XHON BOTTOM3X1H)4HOP
Appendix E – Concluded

1EN6X1HI6X4HONLY6X1HI5X5HFLJ0R6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (E 106)
2I) (E 107)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI (GROUND EFFECT) 16X4H (E 108)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (E 109)
216 FORMAT (1X1HI11X1HI84(1H-1HI32(1H-1HI) (E 110)
217 FORMAT (1X1HI11X1HI36X11TD FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (E 111)
1HI) (E 112)
218 FORMAT (1X131(1H-/)) (E 113)
900 FORMAT (6F10.3) (E 114)
901 FORMAT (1H//3TX*AVERAGE INTERFERENCE OF SEVERAL JETS ON A FIYITE (E 115)
1 SWEPT WING*/3CX*GAMMA =*F7.3,16X*ZETA =*F7.3,15X*LAMBDA =*
2F7.3/30X*SIGMA =*F7.3,16X*ETA =*F7.3,15X*ALPHA =*F7.3/)
903 FORMAT (1131X*RELATIVE*/25X*OVERH*20X*OVERH*20X*OVERH*18X
1*SRENGTH*/1(24XF7.3,19XF7.3,19XF7.3,19XF6.3/)) (E 118)
904 FORMAT (3F7.3,F5.3,3F7.3,F5.3,3F7.3,F5.3) (E 119)
999 STOP (E 121)
END (E 122)

19
APPENDIX F

FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF
WIND-TUNNEL INTERFERENCE OVER THE
SPAN OF A SWEPT WING
CAUSED BY THE PRESENCE OF LIFTING JETS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6600
SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR
MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM
HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY
THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRE-
CISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS
OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN
APPENDIX A.

INPUT WILL BE FOUND AT, AND ABOVE, ADDRESS 1. NOTE THAT THE REFERENCE
ORIGIN HAS BEEN CHOSEN AT THE Apex OF THE SwePT LIFTING LINE. ONLY ONE CON-
FIGURATION OF JETS CAN BE TREATED PER RUN. ANY NUMBER OF WING CONFIGURATIONS,
MAY, HOWEVER, BE TREATED IN ONE RUN FOR THIS ONE JET CONFIGURATION. THE FIRST
VARIABLE REQUIRED (IN FORMAT 103) IS

\[ NJ \]
TOTAL NUMBER OF JETS IN CONFIGURATION

AS MANY AS 10 JETS CAN BE CONSIDERED BY THE PROGRAM AS LISTED HEREIN. IF
MORE JETS ARE REQUIRED, AS MANY AS 99 CAN BE OBTAINED BY SUITABLE INCREASES IN
XH1, YH1, ZH1, AND XLOAD IN THE DIMENSION STATEMENT. FURTHER INCREASES
REQUIRE ALTERATION OF FORMAT 103.

THE NEXT VARIABLES REQUIRED ARE THE LOCATIONS AND THE RELATIVE STRENGTHS
OF THE JETS. AS MANY CARDS MAY BE USED AS NEEDED, HOWEVER, THE TOTAL NUMBER OF
SETS OF DATA MUST AGREE WITH NJ. INPUT VARIABLES FOR THE JETS (IN FORMAT 904) ARE

\[ \begin{align*}
XH1 & \quad X\text{-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMEN-} \\
& \quad \text{SIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT} \\
YH1 & \quad Y\text{-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMEN-} \\
& \quad \text{SIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT} \\
ZH1 & \quad Z\text{-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMEN-} \\
& \quad \text{SIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT} \\
XLOAD & \quad \text{RELATIVE PORTION OF LOAD CARRIED BY JET}
\end{align*} \]
Appendix F – Continued

SUBSEQUENT TO SPECIFICATION OF THE JETS, MODEL CONFIGURATIONS ARE GIVEN
(CONE CARD PER CASE) IN FORMAT 907. THE REQUIRED INPUT VARIABLES ARE

ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL
SEMWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDAG WING SWEEP ANGLE, DEG
ALPHA ANGLE OF ATTACK OF WING, DEG
C EFFECTIVE WAKE SKEW-ANGLE, DEG

IN SYMMETRICAL CASES THIS PROGRAM COMPUTES THE INTERFERENCE DISTRIBUTION
OVER ONE SEMISPAN ONLY. THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH
CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE
PROVIdED BY THE PROGRAM OF APPENDIX E.

PROGRAM WINDTUNL(INP1T,LOUTPUT,TAPESmINPUT,TAPES=GOUTPUT)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(23)
COMMON XDIELA(28),XLOAD(10),XH1(10),YH1(10),ZH1(10),DATE(2)
REAL LAMBDAG
DG 803 L1=1.28
803 XDIELA(L1)=0.
RAD.=0.0174532925159
IFIRST=0
READ (5,103) NJ
READ (5,904) (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)
1 READ (5,903) ZETA1,ETA1,GAMMA,SIGMA,LAMBDAG,ALPHA,C
IF (EOF15) 999148
48 IF (IFIRST.NE.0) GO TO 47
WRITE (6,903) (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)
47 WRITE (6,901) GAMMA,ZETA1,LAMBDAG,SIGMA,ETA1,ALPHA,C
WRITE (6,210)
WRITE (6,211)
WRITE (6,212)
WRITE (6,213)
WRITE (6,214)
WRITE (6,215)
WRITE (6,216)
WRITE (6,217)
WRITE (6,218)
IFIRST=1
LAMBDAG=LAMBDAG*RAD
ALPHA=ALPHA*RAD
SUML=0.
CC 820 M2=1,NJ
SUML=SUML+XLOAD(M2)
820 CONTINUE
SUML=1./SUML
IF (SIGMA,NE.C.) GO TO 811
WRITE (6,655)
CALL CAYTIM (DATE)
WRITE (6,906) DATE  
GO TO 1  
811 IF (ETA1.NE.1.) GO TO 813  
M3=0  
GO 815 M4=1,NJ  
IF (YH1(M4).EQ.0.) GO TO 817  
DO 816 M5=1,NJ  
IF (M5.EQ.M5) GO TO 816  
IF (XH1(M4),EQ.XH1(M5).AND.ZH1(M4),EQ.ZH1(M5).AND.YH1(M4),EQ.-YH1(M5)) GO TO 821  
GO TO 816  
821 M3=M3+1  
816 CONTINUE  
GO TO 815  
817 M3=M3+1  
815 CONTINUE  
IF (M3.NE.NJ) GO TO 813  
IALPHA=10H SYMMETRIC  
MICHEK=5  
GO TO 812  
813 MICHEK=11  
IALPHA=10H ASYMMETRIC  
812 M1=0  
801 DO 802 N1=1,NJ  
YSTAR=(1.,-2.*FLOAT(M1))/10.  
ZETA=ZETA1/ (1.+ZETA1*(ZHI(N1)*COS(ALPHA)-XHI(N1)*SIN(ALPHA)))  
ETA=ETA1-(1./GAMMA)*YH1(N1))  
XOVERH=ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)-(XH1(N1)*COS(ALPHA)- (ZHI(N1)*SIN(ALPHA))  
YOVERH=YSTAR*SIGMA*GAMMA-YH1(N1)  
ZOVERH=ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)-(ZHI(N1)*COS(ALPHA))+(XH1(N1)*SIN(ALPHA))  
CALL DLTAS (C)  
*************** SEE APPENDIX O FOR SUBROUTINE DLTAS ***************  
805 XDELTAL(L1)=XDELTAL(L1)*DELTA(L1)*XLOAD(N1)  
802 CONTINUE  
DO 807 L3=1,28  
8C7 CELTA(L3)=XDELTAL(L3)*SUML  
WRITE (6,149) YSTAR,IALPHA  
WRITE (6,150) (DELTA(I),I=1,25,4)  
WRITE (6,151) (DELTA(I),I=2,26,4)  
WRITE (6,152) (DELTA(I),I=3,27,4)  
WRITE (6,153) (DELTA(I),I=4,28,4)  
DO 814 L4=1,28  
814 XDELTAL(L4)=0.  
M1=M1+1  
IF (M1.LE.MICHEK) GO TO 801  
GO TO 1  
103 FORMAT (I2)  
149 FORMAT (/1X*Y/SEMISPAN =*F4.1,10X,A10* JET CONFIGURATION*/)  
150 FORMAT (3XH(W,17.4))  
151 FORMAT (3XH(W,L17(F17.4))  
152 FORMAT (3XH(W,17(F17.4))  
153 FORMAT (3XH(U,L17(F17.4))  
210 FORMAT (1X131(I1H-))  
211 FORMAT (1X1HI11I1X131X61HCORRECTION FACTORS FOR CORRECTING FROM A 1WIND TUNNEL WHICH IS25X1HI)  
212 FORMAT (1X1HI11I1X1H1117(IH-1HI)  
213 FORMAT (1X1HI11I1X1H116X1HI56HCLOSED05X1HI16X1HI2X12HCLOSED FLOOR2X1  
1HI6X4HOPEN6X1HI6X1HI56HCLOSED4X1HI)
Appendix F – Concluded

214 FORMAT (1X1HI3X5HDELT43X1HI5X6HCLOSED5X1HI4X9HCON BOTTOM3X1HI6X4HOP (F 96) 
1EN6X1HI6X4HONLY6X1HI5X5HFL3OR6X1HI5X6HCLOSED5X1HI3X9HCON BOTTOM3X1H (F 97) 
21) (F 98)
215 FORMAT (1X1HI11X1HI2X1HI6X4HONLY6X1HI16X18HII (GROUND EFFECT) I5X4H (F 99) 
1CNLY6X1HI16X1HI6X4HONLY5X1HI) (F 100)
216 FORMAT (1X1HI11X1HI84X1H-1HI132X1H-1HI) (F 101)
217 FORMAT (1X1HI11X1HI36X1HI TO FREE AIR3TX1HI8X16HTC GROUND EFFECTX1) (F 102) 
1HI) (F 103)
218 FORMAT (1X131X1H-)) (F 104)
900 FORMAT (7F10.3) (F 105)
901 FORMAT (1HI///3TX* DISTRIBUTION OVER FINITE SWEPT WING CAUSED BY SE (F 106) 
1VERAL JETS*/30X*GAMMA =*F7.3,16X*ZETA =*F7.3,15X*LAMRXDA =*F7.3// (F 107) 
230X*SIGMA =*F7.3,16X*ETA =*F7.3,15X*ALPHA =*F7.3//63X*CHI =* (F 108) 
3F7.3//) (F 109)
903 FORMAT (101X*RELATIVE*/25X*XOVERH*23X*YOVERH*23X*ZOVERH*18X 
1*STRENGTH*///(24X7.3,19XF7.3,19XF6.3//)) (F 110)
904 FORMAT (3F7.3,F5.3,3F7.3,F5.3,3F7.3,F5.3) (F 111)
905 FORMAT (///40X*SIGMA EQUALS ZERO - USE AVERAGE INTERFERENCE PROGR (F 112) 
1A#///) (F 113)
999 STOP (F 114)
END (F 115)
APPENDIX G

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL CAUSED BY THE PRESENCE OF LIFTING JETS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTPS WHICH IS GIVEN IN APPENDIX G.

INPUT WILL BE FOUND AT, AND ABOVE, ADDRESS 1. NOTE THAT THE REFERENCE ORIGIN HAS BEEN CHOSEN AT THE APEX OF THE SWEPT LIFTING LINE. ONLY ONE CONFIGURATION OF JETS CAN BE TREATED PER RUN. ANY NUMBER OF WING CONFIGURATIONS, MAY, HOWEVER, BE TREATED IN ONE RUN FOR THIS ONE JET CONFIGURATION. THE FIRST VARIABLE REQUIRED (IN FORMAT 103) IS

\[ \text{NJ} \]

TOTAL NUMBER OF JETS IN CONFIGURATION

AS MANY AS 10 JETS CAN BE CONSIDERED BY THE PROGRAM AS LISTED HEREIN. IF MORE JETS ARE REQUIRED, AS MANY AS 99 CAN BE OBTAINED BY SUITABLE INCREASES IN XH1, YH1, ZH1, AND XLOAD IN THE DIMENSION STATEMENT. FURTHER INCREASES REQUIRE ALTERATION OF FORMAT 103.

THE NEXT VARIABLES REQUIRED ARE THE LOCATIONS AND THE RELATIVE STRENGTHS OF THE JETS. AS MANY CARDS MAY BE USED AS NEEDED, HOWEVER, THE TOTAL NUMBER OF SETS OF DATA MUST AGREE WITH NJ. INPUT VARIABLES FOR THE JETS (IN FORMAT 904) ARE

\[ \text{XH1} \]
X-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

\[ \text{YH1} \]
Y-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

\[ \text{ZH1} \]
Z-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT

\[ \text{XLOAD} \]
RELATIVE PORTION OF LOAD CARRIED BY JET

SUBSEQUENT TO SPECIFICATION OF THE JETS, MODEL CONFIGURATIONS ARE GIVEN (ONE CARD PER CASE) IN FORMAT 903. THE REQUIRED INPUT VARIABLES ARE
Appendix G – Continued

ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAT RATIO OF TAIL SPAN TO TUNNEL WIDTH
TL TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSION-
ALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
TH TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSION-
ALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
ALPHA ANGLE OF ATTACK OF WING, DEG

PROGRAM WINDTUN(INPLT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT) (G 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28) (G 2)
DIMENSICN XDELTA(28),XLOAD(10),XHI(10),YHI(10),ZH1(10),C(18) (G 3)
CATA (C(1),I=1,81/20,30,40,50,60,70,80,90.) (G 4)
DO 803 L1=1,28 (G 5)
803 XDELTA(L1)=0. (G 6)
PI=3.14159265358979 (G 7)
RAD=.0174532925199 (G 8)
IFIRST=0 (G 9)
READ (5,904) (XHI(I),YHI(I),ZH1(I),XLOAD(I),I=1,NJ) (G 10)
1 READ (5,900) ZETA1,ETA1,GAMMA,SIGMAT,TL,TH,ALPHA (G 11)
IF (EOF,5) 999,48 (G 12)
48 IF (IFIRST,NE.0) GO TO 47 (G 13)
47 WRITE (6,903) (XHI(I),YHI(I),ZH1(I),XLOAD(I),I=1,NJ) (G 14)
WRITE (6,901) GAMMA,ZETA1,TL,SIGMAT,ETA1,TH,ALPHA (G 15)
WRITE (6,211) (G 16)
WRITE (6,211) (G 17)
WRITE (6,212) (G 18)
WRITE (6,213) (G 19)
WRITE (6,214) (G 20)
WRITE (6,215) (G 21)
WRITE (6,216) (G 22)
WRITE (6,217) (G 23)
WRITE (6,218) (G 24)
WRITE (6,218) (G 25)
IFIRST=1 (G 26)
LAMDA=LAMDA*RD (G 27)
ALPHA=ALPHA*RD (G 28)
SUML=0. (G 29)
DC 820 M2=1,NJ (G 30)
SUML=SUML+XLOAD(M2) (G 31)
820 CONTINUE (G 32)
SUML=1./4.*SUML (G 33)
DO 41 K=1,8 (G 34)
IF (ETA1,LE.1.) GO TO 813 (G 35)
M3=0 (G 36)
DO 815 M4=1,NJ (G 37)
IF (YHI(M4),EQ.0.) GO TO 817 (G 38)
CO 816 M5=1,NJ (G 39)
IF (M4,EQ.M5) GO TO 816 (G 40)
IF (XHI(M4),EQ.XHI(M5),AND.ZHI(M4),EQ.ZHI(M5),AND.YHI(M4),EQ.-YHI (G 41)
G

