ARMY RESEARCH LABORATORY

A Description on the ARL Force Protection Surveillance System Data Set

by Alex L. Chan

ARL-MR-600 October 2004

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of manufacturer's or trade names does not constitute an official endorsement or approval of the use thereof.

Destroy this report when it is no longer needed. Do not return it to the originator.

Army Research Laboratory
Adelphi, MD 20783-1197

ARL-MR-600 **October 2004**

A Description on the ARL Force Protection Surveillance System Data Set

Alex L. Chan
Sensors and Electron Devices Directorate, ARL

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED (From - To)
October 2004	Data Collection	December 2003 to June 2004

4. TITLE AND SUBTITLE
A Description on the ARL Force Protection Surveillance System Data Set

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Alex L. Chan

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
ATTN: AMSRD-ARL-SE-SE
2800 Powder Mill Road
Adelphi, MD 20783-1197

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-MR-600

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
2800 Powder Mill Road
Adelphi, MD 20783-1197

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This memorandum report provides a concise description on the data set collected by the Image Processing Branch (AMSRD-ARL-SE-SE) of the U.S. Army Research Laboratory for a force protection project. We describe the sensor equipment involved, the target and background settings chosen, as well as various technical and legal constraints imposed on this data collection process. The quantity, properties, and samples of various data types are then provided for the users to consider the types of data that suit their needs. We conclude this report with some thoughts on future works and improvements on this data set.

15. SUBJECT TERMS
Infrared imagery, video sequence, moving target, force protection, data set

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Alex L.Chan
Unclassified	Unclassified	Unclassified	UL	21	19b. TELEPHONE NUMBER (*Include area code*) 301-394-1677

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Contents

List of Figures

List of Tables

Acknowledgment

The author is very grateful to the considerable time and efforts provided by Matthew Thielke of the Army Research Laboratory (ARL) and Bryant Lee, an ARL intern from the University of Maryland, in the long process of preparing and collecting this data set.

INTENTIONALLY LEFT BLANK

1. Introduction

As a part of the research project on the force protection surveillance system (FPSS) funded by the U.S. Army Research Laboratory (ARL) Physical Security Office, a number of video sequences were collected at the Adelphi Laboratory Center (ALC) of ARL to aid the FPSS development efforts. Most of these data are long-wave infrared (LWIR) images obtained through three different forward-looking infrared (FLIR) cameras, while the remaining data consist of color video sequences taken with two color charge-coupled device (CCD) cameras. These sequences were taken at different times of the day and across several seasons of a year to capture the variations exhibited by a given field of view. To achieve a generic representation of typical FPSS scenarios, while avoiding specific details pertain to ALC infrastructures, all image sequences in this data set were taken from the roof of a 4-story building and focused on the main parking lot at the direction toward a public road. No permanent buildings or other significant infrastructures in ALC were captured in these sequences. The moving objects recorded in this data set include people, vehicles, tree branches, and occasionally some animals. Due to significant distances and thermal signal properties, no facial identity of any human target or license plate number of any vehicle can be recognized in these sequences. Other than the date and time of the data collected, no other ground truth information is provided for this data set at this point.

Despite the limited scope of scenery captured in this data set, these sequences still exhibit a wide range of phenomenal variations due to changes in seasons, weather conditions, times of the day, different cameras, as well as the number, distance, style, and speed of all moving objects. Therefore, this data set has been very useful in the development and testing of the FPSS software package. This data set can also be beneficial to the development and validation of similar detection and tracking research projects undertaken by other government-sponsored programs.

2. Data Set

Currently, there are 85 sequences in this data set, with a total of 45,121 image frames occupying 1,284,508kB of disk space. All images are stored in JPEG format to achieve a good trade-off between image qualities and file size. The date of collection, type of image data, name of sequence, file size of data and number of frames for all 85 sequences are listed in table 1.

The first five sequences listed in table 1 are color CCD images taken during the evening hours on December 16, 2003 using a low-lux CCD camera capable of detecting near-infrared signals. Named rf20031216nc1 to rf20031216nc5 and pointing at a slightly different direction, each of

these sequences consists of 500 image frames measuring 640 x 480 pixels in size. Typical frames of these sequences are shown in figure 1. Note that there are some blank pixels near the edges created during the video capturing and digitalization process.

Table 1. Listing of 85 image sequences in the ARL FPSS data set.

