RFSS
EXTENDED TARGET SIMULATION PROGRAM - REVISION II
TECH NOTE 105-046
20 JUN 78

PREPARED FOR: RF SYSTEMS BRANCH (DRDI-M-TDR)
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DISTRIBUTION STATEMENT A
Approved for public release; Distribution Unlimited
On 16 June, discussions were held at MIRADCOM with Dwight McPherson (Boeing) and Robert Smith (NWC/China Lake). As a result of these discussions, two revisions have been made to the extended target simulation program:

1. The target aspect angle is measured from the roll axis, not in the wing plane. This change was implemented in ETGEO by redefining a new angle (ANGL), and in the argument list in SCTAMP.

2. In order to introduce some “randomness” from run to run, a bias angle (ST) is added to the target aspect angle in SCTAMP. It was suggested by R. Smith that this angle be a random variable, uniform over $\pm 10^\circ$, that is chosen at the beginning of each run.

The changes made since 5 May 78 (the version described in MRI Report 149-21) are indicated by a double $$ beginning in column 73. Only MAIN, ETGEO, and SCTAMP are affected.
PROGRAM MAIN (INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT)

C THIS IS A SAMPLE MAIN PROGRAM FOR TEST PURPOSES ONLY.
C
C THIS EXTENDED-TARGET SIMULATION PACKAGE HAS BEEN PREPARED BY
C RL MITCHELL OF MARK RESOURCES, INC (213-822-4955), UNDER CONTRACT TO
C MIRADCOM. IT IS WRITTEN WITH THE INTENTION THAT IT WILL BE MADE PART
C OF A REAL-TIME SIMULATION PROGRAM, ALTHOUGH SOME OF THE CODE IS NOT
C WRITTEN IN COMPLETELY OPTIMUM FORM (IT IS MORE EASILY UNDERSTOOD THIS
C WAY, AND THE REVISIONS ARE EASILY MADE).
C
C ALL ARRAYS IN COMMON SHOULD BE DIMENSIONED IN THE MAIN PROGRAM.
C
C SEE THE SUBROUTINES FOR A DEFINITION OF THE VARIABLES.
C
C RULES FOR DIMENSIONING ARRAYS.....
C
X, Y, Z ................. NSCAT
AMP, DA, DB, DC, DAD ... NSCAT (MAYBE SMALLER)
TWARAY ................. 4*NARAY
VR, VI, DAZ, DEL ....... NTAP
C
C THE CHANGES MADE ON 5 MAY 78 ARE INDICATED WITH A $ SIGN IN COLUMN 73
C THE CHANGES MADE SINCE 5 MAY 78 ARE INDICATED WITH A PAIR OF $$ SIGNS
C
COMMON /T1/ XO, YO, ZO, XOD, YOD, ZOD, PSI, THETA, PHI, BP, BG, BR $
COMMON /T2/ CPSI, SPSI, CTHETA, STHETA, CPHI, SPHI
COMMON /T3/ XM, YM, ZM, XMD, YMD, ZMD
COMMON /T4/ NSCAT, ST, AMPMIN, X(20), Y(20), Z(20)
COMMON /T5/ NTAP, DRTAP, DRGATE, XL, PTGDSQ
COMMON /T6/ NARAY, TWARAY (404)
COMMON /T7/ NS, RO, R1, ROY, AMP(20), DA(20), DB(20), DC(20), DAD(20)
COMMON /T8/ PEFF, VR(B), VI(B), DAZ(B), DEL(B)
C
C DEFINE VARIABLES.....
C
DATA LR, LW/5, 6/
DATA NTAP/8/, DRTAP/30. /, DRGATE/60. /, XL/. 02/, AMPMIN/1. E-10/,
1 PTGDSQ/1. /
DATA DTIME/1. /
DATA NARAY/101/
DATA ST/0. /
$$
READ (LR, 100) XO, YO, ZO
READ (LR, 100) XOD, YOD, ZOD
READ (LR, 100) PSI, THETA, PHI
READ (LR, 100) BP, BG, BR $
READ (LR, 100) XM, YM, ZM
READ (LR, 100) XMD, YMD, ZMD
READ (LR, 101) NSCAT
READ (LR, 100) (X(K), Y(K), Z(K), K=1, NSCAT)

WRITE (LW, 200) X0, Y0, Z0
WRITE (LW, 201) XOD, YOD, ZOD
WRITE (LW, 202) PSI, THETA, PHI
WRITE (LW, 203) BP, BG, BR
WRITE (LW, 204) XM, YM, ZM
WRITE (LW, 205) XMD, YMD, ZMD
WRITE (LW, 206) NSCAT
WRITE (LW, 207) (X(K), Y(K), Z(K), K=1, NSCAT)

C SUBROUTINES TO BE CALLED FROM MAIN OR DRIVER PROGRAM...

