TECHNICAL REPORT ARAED-TR-88019

PASCC1: PICATINNY ARSENAL SHAPED CHARGE CODE, ONE-DIMENSIONAL ANALYSIS VERSION 2.1

ERNEST L. BAKER

OCTOBER 1988

U. S. ARMY ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ARMAMENT ENGINEERING DIRECTORATE
PICATINNY ARSENAL, NEW JERSEY

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.
The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

The citation in this report of the names of commercial firms or commercially available products or services does not constitute official endorsement by or approval of the U.S. Government.

Destroy this report when no longer needed by any method that will prevent disclosure of contents or reconstruction of the document. Do not return to the originator.
# Picatinny Arsenal Shaped Charge Code, One-Dimensional Analysis Version 2.1 (PASCC1)

Picatinny Arsenal Shaped Charge Code, One-dimensional Analysis Version 2.1 (PASCC1) is a phenomenologically based one-dimensional shaped charge program, resident on the CDC 825/74c at Picatinny Arsenal. PASCC1 has the capability of modeling a large variety of shaped charges, including shaped charges with axial explosive composition and density gradients, detonation wave shapers, variable body geometries, variable explosive charge geometries, and variable liner geometries. The shaped charge liner is treated as a series of liner points (mass points). The program uses accelerating Gurney formulation with constant gamma, explosive products polytropic expansion to predict the acceleration of each liner point. The collapse angle of the liner is calculated using a modified Taylor Angle formulation, which compensates for liner point acceleration. The shaped charge jet parameters are calculated using the Pugh-Eichelberger-Rostoker jet/slug formulation.

Use of the program, as well as a preprocessor and post processor, is explained.
# CONTENTS

<table>
<thead>
<tr>
<th>Introduction</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPASCC</td>
<td>1</td>
</tr>
<tr>
<td>PASCC1</td>
<td>2</td>
</tr>
<tr>
<td>GPASCC</td>
<td>2</td>
</tr>
<tr>
<td>Support</td>
<td>3</td>
</tr>
<tr>
<td>References</td>
<td>13</td>
</tr>
<tr>
<td><strong>Appendixes</strong></td>
<td></td>
</tr>
<tr>
<td>A PASCC1 Input Data Format</td>
<td>15</td>
</tr>
<tr>
<td>B PASCC1 Output Data Format</td>
<td>19</td>
</tr>
<tr>
<td>C Shaped Charge Calculation Example 81 mm, 42 Degree Copper Line Comp B Explosive</td>
<td>23</td>
</tr>
</tbody>
</table>

## Distribution List

<table>
<thead>
<tr>
<th>Distribution/Avail. Codes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NTIS GRA&amp;I</td>
<td>X</td>
</tr>
<tr>
<td>Unannounced</td>
<td></td>
</tr>
<tr>
<td>Justification</td>
<td></td>
</tr>
</tbody>
</table>

**Accession For**

<table>
<thead>
<tr>
<th>Distribution/Avail. Codes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td></td>
</tr>
<tr>
<td>FIGURES</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>1 Body and explosive geometry input for LPASCC</td>
<td>5</td>
</tr>
<tr>
<td>2 LPASCC input parameters for the cone liner driver CONEL</td>
<td>5</td>
</tr>
<tr>
<td>3 LPASCC input parameters for the trumpet liner drive TRUMPL</td>
<td>6</td>
</tr>
<tr>
<td>4 LPASCC input parameters for the variable liner drive VARIL</td>
<td>6</td>
</tr>
<tr>
<td>5 GPASCC plotting menu</td>
<td>7</td>
</tr>
<tr>
<td>6 Example GPASCC output</td>
<td>8</td>
</tr>
<tr>
<td>7 Example GPASCC output (jet profile at 50 μs intervals)</td>
<td>10</td>
</tr>
</tbody>
</table>
INTRODUCTION

PASCC1 is a phenomenologically based one-dimensional shaped charge program, resident on the CDC 825/74c at Picatinny Arsenal. PASCC1 was originally developed by the Energetics and Warheads Division of ARDEC in order to evaluate axial explosive density and composition gradient effects on shaped charge jet characteristics. PASCC1 has since been successfully used on a variety of shaped charge applications and is under continual development. PASCC1 has the capability of modeling a large variety of shaped charges, including shaped charges with: axial explosive composition and density gradients, detonation wave shapers, variable body geometries, variable explosive charge geometries, and variable liner geometries. The shaped charge liner is treated as a series of liner points (mass points). The program uses accelerating Gurney formulation with constant gamma explosive products polytropic expansion to predict the acceleration of each liner point. The collapse angle of the liner is calculated using a modified Taylor angle formulation, which compensates for liner point acceleration. The shaped charge jet parameters are calculated using the Pugh-Eichelberger-Rostoker (ref 1) jet/slug formulation. A general review of shaped charge theory may be found in reference 2.

