



Instrumentation for Aim Point Determination in the Close-in Battle

by Gary A. Haas

ARL-TN-0303

December 2007

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.

DESTRUCTION NOTICE—For unclassified, limited documents, destroy by any method that will prevent disclosure of contents or reconstruction of the document.

Army Research Laboratory

Aberdeen Proving Ground, MD 21005-5066

ARL-TN-0303**December 2007**

Instrumentation for Aim Point Determination in the Close-in Battle

Gary A. Haas
Vehicle Technology Directorate, ARL

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) December 2007		2. REPORT TYPE Final		3. DATES COVERED (From - To) October 2006 to January 2007	
4. TITLE AND SUBTITLE Instrumentation for Aim Point Determination in the Close-in Battle				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Gary A. Haas (ARL)				5d. PROJECT NUMBER 622618.H0300	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory Vehicle Technology Directorate Aberdeen Proving Ground, MD 21005-5066				8. PERFORMING ORGANIZATION REPORT NUMBER ARL-TN-0303	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT A rifle-mounted, boresighted camera and rugged video recorder can be used to determine where the rifle is pointed at the time the trigger is pulled. This information can be collected in exercises simulating close combat to help us better understand how to optimize small arms for this battle space. In this report, we examine issues in instrumenting the Soldier and suggest an approach to collecting this sort of data.					
15. SUBJECT TERMS aim point; first person; instrumentaiton; video					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 15	19a. NAME OF RESPONSIBLE PERSON Gary A. Haas
a. REPORT UNCLASSIFIED	b. ABSTRACT UNCLASSIFIED	c. THIS PAGE UNCLASSIFIED			19b. TELEPHONE NUMBER (Include area code) 410-278-8867

Contents

List of Figures	iv
1. Objective and Approach	1
2. Context	1
3. Measurement	1
3.1 Time.....	1
3.2 Aim Point	2
3.3 Range.....	3
3.4 Robustness.....	4
3.5 Media Capacity.....	4
4. Recommendations	5
5. References	7
Distribution List	8

List of Figures

Figure 1. Boresight laser for calibration (http://www.aimshot.com/boresight.php).....	2
Figure 2. Pixel resolution and FOV as a function of range.	3
Figure 3. Rugged helmet-mount camera (http://www.army-technology.com/contractors/surveillance/viotac-inc/viotac-inc1.html).....	5
Figure 4. Rugged camcorder with remote “lipstick” camera (http://www.samsung.com/Products/Camcorder/DigitalMemory/files/scx210wl.pdf).	5
Figure 5. Video recorder (http://reviews.cnet.com/RCA_Lyra_X3030_30GB/4505-6499_7-31813542.html).	6
Figure 6. Macroswiss Guncam, an integrated commercial product (http://www.macroswiss.com/military/guncam_rec_t.html).	6

1. Objective and Approach

The purpose of this report is to consider the feasibility of and limitations on the measurement of a Soldier's aim point in close-quarter¹ encounters with the enemy in an urban setting. In particular, we consider the benefits of using a rifle-mounted camera to record the image "seen" by the weapon at the instant of discharge, during an exercise at a facility similar to Fort Benning's McKenna Military Operations in Urban Terrain (MOUT) site in Georgia.

The motivation for this report is the desire to model engagements of this type, which requires knowledge concerning the associated error budget, including the distribution of the aim point error. The particular approach discussed here is motivated by the availability of small, rugged cameras and recording devices suitable for such an application.

The goal is to determine the real aim point at the time of the trigger pull, with respect to the intended target. One way of making a measurement is to mount a small "lipstick" camera to the rifle with a mount similar to the laser-tag transmitter mount. When the Soldier fires the weapon, the camera takes a picture that captures the true aim point, and the picture is stored on media carried by the Soldier. When the exercise is over, an analyst reviews the snapshots and assesses the intended aim point and the aim point error.

