

HUMAN FACTORS EVALUATION OF DIVISION AIR DEFENSE GUN SYSTEMS

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A human factors evaluation was conducted upon DIVAD Gun prototypes during Operational Test II. It was physically impossible to observe the crew-members during operations; therefore, data were gathered from each of 32 enlisted crew-members by means of five questionnaires drawn from a master set of 506 items. Despite some difficulties experienced by crew-members in responding to the questionnaires, the required data were obtained and the results were submitted to the U.S. Army Operational Test and Evaluation Agency and the DIVAD Gun Source Selection Board.



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The U.S. Army is developing a new air defense gun system, DIVAD Gun, to replace the self-propelled, 20mm, M163 Vulcan System. The DIVAD Gun is designed to:

1. Provide air defense for divisional maneuver elements.
2. Provide air defense for selected critical assets, choke points, and convoys in the division area.
3. Deter easy access to rear areas by low altitude threats.
4. Provide effective ground fire against lightly armored vehicles and enemy personnel.

General Dynamics and Ford Aerospace have each built two prototype DIVAD Gun systems. Both types are mounted on modified M48A5 tank chassis and incorporate government furnished communications equipment, secondary armament, and nuclear, biological, and chemical (NBC) equipment. The XM246, developed by General Dynamics Corporation, uses twin 35mm Oerlikon KDA guns and a fire control based on the US Navy Phalanx, close-in weapon system, gun system. The XM247, designed by Ford Aerospace and Communications Corporation, utilizes a pair of Bofors 40mm guns. The radar-directed fire control is based on the Westinghouse F-16 aircraft radar. The turret structure for both systems contains the armor, gun mount, magazine, crew compartment, and operator controls and displays (Vereb, 1980).

An operational test was conducted on four DIVAD Guns (two of each prototype) by the U.S. Army Operational Test and Evaluation Agency (OTEA). It was performed during the time interval July to November 1980 at North McGregor Range, New Mexico and was divided into four phases: Detection/tracking, aerial live fire, ground live fire, and maneuver (Houser & Donovan, 1980).

The test evaluated:

1. The operational effectiveness of the two prototypes in the areas of fire power, fire control, and total system integration.
2. The mobility and survivability of the systems under operational conditions.
3. The reliability, availability, and maintainability characteristics of the gun systems under operational conditions.
4. The adequacy of the proposed training program and personnel selection criteria.
5. The adequacy of proposed doctrine, tactics and organization for employment of the DIVAD Gun candidates under operational conditions.
6. The susceptibility/vulnerability of the prototype systems in an Electronic Countermeasure (ECM) environment.

The test was run under: (1) two system modes: Moving and stationary, (2) two visibility conditions: Day and night, (3) four levels of ECM: Noise, deception, chaff, and benign, and (4) three environments: Normal, NBC, and dust/smoke.

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) was requested by OTEA to conduct a human factors evaluation of the two systems during the operational test. The purposes of the evaluation were to determine whether the crews can perform all required tasks to accomplish the mission objectives of the DIVAD Gun and to identify man-machine interfaces negatively affecting task accomplishment.

Method

Subjects

Thirty-two male service members, E2 through E6, stationed at Ft Bliss, Texas participated in the operational test. They were from the 1st Battalion (Chaparral/Vulcan), 55th Air Defense Artillery. The service members were separated into eight crews: Two for each of the two Ford systems and two for each of the two General Dynamics systems. A crew consisted of a squad leader, senior gunner, driver, and ammunition handler. Prior to the start of the test, the gun system contractors gave each of their crew members New Equipment Training (NET) appropriate to his gun system. Shortly after the start of the test, one crew member was replaced. The replacement received on-site training.

Apparatus

It had originally been planned to conduct the evaluation by observing the crew members via closed-circuit TV. However, permission to place TV cameras inside the vehicles was denied. It was then decided that written questionnaires would be a feasible method of collecting the data.

A master set of 506 items was developed, using the Questionnaire Construction Manual (Dyer, Matthews, Wright, & Yudowitch, 1976) designed by the ARI Ft Hood Field Unit as a guide. The master set consisted primarily of closed-ended questions (See Table 1). Most of these used 5-point, unipolar rating scales, although there were a few ranking items. The 5-point scales were preferred over 7 or 9-point scales for this use (Dyer, et. al., 1976, Chap VI-G, pg. 2). The 506 items, dealing with 22 subject areas (See Table 2), were used to construct five questionnaires.