Input data can be generated either directly by hand (from drawings, explosive data, etc.) or by a preprocessor program. The currently used preprocessor program is LPASCC. LPASCC calculates the detonation sweep velocities along the liner using desired initiation, explosive, and liner configurations. An explosives library and a materials library exists in the program, but explosive and materials parameters can also be interactively input. When required, a thermo-chemical equation of state program, such as TIGER (ref 3), can be used to generate explosive input parameters.

The output data can either be evaluated directly by hand (read created data files, graph by hand, etc.) or by a postprocessor program. The currently used postprocessor program is GPASCC. GPASCC can plot a large variety of shaped charge parameters including liner mass point initial positions, liner collapse conditions, and jet conditions.

LPASCC

LPASCC is a preprocessor program used to generate input files for the program PASCC1. Either plane, point, or ring initiation can be specified. Bodies can be of constant thickness or the thickness can be fitted with a polynomial. A variety of body materials are included in the library, or desired material parameters can be interactively input. The explosive charge geometry can be cylindrical, cylindrical with a tapered cut, or fit with a polynomial. Possible body and explosive geometry input is shown in figure 1. The explosive material can have constant properties, or have axial density and composition gradients. A variety of explosive materials are included in the explosives library, or explosive properties can be interactively input. LPASCC includes three liner
drivers: CONEL for cone liners, TRUMPI for trumpet liners, and VARIL for variable liners fit with polynomial and/or sinusoid functions. The required input for the three liner drivers is shown in figures 2, 3, and 4. The program can be run interactively on any terminal. Once the program execution begins, the program will prompt for all entry. To begin program execution the following command must be entered:

```
BEGIN,LPASCC,/PASCCL,outfile,id.
```

- `outfile` = user supplied data filename (input file for PASCC1)
- `id` = id under which outfile will be catalogued

**PASCC1**

PASCC1 does the liner collapse and jetting conditions calculations for a shaped charge using the geometry, material, explosive, and detonation data supplied in the input data file. The input data file is produced by LPASCC or by hand. The input data format is presented in appendix A. The liner collapse and jetting conditions are output in a file that can be reduced by the postprocessor program GPASC or by hand. The output data format is presented in appendix B. PASCC1 can be executed by using the following command on the CDC 825/74C:

```
BEGIN,PASCC1,/PASCCL,infile,outfile,id.
```

- `infile` = user supplied input data filename
- `outfile` = user supplied output data filename
- `id` = id under which infile is catalogued and outfile will be catalogued

Program PASCC1 should normally be executed in batch mode (i.e., the above command should be in a batch file).

**GPASC**

GPASC is a data reduction program used to evaluate results from program PASCC1. The program reduces and graphs data from PASCC1 output files. Many graphing options are available in the program, including line types and data symbols. A large variety of shaped charge parameters can be plotted including liner mass point initial positions, liner collapse conditions, jetting conditions, and jet profiles. The GPASC plot menu is presented in figure 5. Some examples of GPASC produced plots are presents in figure 6 and 7. The program must be run interactively on a graphics terminal (TEK4014, etc.). Once program execution begins, the program will prompt for all entry. To begin program execution the following command must be entered:
BEGIN,G/PASCC1,infile,id.

infile = user supplied data filename (output file from PASCC1)
id = id under which infile will be catalogued

SUPPORT

In order to facilitate the initial use of PASCC1, an example shaped charge calculation is presented in appendix C. This manuscript will be periodically updated, as well as PASCC1 capabilities.
Figure 1. Body and explosive geometry input for LPASCC

Figure 2. LPASCC input parameters for the cone liner driver CONEL
Figure 3. LPASCC input parameters for the trumpet liner drive TRUMPL