Date of collection	Type of image data and camera	Name of sequence	Data size of Sequence (kB)	Number of frames
12/16/2003	Color - CCD	rf20031216nc1	23944	500
12/16/2003	Color – CCD	rf20031216nc2	23408	500
12/16/2003	Color – CCD	rf20031216nc3	23960	500
12/16/2003	Color – CCD	rf20031216nc4	24008	500
12/16/2003	Color – CCD	rf20031216nc5	24008	500
12/18/2003	LWIR - Alpha	rf20031218ai1	12000	500
12/18/2003	LWIR – Alpha	rf20031218ai2	6008	500
12/18/2003	LWIR – Alpha	rf20031218ai3	5996	500
12/18/2003	LWIR – Alpha	rf20031218ai4	6000	500
12/18/2003	LWIR – Alpha	rf20031218ai5	6008	500
12/18/2003	LWIR – Alpha	rf20031218ai6	6008	500
12/18/2003	LWIR – Alpha	rf20031218ai7	6008	500
12/23/2003	LWIR - Merlin	rf20031223_1356mi	16008	500
12/23/2003	LWIR – Merlin	rf20031223_1358mi	14008	500
12/23/2003	LWIR – Merlin	rf20031223_1400mi	16008	500
12/23/2003	LWIR - Merlin	rf20031223_1543mi	16008	500
12/23/2003	LWIR - Merlin	rf20031223_1546mi	16008	500
12/23/2003	LWIR - Merlin	rf20031223_1549mi	16008	500
01/30/2004	Color – Sentry	rf20040130_1533fc	28032	500
06/17/2004	Color – Sentry	rf20040617_1637fc	16516	490
06/17/2004	Color – Sentry	rf20040617_1638fc	22772	711
06/17/2004	Color – Sentry	rf20040617_1640fc	12248	340
03/24/2004	LWIR - Sentry	rf20040324_1123fi	16020	500
03/24/2004	LWIR – Sentry	rf20040324_1124fi	16020	500
03/24/2004	LWIR – Sentry	rf20040324_1130fi	16020	500
03/24/2004	LWIR – Sentry	rf20040324_1131fi	16020	500
03/25/2004	LWIR – Sentry	rf20040325_0650fi	12020	500
03/25/2004	LWIR – Sentry	rf20040325_0654fi	12020	500
03/25/2004	LWIR – Sentry	rf20040325_0655fi	12020	500
03/25/2004	LWIR – Sentry	rf20040325_0657fi	12020	500
03/25/2004	LWIR – Sentry	rf20040325_0706fi	8056	335
03/25/2004	LWIR – Sentry	rf20040325_0708fi	7212	300
03/25/2004	LWIR – Sentry	rf20040325_0712fi	12020	500
03/25/2004	LWIR – Sentry	rf20040325_0714fi	6012	250
03/25/2004	LWIR – Sentry	rf20040325_0719fi	10820	450
03/25/2004	LWIR – Sentry	rf20040325_0729fi	9016	375
03/25/2004	LWIR – Sentry	rf20040325_0732fi	7212	300
03/25/2004	LWIR – Sentry	rf20040325_0733fi	6012	250
03/25/2004	LWIR – Sentry	rf20040325_0736fi	6732	280
03/25/2004	LWIR – Sentry	rf20040325_0739fi	6012	250