**1**$ GO TO 821

GO TO 816

821 $M_3=M_3+1$

GO TO 815

816 CONTINUE

817 $M_3=M_3+1$

815 CONTINUE

IF ($M_3.NE.NJ$) GO TO 813

$\text{IALPHA}=10 \text{H SYMMETRIC}$

$M_6=N_6=1$

$M_7=2$

$N_7=N_J$

$\text{CONST1}=2,_.$

IF ($\text{SIGMAT.NE.0.}$) GO TO 812

$M_7=1$

$\text{CONST1}=4,_.$

GO TO 812

813 $M_6=N_6=1$

$M_7=3$

$N_7=N_J$

$\text{CONST1}=1,_.$

$\text{IALPHA}=10 \text{H SYMMETRIC}$

IF ($\text{SIGMAT.NE.0.}$) GO TO 812

$M_7=1$

$\text{CONST1}=4,_.$

812 DO 801 $M_1=M_6,M_7$

801 CONTINUE

802 CONTINUE

805 XDELTA(L1)=XDELTA(L1)+{DELTA(L1)*XLOAD(N1)}

807 DELTA(L3)=XDELTA(L3)*SUML*CONST1

WRITE (6,149) $\text{C(K),IALPHA}$

WRITE (6,150) (DELTA(I),I=1,25,4)

WRITE (6,151) (DELTA(I),I=2,26,4)

WRITE (6,152) (DELTA(I),I=3,27,4)

WRITE (6,153) (DELTA(I),I=4,28,4)

DO 814 $L_4=1,28$

814 XDELTA(L4)=0.

41 CONTINUE

GO TO 1

103 FORMAT (12)$ (G 42)

149 FORMAT (//1X*CHI =+F7.3,6*HA10,* JET CONFIGURATION*/)$ (G 43)

150 FORMAT (3X5H(W,L)7(F17.4))$ (G 44)

151 FORMAT (3X5H(U,L)17(F17.4))$ (G 45)

152 FORMAT (3X5H(W,D)7(F17.4))$ (G 46)

153 FORMAT (3X5H(U,D)17(F17.4))$ (G 47)

-210 FORMAT (1X13I11H-1)$ (G 48)

211 FORMAT (1X1H11X1H131X61HCORRECTION FACTORS FOR CORRECTING FROM A$

1\text{WIND TUNNEL WHICH IS25X1H1}$ (G 49)

212 FORMAT (1X1H11X1H117(1H-1)1H1) (G 50)

213 FORMAT (1X1H111X1H16X1H15X6HCLOSED05X1H16X1H12X12HCLOSED FLOOR2X1) (G 51)
Appendix G – Concluded

1H16X4HOPEN6X1HI6X1HI6XHCL7SED4X1HI) (G 102)
214 FORMAT (1X1H13X5HDELTA3X1H15X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (G 103)
1EN6X1HI6X4HONLY6X1HI5X5HFL3DOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (G 104)
2I) (G 105)
215 FORMAT (1X1HI11X1HI6X1HI6X4HONLY6X1HI16X8H18HI (GROUND EFFECT) 16X4H (G 106)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (G 107)
216 FORMAT (1X1HI11X1HI84(1H-1H)1HI32(1H-1H)1HI) (G 108)
217 FORMAT (1X1HI11X1HI36X1HT0 FREE AIR37X1HI18X16HT0 GROUND EFFECT8X1 (G 109)
1H) (G 110)
218 FORMAT (1X131{1H-}) (G 111)
900 FORMAT (7F13.3) (G 112)
901 FORMAT (1H1//37X*AVERAGE INTERFERENCE AT FINITE TAIL CAUSED BY SE (G 113)
1VERAL JETS*/{31X*GAMMA ==F7.3,10X*ZETA ==F7.3,10X*TAIL LENGTH/H (G 114)
2 ==F6.3//31X*SIGMA(T) ==F7.3,10X*ETA ==F7.3,10X*TAIL HEIGHT/H == (G 115)
3F6.3//57X*ALPHA ==F9.3//) (G 116)
903 FORMAT (101X*RELATIVE*/{25X*OVERH*20X*OVERH*20X*OVERH*18X)
1*STRENGTH*/{24XF7.3,19XF7.3,19XF7.3,19XF6.3//}) (G 117)
904 FORMAT (3F7.3,F5.3,F7.3,F5.3,F7.3,F5.3) (G 118)
999 STOP (G 120)
END (G 121)
APPENDIX H

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A SINGLE ROTOR

This program was written in CDC FORTRAN, version 2.1, to run on CDC 6600 series computers with the SCOPE 3.0 operating system and library tape. Minor modifications may be required prior to use in other computers. This program has been found to be satisfactory on the aforementioned computers which carry the equivalent of approximately 15 decimal digits. Computers of lesser precision may require modification to double precision in order to obtain results of equal accuracy.

This program requires the use of subroutine DLTAS which is given in Appendix Q.

Input will be found at address 1 (one card per case) in format 900. Note that the reference origin is chosen to be at the center of the rotor. The required input variables are:

LI LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHA ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

Program WINOTUN(Input, Output, Tape5=Input, Tape6=Output)

Common Zeta, ETA, Gamma, XoverH, YoverH, Delta(28)

Dimension Xdelta(28), Psi(20), Xload(20), Runif(20), Rtri(20), C(8)

Cata (Runif(I), I=1, 20/4*0.298, 8*0.625, 8*0.8921/
Cata (Rtri(I), I=1, 20/4*0.4386, 8*0.7296, 8*0.9262/
Cata (C(I), I=1, 8/20, 30, 40, 50, 60, 70, 80, 90, /
Pi=3.14159265358979
Radt=174532925199
Do 803 L=1, 28

803 Xdelta(I)=0.

Psi(I)=G(I)/4.

Psi(2)=3*Psi(1)

Psi(3)=5*Psi(1)

Psi(4)=7*Psi(1)

Psi(5)=Psi(13)=G(PI/8.)

Psi(6)=Psi(14)=3*Psi(5)

Psi(7)=Psi(15)=5*Psi(5)

Psi(8)=Psi(16)=7*Psi(5)

Psi(9)=Psi(17)=9*Psi(5)
Appendix H – Continued

\[ \Psi(10) = \Psi(18) = 11 \times \Psi(5) \]
\[ \Psi(11) = \Psi(19) = 13 \times \Psi(5) \]
\[ \Psi(12) = \Psi(20) = 15 \times \Psi(5) \]
1 READ (5, 900) \text{LI, ZETA1, ETA1, GAMMA, SIGMA, ALPH}\a
SUML = 0.025
IF (EOF, 5) 999, 47
47 IF (LI.EQ.1) GO TO 804
I ALPHA = 10 + TRIANGULAR
CO 808 M2 = 1, 20
808 XLOAD(M2) = TRIA(M2)
GO TO 160
804 I ALPHA = 10H UNIFORM
DO 809 M2 = 1, 20
809 XLOAD(M2) = RUNIF(M2)
160 WRITE (6, 901) SIGMA, I ALPHA, ZETA1, ETA1, GAMMA, ALPH\a
WRITE (6, 210)
WRITE (6, 211)
WRITE (6, 212)
WRITE (6, 213)
WRITE (6, 214)
WRITE (6, 215)
WRITE (6, 216)
WRITE (6, 217)
WRITE (6, 218)
ALPHA = ALPHA * RAD
DO 41 K = 1, 8
M7 = N7 = 20
IF (SIGMA.NE.0.) GO TO 815
M7 = N7 = 1
CONST1 = 400.
GO TO 812
815 IF (ETA1.NE.1.) GO TO 813
CONST1 = 2.
GO TO 812
813 CONST1 = 1.
812 DO 801 M1 = 1, M7
DO 802 N1 = 1, N7
IF (ETA1.NE.1.) GO TO 811
IF (PSI(N1).GT.PI) GO TO 802
811 ETA1 = ETA1 - (XLOAD(N1) * SIGMA * SIN(PSI(N1)))
ZETA1 = 1/((1 / ZETA1) - XLOAD(N1) * SIGMA * SIN(ALPHA) * COS(PSI(N1)) * GAMM
A1)
XOVERH = SIGMA * GAMMA * COS(ALPHA) * (XLOAD(M1) * COS(PSI(M1)) - XLOAD(N1) * C
OS(PSI(N1))
YOVERH = SIGMA * GAMMA * (XLOAD(M1) * SIN(PSI(M1)) - XLOAD(N1) * SIN(PSI(N1))
1)
ZOVERH = -SIGMA * GAMMA * SIN(ALPHA) * (XLOAD(M1) * COS(PSI(M1)) - XLOAD(N1) *
1 * COS(PSI(N1))
CALL DLTAS(C(K))
******************************************************* SEE APPENDIX Q FOR SUBROUTINE DLTAS ******************************************************
DO 805 L1 = 1, 28
805 XDELA(L1) = XDELA(L1) + DELTA(L1)
802 CONTINUE
801 CONTINUE
DO 807 L3 = 1, 28
807 DELTA(L3) = XDELA(L3) * SUML * CONST1
WRITE (6, 149) C(K)
WRITE (6, 150) (DELTA(I), I = 1, 25, 4)
WRITE (6, 151) (DELTA(I), I = 2, 26, 4)
WRITE (6, 152) (DELTA(I), I = 3, 27, 4)
WRITE (6, 153) (DELTA(I), I = 4, 28, 4)
Appendix H – Concluded

CO 814 L4=1,28
014 XDELTAL4=0.
41 CONTINUE
GC TO 1
149 FORMAT (//1*X*CHI = ** F7.3/)
150 FORMAT (3X5H1W,L7(F17.4))
151 FORMAT (3X5H(U,L7(F17.4))
152 FORMAT (3X5H(W,D7(F17.4)
153 FORMAT (3X5H(U,D7(F17.4))
210 FORMAT (1X131(1H-))
211 FORMAT (1X1H111X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A
1WIND TUNNEL WHICH IS 25X1HI)
212 FORMAT (1X1H111X1HI17(1H-1HI
213 FORMAT (1X1H111X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X1HCLOSED FLOOR2X1
1H16X4OPEN6X1HI16X1HI5X6HCLOSED4X1HI)
214 FORMAT (1X1H13X5HDELTAX1HI5X6HCLOSED5X1HI1X5H4XHOP
1EN6X1HI6X4HONLY6X1HI5X5HFLOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1HI
21)
215 FORMAT (1X1H111X1HI16X1HI6X4HONLY6X1HI6X1HI8H11GROUN D EFFECT) 16X4H
1ONLY6X1HI16X1HI6X4HONLY5X1HI)
216 FORMAT (1X1H111X1HI84(1H-1HI32(1H-1HI)
217 FORMAT (1X1H111X1HI36X1HIHTO FREE AIR3X1HI8X1H6TC GROUND EFFECT8X1
1HI)
218 FORMAT (1X131(1H-))
900 FORMAT (11,F9.3,6F10.3)
901 FORMAT (1H////40*X*AVERAGE INTERFERENCE OVER FINITE SPAN ROTOR**
140X*SIGMA =**F6.3,12XK10,* Loading**/40*X*ZETA =**F6.3,19X*ETA =**F6.
23//40X*GAMMA =**F6.3,18X*ALPHA =**F5.1/**
999 STOP
END
APPENDIX I

FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF
WIND-TUNNEL INTERFERENCE OVER THE
LATERAL AXIS OF A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.11, TO RUN ON CDC 6000
SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR
MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM
HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY
THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRE-
CISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS
OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLT4S WHICH IS GIVEN IN
APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE
THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE RE-
QUIRED INPUT VARIABLES ARE

LI LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2
FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL
SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHA ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG
C EFFECTIVE WAKE SKEW-ANGLE, DEG

IN SYMMETRICAL CASES THIS PROGRAM COMPUTES THE INTERFERENCE DISTRIBUTION
OVER ONE SEMISPAN ONLY. THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH
CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PRO-
VIDED BY THE PROGRAM OF APPENDIX H.

PROGRAM WINDTUNI(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT) (I 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28) (I 2)
DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20) (I 3)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/ (I 4)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/ (I 5)
PI=3.14159265358979 (I 6)
RAD=0.0174532925199 (I 7)
PSI(1)=(PI/4.) (I 8)
Appendix I – Continued

\[
\begin{align*}
\text{PSI(2)} &= 3 \cdot \text{PSI(1)} \\
\text{PSI(3)} &= 5 \cdot \text{PSI(1)} \\
\text{PSI(4)} &= 7 \cdot \text{PSI(1)} \\
\text{PSI(5)} &= \text{PSI(13)} = (\pi/8) \\
\text{PSI(6)} &= \text{PSI(14)} = 3 \cdot \text{PSI(5)} \\
\text{PSI(7)} &= \text{PSI(15)} = 5 \cdot \text{PSI(5)} \\
\text{PSI(8)} &= \text{PSI(16)} = 7 \cdot \text{PSI(5)} \\
\text{PSI(9)} &= \text{PSI(17)} = 9 \cdot \text{PSI(5)} \\
\text{PSI(10)} &= \text{PSI(18)} = 11 \cdot \text{PSI(5)} \\
\text{PSI(11)} &= \text{PSI(19)} = 13 \cdot \text{PSI(5)} \\
\text{PSI(12)} &= \text{PSI(20)} = 15 \cdot \text{PSI(5)} \\
\text{SUML} &= 0.05 \\
\text{DO 805 } N2 = 1, 28
\end{align*}
\]

805 XDELTAT(N2) = 0.
1 READ (5,103) LI, ZETAT, ETA1, GAMMA, SIGMA, ALPHA, C
IF (EOF.5) 999,700
700 IF (LI.EQ.1) GO TO 806
IALPHA = 10*TRIANGULAR
DO 808 M2 = 1, 20
808 XLOAD(M2) = XTRIA(N2)
GO TO 702
806 IALPHA = 10*UNIFORM
DO 809 M2 = 1, 20
809 XLOAD(M2) = RUNIF(NZ)
702 IF (ET11.EQ.1.) GO TO 813
MICHET = 6
GO TO 47
813 MICHET = 12
47 WRITE (6, 900) SIGMA, IALPHA, ZETAT, ETA1, GAMMA, ALPHA, C
WRITE (6, 210)
WRITE (6, 211)
WRITE (6, 212)
WRITE (6, 213)
WRITE (6, 214)
WRITE (6, 215)
WRITE (6, 216)
WRITE (6, 217)
WRITE (6, 218)
IF (SIGMA.NE.0.) GO TO 803
WRITE (6, 903)
GO TO 1
803 IALPHA = ALPHA*R40
M1 = 0
804 YSTAR = 1.2 - 0.2*FLOAT(M1)
800 CONTINUE
DO 802 N2 = 1, 28
802 DELTA(N2) = XDELTAT(N2) + DELTA(N2) + DELTA(N2)
WRITE (6, 149) YSTAR
WRITE (6, 150) (DELTA(I), I = 1, 25, 4)
WRITE (6, 151) (DELTA(I), I = 2, 26, 4)

*************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ***************
WRITE (6,152) (DELTA(I),I=3,27,4)  
WRITE (6,153) (DELTA(I),I=4,28,4)  
GO TO 810  
810 XDELTA(N2)=0.0  
M1=M1+1  
IF (M1.LE.MCHECK) GO TO 804  
GO TO 1  
810 FORMAT (13H-   )  
103 FORMAT (I1,F9.3,5F10.3)  
149 FORMAT (//10X*Y/R =*F4.1/)  
150 FORMAT (3X5H(W,L)7(F17.4))  
151 FORMAT (3X5H(U,L)7(F17.4))  
152 FORMAT (3X5H(W,D)7(F17.4))  
153 FORMAT (3X5H(U,D)7(F17.4))  
210 FORMAT (1X131(1H-))  
211 FORMAT (1XI1H11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A  
1WIND TUNNEL WHICH IS25X1HI)  
212 FORMAT (1XI1H11X1HI117(1H-1HI))  
213 FORMAT (1XI1H11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12X12HCLOSED FLOOR2X1  
1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)  
214 FORMAT (1XI1H13X9HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP  
1EN6X1HI6X4HONLY6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H  
2I)  
215 FORMAT (1XI1H11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 15X4H  
1ONLY6X1I16X1HI6X4HONLY5X1HI)  
216 FORMAT (1XI1H11X1HI84(IH-1HI32(IH-1HI))  
217 FORMAT (1XI1H11X1HI36X1HIHTO FREE AIR3X1HI8X16HTC GROUND EFFECTR3X1  
1F)  
218 FORMAT (1XI131(1H-))  
900 FORMAT (1HI//31X*INTERFERENCE DISTRIBUTION OVER LATERAL AXIS OF  
1FINITE SPAN ROTOR*/)  
23//40X*GAMMA =*F6.3,19X*ALPHA =*F7.3//56X*CHI =*F8.3//)  
903 FORMAT (1XI40X5H*SIGMA EQUALS ZERO --- USE AVERAGE INTERFERENCE P  
1RCGRAM)  
999 STOP  
END
FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF
WIND-TUNNEL INTERFERENCE OVER THE
LONGITUDINAL AXIS OF A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 5000
SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR
MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM
HAS BEEN FOUND TO BE SATISFACTORY ON THE FOREMENTIONED COMPUTERS WHICH CARRY
THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRE-
CISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS
OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE OLTAS WHICH IS GIVEN IN
APPENDIX J.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE
THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE RE-
QUIRED INPUT VARIABLES ARE

LI LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2
FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL
SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHA ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG
C EFFECTIVE WAKE SKEW-ANGLE, DEG

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE
THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE RE-
QUIRED INPUT VARIABLES ARE

LI LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2
FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL
SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
Appendix J – Continued

SIGMA  RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHA  ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG
C      EFFECTIVE WAKE SKEW-ANGLE, DEG

THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH CASES, THE INTERFERENCE
IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PROVIDED BY THE PROGRAM OF
APPENDIX H.