CALL DATAIN
CALL TAPSET
CALL ETGEO
CALL ETGDM(DTIME)

WRITE (LW, 208) RO, R1, ROD
WRITE (LW, 209) (AMP(K), DA(K), DB(K), DC(K), DAD(K), K=1, NS)
WRITE (LW, 210) DTIME
WRITE (LW, 211) (VR(I), VI(I), DAZ(I), DEL(I), I=1, NTAP)
WRITE (LW, 212) PEFF

STOP

100 FORMAT(3F10. 1)
101 FORMAT(15)
200 FORMAT(//14H X0, Y0, Z0.....,(20X3F12. 6))
201 FORMAT(//17H XOD, YOD, ZOD.....,(20X3F12. 6))
202 FORMAT(//19H PSI, THETA, PHI.....,(20X3F12. 6))
203 FORMAT(//14H BP, BG, BR.....,(20X3F12. 6))
204 FORMAT(//14H XM, YM, ZM.....,(20X3F12. 6))
205 FORMAT(//17H XMD, YMD, ZMD.....,(20X3F12. 6))
206 FORMAT(//11H NSCAT.....,(20XI12))
207 FORMAT(//11H X, Y, Z.....,(20X3F12. 6))
208 FORMAT(//15H RO, R1, ROD.....,(20X3F12. 6))
209 FORMAT(//22H AMP, DA, DB, DC, DAD.....,(20X5F12. 6))
210 FORMAT(//11H DTIME.....,(20XF12. 6))
211 FORMAT(//19H VR, VI, DAZ, DEL.....,(20X4F12. 6))
212 FORMAT(//10H PEFF.....,(20XE12. 5))
END
SUBROUTINE ETGEO

C TRANSFORMATION TO RADAR SPACE FOR N-POINT SCATTERER MODEL
C
C IN THIS SUBROUTINE WE BEGIN WITH THE MODEL OF AN EXTENDED TARGET AND
C THE ENGAGEMENT GEOMETRY IN ORDER TO COMPUTE THE AMPLITUDE AND RADAR
C COORDINATES FOR EACH SCATTERER IN THE MODEL.
C
C THE MODEL IMPLEMENTED IS THE SO-CALLED MEDIUM-RANGE MODEL (SEE MRI
C REPORT 132-44).
C
C ASSUMPTIONS AND LIMITATIONS.....
C
1. ALL SCATTERERS ASSUMED TO BE ILLUMINATED BY SAME TRANSMIT
   ANTENNA GAIN.
2. TARGET ASSUMED TO BE WITHIN LINEAR REGION OF MONOPULSE
   RECEIVE BEAM.
3. THE DOPPLER SHIFT OF THE TARGET CG IS IMPLEMENTED BY MEANS
   OF A FINELY-CONTROLLABLE DELAY LINE (THE LASER DEVICE),
   PLUS THE USE OF THE FREQUENCY SYNTHESIZER.
4. ONLY ONE PHYSICAL TARGET IS SIMULATED PER CALL.

C ALL COMMUNICATION TO AND FROM THIS SUBROUTINE IS THRU COMMON.
C
C ON INPUT.....
C
/T1/ XO, YO, ZO = TARGET CG IN INERTIAL COORDINATES
   XOD, YOD, ZOD = TARGET CG RATE IN INERTIAL COORDINATES
   PSI, THETA, PHI = YAW, PITCH, ROLL ANGLES
   BP, BQ, BR = YAW, PITCH, ROLL ANGLE BODY RATES

/T2/ CPSI, SPST, ETC = SINES AND COSINES OF TARGET ANGLES

/T3/ XM, YM, ZM = MISSILE CG IN INERTIAL COORDINATES
   XMD, YMD, ZMD = MISSILE CG RATE IN INERTIAL COORDINATES

/T4/ NSCAT = NUMBER OF SCATTERERS IN TARGET MODEL
   ST = APPROXIMATE PHYSICAL SIZE OF TARGET
   AMPMIN = AMPLITUDE THRESHOLD FOR SCATTERERS
   X, Y, Z = ARRAYS CONTAINING SCATTERER LOCATIONS IN TARGET
   COORDINATES

/T5/ NTAP = NUMBER OF TAPS IN TAPPED DELAY LINE
   DRTAP = SPACING BETWEEN TAPS (2-WAY RANGE)