05/10/2004	LWIR – Sentry	rf20040510_1253fi	8412	300
05/10/2004	LWIR – Sentry	rf20040510_1254fi	8412	300
06/17/2004	LWIR – Sentry	rf20040617_1458fi	14092	440
06/17/2004	LWIR – Sentry	rf20040617_1530fi	22416	700
06/17/2004	LWIR – Sentry	rf20040617_1531fi	28540	1000
06/17/2004	LWIR – Sentry	rf20040617_1533fi	22804	810
06/17/2004	LWIR – Sentry	rf20040617_1537fi	28020	1000
06/17/2004	LWIR - Sentry	rf20040617_1538fi	21296	760
06/17/2004	LWIR – Sentry	rf20040617_1635fi	10572	440
06/17/2004	LWIR – Sentry	rf20040617_1636fi	11772	490
06/17/2004	LWIR – Sentry	rf20040617_1641fi	24016	1000
06/17/2004	LWIR – Sentry	rf20040617_1642fi	6248	260
06/17/2004	LWIR – Sentry	rf20040617_1643fi	13452	560
06/17/2004	LWIR – Sentry	rf20040617_1830fi	8408	350
06/17/2004	LWIR – Sentry	rf20040617_1832fi	16816	700
06/17/2004	LWIR – Sentry	rf20040617_1836fi	15856	660
06/17/2004	LWIR – Sentry	rf20040617_1837fi	8168	340
06/17/2004	LWIR - Sentry	rf20040617_1838fi	10572	440
06/17/2004	LWIR – Sentry	rf20040617_2135fi	9612	480
06/18/2004	LWIR – Sentry	rf20040618_0030fi	2004	100
06/18/2004	LWIR – Sentry	rf20040618_0330fi	2004	100
06/18/2004	LWIR – Sentry	rf20040618_0630fi	24020	1000
06/18/2004	LWIR – Sentry	rf20040618_0631fi	12012	500
06/18/2004	LWIR - Sentry	rf20040618_0633fi	24020	1000
06/18/2004	LWIR – Sentry	rf20040618_0634fi	24020	1000
06/18/2004	LWIR – Sentry	rf20040618_0636fi	6968	290
06/18/2004	LWIR – Sentry	rf20040618_0637fi	12972	540
06/18/2004	LWIR – Sentry	rf20040618_0638fi	14412	600
06/18/2004	LWIR – Sentry	rf20040618_0930fi	13132	410
06/18/2004	LWIR – Sentry	rf20040618_0931fi	32020	1000
06/18/2004	LWIR – Sentry	rf20040618_0932fi	21456	670
06/18/2004	LWIR – Sentry	rf20040618_0934fi	20176	630
06/18/2004	LWIR – Sentry	rf20040618_0935fi	14408	450
06/18/2004	LWIR – Sentry	rf20040618_0937fi	19212	600
06/18/2004	LWIR – Sentry	rf20040618_0938fi	16012	500
06/18/2004	LWIR – Sentry	rf20040618_1230fi	16328	510
06/18/2004	LWIR – Sentry	rf20040618_1233fi	31976	1000
06/18/2004	LWIR – Sentry	rf20040618_1237fi	18572	580
06/18/2004	LWIR - Sentry	rf20040618_1238fi	21456	670
06/18/2004	LWIR – Sentry	rf20040618_1410fi	9928	310
06/18/2004	LWIR – Sentry	rf20040618_1415fi	26260	820
06/18/2004	LWIR – Sentry	rf20040618_1417fi	27220	850
06/18/2004	LWIR – Sentry	rf20040618_1419fi	13452	420
06/18/2004	LWIR – Sentry	rf20040618_1420fi	16652	520
06/18/2004	LWIR – Sentry	rf20040618_1421fi	22096	690
Total			1,284,508	45,121

Figure 1. Image frames from sequences rf20031216nc1 (top) and rf20031216nc5.

The next 7 sequences were named rf20031218ai1 to rf20031218ai7 because they were taken during the evening hours on December 18, 2003 using the Alpha LWIR camera manufactured by Indigo Systems. The effective resolution of this camera is only 164 x 129 pixels. Therefore, all images captured by this camera were saved at the size of 320 x 240 pixels, except those in rf20031218ai1 (still at 640 x 480 pixels). At this low resolution, the coarseness of these images is unavoidable and expected. Near-freezing outdoor temperature also pushed this camera toward the edge of its operating temperature range. As a result, artifacts in the form of vertical lines are visible in some sequences, as shown in figure 2.

The Merlin is another LWIR camera manufactured by Indigo Systems, but it produces much higher resolution images, as compared to the Alpha LWIR camera, at 320 x 240 pixels. However, the Merlin is even more sensitive to the freezing temperature; hence it was completely unable to function outdoors on the cold December 18, 2003, the day on which the Alpha data were taken. On the much warmer December 23, 2003, a Merlin was successfully used to capture six LWIR sequences between 2 p.m. and 4 p.m. Based on the date and time (day light saving time was wrongly imprinted on the images though) of their collection, these six LWIR sequences were named accordingly from rf20031223_1356mi to rf20031223_1549mi and saved as 640 x 480 frames. Examples from rf20031223_1356mi and rf20031223_1549mi sequences are shown as figure 3. Some blank areas and artifacts are visible near the edges, while the date and time stamps may incur some unwanted distractions as well.