PROGRAM WINDTUN(INPUT,OLPUT,TAPE5=INPUT,TAPE6=OUTPUT)  (J 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)  (J 2)
DIMENSION XDELT(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20)  (J 3)
DATA (RUN IF(I)),I=1,20)/4*0.2981,8*0.6255,8*0.8921/  (J 4)
DATA (RTRIA(I)),I=1,20)/4*0.4386,8*0.7296,8*0.9262/  (J 5)
PI=3.14159265358979  (J 6)
RAD=0.00174532925199  (J 7)
PSI(1)=(PI/4.)  (J 8)
PSI(2)=3.*PSI(1)  (J 9)
PSI(3)=5.*PSI(1)  (J 10)
PSI(4)=7.*PSI(1)  (J 11)
PSI(5)=PSI(13)=(PI/8.)  (J 12)
PSI(6)=PSI(14)=3.*PSI(5)  (J 13)
PSI(7)=PSI(15)=5.*PSI(5)  (J 14)
PSI(8)=PSI(16)=7.*PSI(5)  (J 15)
PSI(9)=PSI(17)=9.*PSI(5)  (J 16)
PSI(10)=PSI(18)=11.*PSI(5)  (J 17)
PSI(11)=PSI(19)=13.*PSI(5)  (J 18)
PSI(12)=PSI(20)=15.*PSI(5)  (J 19)
DO 805 N2=1,28  (J 20)
805 XDELT(1)=.0.
1 READ (5,103) LI,ZETA1,ETA1,GAMMA,SIGMA,ALPHA,C
IF (EOF,5) 999,700  (J 21)
700 SUML=.*05
   CONST=1.
   IF (LI.EC.1) GO TO 806  (J 24)
   IALPHA=10HTRIANGULAR  (J 25)
   GO 808 M2=1,20  (J 26)
808 XLOAD(M2)=RTRIA(M2)  (J 27)
   GO TO 47  (J 28)
806 IALPHA=10H UNIFORM  (J 29)
   DO 809 M2=1,20  (J 30)
809 XLOAD(M2)=RUNIF(M2)  (J 31)
47 WRITE (6,900) SIGMA,IALPHA,ZETA1,ETA1,GAMMA,ALPHA,C  (J 32)
   WRITE (6,210)  (J 33)
   WRITE (6,211)  (J 34)
   WRITE (6,212)  (J 35)
   WRITE (6,213)  (J 36)
   WRITE (6,214)  (J 37)
   WRITE (6,215)  (J 38)
   WRITE (6,216)  (J 39)
   WRITE (6,217)  (J 40)
   WRITE (6,218)  (J 41)
   IF (SIGMA.NE.0.) GO TO 803  (J 42)
   WRITE (6,903)  (J 43)
   GO TO 1  (J 44)
803 IALPHA=ALPHA*RAD  (J 45)
   M1=0  (J 46)
Appendix J – Concluded

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FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLT4S WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THEREFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES FOR THE ROTOR, ON THE FIRST CARD, ARE

- **LI**: LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION
- **ZETA1**: SEMIHEIGHT OF TUNNEL CIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
- **ETA1**: DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
- **GAMMA**: WIDTH-HEIGHT RATIO OF WIND TUNNEL
- **SIGMAR**: RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
- **ALPHA1**: ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, ON THE SECOND CARD, ARE

- **SIGMAT**: RATIO OF TAIL SPAN TO TUNNEL WIDTH
- **TL**: TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
- **TH**: TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
- **ALPHA2**: ANGLE OF ATTACK OF BODY CARRYING TAIL, DEG

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS. THE PROGRAM OF
APPENDIX D CAN BE USED FOR SUCH CASES SINCE THE REPRESENTATION OF THE LIFTING SYSTEMS ARE IDENTICAL WHEN THE SPAN IS VANISHINGLY SMALL.

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
COMMON ZETA,ETA,GAMMA, XOHER,YOHER, ZOHER,DELTA(28)
DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20),C(8)
DATA (C(I),I=1,8)/2C.,3C.,40.,50.,60.,70.,80.,90. /
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/
DATA (RTRI(A)(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/
RAD=0.0174532925199
PI=3.14159265358579

PSI(1)=(PI/4.)
PSI(2)=3.*PSI(1)
PSI(3)=5.*PSI(1)
PSI(4)=7.*PSI(1)
PSI(5)=PSI(13)=(PI/8.)
PSI(6)=PSI(14)=3.*PSI(5)
PSI(7)=PSI(15)=5.*PSI(5)
PSI(8)=PSI(16)=7.*PSI(5)
PSI(9)=PSI(17)=9.*PSI(5)
PSI(10)=PSI(18)=11.*PSI(5)
PSI(11)=PSI(19)=13.*PSI(5)
PSI(12)=PSI(20)=15.*PSI(5)
DO 803 L1=1,28
803 XDELTA(L1)=0.
1 READ (5,9CC) LI,ZETA1,ETA1,GAMMA,SIGMAR,ALPHA1,SIGMAT,TL,TH,
1 ALPHA2
1 IF (EOF,5) 999,47
47 SUML=0.0125
1 IF (LI.EQ.1) GO TO 804
1 IALPHA=10HTRIANGULAR
1 DO 808 M2=1,20
808 XLOAD(M2)=RTRIA(M2)
1 GO TO 48
1 DO 809 M2=1,20
809 XLOAD(M2)=RUNIF(M2)
1 GO TO 48
1 WRITE (6,901) IALPHA,ZETA1,SIGMAR,TL,ALPHA1,ETA1,SIGMAT,TH,
1 ALPHA2,GAMMA
1 WRITE (6,213)
1 WRITE (6,211)
1 WRITE (6,212)
1 WRITE (6,213)
1 WRITE (6,214)
1 WRITE (6,215)
1 WRITE (6,216)
1 WRITE (6,217)
1 WRITE (6,218)
1 IF (SIGMAR.YE.0.) GO TO 800
1 WRITE (6,101)
1 GO TO 1
1 800 ALPHA1 =ALPHA1*RAD
1 ALPHA2=ALPHA2*RAD
1 DO 41 K=1,8
1 IF (SIGMAT.YE.0.) GO TO 811
1 N6=M6=M7=1
1 N7=20
1 N7=20
1 CON1=4.
1 GO TO 812
1 811 IF (ETA1.NE.1.) GO TO 813

38
811 IF (ETA1 .NE. 1.) GO TO 813
N6=M6=1
M7=2
N7=20
CONST1=2.
GO TO 812
813 M6=N6=1
M7=4
N7=20
CONST1=2.
GO TO 812
812 DO 801 M1=M6,M7
DO 802 N1=N6,N7
ETA=ETA1- (XL2AD(N1)*SIGMAR*SIN(PSI(N1)))
ZETA=1./((1./ZETA1)-XLOAD(N1)*SIGMAR*GAMMA*SIN(ALPH1)*COS(PSI(N1)) 1)
XOVERH=SIGMAR*GAMMA* ( (TH*COS(ALPH2))+ (TL* SIN(ALPH2)) - (XLOAD(N1)*CO
IS(ALPH1)*COS(PSI(N1))))
XM=FLOAT(M1)
YOVERH=SIGMAR*GAMMA* ( (2.*XM1-5.)/4.)*(SIGMAT/SIGMAR) - (XLOAD(N1)*
15N(Psi(N1))))
ZOVERH=SIGMAR*GAMMA* ( (TH*SIN(ALPH2)) - (TL* SIN(ALPH2)) + (XLOAD(N1)*S
IN(ALPH1)*COS(PSI(N1))))
CALL DLTAS (C(K))

****************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ******************
DC 805 L1=1,28
805 XDELTA(L1)=XDELTA(L1)*DELTAL(L1)
802 CONTINUE
801 CONTINUE
807 DELTAL(3)=XDELTA(L3)*SUML*CONST1
WRITE (6,149) C(K)
WRITE (6,150) (DELTAL(I),I=1,25,4)
WRITE (6,151) (DELTAL(I),I=2,26,4)
WRITE (6,152) (DELTAL(I),I=3,27,4)
WRITE (6,153) (DELTAL(I),I=4,28,4)
DO 814 L4=1,28
814 XDELTA(L4)=0.
GO TO 1
CONTINUE
GO TO 1
101 FORMAT (//40X*SIGMA(ROTOR) EQUALS ZERO --- USE BASIC PROGRAM*)
149 FORMAT (//5X*CHI = *F5.2/)
150 FORMAT (3XH(S,W,L17(F17.4))
151 FORMAT (3XH(S,W,D17(F17.4))
152 FORMAT (3XH(S,W,D17(F17.4))
153 FORMAT (3XH(S,W,D17(F17.4))
210 FORMAT (1X131(1H-1))
211 FORMAT (1X1HIIIX1HII31X61HCORRECTION FACTORS FOR CORRECTING FROM A
1WIND TUNNEL WHICH IS25X1HI)
212 FORMAT (1X1HI11X1HI112X61H16XHCLOSED5XH15X6HCLOSED4X1HI)
213 FORMAT (1X1HI11X1HI116X1HI5X6HCLOSED5XHI16X1HI2X12HCLOSED FLOOR2X1
1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)
214 FORMAT (1X1HI12XHDELTA3XH15X6XHCLOSED5XH14X9H0N BOTTOM3XH16X4H0P
1EN6X1HI6X4HONLY6XH15X5HFLR6XHI5X6HCLOSED5XH13X90N BOTTOM3XH1
21)
215 FORMAT (1X1HI11X1HI116X1HI6X4ONLY6X1HI16X1HI8H(GROUND EFFECT) 16X4H
1ONLY6X1HI16X1HI6X4HONLY5X1HI)
216 FORMAT (1X1HI11X1HI84(1-1)HI32(1H-1HI)
217 FORMAT (1X1HI11X1HI36X1HI-TO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1
1HI)
218 FORMAT (1X131(1H-1))
900 FORMAT (11,F9.3,4F10.3/4F10.3)
39
Appendix K – Concluded

901 FORMAT (1H1//38X*AVerAGE INTERFERENCE OVER TAIL BEHIND FINITE-SPA (K 118)
900 FORMAT (11,F9.3,4F10.3/4F10.3) (K 119)
901 FORMAT (1H1//38X*AVerAGE INTERFERENCE OVER TAIL BEHIND FINITE-SPA (K 120)
   IN Rotor/*//56X*.1O,* LOADING/*//15X*ZETA =*F6.3,9X*SIGMA(ROTOR) =* (K 121)
2F6.3,9X*TAIL LENGTH/R =*F6.3,9X*ALPHA(ROTOR) =*F7.3//15X*ETA =* (K 122)
3F6.3,9X*SIGMA(TAIL) =*F6.3,9X*TAIL HEIGHT/R =*F6.3,9X*ALPHA(BODY) (K 123)
4 =*F7.3//58X*GAMMA =*F7.3// (K 124)
999 STOP (K 125)
END (K 126)
FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER TANDEM ROTORS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6600 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX O.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE FRONT ROTOR. THE DIAMETERS AND LOAD DISTRIBUTIONS OF THE TWO ROTORS ARE ASSUMED TO BE IDENTICAL. THE REQUIRED INPUT VARIABLES FOR THE FRONT ROTOR, ON THE FIRST CARD, ARE

LI LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
BETA SIDE-SLIP ANGLE, DEG
ALPHAF ANGLE OF ATTACK OF TIP-PATH PLANE OF FRONT ROTOR, DEG
ALPHAB ANGLE OF ATTACK OF BODY CARRYING REAR ROTOR, DEG

THE REQUIRED INPUT VARIABLES FOR THE REAR ROTOR, ON THE SECOND CARD, ARE

LRR DISTANCE OF REAR ROTOR BEHIND ORIGIN AT ALPHAB = 0, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
FRR HEIGHT OF REAR ROTOR ABOVE ORIGIN AT ALPHAB = 0, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
ALPHAR ANGLE OF ATTACK OF TIP-PATH PLANE OF REAR ROTOR, DEG

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT EACH ROTOR DUE TO
ITS OWN PRESENCE AND THE INTERFERENCE AT EACH ROTOR DUE TO THE PRESENCE OF THE
OTHER ROTOR. IN THE LIMIT, WHEN SIGMA IS ZERO, THE TWO ROTORS ARE COINCIDENT,
ALL FOUR INTERFENCES ARE IDENTICAL, AND ONLY ONE SET OF INTERFERENCES IS CAL-
CULATED.