C ON OUTPUT.....
C
/T2/ CPSI, SPST, ETC = SINES AND COSINES OF TARGET ANGLES
C
/T7/ NS = NUMBER OF SCATTERERS VISIBLE
   RO = RANGE TO TARGET CG
   R1 = RANGE TO FIRST TAP
ROD = RANGE RATE OF TARGET CG
AMP(J) = AMPLITUDE OF J-TH SCATTERER
DA(J) = INCREMENTAL A-VECTOR OF J-TH SCATTERER
DB(J) = INCREMENTAL B-VECTOR OF J-TH SCATTERER
DC(J) = INCREMENTAL C-VECTOR OF J-TH SCATTERER
DAD(J) = INCREMENTAL A-VECTOR RATE OF J-TH SCATTERER

THE TARGET CG AND MISSILE CG COORDINATES ARE IN AN INERTIAL COORDINATE
SYSTEM REFERENCED TO THE GROUND (XY-PLANE PARALLEL TO GROUND, Z- DOWN)

THE ABC-VECTORS ARE DEFINED AS:

A - FROM THE TARGET TO THE MISSILE
B - PARALLEL TO THE GROUND, TO THE LEFT AS VIEWED FROM MISSILE
C - PERPENDICULAR TO A AND B IN RIGHT-HAND COORDINATE SYSTEM

THE TARGET COORDINATES ARE:

X - TARGET LONGITUDINAL AXIS, POSITIVE IN DIRECTION OF NOSE
Y - IN DIRECTION OF RIGHT WING
Z - DOWN

THE BODY RATES ARE DEFINED AS:

BP - CW ROTATION RATE ABOUT TARGET X-AXIS
BQ - CW ROTATION RATE ABOUT TARGET Y-AXIS
RQ - CW ROTATION RATE ABOUT TARGET Z-AXIS

THE DIRECTION OF ROTATION IS DEFINED LOOKING OUT FROM THE COORDINATE
ORIGIN.

SEE SUBROUTINE XFORM FOR A DEFINITION OF THE YAW, PITCH, AND ROLL
ANGLES.

THE RFSS CHAMBER COORDINATES ARE ASSUMED TO BE PARALLEL TO THE ABC-
VECTORS. RANGE IS IN -A DIRECTION, RIGHT AZIMUTH IN -B DIRECTION, AND
UP ELEVATION IN -C DIRECTION.

ALL DISTANCES (INCLUDING WAVELENGTH) MUST BE IN THE SAME UNITS. ALL
ANGLES MUST BE IN RADIANS.

DIMENSION A(3), B(3), C(3), WA(3), WB(3), WC(3)
COMMON /T1/ XO, YO, ZO, XOD, YOD, ZOD, PSI, THETA, PHI, BP, BQ, BR
COMMON /T2/ CPSI, SPSI, CTHETA, STHETA, CPHI, SPHI
COMMON /T3/ XM, YM, ZM, XMD, YMD, ZMD
COMMON /T4/ NSCAT, ST, AMPMIN, X(20), Y(20), Z(20)
COMMON /T5/ NTAP, DRTAP
COMMON /T7/ NSRO, R1, ROD, AMP(20), DA(20), DB(20), DC(20), DAD(20)

COMPUTE SINES AND COSINES OF ANGLES
CALL SINCOS(PSI, SPSI, CPSI)
CALL SINCOS(THETA, STHETA, CTHETA)
CALL SINCOS(PHI, SPHI, CPHI)

C COMPUTE RANGE TO TARGET CG AND A-VECTOR
C
A(1)=XM-XO
A(2)=YM-YO
A(3)=ZM-ZO
RO=SQRT(A(1)**2+A(2)**2+A(3)**2)
A(1)=A(1)/RO
A(2)=A(2)/RO
A(3)=A(3)/RO

C COMPUTE RANGE TO FIRST TAP
C
R1=RO-.5*(NTAP-1)*DRTAP
C
C COMPUTE RANGE RATE OF TARGET CG
C
ROD=A(1)*(XOD-XMD)+A(2)*(YOD-YMD)+A(3)*(ZOD-ZMD)
C
C COMPUTE B- AND C-VECTORS
C
RHO=SQRT(A(1)**2+A(2)**2)
B(1)=-A(2)/RHO
B(2)=A(1)/RHO
B(3)=0.
C(1)=-A(3)*B(2)
C(2)=A(3)*B(1)
C(3)=RHO

C TRANSFORM A-, B-, AND C-VECTORS TO TARGET COORDINATES
C
CALL XFORM(A, WA)
CALL XFORM(B, WB)
CALL XFORM(C, WC)