Finally, there are four color and 63 LWIR sequences collected in 2004 using the dual-camera LWIR-CCD Sentry Personnel Observation Device (POD) manufactured by the FLIR Systems. The Sentry POD LWIR sports a resolution of 320 x 240 pixels, while the bore-sighted color CCD camera has almost-similar resolution and field of view as well. All LWIR and color frames are saved as 640 x 480 images. Unlike previous sequences, different numbers (100-1000) of image frames are saved for these 67 sequences, depending of the length of moving activities observed. The two shortest sequences, rf20040618_0030fi and rf20040618_0330fi, do not contain any meaningful moving object at all. They are included in this dataset merely to show the LWIR characteristics of the same field of view around the mid-night and 3:30 a.m. time frames.

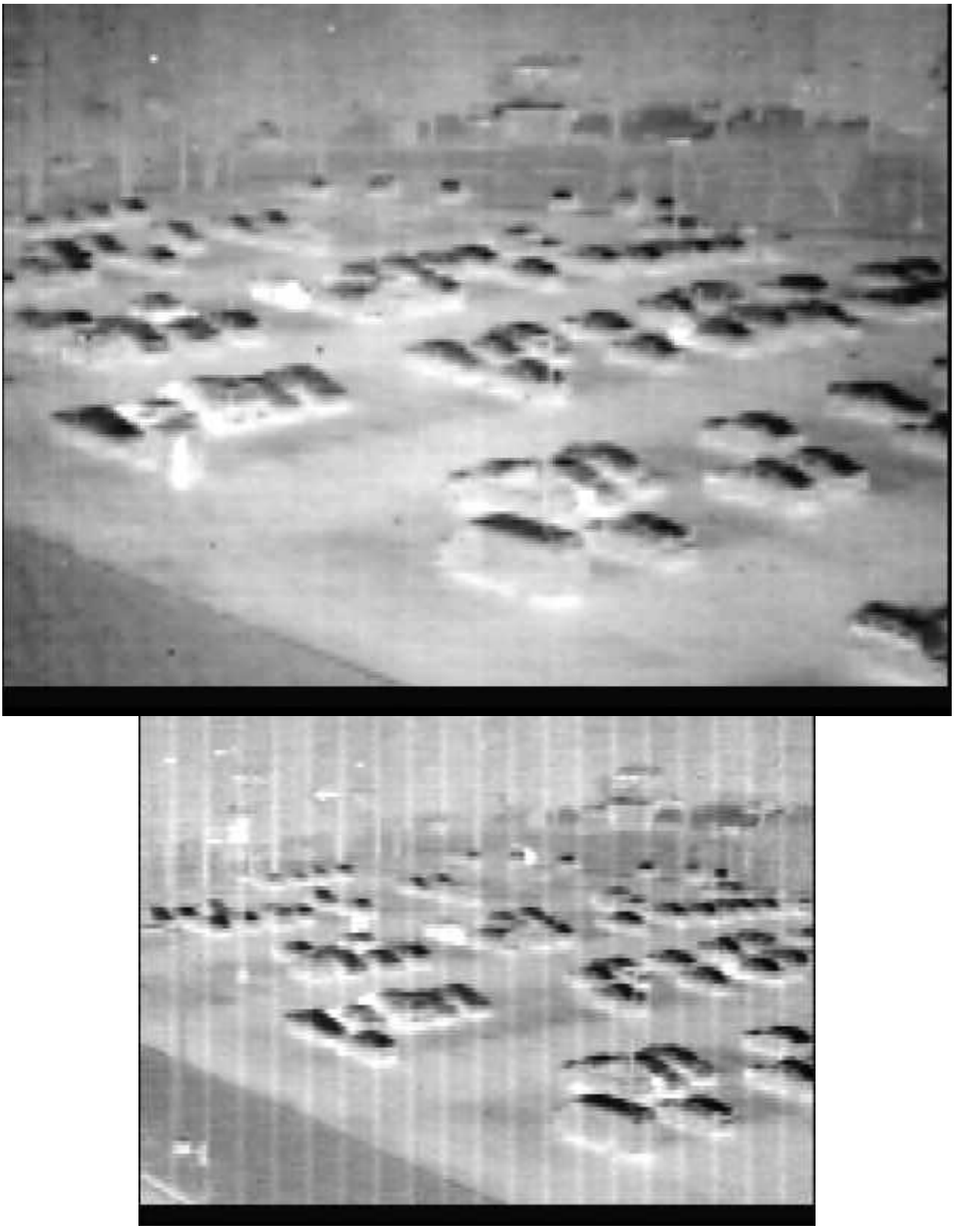

Figure 2. Image frames from sequences rf20031218ai1 (top) and rf20031218ai7.