PROGRAM WINDTUN (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT) (L 1)
COMMON ZETA,ETA,GAMMA,THETAH,YOTHERH,YOTHERH,DIVERH,DELTA(28) (L 2)
DIMENSION XDELTA(28),PSI(29),XLOAD(29),RUNIF(29),RTRIA(29),C(8) (L 3)
REAL LRR (L 4)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/ (L 5)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9267/ (L 6)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90. / (L 7)
PI=3.14159265358979 (L 8)
RAD=0.0174532925199 (L 9)
CO 803 L1=1,20 (L 10)
803 XDELTA(I)=0. (L 11)
PSI(1)=4PI/4.) (L 12)
PSI(2)=3.*PSI(1) (L 13)
PSI(3)=5.*PSI(1) (L 14)
PSI(4)=7.*PSI(1) (L 15)
PSI(5)=PSI(13)=(PI/8.) (L 16)
PSI(6)=PSI(14)=3.*PSI(5) (L 17)
PSI(7)=PSI(15)=5.*PSI(5) (L 18)
PSI(8)=PSI(16)=7.*PSI(5) (L 19)
PSI(9)=PSI(17)=9.*PSI(5) (L 20)
PSI(10)=PSI(18)=11.*PSI(5) (L 21)
PSI(11)=PSI(19)=13.*PSI(5) (L 22)
PSI(12)=PSI(20)=15.*PSI(5) (L 23)
1 READ (5,900) LI,ZETA,ETA,GAMMA,SIGMA,BETA,ALPHAF,ALPHAB, (L 24)
1 LRR,HRR,ALPHAR (L 25)
IF (EOF,5) 999,47 (L 26)
47 AALPF=ALPHAF (L 27)
AALPR=ALPHAR (L 28)
AALPB=ALPHAB (L 29)
ABETA=BETA (L 30)
ALPHAF=ALPHAF*RAD (L 31)
ALPHAR=ALPHAR*RAD (L 32)
ALPHAB=ALPHAB*RAD (L 33)
BETA=BETA*RAD (L 34)
WRITE (6,100) (L 35)
SUML=.0025 (L 36)
IF (LI.EC.1) GO TO 804 (L 37)
IALPHA=10*HTRIANGULAR (L 38)
DO 808 M2=1,20 (L 39)
808 XLOAD(M2)=RTRIA(M2) (L 40)
GO TO 160 (L 41)
804 IALPHA=10*HUNIFOR (L 42)
DO 809 M2=1,20 (L 43)
809 XLOAD(M2)=RUNIF(M2) (L 44)
160 NROT=4 (L 45)
IF (SIGMA.EQ.0.) NROT=1 (L 46)
DO 42 IRTR=1,NROT (L 47)
WRITE (6,701) (L 48)
GO TO (601,602,603,604), IRTR (L 49)
601 IF (SIGMA.EQ.0.) WRITE (6,707) (L 50)
IF (SIGMA.EQ.0.) GO TO 610 (L 51)
WRITE (6,702) (L 52)
GO TO 610 (L 53)
602 WRITE (6,703) (L 54)
GO TO 610 (L 55)
Appendix L – Continued

603 WRITE (6,704)  
GO TO 610  
604 WRITE (6,705)  
610 WRITE (6,706) IALPHA,GAMMA,SIGMA,LRR,ALPHAF,AALPH,BETA,ZETA1,ETA1,  
1 HRR,ALPR,ABETA  
WRITE (6,210)  
WRITE (6,211)  
WRITE (6,212)  
WRITE (6,213)  
WRITE (6,214)  
WRITE (6,215)  
WRITE (6,216)  
WRITE (6,217)  
WRITE (6,218)  
GO 41 K=1,8  
MT=N7=20  
IF (SIGMA.NE.O.) GO TO 815  
MT=N7=1  
CONST1=400.  
GO TO 812  
815 IF (ETA1.NE.1...) OR (ABETA.NE.0.) GO TO 813  
CONST1=2.  
GO TO 812  
813 CONST1=1.  
812 GO 801 M1=1,M7  
GO 802 N1=1,N7  
IF (ETA1.NE.1... OR ABETA.NE.0.) GO TO 811  
IF (PSI(N1).GT.PI) GO TO 802  
811 GO TO (621,622,623,624), IRTR  
621 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1)))*COS(BETA)+  
1 COS(PSI(N1))*COS(ALPHAF)*SIN(BETA))  
ZETA=ZETA1/(1.0-XLOAD(N1))*SIGMA*GAMMA*ZETA1*COS(PSI(N1))  
1 *SIN(ALPHAF))  
XOVERH=SIGMA*GAMMA*(XLOAD(N1)*COS(PSI(N1)))*COS(ALPHAF)*COS(BETA)  
1 -SIN(PSI(N1))*SIN(BETA))-XLOAD(N1)*COS(PSI(N1))*COS(ALPHAF)  
2 *COS(BETA)-SIN(PSI(N1))*SIN(BETA)))  
YOVERH=SIGMA*GAMMA*(XLOAD(N1)*SIN(PSI(N1)))*COS(BETA)+COS(PSI(N1))  
1 *(ALPHAF)*SIN(BETA))+XLOAD(N1)*SIN(PSI(N1))  
2 COS(ETA1-COS(ALPHAF)*SIN(BETA)))  
ZOVERH=-SIGMA*GAMMA*(SIN(ALPHAF))*(XLOAD(N1)*COS(PSI(N1)))-  
1 XLOAD(N1)*COS(PSI(N1)))  
GO TO 630  
622 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1)))*COS(BETA)+COS(PSI(N1))*  
1 COS(ALPHAF)*SIN(BETA))-SIGMA* SIN(BETA)*(LRR*COS(ALPHAF)+  
2 HRR*SIN(ALPHAF))  
ZETA=ZETA1/(1.0-XLOAD(N1))*SIGMA*GAMMA*ZETA1*XLOAD(N1)*COS(PSI(N1))*  
1 SIGMA*ALPHAF)+LRR*SIN(ALPHAF)-HRR*COS(ALPHAF))  
XOVERH=SIGMA*GAMMA*(XLOAD(N1)*COS(PSI(N1)))*COS(ALPHAF)+COS(PSI(N1))  
1 (BETA)-SIN(PSI(N1))*SIN(BETA))-XLOAD(N1)*COS(PSI(N1))  
2 COS(ALPHAF)*SIN(BETA)-SIN(PSI(N1))*SIN(BETA))-COS(BETA)*  
3 (LRR*COS(ALPHAF)-HRR*SIN(ALPHAF))  
YOVERH=SIGMA*GAMMA*(XLOAD(N1)*SIN(PSI(N1)))*COS(BETA)+  
1 COS(PSI(N1))*COS(ALPHAF)*SIN(BETA))-XLOAD(N1)*SIN(PSI(N1))  
2 *COS(BETA)+COS(PSI(N1))*COS(ALPHAF)+SIN(BETA))-  
3 LRR*COS(ALPHAF)-HRR*SIN(ALPHAF))  
ZOVERH=-SIGMA*GAMMA*(XLOAD(N1)*COS(PSI(N1)))*SIN(ALPHAF)-  
1 XLOAD(N1)*COS(PSI(N1))*SIN(ALPHAF)-LRR*SIN(ALPHAF)+  
2 HRR*COS(ALPHAF))  
GO TO 630  
623 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1)))*COS(BETA)+COS(PSI(N1))  
1 *COS(ALPHAF)*SIN(BETA))-SIGMA*SIN(BETA)*(LRR*COS(ALPHAF)
Appendix L – Continued

2 +HRR*SIN(ALPHAB))
ZETA=ZETAI/(1.0-SIGMA*GAMMA*ZETAI*(XLOAD(N1)*COS(Psi(N1))*SIN
(1 (ALPHAB)+LRR*SIN(ALPHAB)-(HRR*COS(ALPHAB)))
XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(Psi(M1))*COS(ALPHAB)*COS
1 (BETA)-SIN(Psi(M1))*SIN(BETA))=XLOAD(N1)*(COS(Psi(N1)))*
2 COS(ALPHA)*COS(BETA)-SIN(Psi(N1))*SIN(BETA)))
YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(Psi(M1))*COS(BETA)*COS
1 (Psi(M1))*COS(ALPHAB)*SIN(BETA))-XLOAD(N1)*(SIN(Psi(N1)))*
2 *COS(BETA)*COS(Psi(N1))*COS(ALPHAB)*SIN(BETA))
ZOVERH=-SIGMA*GAMMA*SIGM41*ALPHAB)*SIN(ALPHAB)*XLOAD(M1)*COS(Psi(M1))-
1 XLOAD(N1)*COS(Psi(N1))
GO TO 630

624 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(Psi(N1))*COS(BETA)*COS(Psi(N1)))*
1 COS(ALPHAB)*SIN(BETA))
ZETA=ZETAI/(1.0-XLOAD(N1)*SIGMA*GAMMA*ZETAI*COS(Psi(N1)))*
1 SIN(ALPHAB))
XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(Psi(M1))*COS(ALPHAB)*COS
1 (BETA)-SIN(Psi(M1))*SIN(BETA))*COS(BETA)*LRR*COS(ALPHAB)
2 +HRR*SIN(ALPHAB))-XLOAD(N1)*(COS(Psi(N1))*COS(ALPHAB)*
3 COS(Psi(N1))*COS(ALPHAB)))
YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(Psi(M1))*COS(BETA)*COS(Psi
1 (M1))*COS(ALPHAB)*SIN(BETA))+SIN(BETA)*(LRR*COS(ALPHAB)+
2 HRR*SIN(ALPHAB))-XLOAD(N1)*(SIN(Psi(N1))*COS(BETA))
3 COS(Psi(N1))*COS(ALPHAB)*SIN(BETA))
ZOVERH=-SIGMA*GAMMA*(XLOAD(M1)*COS(Psi(M1)))*SIN(ALPHAB)+
1 LRR*SIN(ALPHAB)+HRR*COS(ALPHAB)-XLOAD(N1)*COS(Psi(N1)))*
2 SIN(ALPHAB)

630 CALL DLTAS (CTK))

*************** SEE APPENDIX Q FOR SUBROUTINE DLTAS ***************

DO 805 L1=1,28
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)
802 CONTINUE
801 CONTINUE
DO 807 L3=1,28
807 DELTA(L3)=SUML*CONST1
DO 500 LL=1,28
500 DELTA(LL)=DELTA(LL)*PI*(SIGMA**2)*GAMMA/4.0
WRITE (6,149) CIK
WRITE (6,150) (DELTA(I),I=1,25,4)
WRITE (6,151) (DELTA(I),I=2,26,4)
WRITE (6,152) (DELTA(I),I=3,27,4)
WRITE (6,153) (DELTA(I),I=4,28,4)
DO 814 L4=1,28
814 XDELTA(L4)=0.
41 CONTINUE
42 CONTINUE
GO TO 1

100 FORMAT (1H1////////////59X*START NEW CASE*)
149 FORMAT (1X*CHI = F7.3/)
150 FORMAT (3X5H(I,W,L,7)*(F17.4))
151 FORMAT (3X5H(I,W,L,7)*(F17.4))
152 FORMAT (3X5H(W,D,7)*(F17.4))
153 FORMAT (3X5H(W,D,7)*(F17.4))
210 FORMAT (1X13(1H-1))
211 FORMAT (1X1H11*1X1H13*1X6H1C3ORRECTION FACTORS FOR CORRECTING FROM A
1WIND TUNNEL WHICH IS25X1H1)
1WIND TUNNEL WHICH IS25X1H1)
212 FORMAT (1X1H111*1X1H171*1H1=1H1)
213 FORMAT (1X1H111*1X1H171*1X1H15X6HCLOSED5X1H16X1H212X6HCLOSED FLOOR2X1
1H16X6HOPEN6X1H16X1H5X6HCLOSED4X1)
214 FORMAT (1X1H13X5H0DELA3X1H15X6HCLOSED5X1H14X9HON BOTTOM3X1H16X4HOP
1EN6X1H6X4HONLY6X1H15X5HFLOOR6X1H15X6HCLOSED5X1H13X9HON BOTTOM3X1H1)

44
Appendix L – Concluded

21) (L 177)

215 FORMAT (1X1H111X1H116X1H16X4HONLY6X1H16X18H1GROUNDF EFFECT) 16X4H (L 178)
1ONLY6X1H116X1H16X4HONLY5X1H1 (L 179)

216 FORMAT (1X1H111X1H184(1H-)1HI32|1H-1HI) (L 180)

217 FORMAT (1X1H111X1H136X11HTO FREE AIR37X1H18X16HTC GROUND EFFECT8X1
1HI) (L 181)

218 FORMAT (1X131(1H-1/) (L 182)

701 FORMAT (1H1//41X*AVGAM WIND-TUNNEL INTERFERENCE OVER TANDEM ROTO (L 184)
1RS*//) (L 185)

702 FORMAT (49X*EFFECT OF FRONT ROTOR ON FRONT ROTOR*//) (L 186)

703 FORMAT (49X*EFFECT OF REAR ROTOR ON FRONT ROTOR*//) (L 187)

704 FORMAT (48X*EFFECT OF REAR ROTOR ON REAR ROTOR*//) (L 188)

705 FORMAT (49X*EFFECT OF FRONT ROTOR ON REAR ROTOR*//) (L 189)

706 FORMAT (58XA10* LOADING*/6X*GAMMA =*F7.3,10X*SIGMA =*F6.3,
110X*L(RR)/R =*F6.3,10X*ALPHA(FR) =*F8.3,10X*ALPHA(BODY) =*
2F8.3/6X*ZETA =*F7.3,10X*ETA =*F6.3,10X*H(RR)/R =*F6.3,
310X*ALPHA(RR) =*F8.3,14X*ETA =*F8.3/* (L 190)

707 FORMAT (26X*FOR SIGMA = 0, THE EFFECTS OF THE FRONT ROTOR ON THE F
1RGNT ROTOR, THE REAR ROTOR*/26X*ON THE FRONT ROTOR, THE REAR ROTOR (L 195)
2 ON THE REAR ROTOR, AND THE FRONT ROTOR ON THE*/39X*REAR ROTOR ARE (L 196)
3 ALL IDENTICAL, AND ARE GIVEN AS FOLLOWS,*//) (L 197)

900 FORMAT (I1,F9.3,6F10.3/3F10.3) (L 198)

999 STOP (L 199)

END (L 200)
APPENDIX M

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER UNLOADED-ROTOR CONFIGURATIONS

This program was written in CDC FORTRAN, Version 2.1, to run on CDC 6600 series computers with the SCOPE 3.0 operating system and library tape. Minor modifications may be required prior to use in other computers. This program has been found to be satisfactory on the aforementioned computers which carry the equivalent of approximately 15 decimal digits. Computers of lesser precision may require modification to double precision in order to obtain results of equal accuracy.

This program requires the use of subroutine DLTAS which is given in Appendix Q.

Input will be found at address 1 (two cards per case) in format 909. Note that the reference origin is chosen to be at the center of the rotor. The required input variables for the rotor, on the first card, are:

- **LIR** rotor disk-load-distribution indicator, LIR = 1 for uniform loading, LIR = 2 for triangular loading
- **ZETA1** semiheight of tunnel divided by height of origin above floor
- **ETA1** distance from origin to right-hand wall divided by tunnel seminormal
- **GAMMA** width-height ratio of wind tunnel
- **SIGMAR** ratio of rotor diameter to tunnel width
- **ALPHAR** angle of attack of rotor tip-path plane, deg

The required input variables for the wing, given on the second card, are:

- **LIW** wing span-load-distribution indicator, LIW = 1 for uniform loading, LIW = 2 for elliptic loading
- **LW** distance of wing apex behind origin, nondimensionalized with respect to rotor radius
- **HW** distance of wing apex above origin, nondimensionalized with respect to rotor radius
- **SIGMAW** ratio of wing span to tunnel width
- **LAMBDA** wing sweep angle, deg
- **ALPHAB** angle of attack of body carrying wing and tail, deg
THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS.

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE ON THE WING AND ROTOR DUE TO THEIR OWN PRESENCE, AS WELL AS THE INTERFERENCE ON EACH DUE TO THE PRESENCE OF THE OTHER.

PROGRAM WINDTUN1 INPUT=INPUT, OUTPUT=TAPE5=INPUT, TAPE6=OUTPUT

COMMON ZETA, ETA, GAMMA, XOVERH, YOVERH, ZOVERH, DELTA(28)
DIMENSION XDELTA(28), PSI(20), RLOAD(20), RUNIF(20), RTRIA(20),
1 XLE(10), XLOAD(20), C(18)

REAL LAMDA, LW

DATA (RUNIF(11), I=1,20)/4.0, 2981.80, 6255.80, 8921/

DATA (RTRIA(1), I=1,20)/4.0, 4438.60, 7298.80, 9262/

DATA (C(I)), I=1,8)/20, .30, .40, .50, .60, .70, .80, .90,

PI=3.14159265358979

RAD=0.0174532925199

DO 803 L1=1,28

803 XDELTA(11)=0.

PSI(1)=PI/4.

PSI(2)=3.0*PSI(1)

PSI(3)=5.0*PSI(1)

PSI(4)=7.0*PSI(1)

PSI(5)=PSI(13) =PI/8.