C COMPUTE TARGET ASPECT ANGLE (ALPHA=AZIMUTH, BETA=ELEVATION, ANGL=ANGLE TO ROLL AXIS)
C
ALPHA=ATAN2(WA(2), WA(1))
SBETA=-WA(3)
BETA=ATAN2(SBETA, SQRT(1.-SBETA**2))
ANGL=ATAN2(SQRT(1.-WA(1)**2), WA(1))

C LOOP OVER SCATTERERS
C
L=1
DO 20 K=1, NSCAT
   SAMP=SCTAMP(K, ANGL)
   IF (SAMP .LE. AMPMIN) GO TO 20
   AMP(L) = SAMP
C
C COMPUTE INCREMENTAL A, B, C COORDINATE
C
   DA(L) = X(K) * WA(1) + Y(K) * WA(2) + Z(K) * WA(3)
   DB(L) = X(K) * WB(1) + Y(K) * WB(2) + Z(K) * WB(3)
   DC(L) = X(K) * WC(1) + Y(K) * WC(2) + Z(K) * WC(3)
C
C COMPUTE INCREMENTAL A-VECTOR RATE (SMALL ANGLES ARE ASSUMED)
C
   XKD = Z(K) * BQ - Y(K) * BR
   YKD = -Z(K) * BP + X(K) * BR
   ZKD = Y(K) * BP - X(K) * BQ
   DAD(L) = XKD * WA(1) + YKD * WA(2) + ZKD * WA(3)
   L = L + 1
20 CONTINUE
   NS = L - 1
   RETURN
END
SUBROUTINE ETGDM(DTIME)
C
C GLINT AND DOPPLER MODULATION FOR N-POINT SCATTER MODEL
C
C IN THIS SUBROUTINE WE COMPUTE THE GLINT OFFSETS AND MODULATION SIGNALS
C APPLIED TO EACH TAP OF THE TAPPED-DELAY LINE. IT IS TO BE CALLED
C AFTER ETGEO TRANSFORMS COORDINATES TO RADAR SPACE. IT WILL USUALLY
C BE CALLED MORE FREQUENTLY THAN ETGEO. IT IS ALSO THE BEST SUBROUTINE
C TO PLACE IN THE AP120B.
C
C EXCEPT FOR TIME, ALL COMMUNICATION TO AND FROM THIS SUBROUTINE IS THRU
C COMMON.
C
ON INPUT.....

DTIME = TIME SINCE LAST UPDATE IN TARGEO

/T5/ NTAP = NUMBER OF TAPS IN TAPPED DELAY LINE
DRTAP = SPACING BETWEEN TAPS (2-WAY RANGE)
XL = WAVELENGTH
PTGDSG = PRODUCT OF TRANSMIT POWER, GAIN, AND SQUARE OF
RFSS CHAMBER LENGTH

/T7/ NS = NUMBER OF SCATTERERS VISIBLE
RO = RANGE TO TARGET CG
RI = RANGE TO FIRST TAP
AMP(J) = AMPLITUDE OF J-TH SCATTERER
DA(J) = INCREMENTAL A-VECTOR OF J-TH SCATTERER
DB(J) = INCREMENTAL B-VECTOR OF J-TH SCATTERER
DAD(J) = INCREMENTAL A-VECTOR RATE OF J-TH SCATTERER

ON OUTPUT.....

/T8/ PEFF = EFFECTIVE RADIATED POWER AT RFSS ARRAY
VR(I) = IN-PHASE MODULATION SIGNAL TO I-TH TAP
VI(I) = QUADRATURE MODULATION SIGNAL TO I-TH TAP
DAZ(I) = GLINT OFFSET (AZIMUTH) FOR I-TH TAP
DEL(I) = GLINT OFFSET (ELEVATION) FOR I-TH TAP

THE PARAMETER PMIN IS JUST SOME SMALL NUMBER TO PREVENT DIVIDE BY ZERO

ARRAYS VBR, VBI, VCR, VCI MUST BE DIMENSIONED AS LARGE AS NTAP
C

DIMENSION VBR(8), VBI(8), VCR(8), VCI(8)
DIMENSION SS(4), CC(4)
DIMENSION TW(4)
COMMON /T5/ NTAP, DRTAP, DRGATE, XL, PTGDSG
COMMON /T7/ NS, RO, RI, ROD, AMP(20), DA(20), DB(20), DC(20), DAD(20)
COMMON /T8/ PEFF, VR(8), VI(8), DAZ(8), DEL(8)
DATA PMIN/1. E-10/

