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AD-B101 765

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ARI Research Note 85-15

CREW PERFORMANCE OF AN M2 BRADLEY UNDER SIMULATED LASER ATTACK: A PILOT STUDY

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FEBRUARY 1985

U. S. ARMY RESEARCH INSTITUTE

FOR THE BEHAVIORAL AND SOCIAL SCIENCES

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER ARI Research Note 85-15	2. GOVT ACCESSION NO. ADB 101765	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CREW PERFORMANCE OF AN M2 BRADLEY UNDER SIMULATED LASER ATTACK: A PILOT STUDY		5. TYPE OF REPORT & PERIOD COVERED August 1983 - August 1984 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Gary C. Bayer and Thomas J. Thompson		8. CONTRACT OR GRANT NUMBER(s) MDA903-80-C-0545
9. PERFORMING ORGANIZATION NAME AND ADDRESS Litton-Mellonics P.O. Box 2089 Ft. Benning, GA 31905		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q263743A794
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Ave., Alexandria, VA 22333-5600		12. REPORT DATE February 1985 13. NUMBER OF PAGES 18
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) ARI Field Unit P.O. Box 2086 Fort Benning, GA 31905-0686		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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18. SUPPLEMENTARY NOTES

Contract monitored by Seward Smith

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Bradley Fighting Vehicle	Directed energy drills,	Reaction drill
Bradley Training	Crew coordination,	development,
Crew Training (Mechanized),	Pilot test of crew drill,	Response time.
Crew Drill	Simulated blinding,	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A series of limited experiments to determine the effects of, and response to, simulated laser blinding of Bradley Fighting Vehicle Crews was conducted to determine future training requirements. It was found that crew response times could be reduced greatly with simple crew drills and that training appeared to contribute to the reduction of observed crew anxiety regarding directed energy weapons.

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Introduction

The advent of directed energy weapons (DEWs) has brought a host of new tactical and training challenges. One potential DEW is a low power laser which could jam electo-optical systems at tactical ranges and flashblind or permanently blind soldiers at closer ranges. A laser weapon could blind an individual looking through a direct view optic, such as a TOW sight, with virtually no damage to the combat potential of the vehicle. This is a rather unique phenomena of DEWs. Prior to DEWS only chemical weapons were capable of inflicting casualties with little or no damage to the vehicle. Other weapons would have had to destroy or significantly damage a vehicle enroute to injuring the personnel inside. However, a major difference between chemical weapons and lasers is that chemical weapons affect all unprotected individuals in the vehicle equally while lasers injure only the crew members directly exposed to it.

Thus, in laser combat there will be a number of fully functioning vehicles with injured personnel filling critical positions, while at the same time there may be uninjured personnel in the vehicle.

Another aspect of a laser injury which is in-band to visible light, is that it will be relatively painless and sensory dibilitating only; there will be no need for immediate first aid beyond removing the individual from a hazardous position and making him comfortable. This would allow uninjured personnel immediately to assume the combat position of the wounded soldier. The most significant danger of a laser injury would be that the soldier might panic and act counterproductively in the midst of a crisis, thus endangering himself and his crewmates.

This implies the need for several training considerations regarding laser combat. First is the need for more crosstraining of crew members. Crew members usually assigned to lower priority tasks will have to be trained in higher priority tasks, e.g. loader-gunner, infantryman-driver to allow the vehicle crew to maintain its combat effectiveness. Secondly, soldiers will have to learn to exchange places with one another quickly in order to minimize their vulnerability in combat and enhance their mission capability. Finally, there is a need to desensitize troops to DEWs and DEW-type injuries to prevent panic.

The pupose of this pilot study was to: (a) ascertain the approximate downtime of the M2 Bradley Infantry Fighting Vehicle (BIFV) when critical crew members are injured; (b) determine if practice in exchanging places with simulated crew injuries can reduce the downtime; (c) monitor the psychological reactions of the troops to DEWs; (d) determine whether this direction of training research and development holds promise of meaningful performance payoffs given additional time and resources.

Method

A Bradley squad consisting of the M2 vechicle and nine crew members: a Bradley commander (BC) and gunner in the turret, a driver, and six infantry men sitting in the troop compartment who would serve as test subjects. Two such squads were tested individually.