2. Context

Although the essence of the intended aim point/true aim point measurement can be captured in a snapshot, the interpretation of the encounter (and thus the determination of the likely true aim point) depends on the context. A snapshot or still photograph may not convey the context in the same way that "first person shooter" video can. It may be preferable to extract the aim point information from a frame of video, tagged in some way as corresponding to the firing of the weapon. Perhaps both video and firing-triggered snapshots should be collected.

3. Measurement

3.1 Time

Measurements must be timed to coincide as precisely as possible with the triggering of the weapon. Instrumentation used for exercises is (understood to be) triggered by the report of the

¹Close-quarter typically means within 50 meters; however, the focus of the proposed instrumentation is 10 to 20 meters, and the term "close-in" is used for this more limited space.

weapon. This lags the trigger event by probably no more than a couple of milli-seconds (ms), and video frames are acquired at intervals of 17 ms, so use of the report is probably a less significant contributor to inaccuracy than is exposure time. Any significant recoil would tend to blur the image, but the recoil from the blanks or paint rounds used in this sort of MOUT exercise is reported to be minimal (1). At first glance, timing of image acquisition is not expected to be a major contributor to instrumentation error, but this may not be the case for measurements taken from a stream of video.

3.2 Aim Point

The principal measurement of such a study is the determination of the real aim point of the weapon as it is discharged. The pixel corresponding to the boresight of the weapon in the reference frame of the image can be determined in a calibration procedure with a boresighting laser (see figure 1). This pixel will not change appreciably at ranges near the boresighting range. When a video snapshot is recorded at the moment of weapon discharge, the pixel measure between the boresight pixel and the pixel at the center of the target (presumed to be the intended aim point) can be converted to the angular aiming error. The resolution of the measurement is a function of the field of view (FOV) of the lens and the pixel resolution of the imager. The narrower the FOV, the higher the resolution of the measurement. For a reasonable selection of lens and imager, a resolution of less than 1 milliradian (mr) is achievable. At a range of 10 meters, a resolution of 1 mr corresponds to 1 centimeter (cm), which is the desired accuracy of the measurement.



Figure 1. Boresight laser for calibration (<http://www.aimshot.com/boresight.php>).

It is anticipated that the largest contribution to the error of the measurement will be the determination of the intended aim point. Determination of the aim point will necessarily be a judgment call on the part of the analyst, who must guess which target was intended and which point on the target corresponds to the intended aim point of the shooter. In cases when the target is partially occluded, the latter may be difficult, and in cases when the intended aim point is outside the FOV of the weapon-mounted camera, even the former may not be possible. The wider the FOV, the more likely that the target will be visible.

3.3 Range

Conversion of the angular error measurement to the desired linear error measurement requires knowledge of the range from the camera to the target. Figure 2 presents the linear resolution of a single pixel (right ordinate) and the corresponding FOV (left ordinate) as a function of range from the camera, for a lens and imager configuration arbitrarily selected to deliver an FOV of 1 m diameter at a 10-m range. The range to the intended target is not easily determined. Several possibilities suggest themselves. The most obvious method, using the global positioning system coordinates reported by the Soldier's instrumentation, is unsatisfactory. The precision of the measurements from this instrumentation is totally unsuitable for this determination.