DATA FOURPI/12. 5663706/

C
C ZERO ARRAYS
C
CALL XMIT(-NTAP, O., VR)
CALL XMIT(-NTAP, O., VI)
CALL XMIT(-NTAP, O., VBR)
CALL XMIT(-NTAP, O., VBI)
CALL XMIT(-NTAP, O., VCR)
CALL XMIT(-NTAP, O., VCI)
CALL XMIT(-NTAP, O., DAZ)
CALL XMIT(-NTAP, O., DEL)

C
C LOOP OVER NS SCATTERERS
C
DO 40 J=1, NS
C
C COMPUTE TAP NUMBER OF FIRST TAP (ITAP) AND FRACTION (P)
C
R=R0-(DA(J)+DAD(J)*DTIME)
P=(R-R1)/DRTAP+100.
ITAP=P
P=P-ITAP
ITAP=ITAP-100

C
C COMPUTE RANGE DIFFERENCE FROM TAP NUMBER ITAP
C
DR=(P+1.)*DRTAP
C
C FIND TAP WEIGHTS
C
CALL TAPWTS(P, TW)
C
C COMPUTE PHASE ON FOUR TAPS
C
DO 20 I=1, 4
CALL SINCOS(-FOURPI*DR/XL, S, C)
SS(I)=S*AMP(J)*TW(I)
CC(I)=C*AMP(J)*TW(I)
DR=DR-DRTAP
20 CONTINUE
C
C LOOP OVER UP TO FOUR TAPS AND INCREMENT ARRAYS
C
IF(ITAP.GT.NTAP) GO TO 40
IF(ITAP.LT.-2) GO TO 40
I1=MAX0(ITAP, 1)
I2=MINO(ITAP+3, NTAP)
II=I1-ITAP
DO 30 I=I1, I2
30 CONTINUE
II=II+1
VR(I)=VR(I)+CC(II)
VI(I)=VI(I)+SS(II)
VBR(I)=VBR(I)+CC(II)*DB(J)
VBI(I)=VBI(I)+SS(II)*DB(J)
VCR(I)=VCR(I)+CC(II)*DC(J)
VCI(I)=VCI(I)+SS(II)*DC(J)
30 CONTINUE
40 CONTINUE

C COMPUTE QLINT OFFSETS FOR EACH TAP AND PEAK POWER
C
C PEAK=0.
DO 50 I=1,NTAP
POW=VR(I)**2+VI(I)**2
IF(POW.GT.PEAK) PEAK=POW
IF(POW.LT.PMIN) GO TO 50
DAZ(I)=-(VBR(I)*VR(I)+VBI(I)*VI(I))/(RO*POW)
DEL(I)=-(VCR(I)*VR(I)+VCI(I)*VI(I))/(RO*POW)
50 CONTINUE

C NORMALIZE AMPLITUDE
C
ANORM=SQRT(PEAK)
DO 60 I=1,NTAP
VR(I)=VR(I)/ANORM
VI(I)=VI(I)/ANORM
60 CONTINUE

C COMPUTE EFFECTIVE RF POWER
C
PEFF=PEAK*PTGDSQ/(FOURPI*RO**4)

RETURN
END
SUBROUTINE XFORM(A, W)

C IN THIS SUBROUTINE WE TRANSFORM A VECTOR (A) IN INERTIAL COORDINATES TO A VECTOR (W) IN TARGET COORDINATES. THE COORDINATE ROTATIONS, IN THE ORDER OF APPLICATION, ARE:

C
C PSI = CW ROTATION OF Z-AXIS (YAW)
C THETA = CW ROTATION OF Y-AXIS (PITCH)
C PHI = CW ROTATION OF X-AXIS (ROLL)
C
C THE DIRECTION OF ROTATION IS DEFINED LOOKING INTO THE COORDINATE ORIGIN. IN THIS SUBROUTINE THE SINES AND COSINES OF THE ANGLES ARE INPUT THRU COMMON /T2/.