For the purposes of this study the BC, gunner, and the driver were designated as critical crew members who would have to be replaced if they became DE casualities. There are seven different possible combinations of casualities, given the three critical crew positions, which are:

1. Driver only
2. BC only
3. Gunner only
4. Driver, BC, and gunner.
5. Driver and BC

6. BC and gunner

7. Driver and gunner

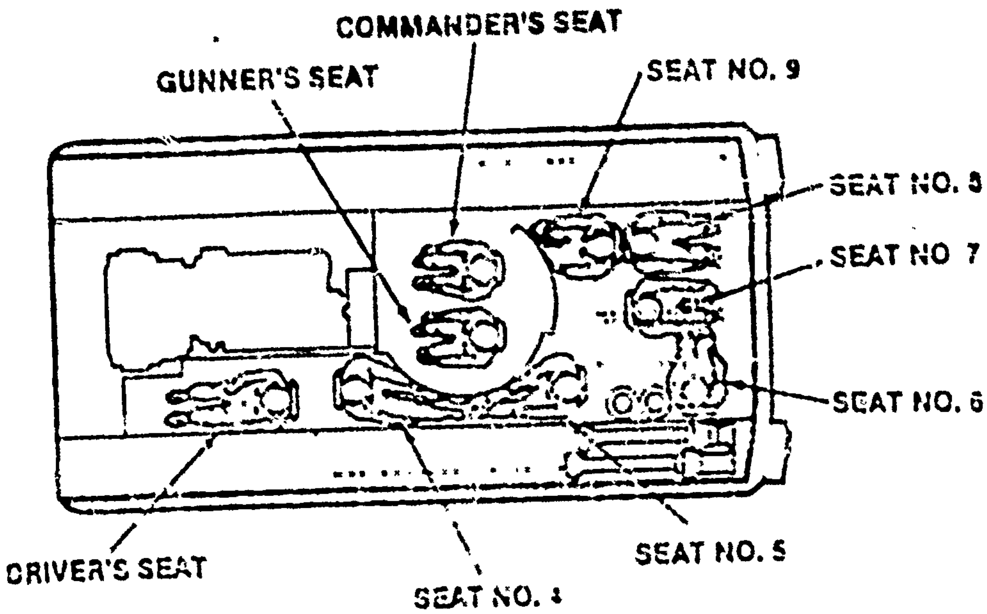

Figure 1. Seating in BIFV.

The experiment used eight soldiers in MOPP gear in a fully loaded Bradley moving at combat speeds over a field. One experimenter rode in the vehicle in the number eight position as an observer. A second experimenter, stationed at a radio in the field, acted as a timekeepper and experiment controller. The BC, driver, and gunner were allowed to remove their protective masks to enable them to hear the controller.

Two different squads were utilized on subsequent days. The first day's squad was instructed not to discuss the purpose or nature of the exercise in order to limit any inadvertent (learning) by the other squad. Both squads were from Ft. Benning's resident Bradley support company and were experienced with the BIFV but none of the troops had any previous exposure to DEWs.

Experiment I Procedure:

The driving course to be traversed during the experiment was on the perimeter of a relatively flat field with one sharp slope of approximately 30 degrees and five feet in height. There was one straightaway of approximately 246 m and another of approximately 187 m. Figure 2 is a map of the course. This course allowed acceleration to combat speeds during the straightaways followed by braking for violent left turns. The slope of the field, the constantly changing speeds, and the frequent sharp turns produced a rough ride which simulated a combat assault.