Figure 3. Image frames from sequences rf20031223_1356mi (top) and rf20031223_1549mi.

Due to the automatic gain control function of the Sentry POD, the LWIR signatures for humans vary significantly depending on the background temperature. When the background temperature was about the same as people, such as around 11:30 a.m. on March 24, 2004, the LWIR signatures of human beings are pretty much buried among the background pixels, hence very difficult to be detected. A typical frame from rf20040324_1123fi sequence is shown at the top part of figure 4. For the data collected around 7 a.m. on the following morning, when the parking lot was still cool and dark, human thermal signatures were much sharper and brighter than their background pixels, such as the one shown at the bottom half of figure 4. When the summer approached, the weather became hotter and the foliage thicker, as we can see from the rf20040510_1253fi sequence. The hotter background made the walking people appeared like dark moving shadows in this case. The top part of figure 5 exemplifies a typical image frame from rf20040510_1253fi sequence. However, the LWIR view of a hot afternoon could be significantly changed by a thunder storm that quickly cools off almost everything except the steaming asphalt, as shown at the lower half of figure 5.

Figure 4. Image frames from sequences rf20040324_1123fi (top) and rf20040325_0650fi.

Figure 5. Image frames from sequences rf20040510_1253fi (top) and rf20040617_1641fi.

3. Conclusion

This brief description is written to provide a quick but accurate glance of the data set that we have collected for the FPSS project at ARL. At the current stage, this data set probably is not as extensive and complete as we have hoped, but it has enabled preliminary development and testing efforts for moving target detection and tracking algorithms. By running the detection and tracking algorithms on a given input sequence and viewing the resulting detections, we can easily grasp the qualitative performance of these algorithms based on the numbers of hits and false alarms. Sequences with different camera, target, and background characteristics may expose the weaknesses and breakpoints of certain algorithms. Therefore, this data set is quite valuable for initial development and testing of detection and tracking algorithms in general.

To make this data set more useful to ours and similar research efforts, additional ground-truth information, including the type and location of all targets of interest on each frame, will be extracted in the near future. Further data collection is also planned in order to achieve a broader variability in target and background characteristics, while adhering to the principle of not revealing any infrastructural information specific to the ALC site.

For further information on this data set, please contact the author via phone, email, or mailing address given below:

Alex L. Chan, Ph.D.
U.S. Army Research Laboratory
Attention: AMSRD-ARL-SE-SE
2800 Powder Mill Road, Adelphi, MD 20783
301-394-1677 (Phone), 301-394-5234 (Fax)
achan@arl.army.mil

Distribution List

ADMNSTR
DEFNS TECHL INFO CTR
ATTN DTIC-OCP (ELECTRONIC COPY)
8725 JOHN J KINGMAN RD STE 0944
FT BELVOIR VA 22060-6218

DARPA
ATTN C SCHWARTZ
ATTN IXO S WELBY
ATTN R HUMMELL
3701 N FAIRFAX DR
ARLINGTON VA 22203-1714

OFC OF THE SECY OF DEFNS
ATTN ODDRE (R&AT)
THE PENTAGON
WASHINGTON DC 20301-3080

ARMY RSRCH PHYSICS DIV
ATTN AMSRD-ARL-RO-MM R LAUNER
PO BOX 12211
RESEARCH TRIANGLE PARK NC 27709-2211

AVCOM
ATTN AMSAM-RD-WS-PL W DAVENPORT
BLDG 7804
REDSTONE ARSENAL AL 35898

US ARMY TRADOC
BATTLE LAB INTEGRATION & TECHL DIRCTRT
ATTN ATCD-B
ATTN ATCH-B
10 WHISTLER LANE
FT MONROE VA 23651-5850

CECOM NVESD
ATTN AMSRD-CER-NV-D J RATCHES
10221 BURBECK RD STE 430
FT BELVOIR VA 22060-5806

US MILITARY ACDMY
MATHEMATICAL SCI CTR OF EXCELLENCE
ATTN LTC T RUGENSTEIN
THAYER HALL RM 226C
WEST POINT NY 10996-1786

US ARMY ABERDEEN TEST CENTER
ATTN CSTE-DT-AT-WC-A F CARLEN
ATTN CSTE-DTC-AT-TC-N D L JENNINGS
400 COLLERAN ROAD
ABERDEEN PROVING GROUND MD 21005-5059