Figure 4. LPASCC input parameters for the variable liner drive VARIL
1) JET VELOCITY (KM/S)
2) SLUG VELOCITY (KM/S)
3) COLLAPSE POINT VELOCITY (KM/S)
4) COLLAPSE VELOCITY WRT COLLAPSE POINT (KM/S)
5) COLLAPSE MACH NUMBER
6) GURNEY VELOCITY (KM/S)
7) COLLAPSE ANGLE (RADIANS)
8) TAYLOR ANGLE (RADIANS)
9) COLLAPSE POINT (MM)
10) COLLAPSE TIME (US)
11) JET MASS FRACTION
12) LINER POINT THICKNESS (MM)
13) LINER POINT AXIAL POSITION (MM)
14) LINER POINT RADIUS (MM)
15) LINER HALF ANGLE AT LINER POINT (RADIANS)
**** JET PROFILE, ACCOUNTS FOR INVERSE GRADIENT ****
16) JET PROFILE AXIAL POSITION (MM)
17) JET PROFILE RADIAL THICKNESS (MM)
18) ACCUMULATED JET MASS (G)
19) ACCUMULATED JET ENERGY (J)
ENTER DESIRED X AND Y VARIABLES:

Figure 5. GPASCC plotting menu
Figure 6. Example GP:ASCC output
Figure 6. (cont)
Figure 7. Example GPASCC output (jet profile at 50 μs intervals)
Figure 7. (cont)
Figure 7. (cont)
REFERENCES


APPENDIX A

PASCC1 INPUT DATA FORMAT
The input data format for PASCCi is as follows:

```
---------
:ISHCH:
---------
:RHL0:CSL:RHOB:
---------
:IPT:IGEM:IGCM:
---------
---------
```

Variable Definitions:

ISHCH = NUMBER OF SHAPED CHARGES TO BE ANALYZED
RHOL = LINER DENSITY (Km/s)
CSL = LINER MATERIAL SOUND SPEED (Km/s)
RHOB = BODY DENSITY (Km/s)
IPT = NUMBER OF LINER POINTS TO BE INPUT
IGEM = SHAPED CHARGE GEOMETRY (1 Linear, 2 Cylindrical)
IGCM = CHARGE/MASS RATIO GEOMETRY (1 Linear, 2 Cylindrical)
R = LINER POINT RADIUS (mm)
X = LINER POINT AXIAL POSITION (mm)
A = LINER HALF ANGLE AT LINER POINT (radians)
XC = CHARGE LENGTH AT LINER POINT (mm)
XL = LINER THICKNESS AT LINER POINT (mm)
U = DETONATION SWEEP VELOCITY ACROSS LINER POINT (Km/s)
RHOC = CHARGE DENSITY (g/cc)
CGUR = GUINEY CONSTANT (Km/s)
GAM = EXPLOSIVE PRODUCTS CONSTANT GAMMA
APPENDIX B

PASCC1 OUTPUT DATA FORMAT
The output data format for FASCCI is as follows:

```

:ISHCH:
--------------
:RHOL:CSL:RHOB:
--------------
:IJPT:IGEOM:
--------------
:U:RHOC:GAM:CGUR:
--------------
```

Variable Definitions:

ISHCH = NUMBER OF SHAPED CHARGES ANALYZED
RHOL = LINER DENSITY (g/cc)
CSL = LINER MATERIAL SOUND SPEED (km/s)
RHOB = BODY DENSITY (g/cc)
IJPT = NUMBER OF JET POINTS OUTPUT
IGEOM = SHAPED CHARGE GEOMETRY (1 Linear, 2 Cylindrical)
U = DETONATION SWEEP VELOCITY ACROSS LINER POINT (km/s)
RHOC = CHARGE DENSITY (g/cc)
GAM = EXPLOSIVE PRODUCTS CONSTANT GAMMA
CGUR = GURNEY CONSTANT (km/s)
VJ = JET POINT VELOCITY (km/s)
VS = SLUG POINT VELOCITY (km/s)
VI = COLLAPSE POINT VELOCITY (km/s)
V = COLLAPSE VELOCITY WITH RESPECT TO THE COLLAPSE POINT (km/s)
CMN = COLLAPSE MACH NUMBER
VO = FINAL GURNEY VELOCITY (km/s)
B = COLLAPSE ANGLE (radians)
DEL = FINAL TAYLOR ANGLE (radians)
X = COLLAPSE POINT POSITION (mm)
BT = COLLAPSE TIME (fs)
FMJ = JET MASS FRACTION
XL = LINER POINT INITIAL THICKNESS (mm)
X0 = LINER POINT INITIAL AXIAL POSITION (mm)
RO = LINER POINT INITIAL RADIAL POSITION (mm)
A = LINER HALF ANGLE AT LINER POINT (radians)
APPENDIX C