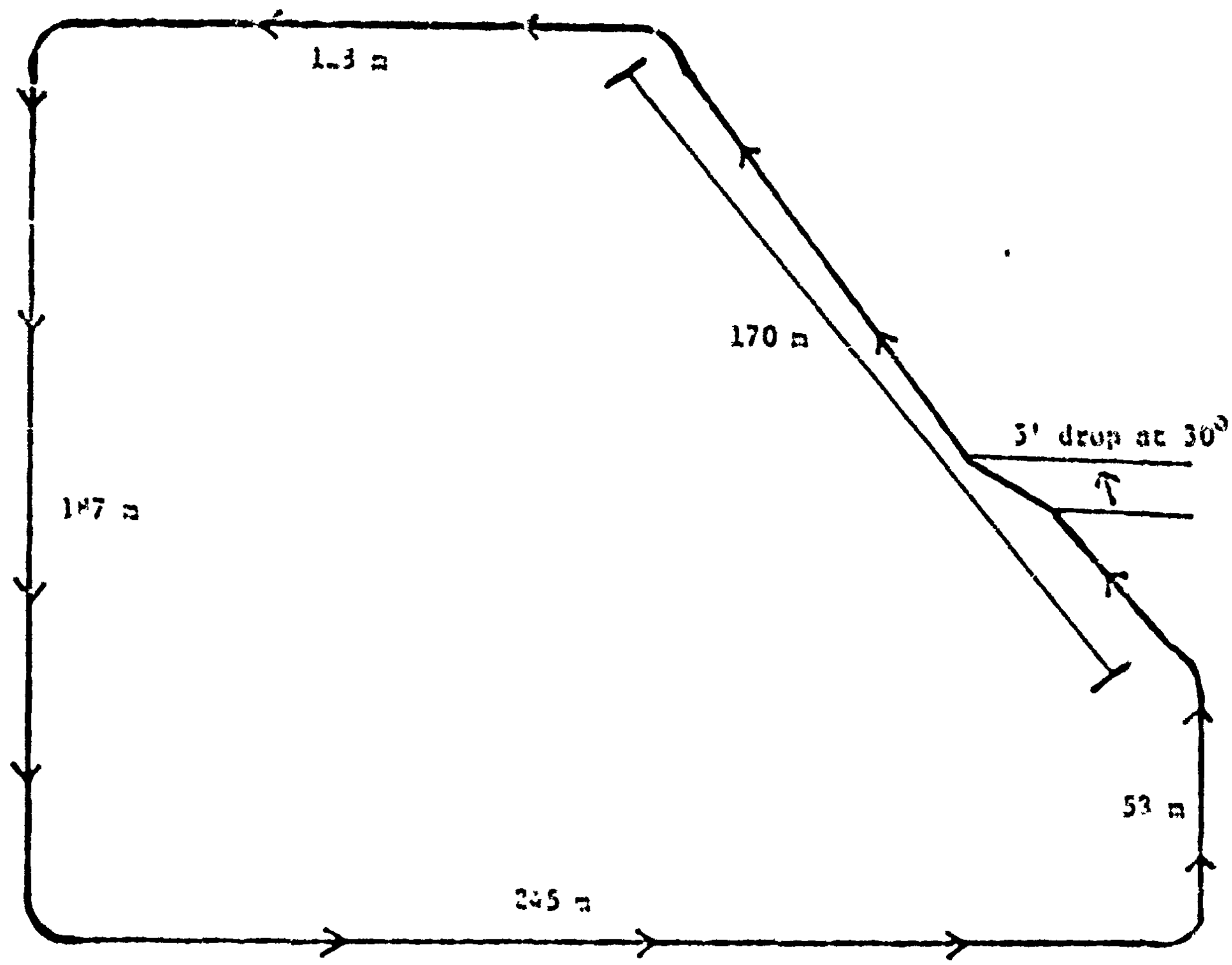

Figure 2. Experimental Course (approximate distances.)

Each crew was briefed on the purpose of the exercise: determination of the potential effects of a laser attack on a Bradley crew's performance. The crews were informed that in the future lasers could be used as weapons against them in combat. Injury from such a laser weapon would not cause pain but its blinding effects could be anything from an instantaneous flashblinding to a permanent blinding and everything in-between. For the purpose of this drill they were instructed to assume that once they were told they were hit, they were to pretend they were blinded but they would feel no pain. Also they were not to recover until the end of each trial. To ensure compliance each victim was issued a pillow case and as soon as he was declared "blinded" he immediately covered his head. Finally, crews were informed that although such laser injuries could occur to just one crew member or a combination of crew members, for this exercise only the driver, BC, and gunner would be casualties. Before testing began the crews were encouraged to make preliminary contingency plans regarding replacing the three potential casualties.