US ARMY ARDEC
ATTN AMSTA-AR-TD
BLDG 1
PICATINNY ARSENAL NJ 07806-5000

US ARMY AVIATION & MIS LAB
ATTN AMSRD-AMR-SG-IP H F ANDERSON
BLDG 5400
REDSTONE ARSENAL AL 35809

US ARMY AVN & MIS CMND
ATTN AMSAM-RD-SG-IP R SIMS
BLDG 5400
REDSTONE ARSENAL AL 35898

COMMANDING GENERAL
US ARMY AVN & MIS CMND
ATTN AMSAM-RD W C MCCORKLE
REDSTONE ARSENAL AL 35898-5000

US ARMY CERDEC, NVESD
ATTN AMSRD-CER-NV-XX J HILGER
ATTN AMSRD-CER-NV-XX P PERCONTI
ATTN AMSRD-CER-NV-XX R DRIGGERS
10221 BURBECK RD STE 430
FT BELVOIR VA 22060-5806

US ARMY NATICK RDEC
ACTING TECHL DIR
ATTN SBCN-TP P BRANDLER
KANSAS STREET BLDG 78
NATICK MA 01760-5056

US ARMY PM NV/RSTA
ATTN SFAE-IEW&S-NV D FERRETT
10221 BURBECK RD
FT BELVOIR VA 22060-5806

US ARMY RDECOM ARDEC
ATTN AMSRD-AAR-QES P WILSON
RADIOGRAPHIC LABORATORY, B.908
PICATINNEY ARSENAL NJ 07806-5000

US ARMY SOLDIER & BIOLOGICAL CHEM CTR
ATTN AMSSB-RRT-DP B LOEROP
EDGEWOOD CHEM & BIOLOGICAL CTR BLDG E-5544
ABERDEEN PROVING GROUND MD 21010-5424

US ARMY TANK-AUTOMTV CMND RDEC
ATTN AMSTA-TR-R G GERHART
WARREN MI 48397-5000

US ARMY TOPOGRAPPHIC ENGRG CTR
ATTN CEERD-RR-S R RAND
7701 TELEGRAPH RD
ALEXANDRIA VA 22315

COMMANDER
USAISEC
ATTN AMSEL-TD BLAU
BUILDING 61801
FT HUACHUCA AZ 85613-5300

AFRL/SNAA
ATTN M JARRATT
2241 AVIONICS CIRCLE AREA B, BLDG 620
WRIGHT PATTERSON AFB OH 45433-7321

CMTCO
ATTN MAJ A SUZUKI
1030 S HIGHWAY A1A
PATRICK AFB FL 23925-3002

PALISADES INST FOR RSRCH SVC INC
ATTN E CARR
1745 JEFFERSON DAVIS HWY STE 500
ARLINGTON VA 22202-3402

SITAC
ATTN H STILES
ATTN K WHITE
ATTN R DOWNIE
11981 LEE JACKSON MEMORIAL HWY
SUITE 500
FAIRFAX VA 22033-3309

US ARMY RSRCH LAB
ATTN AMSRD-ARL-WM-BF G HAAS
ATTN AMSRD-ARL-WM-BF W OBERLE
ABERDEEN PROVING GROUND MD 21005-5067

DIRECTOR
US ARMY RSRCH LAB
ATTN AMSRD-ARL-RO-D JCI CHANG
ATTN AMSRD-ARL-RO-EN W D BACH
ATTN AMSRD-ARL-RO-EL W SANDER
ATTN AMSRD-ARL-RO-PP R HAMMOND
PO BOX 12211
RESEARCH TRIANGLE PARK NC 27709-2211

US ARMY RSRCH LAB
ATTN AMSRD-ARL-D A GRUM
ATTN AMSRD-ARL-D J M MILLER
ATTN IMNE-AD-IM-DR MAIL & RECORDS
MGMT
ATTN AMSRD-ARL-CI-OK-T TECHL PUB
(2 COPIES)
ATTN AMSRD-ARL-CI-OK-TL TECHL LIB
(2 COPIES)
ATTN AMSRD-ARL-SE J PELLEGRINO
ATTN AMSRD-ARL-SE J ROCCHIO
ATTN AMSRD-ARL-SE-S J EICKE
ATTN AMSRD-ARL-SE-SE A CHAN
(30 COPIES)
ATTN AMSRD-ARL-SE-SE N NASRABADI
ATTN AMSRD-ARL-SE-SE P GILLESPIE
ADELPHI MD 20783-1197