PSI(6)=PSI(14) =3.0*PSI(5)

PSI(7)=PSI(15) =5.0*PSI(5)

PSI(8)=PSI(16) =7.0*PSI(5)

PSI(9)=PSI(17) =9.0*PSI(5)

PSI(10)=PSI(18) =11.0*PSI(5)

PSI(11)=PSI(19) =13.0*PSI(5)

PSI(12)=PSI(20) =15.0*PSI(5)

XLE(1)=XLE(10)=0.43579

XLE(2)=XLE(9) =0.71422

XLE(3)=XLE(8) =C.86603

XLE(4)=XLE(7) =C.9534

XLE(5)=XLE(6) =0.99499

1 READ (5,500) L1, ZETAI, ETAI, GAMMA, SIGMAI, ALPHARI, LIW, LW, HW,

1 SIGMA, LAMDA, ALPHAB

IF (EOF, 5) 999, 47

47 AALPR=ALPHAR

AAIPB=ALPHAB

ALAM=LAMBA

LAMDA=LAMDA*RAD

ALPHAR=ALPHAB*RAD

ALPHAB=ALPHAB*RAD

WRITE (6,100)

IF (LIR.EQ.1) GO TO 804

I ALPHAR=10HTRIANGULAR

DO 808 M2=1,20

808 RLOAD(M2)=RTRIA(M2)

GO TO 806

804 I ALPHAR=10HUNIFORM

DO 809 M2=1,20

809 RLOAD(M2)=RTRIA(M2)

806 IF (LIW.EQ.1) GO TO 852

I BETA=8*ELLIPIC

DO 851 M3=1,10

851 XLOAD(M3)=XLE(M3)
Appendix M – Continued

GO TO 850
852 IBETA=8 HUNIFORM
GO 853 M3=1,10
853 XLOAD(M3)=1.0
850 IF (SIGMAR.NE.0.) GO TO 855
   WRITE (6,701) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
   HW,4ALPB,GAMMA,ALAM
   WRITE (6,210)   WRITE (6,211)   WRITE (6,212)   WRITE (6,213)   WRITE (6,214)   WRITE (6,215)   WRITE (6,216)   WRITE (6,217)   WRITE (6,218)   WRITE (6,707)
GO TO 1
855 DO 42 IELEM=1,4
   WRITE (6,701)   GO TO (601,602,603,604), IELEM
601 WRITE (6,702) GC TO 610
602 WRITE (6,703) GC TO 610
603 WRITE (6,704) GC TO 610
604 WRITE (6,705)   WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,
   HW,4ALPB,GAMMA,ALAM
   WRITE (6,210)   WRITE (6,211)   WRITE (6,212)   WRITE (6,213)   WRITE (6,214)   WRITE (6,215)   WRITE (6,216)   WRITE (6,217)   WRITE (6,218)   WRITE (6,707)
   GO 41 K=1,8
   M7=N7=20
   GO TO (611,612,613,614), IELEM
C  RCTOR ON R3TOR
C  611 SUML=0.0025
   IF (ETA1.EQ.1.) SUML=0.005
   GO TO 812
C  612 SUML=0.0063052
   IF (SIGMAW.EQ.0.) GO TO 615
   IF (L1W.EQ.1) SUML=0.005
   N7=10
   IF (ETA1.NE.1.) GO TO 812
   SUML=0.0126104
   IF (L1W.EQ.1) SUML=0.010
   N7=5
   GO TO 812
Appendix M – Continued

615 \text{SUML} = 0.05 \\
N7 = 1 \\
XLOAD(1) = 1.0 \\
\text{IF} (\text{ETA1} = 1.0) \text{ SUML} = 0.10 \\
\text{GO TO 812} \\
C \\
C \text{ WING ON WING} \\
C \\
613 \text{SUML} = 0.0126104 \\
\text{IF} (\text{SIGMAW} = 0.0) \text{ GO TO 616} \\
\text{IF} (\text{L1W} = 1.0) \text{ SUML} = 0.010 \\
M7 = 10 \\
N7 = 10 \\
\text{IF} (\text{ETA1} = 1.0) \text{ GO TO 812} \\
\text{SUML} = 0.0252208 \\
\text{IF} (\text{L1W} = 1.0) \text{ SUML} = 0.020 \\
N7 = 5 \\
\text{GO TO 812} \\
616 \text{SUML} = 1.0 \\
XLOAD(1) = 1.0 \\
M7 = N7 = 1 \\
\text{GO TO 812} \\
C \\
C \text{ ROTOR ON WING} \\
C \\
614 \text{SUML} = 0.0050 \\
\text{IF} (\text{ETA1} = 1.0) \text{ SUML} = 0.010 \\
M7 = 10 \\
\text{IF} (\text{SIGMAW} = 0.0) \text{ GO TO 812} \\
M7 = 1 \\
\text{SUML} = 0.05 \\
\text{IF} (\text{ETA1} = 1.0) \text{ SUML} = 0.10 \\
812 \text{ DO 801 M1 = 1, M7} \\
\text{DO 802 N1 = 1, N7} \\
XSTAR(11) = (1.2 \times \text{FLOAT}(11)) / 10. \\
YSTAR(11) = (1.2 \times \text{FLOAT}(11)) / 10. \\
811 \text{GO TO (621, 622, 623, 624), IELEM} \\
C \\
C \text{ WING ON ROTOR} \\
C \\
621 \text{IF} (\text{ETA1} = 1.0) \text{ GO TO 625} \\
\text{IF} (\text{PSI}(11) = \text{PI}) \text{ GO TO 802} \\
625 \text{ETA} = \text{ETA1} - \text{LOAD(N1)} \times \text{SIGMA} \times \text{SIN(Psi(N1))} \\
\text{ZETA} = \text{ZETA1} / (1.0 - \text{LOAD(N1)} \times \text{SIGMA} \times \text{Gamma} \times \text{ZETA1} \times \text{COS(Psi(N1))}) \\
1 \times \text{TAN} (\text{ALPHA}) \\
XOVER = \text{SIGMA} \times \text{Gamma} \times \text{COS(ALPHA1)} \times (\text{LOAD(N1)} \times \text{COS(Psi(N1))}) \\
1 - \text{LOAD(N1)} \times \text{COS(Psi(N1))} \\
YOVER = \text{SIGMA} \times \text{Gamma} \times (\text{LOAD(M1)} \times \text{SIN(Psi(M1)}) - \text{LOAD(N1)} \times \text{SIN(Psi(N1))}) \\
1 \times \text{TAN} (\text{ALPHA}) \\
XLOAD(N1) = 1.0 \\
\text{GO TO 630} \\
C \\
C \text{ WING ON WING} \\
C \\
622 \text{IF} (\text{ETA1} = 1.0) \text{ OR} (\text{SIGMAW} = 0.0) \text{ G3 TO 627} \\
\text{IF} (\text{PSI}(11) = \text{PI}) \text{ GO TO 802} \\
627 \text{ETA} = \text{ETA1} - \text{YSTAR} \times \text{SIGMA} \\
\text{ZETA} = \text{ZETA1} / (1.0 - \text{SIGMA} \times \text{Gamma} \times \text{ZETA1} \times \text{ABS(YSTAR)} \times (\text{SIGMAW} / \text{SIGMA}) \\
1 \times \text{TAN} (\text{LAMDBA}) \times \text{SIN(ALPHA)} \times \text{LW} \times \text{SIN(ALPHA)} - \text{HW} \times \text{COS(ALPHA)}) \\
\text{(M 113)} \\
\text{(M 114)} \\
\text{(M 115)} \\
\text{(M 116)} \\
\text{(M 117)} \\
\text{(M 118)} \\
\text{(M 119)} \\
\text{(M 120)} \\
\text{(M 121)} \\
\text{(M 122)} \\
\text{(M 123)} \\
\text{(M 124)} \\
\text{(M 125)} \\
\text{(M 126)} \\
\text{(M 127)} \\
\text{(M 128)} \\
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\text{(M 137)} \\
\text{(M 138)} \\
\text{(M 139)} \\
\text{(M 140)} \\
\text{(M 141)} \\
\text{(M 142)} \\
\text{(M 143)} \\
\text{(M 144)} \\
\text{(M 145)} \\
\text{(M 146)} \\
\text{(M 147)} \\
\text{(M 148)} \\
\text{(M 149)} \\
\text{(M 150)} \\
\text{(M 151)} \\
\text{(M 152)} \\
\text{(M 153)} \\
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\text{(M 155)} \\
\text{(M 156)} \\
\text{(M 157)} \\
\text{(M 158)} \\
\text{(M 159)} \\
\text{(M 160)} \\
\text{(M 161)} \\
\text{(M 162)} \\
\text{(M 163)} \\
\text{(M 164)} \\
\text{(M 165)} \\
\text{(M 166)} \\
\text{(M 167)} \\
\text{(M 168)} \\
\text{(M 169)} \\
\text{(M 170)} \\
\text{(M 171)} \\
\text{(M 172)} \\
\text{(M 173)}
XCOVERH = SIGMAR * GAMMA * (RLOAD(M1) * COS(ALPHAB) * COS(PSI(M1)))
1 - ABS(YSTAR) * SIGMAW * SIGMAR * TAN(LAMBDA) * COS(ALPHAB) (M 174)
2 - LW * COS(ALPHAB) - HW * SIN(ALPHAB) (M 175)
YCOVERH = SIGMAR * GAMMA * (RLOAD(M1) * SIN(PSI(M1)) - YSTAR) * (SIGMAW / SIGMAR) (M 176)
ZOVERH = - SIGMAR * GAMMA * RLOAD(M1) * SIN(ALPHAB) * COS(PSI(M1)) (M 177)
1 - ABS(YSTAR) * SIGMAW / SIGMAR * TAN(LAMBDA) * COS(ALPHAB) (M 178)
GO TO 630 (M 179)

C WING ON WING

623 ETA = ETA1 - SIGMAW * YSTAR
ZETA = ETA1 / (1.0 - SIGMAR * GAMMA * ZETA1 * (ABS(YSTAR) * (SIGMAW / SIGMAR))
1 * TAN(LAMBDA) * SIN(ALPHAB) + LW * SIN(ALPHAB) - HW * COS(ALPHAB)) (M 180)
XCOVERH = SIGMAR * GAMMA * TAN(LAMBDA) * COS(ALPHAB) * (ABS(XSTAR))
1 - ABS(YSTAR)) (M 181)
GO TO 630 (M 182)

C ROTOR ON WING

624 IF (ETA1 .LE. 1.0) GO TO 626
IF (PSI(N1) .GT. PI) GO TO 802 (M 183)
626 ETA = ETA1 - RL3AD(N1) * SIGMAR * SIN(PSI(N1))
ZETA = ETA1 / (1.0 - RLOAD(N1) * SIGMAR * GAMMA * ZETA1 * COS(PSI(N1))
1 * SIN(ALPHAB)) (M 184)
XCOVERH = SIGMAR * GAMMA * (ABS(XSTAR) * SIGMAW / SIGMAR) * TAN(LAMBDA) * COS(ALPHAB)
1 + LW * COS(ALPHAB) + HW * SIN(ALPHAB) - RLOAD(N1) * (M 185)
2 * COS(ALPHAB) * COS(PSI(N1)) (M 186)
YCOVERH = SIGMAR * GAMMA * (XSTAR * SIGMAW / SIGMAR) * TAN(LAMBDA) * (M 187)
ZOVERH = SIGMAR * GAMMA * (ABS(XSTAR) * SIGMAW / SIGMAR) * TAN(LAMBDA) * (M 188)
1 * SIN(ALPHAB) + LW * IN(ALPHAB) - HW * COS(ALPHAB) - RLOAD(N1) * (M 189)
2 * SIN(ALPHAB) * COS(PSI(N1)) (M 190)
XLOAD(N1) = 1.0 (M 191)
630 CALL DLTAS (C(K)) (M 192)

********* SEE APPENDIX Q FOR SUBROUTINE DLTAS ***********
Appendix M – Concluded

210 FORMAT (1X131(1H-))          (M 234)
211 FORMAT (1X1H111X1H131X61HCORRECTION FACTORS FOR CORRECTING FROM A (M 235)
1WIND TUNNEL WHICH IS25X1H1)     (M 236)
212 FORMAT (1X1H111X1H117(1H-1H1) (M 237)
213 FORMAT (1X1H111X1H16X1H15X6HCLOSED5X1H16X1H2X12HCLOSEDFLOOR2X1 (M 238)
1H16X4HOPEN6X1H16X1H15X6HCLOSED4X1H1) (M 239)
214 FORMAT (1X1H13X5MODELTA3X1H15X6HCLOSED5X1H14X9HON BOTTOM3X1H16X4HOP (M 240)
1EN6X1H16X4HONLY6X1H15X5HFLOOR6X1H15X6HCLOSED5X1H13X9HON BOTTOM3X1H1 (M 241)
21) (M 242)
215 FORMAT (1X1H111X1H16X1H16X4HONLY6X1H16X18H(GROUND EFFECT) ISX4H (M 243)
1ONLY6X1H16X1H16X4HONLY5X1H1)     (M 244)
216 FORMAT (1X1H111X1H134(1H-1H132(1H-1H1) (M 245)
217 FORMAT (1X1H111X1H136X1H1TO FREE AIR37X1H18X16HTO GROUND EFFECT8X1 (M 246)
1H1)                              (M 247)
218 FORMAT (1X131(1H-)/)          (M 248)
701 FORMAT (1H1//42X*AVGVERAGE INTERFERENCE OVER AN UNLOADED ROTOR MODEL (M 249)
1*)                                (M 250)
702 FORMAT (54X*EFFECT OF Rotor ON ROTOR*/)                             (M 251)
703 FORMAT (55X*EFFECT OF WING ON ROTOR*/)                              (M 252)
704 FORMAT (55X*EFFECT OF WING ON WING*/)                               (M 253)
705 FORMAT (55X*EFFECT OF ROTOR ON WING*/)                              (M 254)
706 FORMAT (34X,A10* ROTOR LOADING*19X,A8* WING LOADING*/)              (M 255)
   119X*SIGMA(ROTOR) =*F6.3,10X*ZETA =*F6.3,10X*LW/R =*F6.3,13X        (M 256)
   2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING) =*F6.3,10X*ETA =*F6.3,       (M 257)
   310X*HW/R =*F6.3,10X*ALPHA(BODY) =*F7.3//39X*GAMMA =*F6.3,         (M 258)
   427X*LAMBDA =*F7.3//          (M 259)
707 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE (M 260)
1 FOR USE WITH SUCH CASES.*)       (M 261)
900 FORMAT (11,F9.3,4F10.3/11,F9.3,4F10.3)                               (M 262)
999 STOP                                                                    (M 263)
END                                                                       (M 264)
APPENDIX N

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND AN UNLOADED- ROTOR CONFIGURATION

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (THREE CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR, THE REQUIRED INPUT VARIABLES FOR THE ROTOR, ON THE FIRST CARD, ARE

LIR          ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1        SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETAL1        DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
 GAMMA        WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR        RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHAR        ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE

LIW          WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW           DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW           DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW       RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDAA      WING SWEEP ANGLE, DEG
Appendix N — Continued

ALPHAB ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, ON THE THIRD CARD, ARE

SIGMAT RATIO OF TAIL SPAN TO TUNNEL WIDTH

TL TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS

TH TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS.

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT THE TAIL DUE TO THE PRESENCE OF BOTH THE WING AND THE ROTOR.