For each trial these procedures were followed:

1. The crew was informed in advanced, in part as a safety precaution, of the intended victim. Noninjured personnel were instructed to ignore the radio transmission when the controller informed the victim he was blinded. The crew was to carry-on with its duties until advised by the victim of his injury.

2. The vehicle accelerated to combat speed and the turret was put in the three or nine o'clock position in relationship to the front of the vehicle being in the 12 o'clock position;

3. The external controller announced on the radio to the victim that he was injured.

4. The victim immediately pulled the pillow case over his head and attempted to communicate to others that he was blinded.

5. As soon as there was any external evidence of an injury timing began. Time started for the BC or the gunner as soon as the turret began to swing to the 12 o'clock position to exit the injured party. In a Bradley the main gun tube must be oriented forward to align the turret with the exit doors to the troop compartment interior. In the case of the driver, time started as soon as the vehicle began to slow down. When there was a combination of injuries to the

driver and turret personnel, whichever of the above two occured first was the signal to start timing.

6. Timing stopped when the vehicle began to regain speed or when the gun turret was reoriented to the orginal position with the appropriate new crew member(s) in place. With an injury to the driver and one other, the times of both events were noted. Such timing rules were used because these actions are what would be evident to an enemy who has lased a Bradley. The enemy would not know if he had been successful until there was some outside evidence of it.

Experiment II Procedure:

Experiment II was a stationary exercise designed to ascertain the relative contribution of vehicle movement on BC and gunner replacement times. If exchanging places while the vehicle was stopped was signifcantly faster than while it was moving, it might be expedient to completely stop the vehicle to replace injured personnel rather than to attempt to do it while the vehicle is moving.

The same procedures were used in Experiment I except that the vehicle remained stationary and therefore the driver did not participate.

Experiment III Procedure:

In combat there may be times when it would be better to verbally guide a blinded driver to drive to a defilade position instead of bringing the vehicle to a halt while exposed to hostile fire in order to replace the injured driver. This experiment was designed to asertain how well a BC could guide a blinded driver through a course to a defilade position. The findings from this experiment could help determine the relative vulnerability between an immediate switch of drivers (in an exposed location) as opposed to the BC attempting to guide an injured driver to move the vehicle to defilade.

Figure 3 is a diagram of the Drive to Defilade Course. The vehicle was accelerated through the straightaway and the driver was "blinded". He immediately pulled a pillow case over his head and timing was started. Timing stopped when the vehicle reached the defilade position.

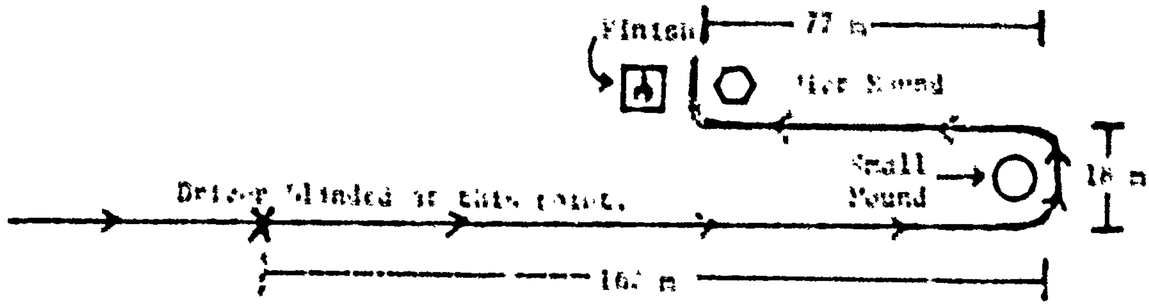

Figure 3. Drive to Defilade Course (approximate distance).

Experiment IV Procedure:

As the driver space was the most cramped position, physical size of the soldiers may have been a significant factor influencing the speed of exchange. This experiment attempted to ascertain the effects of the size of the drivers on the speed of the exchange.

Three different sets of drivers were used: (a) experienced drivers, those who participated in Experiment I (these were of average size); (b) large size, inexperienced drivers, (6'8"/268 lbs and 5'11"/170 lbs); and (c) average size, inexperienced drivers, (5'11"/146 lbs and 5'9"/160 lbs).