Procedure

The questionnaires were to be administered to the Ford and General Dynamics crew members in separate locations just after the crew members had participated in relevant exercises (for example, night firing).

Two types of problems were encountered. The first type of problem was caused by scheduling changes, which sometimes resulted in crew members receiving questions concerning events in which they had not yet participated. When this occurred, those questions had to be recycled into the next questionnaire.

The other type of problem concerned the questions themselves. Prior to assembling the questionnaires, all the questions had been edited by subject matter experts, both for accuracy and for reading level. However, some of the crew members still did not understand some of the questions. Also, some of the crew members, despite written and verbal instructions, reacted to the ranking items as if they had been checklists.

Following the administration of the first questionnaire, the vocabulary used in the remaining items in the master set was further simplified as required. Also, simplified versions of those items which had been misunderstood on the first questionnaire were recycled into later questionnaires. The ranking items were replaced by items asking how often the events in question had occurred.

It has been suggested (Oppenheim, 1966, pp. 85 & 86) that the order of the response alternatives on ranking items be varied so that the first alternative is neither always positive nor always negative. This advice was followed but abandoned after the crew members expressed confusion.

To further clarify the answers to some of the questionnaire items, group discussions were held with the crew members.

Results and Discussion

ARI succeeded in obtaining answers to all of the items in the questionnaire. These results will be published in a future paper.

Today's soldiers have a wide range of reading ability. Therefore, individual interviews are probably preferable to written questionnaires. Unfortunately, giving individual interviews is not always practical, and a certain amount of data will be lost in group interviews. If questionnaires are used and it is not possible to perform a pilot study, the questions should be edited by soldiers of the same Military Occupational Speciality, educational level, and rank as those in the target population. Also, discussion sessions should be planned with at least a sample of the target population, to clarify, and perhaps expand upon, their responses.

References

- Dyer, R. F., Matthews, J. J., Wright, C. E., & Yudowitch, K. L. Questionnaire construction manual. Ft Hood, TX: U. S. Army Research Institute for the Behavioral and Social Sciences, Ft Hood Field Unit, 1976.
- Houser, B. J., & Donovan, J. Division air defense gun development/operational combined test plan (TDP-OT-582 3 WE-100-DIV-001). Falls Church, VA: U. S. Army Operational Test and Evaluation Agency, March 1980.
- Oppenheim, A. N. Questionnaire design and attitude measurement. New York: Basic Books, Inc., 1966.
- Vereb, T. A. The division gun program from the beginning to now. Air Defense Magazine, October-December, 1980, 26-29.

Table 1

SAMPLE QUESTIONS

012. How easy or hard is it to get out of the fire unit?

- VERY EASY
- EASY
- BORDERLINE
- HARD
- VERY HARD
- NO OPINION/DON'T KNOW

H5. Rate the quality of the view through the optical sight when DIVAD Gun is moving.

- EXCELLENT
- GOOD
- BORDERLINE
- POOR
- TERRIBLE
- NO OPINION/DON'T KNOW

024. Did your eyes get tired after watching the plasma display?

- NOT AT ALL TIRED
- A LITTLE TIRED
- TIRED
- QUITE TIRED
- EXTREMELY TIRED
- NO OPINION/DON'T KNOW

037. Which displays, gauges, dials, etc. (if any) are hard to read?

Table 2

The Number and Type of Question for Each Area

Area Title	Question Types				Total Number of Questions
	Closed-Ended		Open-Ended		
	5-Point Scale		Other		
	Unipolar	Bipolar			
Detection	31	0	1	1	33
Identification	23	0	1	5	29
Achieving Lock	19	0	0	2	21
Reasons for Breaking Lock	0	0	20	5	25
Smoke + Blast Signatures	8	0	0	0	8
ECM (Jamming)	11	0	1	1	13
Collimation + Alignment	6	0	1	2	8
Moving DIVAD Gun	9	0	1	1	11
Ammunition Reload	7	0	0	1	8
Bite Diagnostics	3	0	0	1	4
Training	20	10	10	0	40
Ground Targets	18	0	10	6	34
Night Operations	19	0	1	2	22
Logistics	20	0	0	3	23
Human Factors	52	5	5	10	72
Self + Mutual Defense	17	0	0	0	17
NBC	32	0	0	6	38
Camouflage	10	0	1	1	12
March Order/Emplacement	4	0	2	4	10
Doctrine + Tactics	25	0	0	17	42
Organization	7	0	1	8	16
Summary	13	0	1	1	20