SHAPED CHARGE CALCULATION EXAMPLE
81mm, 42 DEGREE COPPER LINE
COMP B EXPLOSIVE
PREPROCESSING:

COMMAND- et1,500
COMMAND- begin.lpascc./pascci.dibr1.mvid
AT CY= 012 SN=FFSET
AT CY= 002 SN=FFSET
************LPASCC************

Liner Input Driver for PASCC

************LPA$$$************

ENTER THE NUMBER OF SHAPED CHARGES TO BE ANALYZED: 1
1) LINEAR SHAPED CHARGE
2) CYLINDRICAL SHAPED CHARGE

ENTER DESIRED SHAPED CHARGE GEOMETRY: 2
1) LINEAR CHARGE TO MASS CALCULATION
2) CYLINDRICAL CHARGE TO MASS CALCULATION

ENTER DESIRED CHARGE TO MASS CALCULATION METHOD: 2
1) NORMAL UNIFORM CHARGE FILL
2) NON-UNIFORM CHARGE FILL

ENTER DESIRED EXPLOSIVE CHARGE TYPE: 1

1) LX-14, 1.82 G/CC
2) OCTOL(85/15), 1.835 G/CC
3) OCTOL(69/31), 1.778 G/CC
4) COMP A3, 1.63 G/CC
5) TNT, 1.63 G/CC

99) EXPLOSIVE VALUES MANUAL ENTRY

ENTER DESIRED EXPLOSIVE NUMBER: 99

ENTER EXPLOSIVE DENSITY (G/CC): 1.717

ENTER EXPLOSIVE DETONATION VELOCITY (KM/S): 7.9%

ENTER EXPLOSIVE CONSTANT POLYTROPIC GAMMA: 2.76

ENTER EXPLOSIVE GURNEY CONSTANT (KM/S): 2.8

1) CYLINDRICAL CHARGE
2) CYLINDRICAL CHARGE WITH TAPERED CUT

ENTER DESIRED CHARGE CONFIGURATION NUMBER: 1

ENTER THE CYLINDRICAL CHARGE RADIUS (MM): 40.5

1) PLANE INITIATION
2) POINT INITIATION

ENTER DESIRED EXPLOSIVE INITIATION: 2

ENTER THE RADIAL DISTANCE OF THE INITIATION
POINT FROM THE LINER APEX (MM): 0.

1) NO BODY
2) CONSTANT THICKNESS BODY
3) VARIABLE THICKNESS BODY
ENTER DESIRED BODY TYPE NUMBER: 2
ENTER THE BODY THICKNESS (MM): 4.35

1) COPPER
2) ALUMINIUM 2024
3) STAINLESS STEEL 304
4) NICKEL
5) TANTALUM
6) MOLYBDENUM
99) MATERIAL VALUE MANUAL ENTRY
ENTER DESIRED BODY MATERIAL NUMBER: 2

1) COPPER
2) ALUMINIUM 2024
3) STAINLESS STEEL 304
4) NICKEL
5) TANTALUM
6) MOLYBDENUM
99) MATERIAL VALUE MANUAL ENTRY
ENTER DESIRED LINER MATERIAL NUMBER: 1

1) CONE LINER
2) TRUMPET LINER
3) VARIABLE LINER
ENTER DESIRED LINER TYPE NUMBER: 1
CONEL**********CONE LINER INPUT DRIVER FOR PASCC
**********CONE LINER**********

ENTER THE DESIRED NUMBER OF CONE PTS: 150

ALPHA = LINER HALF ANGLE (RADIANS)
A = CONE THICKNESS FRACTION OF CYLINDER RADIUS
ENTER ALPHA AND A: 0.36651914. 0.046875
STOP
27100 MAXIMUM EXECUTION FL.
0.819 CP SECONDS EXECUTION TIME.
INITIAL CATALOG
RF = 050 DAYS
CT ID= MYID PFN=DIBRL
CT CY= 001 SN=PFSET 0000001664 WORDS.
COMMAND-
MAIN PROCESSING:

COMMAND- senator
--- get rpascc.myid
  3 LINES
--- list
  100 PASCCI.CM120000,T4000,102000.ST74C.
  110 COMMENT.(XXX-YYY,01291T),MYID
  120 BEGIN,PASCCI./PASCCI.DIBRL.DOBR,MID.
--- save rpascc
--- bye
COMMAND- batch.rpascc.input here
NAME-PASCC6S, DISP-INPUT , ID-XX/
COMMAND- logout

POST PROCESSING:

COMMAND- files
--- REMOTE OUTPUT FILES--
PASCC67
COMMAND- batch.pascc67.local
COMMAND- senator
--- old pascc67
  2 RECORDS/FILES
  46 LINES
--- list
  100 S
  110 OBATCH CREATED- TODAY IS 3/25/88
  120
  130
  140 12/30/87 ***** NEW VERS OF SCL FOR NOS/VE
QUICK REF *****
  150 NEW VERSION OF SCL FOR NOS/VE QUICK REFERENCE MANUAL,
PUB 60464018.
  160 REVISION F, LEVEL 688, IS NOW AVAILABLE TO USERS.
  170 CONTACT KATHY HUBERT, BLDG 350-N. ROOM 3, X 5870.
  180
  190 *EOR
  200 S
  210 1 74C NOS/BE 1.5 LEV 664-J CYBER 74 5/14/87
  220 14.17.37.PASCC67 FROM FEY/XX
  230 14.17.37.IP 00000128 WORDS - FILE INPUT , DC 04, ID= XX
XX
  240 14.17.38.PASCC1.CM120000,T4000,102000.ST74C.
  250 14.17.38.(XXX-YYY,01291T).MYID

27
260 14.17.39.BEGIN,PASCC1,PARSC1,DIBRL,DOBRL,MYID.
270 14.17.40.AT CY= 012 SN=PFSET
280 14.17.41.IFE,MYIDS.EQ.,NOME.,NOM.
290 14.17.41.ENDIF,NOM.
300 14.17.41.ATTACH,RPASC1,RPASC1,ID=FASCC1.
310 14.18.07.AT CY= 004 SN=PFSET
320 14.18.07.REQUEST,TAPE2,PF.
330 14.18.07.ATTACH,TAPE1,DOBRL,ID=MYIDS.
340 14.18.07.AT CY= 001 SN=PFSET
350 14.18.08.RPASC1.
360 14.18.11. CM LWA+1 = 14373B, LOADER USED 32400B
370 14.35.18. STOP
380 14.35.18. 25600 MAXIMUM EXECUTION FL.
390 14.35.18. 736.238 CP SECONDS EXECUTION TIME.
400 14.35.18.CATALOG,TAPE2,DOBRL,MYIDS.
410 14.35.18.INITIAL CATALOG
420 14.35.18.RP=050 DAYS
430 14.35.18.CT ID= MYID PFN=DOBRL
440 14.35.18.CT CY= 001 SN=PFSET 000004032 WORDS.
450 14.35.18.REVERT.
460 14.35.19.OP 00000616 WORDS - FILE OUTPUT . DC 4U, ID= XX

CURRENT DATA SET:1
1) JET VELOCITY (KM/S)
2) SLUG VELOCITY (KM/S)
3) COLLAPSE POINT VELOCITY (KM/S)
4) COLLAPSE VELOCITY WRT COLLAPSE POINT (KM/S)
5) COLLAPSE MACH NUMBER
6) GURNEY VELOCITY (KM/S)
7) COLLAPSE ANGLE (RADIANS)
8) TAYLOR ANGLE (RADIANS)
9) COLLAPSE POINT (MM)
10) COLLAPSE TIME (US)
11) JET MASS FRACTION
12) LINER POINT THICKNESS (MM)
13) LINER POINT AXIAL POSITION (MM)
14) LINER POINT RADIUS (MM)
15) LINER HALF ANGLE AT LINER POINT (RADIANS)
*** JET PROFILE, ACCOUNTS FOR INVERSE GRADIENT ***
16) JET PROFILE AXIAL POSITION (MM)
17) JET PROFILE RADIAL THICKNESS (MM)
18) ACCUMULATED JET MASS (G)
19) ACCUMULATED JET ENERGY (J)

ENTER DESIRED X AND Y VARIABLES: 13,1

INPUT THE NUMERIC CODE FROM THE LIST BELOW WHICH SPECIFIES YOUR TERMINAL TYPE.