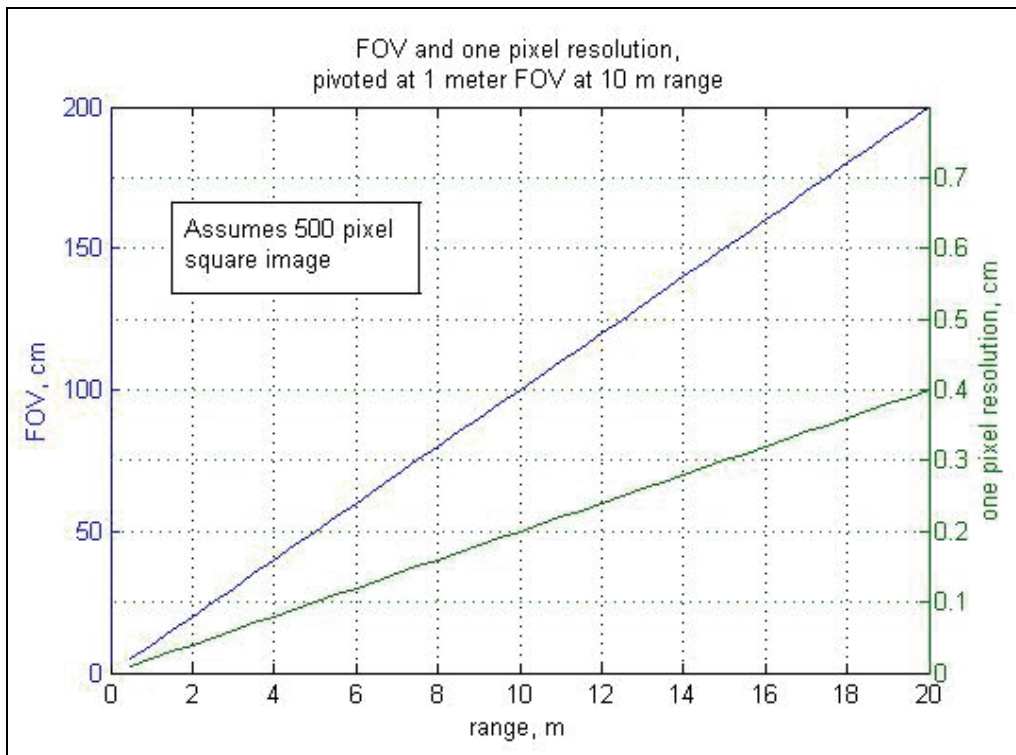


Figure 2. Pixel resolution and FOV as a function of range.

Laser range finders offer a tempting solution to the determination of range to target. Commercially available range finders discovered in an internet market survey are too large for the intended use, and the only military range finder that the author is aware of is a developmental component of the Objective Individual Combat Weapon (OICW), which is not readily available. Both types of range finder may require more time on target than is expected in the close-in battle. The range finder has to be mechanically boresighted, which is a more painstaking task than boresighting the camera, where one simply identifies the boresighted pixel. Range finder technology does not seem to be the solution to the problem at hand.

A third possibility takes advantage of the instrumentation at the McKenna site. A set of fixed video cameras emplaced at the site captures video from the exercise. From these cameras, an

estimate of distance between shooter and target could be made, however crudely. I have not observed the effectiveness of these cameras in tracking the participants as they move from place to place at the site, but it would seem a difficult task to keep both shooter and target visible. This measurement is a possible but probably unlikely solution to the problem.

Another possibility is to estimate dimensions of some aspect of the target (for example, diameter of the helmet) and estimate range based on the ratio of apparent dimension in the image to known real dimension. This seems achievable for at least some images but is probably not very accurate. It may be effective for a coarse estimation of engagement ranges but not for precise conversion of angular measures to linear measures. The bottom line is that accurate miss distances are available only in angular units.

3.4 Robustness

The only study the author discovered that used a barrel-mounted camera to instrument an aiming study was a study of a shotgun. The video cameras did not withstand the recoil well (2). In our study, as noted previously, recoil is not expected to be a challenge. Soldiers will, however, expose the instrumentation to shock in other ways as they maneuver to avoid becoming targets themselves. The author has not looked at specifications for shock limits in other military equipment, and such limits tend to be difficult to find for consumer grade devices, even those intended for “extreme” environments. Suffice it to say, the fewer moving parts, the better. In practice, this leads to a desire for solid state media, as opposed to tape or digital video disk (DVD) writers, and a fixed focal length lens, rather than a zoom lens. Fortunately, a zoom lens is unnecessary for the proposed task, and recording media based on solid state flash memory is becoming affordable.

3.5 Media Capacity

Large capacity storage media is still dominated by disk drive technology, and storage of video calls for large capacity. Recently, real-time compression and encoding has become available in the MPEG-4² suite of standards, which has eased the trade-off between robustness and capacity. A number of vendors now promise an hour of “near-DVD” quality on solid state media. This should be adequate to record substantial action, although not necessarily an entire exercise. However, MPEG-4 has some implementation details that are not necessarily available in the equipment brochure. In the domain of commercial off-the-shelf (COTS) equipment, reviews are available on line, but equipment selection appears to have an element of trial and error.