In this experiment the vehicle remained stationary and the driver's hatch was open to allow the experimenter to observe and time the exchange. The drivers were instructed to make exchanges as quickly as they could.

Results of Experiments I-IV:

Table 1 shows the results of Experiment I, downtime of the test BIFV.

Table 1

Times of Critical Position Exchange While Vehicle is Moving

	Squad 1		Squad 2	
Casualty	Trial 1	Trial 2 (in seconds)	Trial 1	Trial 2
Driver	20	13	30	22
BC	a	25	42	16
Gunner	50	29[b]	37	23
Driver, BC & Gunner	11[c]/51[d]	10/42	27/52	e
Driver, BC	16/38	15/28	23/23	e
BC, Gunner	77	50	49	e
Driver, Gunner	a	13/23	12/18	e

[a]Lost data

[b]Temporary loss of turret power

[c]Vehicle began to regain speed

[d]Turret was reoriented

[e]Vehicle deadlined

It was orginally planned to have the squads complete three iterations of the drills. Unfortunately, due to scheduling and vehicle maintenance difficulties, all iterations were not collected. One crew participated in two iterations before the vehicle broke down and the one crew completed 1-1/2 iterations before the vehicle was deadlined due to a faulty turret shield door.

Table 1 shows the preliminary indications of improved performance from the first to second trial in both squads. Also it should be noted that the driver-only performances are generally slower than when the driver was injured in combination with another critical crew member. This is due to the fact that timing started immediately when the driver was blinded alone. In the combination conditions, however, the driver was able to react early because timing was not begun until the turret began to rotate.

Table 2 shows the results of Experiment II, stationary exchange of turret personnel.

Table 2

Times of BC & Gunner Exchange While Vehicle is Stationary

Casualty	Trial (in seconds) 1st	2nd
BC	30	21
Gunner	20	27
BC & Gunner	46	35

NOTE: Squad 2 did not do Experiment II due to a deadlined vehicle.

As expected turret personnel exchange was generally faster when the vehicle was stationary compared to when it was moving (see Table 1 vs Table 2) but this difference was not great.

Table 3 shows the results of Experiment III, drive to defilade.

Generally, drivers were able to cover the same course using sight in half the time it required them when they were blinded. Also the squad 1 driver ended his first trial with one set of tracks on top of the dirt mound. In the following two trials he was very cautious and therefore had much slower times than the Squad 2 driver.

Table 3

Drive to Defilade Course Completion Times

	Blinded			W/Vision	
Trial	1st	2nd	3rd (in seconds)	1st	2nd
Squad 1[a]	87	123	135	42	35
Squad 2	62	58	55	30	28

[a]Squad 1 driver was excessively cautious on Trails 2 & 3 because ended on dirt mount on Trail 1

Table 4 shows the results of Experiment IV, the effect of driver size. The size of the drivers appears to make little difference after some practice in the speed of driver replacement. The inexperienced average size drivers took much longer on trails 1 and 3 than the large size drivers because their clothing or equipment during those trials became snagged.

Table 4

Times of Driver Exchange While Vehicle is Stationary[a]

Drivers	Trial 1	2	3	4
		(in seconds)		
Practiced[b]	[illegible]	16	--	--
Inexperienced				
Large Size		23	21	21
Inexperienced				
Average Size	38	21	26	19

[a]Squad 2 only

[b]Drivers who participated in Experiment 1

Discussion

No quantitative anyalysis of the above data was attempted because this was a pilot study and stringent experimental controls were not possible.

These times should be considered the lower limit of the performance potential for such exercises. These drills were held under optimal conditions and despite instructions to ignore the radio transmissions from the controller, other crew members could hear the controller. Thus they could prepare to take action before they were advised by the victim to do so. In additon, there was no competition for the crew's attention. They did not have other combat-related tasks to perform while participating in the experiment. Further, the noise level in the vehicle did not simulate combat conditions. There was little radio traffic no concern about potential threats, and no weapons firing. All of these factors would make it more difficult for a victim under real combat conditions to communicate the fact that he was injured. Nevertheless, some preliminary performance differences trend may be too strong given 2 data points can legitmately be noted and there were a number of lessons learned.