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT) (N 1)
COMMON ETA, GAMA, XOVERH, YOVERH, ZOVERH, DELTA(28) (N 2)
DIMENSION XDELTA(28), PSI(20), RLOAD(20), RUNIF(20), RTRIA(20), (N 3)
1 XLE(10), XLOAD(20), C(8) (N 4)
REALSELFABX(WL)
DATA (RUNIF(I),I=1,20),/4*0.2981,8*0.6255,8*0.8921/ (N 6)
DATA (RTRIA(I),I=1,20),/4*0.4386,8*0.7296,8*0.9262/ (N 7)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./ (N 8)
PI=3.14159265358979 (N 9)
RAD=0.0174532925199 (N 10)
DO 803 L1=1,28 (N 11)
803 XDELTA(L1)=0. (N 12)
PSI(1)=PI/4. (N 13)
PSI(2)=3.*PSI(1) (N 14)
PSI(3)=5.*PSI(1) (N 15)
PSI(4)=7.*PSI(1) (N 16)
PSI(5)=PSI(13)=(PI/8.) (N 17)
PSI(6)=PSI(16)=3.*PSI(5) (N 18)
PSI(7)=PSI(15)=5.*PSI(5) (N 19)
PSI(8)=PSI(16)=7.*PSI(5) (N 20)
PSI(9)=PSI(17)=9.*PSI(5) (N 21)
PSI(10)=PSI(18)=11.*PSI(5) (N 22)
PSI(11)=PSI(19)=13.*PSI(5) (N 23)
PSI(12)=PSI(20)=15.*PSI(5) (N 24)
XLE(1)=XLE(10)=0.43579 (N 25)
XLE(2)=XLE(9)=0.71422 (N 26)
XLE(3)=XLE(8)=0.86603 (N 27)
XLE(4)=XLE(7)=0.95394 (N 28)
XLE(5)=XLE(6)=0.99499 (N 29)
1 READ (5,900) LIR,ZETA,ETA,GAMA,SIGMA,ALPHAB,LIW, LW,HW, (N 30)
1 SIGMA, LAMBDAB, ALPHAB, SIGMAT, TL, TH (N 31)
IF (EOF(5)) 999,47 (N 32)
47 AALP=ALPHAB (N 33)
 AALPB=AALP (N 34)
 ALAMBDA=LAMBDAB (N 35)
 LAMBDAB=LAMBDAB*RAD (N 36)
 ALPHAB=ALPHAB*RAD (N 37)
ALPHAB=ALPHAB*RAD
WRITE (6,100)
IF (LIR.EQ.1) GO TO 804
IALPHA=10*TRIANGULAR
CC 808 M2=1.20
808 LOAD(M2)=RTRIA(M2)
GO TO 806
804 IALPHA=10*HORIZONTAL
DO 809 M2=1.20
809 LOAD(M2)=RTRIA(M2)
806 IF (LIR.EQ.1) GO TO 852
IBETA=8*ELLPTIC
DO 851 M3=1,10
851 LOAD(M3)=XLE(M3)
GO TO 85C
852 IBETA=8*UNIFORM
DO 853 M3=1,10
853 LOAD(M3)=1.0
850 IF (SIGMAR.NE.0.) GO TO 855
WRITE (6,711)
WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,1
HW,AALPB,SIGMAT,TL,TH,GAMMA,ALAM
WRITE (6,210)
WRITE (6,211)
WRITE (6,212)
WRITE (6,213)
WRITE (6,214)
WRITE (6,215)
WRITE (6,216)
WRITE (6,217)
WRITE (6,218)
WRITE (6,707)
GO TO 1
855 GO 42 IELEM=1,2
WRITE (6,731)
GO TO (601,602), IELEM
601 WRITE (6,702)
GO TO 61C
602 WRITE (6,703)
610 WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,1
HW,AALPB,SIGMAT,TL,TH,GAMMA,ALAM
WRITE (6,210)
WRITE (6,211)
WRITE (6,212)
WRITE (6,213)
WRITE (6,214)
WRITE (6,215)
WRITE (6,216)
WRITE (6,217)
WRITE (6,218)
DO 41 K=1,8
N7=20
M7=4
GO TO (611,613), IELEM
C
C EFFECT OF ROTOR
C
611 SUML=0.0125
IF (ETA1.EQ.1.) SUML=0.025
IF (SIGMAR.NE.0.) GO TO 812
SUML=0.050

Appendix N – Continued

IF (EETA.EQ.1.) SUML=C.100
M7=1
GO TO 812
C
C EFFECT OF WING
C
613 SUML=O.031526
IF (SIGMAW.EQ.O..OR.SIGMAT.EQ.O.) GO TO 616
IF (LIW.EQ.1.) SUML=O.025
M7=4
N7=10
IF (EETA.NE.1.) GO TO 812
SUML=O.063052
IF (LIW.EQ.1.) SUML=O.050
N7=5
GO TO 812
616 IF (SIGMAW.EQ.O..AND.SIGMAT.NE.O.) GO TO 612
IF (SIGMAW.NE.O..AND.SIGMAT.EQ.O.) GO TO 614
SUML=1.0
XLOAD(1)=1.0
M7=N7=1
GO TO 812
612 SUML=O.25
M7=4
N7=1
XLOAD(1)=1.0
IF (EETA.NE.1.) GO TO 812
M7=2
SUML=O.50
GO TO 812
614 SUML=O.126104
IF (LIW.EQ.1.) SUML=O.100
N7=10
M7=1
IF (EETA.NE.1.) GO TO 812
SUML=O.25208
IF (LIW.EQ.1.) SUML=O.200
N7=5
812 DO 801 ML=1,M7
GO 802 NL=1,N7
XSTAR= (11..-2.*FLOAT(ML))/10.*
YSTAR= (11..-2.*FLOAT(NL))/10.*
GO TO (621~622) IELEM
C
C EFFECT OF ROTOR
C
621 ETA=EETA-RLJAD(N1)*SIGMAR*SIN(PSI(N1))
ZETA=ZETA1/(1.0-XLOAD(N1))*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))*
1 SIN(ALPHAR))
XOVERH=SIGMAR*GAMMA*(TL*COS(ALPHAB)+TH*SIN(ALPHAB)-RLOAD(N1)*
1 COS(ALPHAR)*COS(PSI(N1)))
YOVERH=SIGMAR*GAMMA*(O.25*(5.0-2.*FLOAT(M1))*SIGMAT/SIGMAR-
1 RLOAD(N1))*SIN(PSI(N1)))
ZOVERH=SIGMAR*GAMMA*(TH*COS(ALPHAB)-TL*SIN(ALPHAB)+RLOAD*
1 SIN(ALPHAR)*COS(PSI(N1)))
XLOAD(N1)=1.0
GO TO 630
C
C EFFECT OF WING
C
622 ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR))*(SIGMAW/SIGMAR)
Appendix N - Concluded

1 *TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB))
ETA=ETA1-YSTAR*SIGMA
XOVER=SIGMAR*GAMMA*(TL-LW)/COS(ALPHAB)+(TH-HW)*SIN(ALPHAB)-
1 ABY(YSTAR)/(SIGMAR/SIGMA)*TAN(LAMBDA)*COS(ALPHAB))
YOVER=SIGMAR*GAMMA*(0.25*(5.0-2.0)*FLOAT(M1))*SIGMAT-YSTAR*SIGMA
ZOVER=-SIGMAR*GAMMA*(TL-LW)*SIN(ALPHAB)+(TH-HW)*COS(ALPHAB)-
1 ABY(YSTAR)/(SIGMA/SIGMA)*TAN(LAMBDA)*SIN(ALPHAB))
630 CALL DL TAS (C(K))

************* SEE APPENDIX Q FOR SUBROUTINE DL TAS *************

DO 805 L1=1,28
805 XDETA(L1)=XDETA(L1)+DETA(L1)*XLOAD(N1)
802 CONTINUE
801 CONTINUE
DO 807 L3=1,28
807 DELTA(L3)=DETA(L3)*SUML
WRITE (6,149) (C(K))
WRITE (6,150) (DETA(I),I=1,25,4)
WRITE (6,151) (DETA(I),I=2,26,4)
WRITE (6,152) (DETA(I),I=3,27,4)
WRITE (6,153) (DETA(I),I=4,28,4)
DO 814 L4=1,28
814 XDETA(L4)=0.
41 CONTINUE
42 CONTINUE
GO TO 1

100 FORMAT (1H1///////////59X*START NEW CASE*)
149 FORMAT (1X*CHI =* F7.3/)
150 FORMAT (3X5H(W,L)7(F17.4/)
151 FORMAT (3X5H(U,L)7(F17.4/)
152 FORMAT (3X5H(W,D)7(F17.4/)
153 FORMAT (3X5H(U,D)7(F17.4/)
210 FORMAT (1X131(1-1-))
211 FORMAT (1X1H111XH31X61H1CORRECTION FACTORS FOR CORRECTING FROM A
1WIND TUNNEL WHICH IS25X1H1)
212 FORMAT (1X1H11I1XH11I7(11-11HI)
213 FORMAT (1X1H111XH116XH5X6XHCLOSE05X1H16XH2X12XHCLOSED FLOOR2X1)
11H6XHOPEN6XHI16XHI5X6XHCLOSED4X1H1
214 FORMAT (1X1H13X5+DETA3X1H5X6XHCLOSED5X1H14XH4DNH0 T0M3X1H16XH4HOP
1E6XH16XH4DNLY6XHI5X5HFLDOR6XH15X6HCLOSED5X1H13X9H0N BOTTOM3X1H
21)
215 FORMAT (1X1H111XH116XH16XH4DNLY6XHI16XH16H1H(GROUND EFFECT) I6X4H
10NY6XHI16XHI6X4HONLY5X1H1)
216 FORMAT (1X1H11I1XH18(1H-1H132(1H-1H1)
217 FORMAT (1X1H111XH136X1H0 TO FREE AIR37X1H18X16HTO GROUND EFFECT8X1
1H1)
218 FORMAT (1X131(1H-1-))
701 FORMAT (1H1/35X*AVG 1ERE INTERFERENCE OVER A TAIL BEHIND AN UNLOAD
1ED ROTOR MODEL/)
702 FORMAT (1H1/35X*EFFECT OF RCTOR ON TAIL/)
703 FORMAT (1H1/35X*EFFECT OF WING ON TAIL/)
706 FORMAT (34X,4H10*R 0 T0K LOADING19X,A8* WING LOADING//)
11X*SIGMA(ROTOR)*=*F6.3,10X*ZETA=*F6.3,10X*LW/R=*F6.3,10X
2*ALPHA(ROTOR)=*F7.3//19X*SIGMA(WING)=*F5.3,10X*ETA=*F6.3,
310X*HW/R =*F6.3,10X*ALPHA(BODY) =*F7.3//19X*SIGMA(TAIL) =*
5*LAMBDA =*F7.3//)
707 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE (N 215)
1 FOR USE WITH SUCH CASES.*)/)
900 FORMAT (11,F9.3,4F10.3/11,F9.3,4F10.3/3F10.3)
999 STOP
END

56
APPENDIX Q

FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER SIDE-BY-SIDE ROTOR CONFIGURATIONS

This program was written in CDC FORTRAN, Version 2.1, to run on CDC 5000 series computers with the SCOPE 3.0 operating system and library tape. Minor modifications may be required prior to use in other computers. This program has been found to be satisfactory on the aforementioned computers which carry the equivalent of approximately 15 decimal digits. Computers of lesser precision may require modification to double precision in order to obtain results of equal accuracy.

This program requires the use of subroutine OLTAS which is given in Appendix Q.

Input will be found at address 1 (three cards per case) in format 937. Note that the reference origin is chosen at the point midway between the two rotors. The required input variables for the rotors, given on the first card, are:

LIR, ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1, SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1, DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA, WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA, RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
SR, DISTANCE BETWEEN ROTOR CENTERS DIVIDED BY ROTOR DIAMETER
ALPHA, ANGLE OF ATTACK OF TIP-PATH PLANE OF ROTORS, DEG

The required input variables for the wing, given on the second card, are:

LIW, WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW, DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW, DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW, RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA, WING SWEEP ANGLE, DEG

57
THIS PROGRAM REJECTS CASES OF ZERO SPAN, SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS. THIS PROGRAM ALSO DETERMINES AND REJECTS CASES IN WHICH TOTAL ROTOR SPAN EXCEEDS THE TUNNEL WIDTH.

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT EACH OF THE THREE ELEMENTS DUE TO ITS OWN PRESENCE, AS WELL AS THE INTERFERENCE ON EACH DUE TO THE PRESENCE OF THE OTHER TWO ELEMENTS. IN SYMMETRICAL CASES, THE EFFECTS ON, AND CAUSED BY, EACH OF THE ROTORS IS IDENTICAL. CONSEQUENTLY, ONLY THE INTERFERENCES RELATED TO ONE OF THE ROTORS IS CALCULATED.

NOTE THAT THIS PROGRAM IS ALSO SUITABLE FOR TWIN-PROPELLER TILT-WING MODELS, TILT-ROTOR MODELS, FAN-IN-WING MODELS, AND OTHER SIMILAR TYPES. JUDICIOUS CHOICE OF INPUT VARIABLES WILL SATISFY THE REQUIREMENTS OF THESE, AND MANY OTHER MODELS.

```
PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
COMMON ZETA,ETA,GAMMA,XOVER4,YOVER4,ZOVER4,DELTA(28)
DIMENSION XDELTA(28),PSII(27),RLOAD(27),RUNIF(20),RTRIA(20)
1
REAL LAMBDAL,W
DATA (RUNIF(I),I=1,20)/4.*2981,8*3,6255,8*2,8921/
DATA (RTRIA(I),I=1,20)/4.*0.4386,9*0.7296,9*0.9262/
DATA (C(I),I=1,8)/3.0,30.0,49.0,57.0,65.0,73.0,80.0,97.0/
PI=3.14159265358979
RAD=0.714532926199
D') 303 L1=1,28
803 XDELTA(I)=I.
PSI(1)=(PI/4.)
PSI(2)=3.*PSI(1)
PSI(3)=5.*PSI(1)
PSI(4)=7.*PSI(1)
PSI(5)=PSI(13)=(PI/8.)
PSI(6)=PSI(14)=3.*PSI(5)
PSI(7)=PSI(15)=5.*PSI(5)
PSI(8)=PSI(16)=7.*PSI(5)
PSI(9)=PSI(17)=9.*PSI(5)
PSI(10)=PSI(18)=11.*PSI(5)
PSI(11)=PSI(19)=13.*PSI(5)
PSI(12)=PSI(20)=15.*PSI(5)
XLE(1)=XLE(17)=0.49579
XLE(2)=XLE(9) =0.71422
XLE(3)=XLE(8) =0.86603
XLE(4)=XLE(7) =0.95394
XLE(5)=XLE(6) =0.99490
1 READ (5,990)LIR,ZETA1,ETA1,GAMMA,SIGMAR,SR,ALPHAR,LIRW,LW,HW
1 SIGMAR,LAMBDAM,ALPHAB
IF (EOF,5) 99,47
47 ALPR=ALPHAR
ALP3=ALPHAB
ALAM=LAMBDAM
LAMBDAM=LAMBDAM*RAD
ALPHAR=ALPHAR*RAD
ALPHAR=ALPHAR*RAD
WRITE (6,100)
IF (LIR.EQ.1) GO TO 84
```

58
Appendix O – Continued

IALPHA=10

DO 808 M2 = 1, 120

808 LOAD(M2) = RTRIA(M2)

GO TO 806

804 IALPHA = I3

DO 819 M2 = 1, 120

809 LOAD(M2) = RUNIF(M2)

IF (L14.EQ.1.) GO TO 852

IBETA = 8HELIPTIC

DJ ASL M3 = 1, 10

851 LOAD(M3) = XLF(M3)

GO TO 850

852 IBETA = 8UNIFORM

DJ ASL M3 = 1, 10

R53 LOAD(M3) = 1.