C
DIMENSION A(3), W(3)
COMMON /T2/ CPSI, SPSI, CTHETA, STHETA, CPHI, SPHI
UX=A(1)*CPSI-A(2)*SPSI
UY=A(1)*SPSI+A(2)*CPSI
UZ=A(3)
VX= UX*CTHETA+UZ*STHETA
VY= UY
VZ=-UX*STHETA+UZ*CTHETA
W(1)=VX
W(2)=VY*CPHI-VZ*SPHI
W(3)=VY*SPHI+VZ*CPHI
RETURN
END
SUBROUTINE TAPWTS(P, TW)

C IN THIS SUBROUTINE FOUR TAP WEIGHTS ARE RETURNED IN ARRAY TW ACCORDING
C TO THE FRACTION P. THE WEIGHTS ARE EXTRACTED FROM A PRECOMPUTED TABLE
C (SEE SUBROUTINE TAPSET).
C
C ARRAY TWARAY IS USED AS IF IT WERE DIMENSIONED (4, NARAY).
C
DIMENSION TW(4)
COMMON /T6/ NARAY, TWARAY(1)
DATA LW/6/
INDEX=(NARAY-1)*P+1.5
CALL XMIT(4, TWARAY(4*INDEX-3), TW)

RETURN
END
SUBROUTINE TAPSET

C IN THIS SUBROUTINE THE TAP WEIGHT TABLE IS COMPUTED. IT IS A
C COMPANION SUBROUTINE TO TAPWTS, AND IT IS TO BE CALLED AS AN INITIAL-
C IZATION STEP PRIOR TO THE BEGINNING OF THE SIMULATED MISSION.

C /T5/ DRTAP = SPACING BETWEEN TAPS (2-WAY RANGE)
C DROATE = SPACING BETWEEN RECEIVER GATES (2-WAY RANGE)

C ARRAY TWARAY MUST BE DIMENSIONED AS LARGE AS 4*NARAY.

C

DIMENSION A(4,4),X(4)
COMMON /T5/ NTAP,DRTAP,DRGATE
COMMON /T6/ NARAY,TWARAY(1)
D=DRTAP/DRGATE
L=1
DO 30 K=1,NARAY
P=(K-1)/FLOAT(NARAY-1)
DO 10 J=1,4
X(J)=CHI(D*(P+2-J))
10 CONTINUE
DO 20 I=1,4
DO 20 J=1,4
A(I,J)=CHI(D*(I-J))
20 CONTINUE
CALL SIMO(A,X,4,IERR)
IF(IERR.GT.0) STOP
CALL XMIT(4,X,TWARAY(L))
L=L+4
30 CONTINUE
RETURN
END
FUNCTION CHI(P)
C
C RANGE GATE RESPONSE. THE ARGUMENT P IS THE RANGE MISMATCH NORMALIZED
C TO THE RECEIVER GATE SPACING. INTERPOLATION IS USED ON THE SAMPLES
C STORED IN THE A-ARRAY, WHERE THE SPACING IS 0.1 UNIT.
C
C THE RESIDUAL ERROR IN THE INTERPOLATION IS LESS THAN .0003
C
C P MUST BE LESS THAN 1.5 IN MAGNITUDE.
C
C THE SAMPLES ARE OF THE RESPONSE DERIVED IN MRI REPORT 149-4.
C
DIMENSION A(18)
DATA A/(1.00000, .98104, .92193, .81903, .67431, .50112, .32385, 1
   .17071, .06308, .00731, -.00651, .00182, .01262, .01458, 2
   .00713, -.00313, -.00898, -.00762) /
H=10. *ABS(P)
IF(H.GT.15.) STOP 55
I=H
H=H-1
IP1=I+1
IP2=I+2
IP3=I+3
IF(I.LE.0) I=2
CHI=-.16667*H*(H-1.)*(H-2.)*A(I) + .5*(H**2-1.)*(H-2.)*A(IP1)
   1 + -.5*H*(H+1.)*(H-2.)*A(IP2) + .16667*H*(H**2-1.)*A(IP3)
RETURN
END
SUBROUTINE SIMQ(A, B, N, IERR)

C SOLVES SET OF N SIMULTANEOUS EQUATIONS....

C A * X = B

C WHERE ARRAY A IS 2-DIMENSIONAL. ARRAY X IS RETURNED IN ARRAY B, AND
C ARRAY A IS DESTROYED. COMPUTATION IS VALID IF IERR=0

DIMENSION A(1), B(1)
IERR = 0
IF (N.GT.0) GO TO 10
IERR = 1
RETURN

FORWARD SOLUTION

10 TOL = 0.0
KS = 0
JJ = -N
DO 65 J = 1, N
JJ = JJ + 1
BIQA = 0.
IT = JJ - J
DO 30 I = J, N

SEARCH FOR MAXIMUM COEFFICIENT IN COLUMN

IJ = IT + I
IF (ABS(BIQA)-ABS(A(IJ))) 20, 30, 30
20 BIQA = A(IJ)
IMAX = I
30 CONTINUE

TEST FOR PIVOT LESS THAN TOLERANCE (SINGULAR MATRIX)