²Moving Picture Experts Group (MPEG)-4 is the most recent standard for video and audio compression released by the MPEG of the international standards body, International Organization for Standardization/International Electrotechnical Commission.

4. Recommendations

An incremental approach to this problem is needed. The feasibility of the approach and the usefulness of the data derived therefrom should be evaluated with COTS equipment and local resources. Recorders and cameras for the extreme sports market are probably rugged enough for the initial evaluation and are reasonably priced (see figures 3, 4, and 5). If the data look useful and the equipment is adequate, candidate equipment should be purchased and evaluated and modifications engineered as necessary. Otherwise, a more thorough market survey should be conducted, which looks at equipment for the police and military markets (see figure 6). The author expects that the COTS equipment will be useful only in limited scenarios (perhaps day-light, limited precision range estimates), so some development or adaptation will be necessary.

An initial trial should be conducted at the Aberdeen Proving Ground MOUT site, using ARL personnel, a rifle-mounted camera (for narrow FOV aim point), and a helmet-mounted camera (for wide-FOV context). Only one person need be so outfitted. Equipment similar to that shown in figures 3, 4, and 5 is recommended.



Figure 3. Rugged helmet-mount camera (<http://www.army-technology.com/contractors/surveillance/viotac-inc/viotac-inc1.html>).



Figure 4. Rugged camcorder with remote “lipstick” camera (<http://www.samsung.com/Products/Camcorder/DigitalMemory/files/scx210wl.pdf>).



Figure 5. Video recorder (http://reviews.cnet.com/RCA_Lyra_X3030_30GB/4505-6499_7-31813542.html).



Figure 6. Macroswiss Guncam, an integrated commercial product (http://www.macroswiss.com/military/guncam_rec_t.html).

5. References

1. Brosseau, T. Personal communication; U.S. Army Research Laboratory: Aberdeen Proving Ground, MD, 2007.
2. Fry, T. Personal communication; U.S. Army Research Laboratory: Aberdeen Proving Ground, MD, 2007.

NO. OF
COPIES ORGANIZATION

- 1 DEFENSE TECHNICAL
(PDF INFORMATION CTR
ONLY) DTIC OCA
8725 JOHN J KINGMAN RD
STE 0944
FORT BELVOIR VA 22060-6218
- 1 US ARMY RSRCH DEV & ENGRG CMD
SYSTEMS OF SYSTEMS INTEGRATION
AMSRD SS T
6000 6TH ST STE 100
FORT BELVOIR VA 22060-5608
- 1 DIRECTOR
US ARMY RESEARCH LAB
IMNE ALC IMS
2800 POWDER MILL RD
ADELPHI MD 20783-1197
- 1 DIRECTOR
US ARMY RESEARCH LAB
AMSRD ARL CI OK TL
2800 POWDER MILL RD
ADELPHI MD 20783-1197
- 2 DIRECTOR
US ARMY RESEARCH LAB
AMSRD ARL CS OK T
2800 POWDER MILL RD
ADELPHI MD 20783-1197
- ABERDEEN PROVING GROUND
- 1 DIRECTOR
US ARMY RSCH LABORATORY
ATTN AMSRD ARL CI OK (TECH LIB)
BLDG 4600
- 2 US ARMY RESEARCH LABORATORY
ATTN AMSRD ARL HR SF T FRY
AMSRD ARL HR MX D SCRIBNER
BLDG 459
- 5 US ARMY RESEARCH LABORATORY
ATTN AMSRD ARL VT UV H EDGE
M FIELDS G HAAS
J OWENS S WILKERSON
BLDG 1120A
- 2 US ARMY RESEARCH LABORATORY
ATTN AMSRD ARL WM B J NEWILL
AMSRD ARL WM BF W OBERLE
BLDG 390