85C WIDTH = SIGMAR*(1.+SR)

IF (WIDTH LT 1. AND. SIGMAR NE 0.) GO TO 855

WRITE (6, 701)

WRITE (6, 711) IALPHA, IBETA, SIGMAR, ZETA, LW, AALPR, SIGMAW, ETA1,

1

WRITE (6, 711) HA, AALPR, GAMMA, SR, ALAM

WRITE (6, 711)

WRITE (6, 711)

WRITE (6, 711)

WRITE (6, 711)

WRITE (6, 711)

WRITE (6, 711)

WRITE (6, 711)

WRITE (6, 711)

WRITE (6, 711)

IF (SIGMAR.EQ.0.) WRITE (6, 712)

IF (WIDTH.GE.1.) WRITE (6, 717)

GO TO 1

R55 DO 42 IELEM = 1, 5

IF (ETAI.EQ.1.) GO TO (6(601, 500, 600, 605, 42, 42, 42, 600, 600, 42), IELEM

60C WRITE (6, 731)

IF (ETAI.EQ.1.) GO TO (5(501, 502, 503, 42, 42, 42, 607, 504, 42), IELEM

GO TO (601, 507, 508, 509, 604, 605, 606, 607, 608, 609)

IELEM

601 WRITE (6, 732)

GO TO 610

602 WRITE (6, 733)

GO TO 610

603 WRITE (6, 704)

GO TO 610

604 WRITE (6, 705)

GO TO 610

605 WRITE (6, 706)

GO TO 610

606 WRITE (6, 707)

GO TO 610

607 WRITE (6, 708)

GO TO 610

608 WRITE (6, 709)

GO TO 610

609 WRITE (6, 710)

GO TO 610

501 WRITE (6, 713)

GO TO 517

512 WRITE (6, 714)

GO TO 610

513 WRITE (6, 715)

GO TO 610

59
Appendix O – Continued

504 WRITE (6,716)
610 WRITE (6,711) TALPHA,IBETA,SIGMA,ETAL,LW,AALPR,SIGMAW,ETAL,
1    HW,AALPB,GAMMA,SR,ALAM
    WRITE (6,217)
    WRITE (6,211)
    WRITE (6,212)
    WRITE (6,213)
    WRITE (6,214)
    WRITE (6,215)
    WRITE (6,216)
    WRITE (6,217)
    WRITE (6,219)
D=41 K=1,Z
M7=N7=20
GO TO (611,611,612,611,611,612,613,614,614), TELEM
C C    ROTOR ON ROTOR
C
611 SUML=0.0025
    GO TO 812
C C    WING ON ROTOR
C
612 SUML=0.063157
    IF (SIGMAW.EQ.0.) GO TO 615
    IF (LW.EQ.1) SUML=0.008
    N7=10
    GO TO 912
615 SUML=0.95
    XLOAD(1)=1.0
    N7=1
    GO TO 812
C C    WING ON WING
C
613 SUML=0.4126194
    IF (SIGMAW.EQ.0.) GO TO 616
    IF (LW.EQ.1) SUML=0.010
    M7=10
    N7=1
    IF (ETAL.NE.1.0) GO TO 912
    SUML=0.022788
    IF (LW.EQ.1) SUML=0.920
    N7=5
    GO TO 912
616 SUML=1.0
    XLOAD(1)=1.0
    M7=N7=1
    GO TO 812
C C    ROTOR ON WING
C
614 SUML=0.9950
    M7=10
    IF (SIGMAW.NE.0.0) GO TO 812
    M7=1
    SUML=0.05
812 GO 811 M1=1,M7
   GO 802 N1=1,N7
   XSTAR=(11.-2.*FLOAT(M1))/10.
   YSTAR=(11.-2.*FLOAT(N1))/10.

60
Appendix O – Continued

811 GJ T0 (621,622,623,624,625,626,627,528,529), TELEM
(0 163)
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(0 222)
(0 223)
Appendix O – Continued

ZETA = ZETA1 / (1 - SIGMA * GAMMA * ZETA1 * (YSTAR * (SIGMA * W / SIGMA))
1   TAN(LAMBDAA) * SIN(ALPHAA) + LW * SIN(ALPHAA) * W / COS(ALPHAA))
 XOVER = SIGMA * GAMMA * TAN(LAMBDAA) * COS(ALPHAA) * (ABS(XSTAR) -
1   ABS(YSTAR))
 YOVER = L2 * SIGMA * GAMMA * (FLOAT(N1) - FLOAT(M))
 ZOVER = -SIGMA * GAMMA * TAN(LAMBDAA) * SIN(ALPHA) * (ABS(XSTAR) -
1   ABS(YSTAR))
 G) GO TO 640

C) RIGHT ROTOR ON WING

628 ETA = ETA1 - RLADO * SIGMA * SIN(P(1)) - SR * SIGMAR
 YOVER = SIGMAR * GAMMA * (XSTAR * (SIGMA * W / SIGMAR) - RLOAD(N1) * SIN(P(1))
1   (N1) - SR)
 G) GO TO 633

C) LEFT ROTOR ON WING

629 ETA = ETA1 - RLADO * SIGMA * SIN(P(1)) + SR * SIGMAR
 YOVER = SIGMAR * GAMMA * (XSTAR * (SIGMA * W / SIGMAR) - RLOAD(N1) * SIN(P(1))
1   (N1) + SR)
633 ZETA = ZETA1 / (1 - SIGMAR * GAMMA * ZETA1 * RLOAD(N1) * SIN(ALPHAA)
1   COS(P(1))
 XOVER = SIGMAR * GAMMA * (ABS(XSTAR) * (SIGMA * W / SIGMAR) * TAN(LAMBDAA)
1   COS(ALPHAA) * LW * COS(ALPHAA) * W / SIN(ALPHAA) - RLOAD(N1))
2   COS(ALPHAA) * COS(P(1))
 ZOVER = SIGMAR * GAMMA * (ABS(XSTAR) * (SIGMA * W / SIGMAR) * TAN(LAMBDAA)
1   SIN(ALPHAA) * LW * SIN(ALPHAA) * W / COS(ALPHAA) - RLOAD(N1)
2   SIN(ALPHAA) * COS(P(1))
 XLOAD(N1) = 1.7

64) CALL DLTAS (C(K))

*************** SEE APPENDIX O FOR SUBROUTINE DLTAS ***************

DO 805 LI = 1, 28
805 XDELTA(LI) = XDELTA(LI) + DELTA(LI) * XLOAD(N1)
806 CONTINUE
807 CONTINUE
DO 807 L3 = 1, 28
807 DELTA(L3) = XDELTA(L3) * SML
WRITE (6, 149) C(K)
WRITE (6, 150) (DELTA(L), I = 1, 25, 4)
WRITE (6, 151) (DELTA(L), I = 2, 26, 4)
WRITE (6, 152) (DELTA(L), I = 3, 27, 4)
WRITE (6, 153) (DELTA(L), I = 4, 28, 4)
808 L4 = 1, 29
814 XDELTA(L4) = N.
41 CONTINUE
42 CONTINUE

GO TO 1

100 FORMAT (1H1) // // // // // /50X*START NEW CASE*)
149 FORMAT (1X*CHI = * F7.3)
150 FORMAT (3X5H(W+L)7(F17.4))
151 FORMAT (3X5H(U+L)7(F17.4))
152 FORMAT (3X5H(W+D)7(F17.4))
153 FORMAT (3X5H(U+D)7(F17.4)///)
210 FORMAT (1X13L(H=))
211 FORMAT (1X14H1) // // // // // /50X*START NEW CASE*)
212 FORMAT (1X14H1) // // // // // /50X*START NEW CASE*)
213 FORMAT (1X14H1) // // // // // /50X*START NEW CASE*)
214 FORMAT (1X14H1) // // // // // /50X*START NEW CASE*)

62
Appendix O – Concluded

1EN6X1H16X4H0NL6X1H16X5H0FL0D6X1H15X5HL0C0D5X1H13X9H0N R0T0M3X1H (0 284)
21
215 FORMAT (1X1H11X1H11X1H16X4H0NL6X1H14X1H14X1H1G0UND 0FFECT1 16X4H (0 286)
10NLY6X1H11X1H16X4H0NL5X1H1) (0 287)
216 FORMAT (1X1H11X1H14X1H11H1132X1H1-1H11) (0 298)
217 FORMAT (1X1H11X1H13X11H1T0 FREE AIR37X1H1R16X1HT0 G0UND 0FFECT9X1 (0 299)
11H1) (0 290)
218 FORMAT (1X1H11X1H1-11-1) (0 291)
701 FORMAT (1H1//35X*AV0RAGE INTERFERENCE OVE0 SIDE-BY-SIDE AND/0R T1L (0 292)
1T-0R0T0R MO0DELS//) (0 293)
702 FORMAT (48X*EFFECT OF RIGHT ROT0R ON RIGHT ROT0R//) (0 294)
703 FORMAT (48X*EFFECT OF LEFT ROT0R ON RIGHT ROT0R//) (0 295)
704 FORMAT (31X*EFFECT OF WING ON RIGHT ROT0R//) (0 296)
705 FORMAT (49X*EFFECT OF LEFT ROT0R ON LEFT ROT0R//) (0 297)
706 FORMAT (48X*EFFECT OF RIGHT ROT0R ON LEFT ROT0R//) (0 298)
707 FORMAT (52X*EFFECT OF WING ON LEFT ROT0R//) (0 299)
708 FORMAT (55X*EFFECT OF WING ON WING//) (0 300)
709 FORMAT (51X*EFFECT OF RIGHT ROT0R ON WING//) (0 301)
710 FORMAT (52X*EFFECT OF LEFT ROT0R ON WING//) (0 302)
711 FORMAT (34X,A1P* ROT0R LOADING19X,AR* WING LOADING//) (0 303)
119X*SIGMA(ROT0R) =F6.3,10X*EETA =F6.3,10X*GAMM0A =F6.3,10X (0 304)
2*ALPHA(ROT0R) =F7.3//19X*SIGMA(WING) =F6.3,10X*EETA =F6.3, (0 305)
31X*HW/R =F6.3,10X*ALPHA(BODY) =F7.3//19X*GAMMA =F6.3, (0 306)
42X*5R/R =F6.3,27X*LAM0DA =F7.3// (0 307)
712 FORMAT (40X*SIGMA(ROT0R) EQUALS ZER0, THIS PROGRAM IS NOT SUITABLE (0 308)
1 FOR USE WITH SUCH CASES//) (0 309)
713 FORMAT (47X*EFFECT OF EITHER ROT0R ON ITSELF//) (0 310)
714 FORMAT (47X*EFFECT OF OTHER ROT0R ON EITHER ROT0R//) (0 311)
715 FORMAT (51X*EFFECT OF WING ON EITHER ROT0R//) (0 312)
716 FORMAT (51X*EFFECT OF EITHER ROT0R ON WING//) (0 313)
717 FORMAT (40X*ROT0R SYSTEM IS TOO WIDE FOR THE WIND TUNNEL//) (0 314)
900 FORMAT (11,F9.3,5F10.3//11,F9.3,4F10.3) (0 315)
999 STOP (0 316)
END (0 317)
FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND A SIDE-BY-SIDE ROTOR CONFIGURATION

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (THREE CARDS PER CASE) IN FORMAT 909. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN AT THE POINT MIDWAY BETWEEN THE TWO ROTORS. THE REQUIRED INPUT VARIABLES FOR THE ROTORS, GIVEN ON THE FIRST CARD, ARE:

LIR       ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1     SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1      DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA     WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR    RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
SR        DISTANCE BETWEEN ROTOR CENTERS DIVIDED BY ROTOR DIAMETER
ALPHAR    ANGLE OF ATTACK OF TIP-PATH PLANE OF ROTORS, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE:

LIW       WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW        DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW        DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW    RATIO OF WING SPAN TO TUNNEL WIDTH
Appendix P – Continued

<table>
<thead>
<tr>
<th>LAMBDA</th>
<th>WING SWEEP ANGLE, DEG</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHAB</td>
<td>ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG</td>
</tr>
</tbody>
</table>

The required input variables for the tail, on the third card, are:

<table>
<thead>
<tr>
<th>SIGMAT</th>
<th>RATIO OF TAIL SPAN TO TUNNEL WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL</td>
<td>TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONIZED WITH RESPECT TO ROTOR RADIUS</td>
</tr>
<tr>
<td>TH</td>
<td>TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONIZED WITH RESPECT TO ROTOR RADIUS</td>
</tr>
</tbody>
</table>

This program computes independently the interference at the tail caused by the presence of the three lifting elements. In symmetrical cases, the effect of the two rotors is identical. Consequently, only the interference caused by one rotor is calculated.

This program rejects cases of zero span. Since the equations are formed in terms of rotor radius, such cases represent input errors. This program also determines and rejects cases in which total rotor span exceeds the tunnel width.

Note that this program is also suitable for twin-propeller tilt-wing models, tilt-rotor models, fan-in-wing models, and other similar types. Judicious choice of input variables will satisfy the requirements of these, and many other models.

```plaintext
PROGRAM WINDTUN(INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT)
     COMMON ZETA, ETA, GAMMA, XOHERH, YOVERH, ZOVERH, DELTA(28)
     DIMENSION XDELTA(28), PSI(20), RLOAD(20), RUNIF(20), RTRIA(20),
     1 XLE(10), XL04, C(8)
     REAL LAMBDA, LW
     CATA (RUNIFI), I=1,20/4+0.2981, 8*0.6255, 8*0.8921/
     DATA (RTRIA), I=1,20/4+0.4386, 8*0.7296, 8*0.9262/
     CATA (C(I)), I=1,8/20, 30, 40, 50, 60, 70, 80, 90, 100/
     PI=3.14159265358979
     RAD=0.0174532925199
     DO 803 LI=1,28
     803 XDELTA(LI)=0.
     PSI(1)=(PI/4.)
     PSI(2)=3.*PSI(1)
     PSI(3)=5.*PSI(1)
     PSI(4)=7.*PSI(1)
     PSI(5)=PSI(13)=(PI/8.)
     PSI(6)=PSI(14)=3.*PSI(5)
     PSI(7)=PSI(15)=5.*PSI(5)
     PSI(8)=PSI(16)=7.*PSI(5)
     PSI(9)=PSI(17)=9.*PSI(5)
     PSI(10)=PSI(18)=11.*PSI(5)
     PSI(11)=PSI(19)=13.*PSI(5)
     PSI(12)=PSI(20)=15.*PSI(5)
     XLE(1)=XLE(10)=0.43579
     XLE(2)=XLE(9) =0.71422
     XLE(3)=XLE(8) =0.86603
```
Appendix P – Continued

XLE(4)=XLE(7) =0.95394
XLE(5)=XLE(6) =0.99499
1 READ (5,900) LIR,ZETAL,ETAL,GAMMA,SIGMAR,SRL,ALPHAR,LIW,LW,HW,
1 SIGMAR,ALPHAB,SI GMAT,TL,TH
IF (EOF,51) GO TO 47

47 AALPR=ALPHAR
AALPB=ALPHAB
ALAM=LAMBCA
LAMBDA=LAMBDA*RAD
ALPHAR=ALPHAR*RAD
ALPHAB=ALPHAB*RAD
WRITE (6,120)
IF (LIR.EQ.1) GO TO 804
IALPHA=10HTRIANGULAR
DO 808 M2=1,20
808 RLOAD(M2)=RTRIA(M2)
GO TO 806
804 IALPHA=10HUNIFORM
DO 809 M2=1,20
809 RLOAD(M2)=RUNIF(M2)
806 IF (LIW.EQ.1) GO TO 852
IBETA=8HELPICTIC
CO 851 M3=1,10
851 XLOAD(M3)=XLE(M3)
GO TO 850
852 IBETA=8HUNIFORM
GO 853 M3=1,10
853 XLOAD(M3)=1,0
850 WIDTH=SIGMAR*(1.0+SR)
IF (WIDTH.LE.1.0.AND.SIGMAR.NE.0.) GO TO 855
WRITE (6,701)
WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETAL,LIW,AALPR,SIGMAW,ETAL,
1 HW,AALPB,SIGMAT,TL,TH,SRL,GAMMA,ALAM
WRITE (6,6210)
WRITE (6,6211)
WRITE (6,6212)
WRITE (6,6213)
WRITE (6,6214)
WRITE (6,6215)
WRITE (6,6216)
WRITE (6,6217)
WRITE (6,6218)
IF (SIGMAR.EQ.0.) WRITE (6,707)
IF (WIDTH.GE.1.) WRITE (6,708)
GO TO 855
CO 42 IELEM=1,3
IF (ETAL.EQ.1.) GO TO (600,42,600), IELEM
600 WRITE (6,701)
IF (ETAL.EQ.1.) GO TO (604,42,603), IELEM
GO TO (661,46,603), IELEM
601 WRITE (6,702)
GO TO 610
602 WRITE (6,703)
GO TO 610
603 WRITE (6,704)
GO TO 610
604 WRITE (6,705)
610 WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETAL,LIW,AALPR,SIGMAW,ETAL,
1 HW,AALPB3,SIGMAT,TL,TH,SRL,GAMMA,ALAM
WRITE (6,6210)
WRITE (6,6211)
WRITE (6,212)
WRITE (6,213)
WRITE (6,214)
WRITE (6,215)
WRITE (6,216)
WRITE (6,217)
WRITE (6,218)
GO TO 614
K=1,8
N7=20
M7=4
GO TO (611,611,612), IELEM
C C EFFECT OF ROTOR
C 611 SUML=0.0125
GO TO 812
C C EFFECT OF WING
C 612 SUML=0.031526
IF (SIGMAE.EQ.0.,OR,SIGMAT.EQ.0.) GO TO 615
IF (LIW.EQ.1) SUML=0.025
N7=10
IF (ETA1.NE.1.) GO TO 812
SUML=0.01261C4
IF (LIW.EQ.1) SUML=0.050
N7=5
GO TO 812
615 IF (SIGMAE.EQ.0.,AND,SIGMAT.NE.0.) GO TO 613
IF (SIGMAE.NE.0.,AND,SIGMAT.EQ.0.) GO TO 616
SUML=1.0
XLOAD(1)=1.0
M7=N7=1
GO TO 812
613 SUML=0.25
M7=4
N7=1
XLOAD(1)=1.0
IF (ETA1.NE.1.) GO TO 812
SUML=0.50
M7=2
GO TO 812
616 SUML=0.1261C4
IF (LIW.EQ.1) SUML=0.100
N7=10
M7=1
IF (ETA1.NE.1.) GO TO 812
SUML=0.25208
IF (LIW.EQ.1) SUML=0.200
N7=5
GO TO 812
812 DO 801 M1=1,M7
DO 802 N1=1,N7
XSTAR=(11.0-2.0*FLOAT(M1))/1.
YSTAR=(11.0-2.0*FLOAT(N1))/1.
GO TO (622,623,621), IELEM
C C EFFECT OF RIGHT ROTOR
C 622 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))-SR*SIGMAR
YOVERH=SIGMAR*GAMMA*(0.25*(2.5*FLOAT(M1)-5.0)*SIGMAT/SIGMAR)*KLOAD(V1)*SIN(PSI(N1))+SR
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Appendix P  – Continued