1. TEK 4010
2. TEK4014
3. TEK4014-1
4. TEK4027
5. TEK4112
6. VT100 RETROGRAPHICS
7. GENISCO G-1000
8. TEK4113
9. TAB 132/15-G
10. MODGRAPH G100
11. TEK4027 CENTERED
12. TEK4027 ROTATED
13. IBM XY/750 PLOTTER
14. TEK4663 2-PEN PLOTTER
15. TEK4662 1-PEN PLOTTER
16. TEK4662 8-PEN PLOTTER
17. TEK 4054
18. TEK4105
19. TEK4107
20. TEK4109
21. TEK4115
22. HP2623A
23. DATAMEDIA DSCAN10(4010)
24. DATAMEDIA DSCAN10(4027)
25. GRIDVT100
26. MACINTOSH TEKALIKE
27. MACINTOSH VERSATERM
28. CIT-467(4014)
29. CIT-467(4027)

MY TYPE IS =3

ENTER X TITLE (40 CHARACTERS MAX):
LINER POSITION *mm*

ENTER Y TITLE (40 CHARACTERS MAX):
JET VELOCITY *Km/s*

(at this point plots are produced)
DISTRIBUTION LIST

Commander
Armament Research, Development and Engineering Center
U.S. Army Armament, Munitions and Chemical Command
ATTN: SMCAR-IMI-I (5)
SMCAR-CO
SMCAR-TD
SMCAR-TDC
SMCAR-AE (3)
SMCAR-AEE (3)
Picatinny Arsenal, NJ 07806-5000

Commander
U.S. Army Armament Research, Development and Engineering Center
ATTN: AMSMC-GCL(D)
AMSMC-DSM-B (D)
Picatinny Arsenal, NJ 07806-5000

Administrator
Defense Technical Information Center
ATTN: Accessions Division (12)
Cameron Station
Alexandria, VA 22304-6145

Director
U.S. Army Materiel Systems Analysis Activity
ATTN: AMXSY-MP
Aberdeen Proving Ground, MD 21005-5066

Commander
Chemical Research, Development and Engineering Center
U.S. Army Armament, Munitions and Chemical Command
ATTN: SMCCCR-MSI
Aberdeen Proving Ground, MD 21010-5423

Commander
Chemical Research, Development and Engineering Center
U.S. Army Armament, Munitions and Chemical Command
ATTN: SMCCCR-RSP-A
Aberdeen Proving Ground, MD 21010-5423
Chief
Benet Weapons Laboratory, CCAC
Armament Research, Development and Engineering Center
U.S. Army Armament, Munitions and Chemical Command
ATTN: SMCAR-CCB-TL
Watervliet, NY 12189-5000

Commander
U.S. Army Armament, Munitions and Chemical Command
ATTN: SMCAR-ESP-L
Rock Island, IL 61299-6000

Director
U.S. Army TRADOC Systems Analysis Activity
ATTN: ATAA-SL
White Sands Missile Range, NM 88002

Director
Ballistic Research Laboratory
ATTN: AMXBR-OD-ST
SLCBR-TB-EE
Aberdeen Proving Ground, MD 21005-5066

Commander
Naval Weapons Center
ATTN: L. Smith, Code 3205
A. Amster, Code 385
R. Reed, Jr., Code 388
K.J. Grahaam, Code 3835
China Lake, CA 93555

Director
Lawrence Livermore National Laboratory
University of California
P.O. Box 808
ATTN: M. Finger
Livermore, CA 94550

Director
Los Alamos National Laboratory
ATTN: Group T14
Los Alamos, NM 87545
Director
Sandia National Laboratory
Albuquerque, NM  87165

Commander
Naval Surface Weapons Center
ATTN: Code G13
Dahlgren, VA  22448

Commander
Naval Surface Weapons Center
ATTN:  L. Roslund, R122
       M. Stosz, R121
       Code X211, Lib
       E. Zirnet, R13
       R.R. Bernecker, R13
       J.W. Forbes, R13
       S.J. Jacobs, R10
       C. Dickinson
       J. Short, R12
Silver Spring, MD  20910

Air Force Armament Laboratory
ATTN:  J. Forster, AFATL-MNW
       G. Parson, AFATL-MNE
Eglin Air Force Base, FL  32542-5434