The results suggest that improvements in crew performances can be expected after just a few practice trials. A simple training program with potentially few sessions could produce asymptotic performance. This approach to training is low cost and might reasonably provide high payoff in terms of sustained crew combat performance.

There was also a qualitative improvement of the techniques used by the crew members to assist injured personnel during the drills. For example, when the injured turret personnel initially exited the vehicle, they felt around to orient themselves. This sometimes involved hitting their heads against obstacles and tripping over items as the vehicle moved. By the end of the exercise, one squad developed a technique where an uninjured crew member would place one hand on top of the victim's helmet, and grip the front of his shirt, and guide the victim directly to his seat. All the casualty had to do was relax and follow the lead of his fellow crew member. In the case of an injured BC, the guide connected the commanders CVC intercom immediately so the wounded BC could communicate with the assistant squad leader. Such procedures were spontaneous and proved very efficient.

An unexpected finding was that the driver exchange was faster than the turret personnel exchange. It was orginally hypothesized that since the driver's area was so cramped it would take longer for this casualty evacuation, but this was not the case. The turret evacuation times were longer in part because the turret had to be reoriented for personnel to exit. This was especially difficult when both the gunner and the BC were blinded because other crew members had to yell through the turret shield door and instruct those inside to rotate the turret to the correct exit position. This proved difficult on occasion because there are no markings on the interior of the troop compartment of the Bradley to indicate the current turret orientation to the crew compartment members. Consequently, on a few trials, crew members gave instructions to rotate the turret the "long way around". Some distinctive markings which can be seen from the crew compartment would alleviate the turret orientation problem.

Victims also used several phrases to indicate they were wounded: "I have been blinded", "I have been hit", "I can't see", "I've been lased", "I have been zapped". Of all of these, the term "zapped" appeared to have the most utility. Zapped unambiguously and succinctly denotes a particular type of injury. All soldiers in this experiment appeared to instantly know what is meant by this term. It is important to differentiate between laser blinding and a blinding caused by conventional weapons because different counteractions are indicated for each type of injury. Statements such as, "I can't see" could be interpreted to mean a person's vision was blocked by an obstacle or that the casualty was wounded by a conventional munition. In such cases other crew members may be tempted to offer assistance by looking in the same direction. This would not be the appropriate action in a laser environment because it would put the uninjured crew member in jeopardy. Secondly, the word "zapped" has a very distinctive sound which is not likely to be misunderstood for other words over the intercom. This is important because frequently there is a high blocking noise to sound ratio in the Bradley intercom system.

The results from Experiment I and Experiment II tentatively suggest that vehicle movement only slightly lengthens the time it takes to evacuate the turret causalties. The times of the turret personnel exchanges in Table 1 are little longer than the times in Table 2. Therefore if an injury occurs, it would appear to be better to continue movement while making an exchange. This would cost a few extra seconds but the vehicle could remain moving, therefore decreasing its vulnerability. It would also give less feedback to enemy DEW gunners because they would not know if they had completed a successful attack.

The data from Table 3 indicates that it took almost twice as long for a blinded driver to be guided to a defilade position than for a sighted driver to travel the same distance with sight. This suggests that if a driver was wounded, it probably would put the crew in less jeopardy if he were immediately replaced by another driver than to attempt to verbally guide him to a defilade position.

Another issue arises from this recommendation which requires further consideration. When the drivers make an immediate exchange, the BC is taken out of the decision loop. There may be some circumstances when the commander may not want do this. However, bringing the BC into the decision process will also increase the downtime of the vechicle. Additional research is needed to determine the relative cost/benefits of introducing the BC in the decision loop.

An observation not reflected in the data is the difficulty of the BC to verbally guide the blinded driver. This was especially obvious after about 30 seconds into the exercise as the BC got increasingly excited and gave the driver ambiguous instructions, e.g. "Turn now!, Turn now!" without indicating which direction to turn or how large of a turn was needed. Coordination between the driver and BC could certainly improve with some practice.

The findings from Experiment IV suggest that the driver's sizes and his replacement do not appear to have a significant effect on the speed of a driver exchange. There was only a small difference between the large and small driver exchange in this pilot test. The longest delays in the exchange of positions were due to articles of clothing getting snagged on equipment.