C EFFECT OF LEFT RCTOR

623 ETA=ETA1-RLOAD(N1)*SIGMAR*SIGMA(N1)^*+SIGMAR

GO TO 625

C EFFECT OF WING

621 YSTAR=(11.0-2.0*FLOAT(N1))/10.0

ETA=ETA1/YSTAR*SIGMA

ZETA=ZETA1/(L.0-SIGMAR*GAMMA*ZETA1*(ABS(ystar)*(SIGMA/SIGMAR) )

XOVERH=SIGMAR*GAMMA*TSIGMA/SUN(ALPHAB) TH-HW IWSIGMA(S)

ZETA=SIGMAR*GAMMA*(T-HW)*SIN(ALPHAB) -coh(alpahb)

1 =ABS(ystar)*(SIGMA/SIGMAR)*TAN(ALPHAB)*SIN(ALPHAB))

YOVERH=SIGMAR*GAMMA*TSIGMA/SUN(ALPHAB) -coh(alpahb)

ZETA=SIGMAR/ALPHA*TSIGMA/SUN(ALPHAB) -coh(alpahb)

XOVERH=TSIGMA/SUN(ALPHAB) TH-HW IWSIGMA(S)

ZETA=SIGMA/ALPHA*TSIGMA/SUN(ALPHAB) -coh(alpahb)

XLOAD(N1)=1.0

630 CALL DLTAS (C(I))

********************** SEE APPENDIX Q FOR SUBROUTINE DLTAS **********************

DO 805 L3=1,28

805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)

802 CONTINUE

801 CONTINUE

DO 807 L3=1,28

807 DELTA(I,L3)=XDELTA(L1)*SUML

WRITE (6,149) (K)

WRITE (6,150) (DELT(A(I),I=1,25,4)

WRITE (6,151) (DELT(A(I),I=2,26,4)

WRITE (6,152) (DELT(A(I),I=3,27,4)

WRITE (6,153) (DELT(A(I),I=4,28,4)

DO 814 L4=1,28

814 XDELTA(L4)=0

41 CONTINUE

42 CONTINUE

100 FORMAT (1H1/////59X START NEW CASE*)

149 FORMAT (1X*CHI = F7.3/)

150 FORMAT (3X5H1W,L17(F17.4))

151 FORMAT (3X5H1U,L17(F17.4))

152 FORMAT (3X5H1W+D7(F17.4))

153 FORMAT (3X5H1U+D7(F17.4))

210 FORMAT (1X131(I1H-1))

211 FORMAT (1X1H111X1H131X61HCORRECTION FACTORS FOR CORRECTING FROM A 1WIND TUNNEL WHICH IS25X1HI)

212 FORMAT (1X1H111X1H1117(I1H-1))

213 FORMAT (1X1H111X1H116X1H15X61HCLOSED5X1H16X1H12X1H 1CLOSED FLOATR2X1

1H16X4HOPEN6X1H16X1H5X6HCLOSED4X1H1)

214 FORMAT (1X1H113X5H1DELTA3X1H5X61HCLOSED5X1H4X9HON 1BOTTM3X1H16X4HDP

1EN6X1H6X4HONLY6X1H5XHFLOR6X1H15X6HCLOSED5X1H3X9HON 1BOTTM3X1H

2I)

68
Appendix P – Concluded

215 FORMAT (1X1H11X1H16X1H16X1H4HONLY6X1H16X1H18H1 (GROUND EFFECT) 16X4H (P 210)
1ONLY6X1H16X1H16X1H4HONLY5X1H1) (P 211)
216 FORMAT (1X1I11X1H164I1H1132I1H11H1) (P 212)
217 FORMAT (1X1H11X1H136X11HTO FREE AIR37X1H18X16HTC GROUND EFFECT8X1 (P 213)
1H1) (P 214)
218 FORMAT (1X131I1H1/) (P 215)
701 FORMAT (1H1//28X* AVERAGE INTERFERENCE OVER A TAIL BEHIND SIDE-BY-SIDE AND/OR TILT ROTOR MODELS*/) (P 216)
702 FORMAT (55X* EFFECT OF RIGHT ROTOR*/) (P 217)
703 FORMAT (56X* EFFECT OF LEFT ROTOR*/) (P 218)
704 FORMAT (59X* EFFECT OF WING*/) (P 219)
705 FORMAT (55X* EFFECT OF EITHER ROTOR*/) (P 220)
706 FORMAT (34X, A10* ROTOR LOADING*19X, A8* WING LOADING*/) (P 221)
119X*SIGMA(ROTOR) =*F6.3, 10X*ZETA =*F6.3, 10X*LW/R =*F6.3, 10X
2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING) =*F6.3, 10X*ETA =*F6.3, (P 222)
310X*HW/R =*F6.3, 10X*ALPHA(BODY) =*F7.3//19X*SIGMA(TAIL) =*F6.3, (P 223)
410X*TL/R =*F6.3, 10X*TH/R =*F6.3, 10X*SR/R =*F7.3//39X (P 224)
5*GAMMA =*F6.3, 29X*LAMBDA =*F7.3//1 (P 225)
707 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE FOR USE WITH SUCH CASES*/) (P 226)
1 FOR USE WITH SUCH CASES*/) (P 227)
708 FORMAT (40X* ROTOR SYSTEM IS TOO WIDE FOR WIND TUNNEL*/) (P 228)
900 FORMAT (11, F9.3, 5F10.3/11, F9.3, 4F10.3/3F10.3) (P 229)
999 STOP (P 230)
END (P 231)

THIS SUBROUTINE WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS SUBROUTINE HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS SUBROUTINE IS REQUIRED BY THE PROGRAMS OF ALL PRECEDING APPENDICES.

SUBROUTINE DLTAS (ANGL)
COMMON ZETA, ETA, GAMMA, XOVERH, YOVERH, ZOVERH, DELTA(28) (Q 1)
DIMENSION V(319), ADEL(28) (Q 2)
SC=SQRT(ANGL*0.0174532925199) (Q 3)
CC=COS(ANGL*0.0174532925199) (Q 4)
Z=ZETA*ZOVERH+1. (Q 5)
Z8=Z6 (Q 6)
Z7=Z8-1. (Q 7)
DO 8 J1=1,28 (Q 8)
8 CELTA(J1)=C. (Q 9)
DO 10 M=1,7 (Q 10)
DO 10 N=1,7 (Q 11)
IF (N.EQ.4. AND. M.EQ.4) GO TO 10 (Q 12)
DO 11 J1=1,3 (Q 13)
DO 11 J2=1,9 (Q 14)
11 V(J1,J2)=0. (Q 15)
DO 12 J1=1,28 (Q 16)
12 ADEL(J1)=0. (Q 17)
AN=M-4 (Q 18)
AM=N-4 (Q 19)
X=ZETA*XOVERH (Q 20)
Y=ZETA*(YOVERH-2.*AM*GAMMA+GAMMA*(1.-ETA)*(1.-(-1.)*M)) (Q 21)
Z=ZETA*(ZOVERH-4.*AN) (Q 22)
A=SQRT(X*X+Y*Y+Z*Z) (Q 23)
B=A+X**CC-X**SC (Q 24)
V(1,1)=((X*X+Y*Y)/(B*A*A*A))-(Z+4*A)/(B*A)**2 (Q 25)
V(1,2)=-((X*Z)/(B*A*A*A))-(Z+4*A)/(X-A*SC)/(B*B*A*A) (Q 26)
V(1,3)=-(X*Z)/(B*A*A*A) -(Z+4*A)/(X-A*SC)/(B*B*A*A) (Q 27)
Z=-Z-2. (Q 29)
B=A+X**CC-X**SC (Q 30)
V(1,3)=((X*X+Y*Y)/(B*A*A*A))-(Z+4*A)/(B*A)**2 (Q 31)
V(3,3)=-(X*Z)/(B*A*A*A) -(Z+4*A)/(X-A*SC)/(B*A)**2 (Q 33)
IF (ANGL.EQ.90.0) GO TO 13 (Q 34)
X=X-(SC/CC) (Q 35)
Z=-Z-1. (Q 36)
A=SQRT(X*X+Y*Y+Z*Z) (Q 37)
B=A+Z**CC-Z**SC (Q 38)
V(1,2)=((X*X+Y*Y)/(B*A*A*A))-(Z+4*A)/(B*A)**2 (Q 39)
V(2,2)=-(X*Z)/(B*A*A*A) -(Z+4*A)/(X-A*SC)/(B*B*A*A) (Q 40)
70
Appendix Q – Continued

\[ V(3,2) = \frac{(Y*Y+Z*Z)}{(B*A*A*A)} - \frac{(X-A*SC)}{(B*A)} \]
\[ B = A - X \]
\[ V(1,5) = \frac{((X*X+Y*Y)}{(B*A*A*A)} - \frac{(Z/(B*A))}{**2} \]
\[ V(2,5) = \frac{Z/((A*A*A*A)} \]
\[ V(3,5) = \frac{X/((A*A*A*A)} \]
\[ Z = Z \]
\[ B = A + Z*CC - X*SC \]
\[ V(1,4) = \frac{((X*X+Y*Y)}{(B*A*A*A)} - \frac{((Z+A*CC)}{(B*A)} \]
\[ V(2,4) = \frac{(-X*Z)}{(B*A*A*A)} - \frac{((Z+A*CC)}{(X-A*SC)} \]
\[ V(3,4) = \frac{((Y*Y+Z*Z)}{(B*A*A*A)} - \frac{((Z+A*CC)}{(X-A*SC)} \]

13 \[ \text{ADEL}(1) = V(1,1) - V(1,2) - V(1,3) + V(1,4) \]
\[ \text{ADEL}(2) = V(2,1) - V(2,2) + V(2,3) - V(2,4) \]
\[ \text{ADEL}(3) = V(3,1) - V(3,2) + V(3,3) - V(3,4) \]
\[ \text{ADEL}(4) = V(4,1) - V(4,2) + V(4,3) - V(4,4) \]
\[ \text{ADEL}(5) = (((1,1)**(M+N)**(DEL1(1) \]
\[ \text{ADEL}(6) = (((1,1)**(M+N)**(DEL1(2) \]
\[ \text{ADEL}(7) = (((1,1)**(M+N)**(DEL1(3) \]
\[ \text{ADEL}(8) = (((1,1)**(M+N)**(DEL1(4) \]
\[ \text{ADEL}(9) = (((1,1)**M)**(V(1,1)-V(1,2)+V(1,3)-V(1,4)) \]
\[ \text{ADEL}(10) = (((1,1)**M)**(V(2,1)-V(2,2)+V(2,3)-V(2,4)) \]
\[ \text{ADEL}(11) = (((1,1)**M)**(V(3,1)-V(3,2)+V(3,3)-V(3,4)) \]
\[ \text{ADEL}(12) = (((1,1)**M)**(V(4,1)-V(4,2)+V(4,3)-V(4,4)) \]

DO 14 J1 = 1, 12

14 \[ \text{DELTA}(J1) = \text{DELTA}(J1) + \text{ADEL}(J1) \]

10 CONTINUE

DO 15 J1 = 1, 8

15 \[ \text{DELTA}(J1+20) = \text{DELTA}(J1) \]

X = ZETA*XCOVERH
Y = ZETA*YCOVERH
Z = Z7
A = SQRT(\(X*X+Y*Y+Z*Z\))
B = A + Z*CC - X*SC
V(1,7) = \(\frac{(X*X+Y*Y)}{(B*A*A*A)} - \frac{(Z+A*CC)}{(B*A)} \]
V(2,7) = \(-\frac{X*Z)}{(B*A*A*A)} - \frac{(Z+A*CC)}{(X-A*SC)} \]
V(3,7) = \(\frac{(Y*Y+Z*Z)}{(B*A*A*A)} - \frac{(Z+A*CC)}{(X-A*SC)} \]
IF (ANGL EQ 90.0) GO TO 16

X = X - (SC/CC)
Z = Z6
A = SQRT(\(X*X+Y*Y+Z*Z\))
B = A + Z*CC - X*SC
V(1,6) = \(\frac{(X*X+Y*Y)}{(B*A*A*A)} - \frac{(Z+A*CC)}{(B*A)} \]
V(2,6) = \(-\frac{X*Z)}{(B*A*A*A)} - \frac{(Z+A*CC)}{(X-A*SC)} \]
V(3,6) = \(\frac{(Y*Y+Z*Z)}{(B*A*A*A)} - \frac{(Z+A*CC)}{(X-A*SC)} \]
B = A - X
V(1,9) = \(\frac{(X*X+Y*Y)}{(B*A*A*A)} - \frac{(Z/(B*A))}{**2} \]
V(2,9) = \(\frac{Z/((A*A*A*A)} \]
V(3,9) = \(\frac{X/((A*A*A*A)} \]
Z = Z8
B = A + Z*CC - X*SC
V(1,8) = \(\frac{(X*X+Y*Y)}{(B*A*A*A)} - \frac{(Z+A*CC)}{(B*A)} \]
V(2,8) = \(-\frac{X*Z)}{(B*A*A*A)} - \frac{(Z+A*CC)}{(X-A*SC)} \]
V(3,8) = \(\frac{(Y*Y+Z*Z)}{(B*A*A*A)} - \frac{(Z+A*CC)}{(X-A*SC)} \]

16 \[ \text{DELTA}(13) = -V(1,6) - V(1,7) + V(1,8) \]
\[ \text{DELTA}(14) = V(2,6) + V(2,7) - V(2,8) \]
\[ \text{DELTA}(15) = V(1,2) - V(2,7) + V(2,8) + 2*V(2,9) \]
\[ \text{DELTA}(16) = V(3,6) + V(3,7) - V(3,8) + 2*V(3,9) \]
\[ \text{DELTA}(17) = V(1,6) + V(1,7) - V(1,8) + 2*V(1,9) \]
\[ \text{DELTA}(18) = \text{DELTA}(15) \]
\[ \text{DELTA}(19) = \text{DELTA}(14) \]
\[ \text{DELTA}(20) = V(3,6) - V(3,7) + V(3,8) \]

DO 17 J1 = 1, 4
17 CELTA(J1) = DELTA(J1) + DELTA(J1+12)  
DO 18 J1=5,12  
18 CELTA(J1) = DELTA(J1) + DELTA(J1+8)  
   AMT=-2.*GAMMA*ZETA*ZETA/3.14159265358979  
   CO 19 J1=1,28  
19 CELTA(J1) = AMT*DELTA(J1)  
   RETURN  
   END