IF (ABS(BIQA)-TOL) 35, 35, 40
35 IERR = 2
RETURN

INTERCHANGE ROWS IF NECESSARY

40 II = J + N*(J-2)
IT = IMAX - J
DO 50 K = J, N
II = II + N
I2 = II + IT
SAVE = A(I1)
A(I1) = A(I2)

50 CONTINUE
A(I2) = SAVE

DIVIDE EQUATION BY LEADING COEFFICIENT

50 A(I1) = A(I1)/BIGA
SAVE = B(IMAX)
B(IMAX) = B(J)
B(J) = SAVE/BIGA

ELIMINATE NEXT VARIABLE

IF (J-N) 55, 70, 55
55 IGS = N*(J-1)
DO 65 IX = JY, N
IXJ = IGS + IX
IT = J - IX
DO 60 JX = JY, N
IXJX = N*(JX-1) + IX
JJX = IXJX + IT
60 A(IXJX) = A(IXJX) - (A(IXJ)*A(JJX))
65 B(IX) = B(IX) - (B(J)*A(IXJ))

BA SOLUTION

70 NY = N - 1
IT = N*N
DO 80 J = 1, NY
IA = IT - J
IB = N - J
IC = N
DO 80 K = 1, J
B(IB) = B(IB) - A(IA)*B(IC)
IA = IA - N
80 IC = IC - 1
RETURN
END
SUBROUTINE XMIT(N, A, B)

C IN THIS SUBROUTINE WE EITHER TRANSMIT ARRAY A TO ARRAY B (IF N.GT.0)
C OR WE TRANSMIT THE CONSTANT A TO ARRAY B (IF N.LT.0). IN EITHER CASE
C THE ARRAY LENGTH IS IABS(N).
C
C THIS SUBROUTINE SHOULD BE WRITTEN IN ASSEMBLY LANGUAGE
C
DIMENSION A(1), B(1)
IF(N) 10, 20, 25
10 NN=-N
   AA=A(1)
   DO 15 K=1, NN
      B(K)=AA
15 CONTINUE
20 RETURN
25 DO 30 K=1, N
      B(K)=A(K)
30 CONTINUE
RETURN
END
SUBROUTINE SINCOS(ARG, S, C)

C
C THIS SUBROUTINE SHOULD BE WRITTEN IN ASSEMBLY LANGUAGE, USING THE
C TABLE-LOOKUP METHOD DESCRIBED BY MITCHELL (RADAR SIGNAL SIMULATION).
C
S=SIN(ARG)
C=COS(ARG)
RETURN
END
SUBROUTINE ETOD1(DTIME)

C QLINT AND DOPPLER MODULATION FOR N-POINT SCATTER MODEL
C NO RANGE EXTENSION
C SUBROUTINE REPLACES ETQDM
C ON INPUT.....

C DTIME = TIME SINCE LAST UPDATE IN TARGET
C
C /T5/ XL = WAVELENGTH
C PTGDSQ = PRODUCT OF TRANSMIT POWER, GAIN, AND SQUARE OF
C RFSS CHAMBER LENGTH
C /T7/ NS = NUMBER OF SCATTERERS VISIBLE
C AMP(J) = AMPLITUDE OF J-TH SCATTERER
C DA(J) = INCREMENTAL A-VECTOR OF J-TH SCATTERER
C DB(J) = INCREMENTAL B-VECTOR OF J-TH SCATTERER
C DC(J) = INCREMENTAL C-VECTOR OF J-TH SCATTERER
C DAD(J) = INCREMENTAL A-VECTOR RATE OF J-TH SCATTERER
C
C ON OUTPUT.....
C
C /T8/ PEFF = EFFECTIVE RADIATED POWER AT RFSS ARRAY
C /T9/ VR, VI = DOPPLER MODULATION SIGNAL
C DR, DAZ, DEL = RANGE, AZIMUTH, AND ELEVATION QLINT OFFSETS
C
C COMMON /T5/ NTAP, DRTAP, DRQATE, XL, PTGDSQ
C COMMON /T7/ NS, RO, R1, ROD, AMP(20), DA(20), DB(20), DC(20), DAD(20)
C COMMON /T8/ PEFF
C COMMON /T9/ VR, VI, DR, DAZ, DEL
C DATA FOURPI/12. 5663706/
C
C ZERO ACCUMULATORS
C
C VR=0.
C VI=0.
C VAR=0.
C VAI=0.
C VBR=0.
C VBI=0.
C VCR=0.
C VCI=0.
C
C LOOP OVER NS SCATTERERS
C
DO 40 J=1,NS
CALL SINCOS(FOURPI*(DA(J)+DAD(J)*DTINE)/XL,S,C)
C=C*AMP(J)
S=S*AMP(J)
VR =VR +C
VI =VI +S
VAR=VAR+C*DA(J)
VAI=VAI+S*DA(J)
VBR=VBR+C*DB(J)
VBI=VBI+S*DB(J)
VCR=VCR+C*DC(J)
VCI=VCI+S*DC(J)
40 CONTINUE
POW=VR**2+VI**2
AMPL=SQRT(POW)