Some comments about the soldier's reactions to this experiment are appropriate at this point. Most had never participated in any crew extraction drills previously and all agreed such drills should be part of training even independent of a laser threat.

Secondly, there appeared to be a shift in their attitude towards DEWs. This is a subjective observation that should be verified by more detailed empirical research. However, when both crews were initially briefed as to the purpose of the experiment and to the possibility of confronting a threat laser weapon in combat, they appeared to be quite serious. They listened very attentively, made few jokes, and asked few questions. When the experiment began they also had some difficulty announcing that they were "blinded". There was some hesitation in their voices and a struggle to choose the right words. However by the time the exercise was completed the soldiers appeared to be much more comfortable with the reality of laser weapons. The troops were freely talking about lasers and laser capabilities. Occasionally there were some jokes about lasers, but they no longer struggled to announce they were "blinded". They were able to participate in this exercise as they would in other conventional weapon exercises. It is the author's opinion that the free talking and jokes about lasers are evidence that the soldiers were psychologically assimilating the reality of DEWs.

Certainly, much of the above could be explained by non-DEW factors, such as this was an experiment with "scientific" observers and the troops were initially uncomfortable in that situation. Still it is hard to believe that some psychological desensitization did not occur as well. This assertion will have to be verified by additional empirical research. Lasers are shocking weapons and the thought of being blinded can be terrifying, but so are many other weapons and related battlefield injuries. Soldiers have been trained to fight against machineguns, tanks, and chemical weapons without panic. There is no reason to believe the same would not be true of lasers given a proper training program. Drills such as these could go a long way in psychologically preparing soldiers to respond efficiently in a DE combat environment.

Conclusions

This research suggests that practicing extraction procedures could reduce the down time of a M2 crew under laser attack. It also suggests the term "zapped" has utility and can communicate a very specific type of injury requiring a specific crew response; that is, injured crew members would be extracted while the remaining sighted members would exercise caution regarding sights and viewing ports. Further, this research indicates some decision rules can be developed regarding the most appropriate response to a laser attack. Finally, there appeared to be some reduction in the anxiety level of the troops regarding DEWs after they participated in this study.

Much additional research needs to be conducted regarding the training of tactical responses to DEW attacks. First of all, the same study with a larger sample size and better experimental controls is needed to verify the limited findings noted in this study. Secondly, crew drills for other vehicles need to be developed and specific decision matrices established. The findings from this study may not generalize beyond the M2. For example, based on the results of this pilot study it appears better to immediately remove an injured driver rather than to verbally guide him to defilade in an M2; the same may not be true in an M1 tank. Also this research involved one squad in almost ideal conditions of isolation. There may be other tactics at the platoon or company level that should be explored. Another question that needs investigation is the effects of having the BC introduced into the decision loop before driver exchange is executed. Further, only a few of the crew members were injured in this drill and there are other potential casualty combinations which should be tested as well. There is the need to explore what happens while the Bradley fights in a defensive position, during an attack, and when the infantry element dismounts. Different ways to generate dust clouds as a countermeasure against lasers would also be fruitful research.

DEWs have brought a new dimension to the modern battlefield and have necessitated a complete review of how the Army will fight the next war. This involves all levels of Army preparation from Army 21 to how troops should dismount a vehicle in combat. Certainly some of the solutions to this new challenge will come from the materiel development community in the form of countermeasure devices. However, the contributions of the materiel developers will not be total; the remainder of the challenge must be placed on the user community (TRADOC and FORSCOM) to develop tactics and training to maximize the contributions of the materiel developers and to adjust conventional tactics and training to fight a DEW war. Research regarding DEWs affecting weapon systems under different tactical conditions needs to be completed to identify the best possible tactical countermeasures. As these countermeausres are identified they should be incorporated into soldier training as soon as possible. The materiel developers have already been working on these issues and it is now time for the user community to get involved as well.

SUPPLEMENTARY

INFORMATION

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REPLY TO
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SUBJECT: ARI Research Note 85-15

1. U.S. Army Research Institute (ARI) Research Note (RN) 85-15 (AD B101 765) is now approved for public release.

DAVID W. WITTER
Chief, Scientific and Technical
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