C COMPUTE OLLINT OFFSETS
C
DR=-(VAR*VR+VAI*VI)/POW
DAI=-(VBR*VR+VBI*VI)/(RO*POW)
DEL=-(VCR*VR+VCI*VI)/(RO*POW)

C COMPUTE EFFECTIVE RF POWER
C
PEFF=POW*PTGDBG/(FOURPI*RO**4)
C
C NORMALIZE
C
VR=VR/AMPL
VI=VI/AMPL
RETURN
END
SUBROUTINE DATAIN
C READS TARGET SCATTERING DATA SUPPLIED BY M. MUMFORD (SEE SCTAMP).
C
DIMENSION IA(1), AA(4), XX(4), YY(4), ZZ(4)
COMMON /DP/ P(100), IP(100)
COMMON /DG/ Q(918)
COMMON /T4/ NSCAT
DATA LR, LW/5, 6/
NSCAT=10
M=1
DO 20 I=1, NSCAT
PRINT 99, I
L=10*(I-1)
10 L=L+1
READ (LR, 100) IA, P(L), AA, XX, YY, ZZ
WRITE (LW, 100) IA, P(L), AA, XX, YY, ZZ
IP(L)=M
IA=IA-2
CALL XMIT(17, IA, Q(M))
M=M+17
IF(P(L).LT.180.) GO TO 10
20 CONTINUE
RETURN
99 FORMAT(/29H TARGET DATA FOR SCATTERER NO13//)
100 FORMAT(1XI1, 12XFB.3, 4E14.8/(22X4E14.8))
END
FUNCTION SCTAMP(K, ANGL)

C IN THIS SUBROUTINE WE COMPUTE THE AMPLITUDE (SQRT(RCS)) OF THE K-TH
C SCATTERER AS VIEWED FROM THE TARGET ASPECT.....
C
C ANGL = ANGLE FROM ROLL AXIS MEASURED FROM NOSE (RAD)  **
C
C IN ADDITION IN COMMON /T4/..... **
C
ST = BIAS THAT IS ADDED TO ANGL (RAD)  **
C
C THIS SUBROUTINE ACCESSES TARGET DATA SUPPLIED BY MIKE MUMFORD AT NWC/
C CHINA LAKE IN THE FORMAT DEFINED BY A COMPUTER PROGRAM WRITTEN 5/11/78
C BY E. HUTTON X3219.
C
DIMENSION IA(1), AA(4), XX(4), YY(4), ZZ(4)
COMMON /T4/ NSCAL, ST, AMPMIN, X(20), Y(20), Z(20)
COMMON /DP/ P(100), IP(100)
COMMON /DQ/ Q(918)

ANG=ABS(ANGL+ST)*57.2957795 **
IF(ANG. GT. 180. ) ANG=180. **
I1=10*(K-1)+1
I2=I1+9
DO 20 I=I1, I2
IF(ANG.LT.P(I)) GO TO 25
20 CONTINUE
25 M=IP(I)
   CALL XMIT(17, Q(M), IA) **
   IF(IA) 30, 31, 32
30 SCTAMP=AA(1)+ANG*(AA(2)+ANG*(AA(3)+ANG*AA(4)))
   GO TO 35
31 SCTAMP=EXP(AA(1)+ANG*AA(2))
   GO TO 35
32 SCTAMP=EXP(AA(1)+ANG*AA(2))-EXP(AA(3)+ANG*AA(4))
35 SCTAMP=.09004*SCTAMP **
IF(SCTAMP.LT.AMPMIN) RETURN **
X(K)=XX(1)+ANG*(XX(2)+ANG*(XX(3)+ANG*XX(4)))
Y(K)=YY(1)+ANG*(YY(2)+ANG*(YY(3)+ANG*YY(4)))
Z(K)=ZZ(1)+ANG*(ZZ(2)+ANG*(ZZ(3)+ANG*ZZ(4)))
Y(K)=-Y(K) **
Z(K)=-Z(K) **
RETURN
END